

Package ‘EDE’

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Title Extinction Date Estimation from Sighting Records

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Description Estimates the historic date of extinction of a species from a time-ordered record of sighting events. Given a table of sighting counts per year, computes extinction date estimators from the sighting-record literature: optimal linear estimation and its Weibull extreme-value persistence test (Roberts & Solow, 2003; Solow, 2005), constant-rate and declining-rate persistence tests (Solow, 1993), a sighting-rate persistence test comparable across records with different observation periods (McInerny, Roberts, Davy & Cribb, 2006), a classical confidence interval on the end of a temporal range (Strauss & Sadler, 1989), a truncation-point extrapolation (Robson & Whitlock, 1964), and a combinatorial persistence test based on inclusion-exclusion over sighting-gap occupancy (Burgman, Grimson & Ferson, 1995). Also implements a nonparametric endpoint test (Solow & Roberts, 2003), a sighting-interval trend index (Jarić & Ebenhard, 2010), and reliability-adjusted inference for uncertain records (Jarić & Roberts, 2014). Every estimator is built on a validated input object and returns a common result class with, where defined, a point estimate, a confidence interval, or a full p-value curve.

Language en-US

License GPL (>= 3)

URL <https://github.com/rodrigossqrt3/EDE>

BugReports <https://github.com/rodrigossqrt3/EDE/issues>

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burgman1995	<i>Burgman, Grimson & Ferson (1995) combinatorial persistence test</i>
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Description

Computes the probability that, if sighting events were distributed uniformly at random over the candidate observation window, a run of empty periods at least as long as the largest observed run would occur. Uses an inclusion-exclusion (Stirling-number) argument on the occupancy of time bins by sighting events (equation 4 of the source paper).

Usage

```
burgman1995(sd, alpha = 0.05, test_year, data_out = FALSE)
```

Arguments

sd	A sighting_data object.
alpha	Significance level, in (0, 1). Persistence is rejected for the first candidate year at which the p-value falls to or below alpha.
test_year	Latest year to test. Must be supplied as a number.
data_out	If TRUE, return the full p-value curve instead of the single first-rejection year.

Value

An [ede_estimate](#) object, or (if `data_out = TRUE`) a data frame with columns `time` and `chance`.

References

Burgman, M. A., Grimson, R. C., & Ferson, S. (1995). Inferring threat from scientific collections. *Conservation Biology*, 9(4), 923-928.

ede_estimate	<i>Extinction date estimate</i>
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Description

Common S3 result class returned by every estimator in this package.

Format

A list with components:

estimate Point estimate, or NA if not defined for this method.

lower, upper Confidence interval bounds, or NA if not defined.

interval_type Either "two-sided" or "one-sided".

method Character string identifying the estimator.

alpha Significance level used to compute the estimate.

jaric2010	<i>Jaric & Ebenhard (2010) sighting-trend index</i>
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Description

Tests persistence from the average interval between distinct sighting times, optionally adjusted by the mean trend in consecutive interval lengths. The trend-adjusted calculation implements equations 5-6 of Jaric & Ebenhard (2010); `trend = FALSE` implements equations 3-4.

Usage

```
jaric2010(sd, alpha = 0.05, test_year, data_out = FALSE, trend = TRUE)
```

Arguments

<code>sd</code>	A sighting_data object.
<code>alpha</code>	Significance level, in (0, 1). Persistence is rejected for the first candidate year at which the p-value falls to or below <code>alpha</code> .
<code>test_year</code>	Latest year to test. Must be supplied as a number.
<code>data_out</code>	If TRUE, return the full p-value curve instead of the single first-rejection year.
<code>trend</code>	Logical. If TRUE (the default), adjust the average interval by the mean change in consecutive interval lengths.

Value

An [ede_estimate](#) object, or (if `data_out = TRUE`) a data frame with columns `time` and `chance`. The latter contains index p-values; the column name is retained for compatibility with EDE 0.1.0.

References

Jaric, I., & Ebenhard, T. (2010). A method for inferring extinction based on sighting records that change in frequency over time. *Wildlife Biology*, 16(3), 267-275.

jaric_roberts2014	<i>Reliability-adjusted extinction inference</i>
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Description

Modifies the constant-rate Solow model by assigning a reliability in $[0, 1]$ to each occupied sighting time. Implements equations 4, 6, and 8-10 of Jaric & Roberts (2014), returning the reliability-adjusted point estimate and upper confidence bound.

Usage

```
jaric_roberts2014(sd, reliability, alpha = 0.05)
```

Arguments

<code>sd</code>	A sighting_data object. This method currently requires binary counts (zero or one) because reliability is assigned to individual observations.
<code>reliability</code>	Numeric reliabilities in $[0, 1]$, supplied either for every row of <code>sd</code> or for the positive-count rows only.
<code>alpha</code>	Significance level, in $(0, 1)$, for the upper confidence bound.

Value

An [ede_estimate](#) object.

References

Jaric, I., & Roberts, D. L. (2014). Accounting for observation reliability when inferring extinction based on sighting records. *Biodiversity and Conservation*, 23(11), 2801-2815.

mcinerny2006	<i>McInerny, Roberts, Davy & Cribb (2006) sighting-rate persistence test</i>
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Description

A modification of the Solow (1993) persistence test that conditions on the sighting rate observed up to the last sighting, n / t_n , instead of on the length of the whole observation window. This makes the test comparable across records with very different total observation periods: species discovered recently and species discovered long ago, but sighted at the same rate, are inferred extinct after the same length of silence.

Usage

```
mcinerny2006(sd, alpha = 0.05, test_year, data_out = FALSE)
```

Arguments

sd	A sighting_data object.
alpha	Significance level, in (0, 1). Persistence is rejected for the first candidate year at which the p-value falls to or below alpha.
test_year	Latest year to test. Must be later than the last sighting.
data_out	If TRUE, return the full p-value curve instead of the single first-rejection year.

Details

Following the source paper, the first sighting is used to anchor the time origin ($t = 0$) rather than counted as one of the n sighting events being tested, so the count entering the formula is $n - 1$, where n is the number of distinct sighting times with a positive count.

Value

An [ede_estimate](#) object, or (if `data_out = TRUE`) a data frame with columns time and chance.

References

McInerny, G. J., Roberts, D. L., Davy, A. J., & Cribb, P. J. (2006). Significance of sighting rate in inferring extinction and threat. *Conservation Biology*, 20(2), 562-567.

ole	<i>Optimal Linear Estimation of extinction date</i>
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Description

Estimates the extinction date from the sighting times with a positive count, using the best linear unbiased estimator (BLUE) of Roberts & Solow (2003) under a Weibull-type record-value model for the spacing of the largest order statistics.

Usage

```
ole(sd, alpha = 0.05, k = NULL)
```

Arguments

sd	A sighting_data object.
alpha	Significance level for the confidence interval, in (0, 1).
k	Number of most recent sighting events to use. Counts greater than one are treated as independent events at the recorded time. By default, all sighting events are used. Must be at least 3.

Value

An [ede_estimate](#) object.

References

Roberts, D. L., & Solow, A. R. (2003). Flightless birds: When did the dodo become extinct? *Nature*, 426(6964), 245. Solow, A. R. (2005). Inferring extinction from a sighting record. *Mathematical Biosciences*, 195(1), 47-55.

robson1964	<i>Robson & Whitlock (1964) truncation point estimator</i>
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Description

Estimates the extinction date by jackknife bias correction of the most recent sighting. If the two most recent distinct sighting times are $t[n-1]$ and $t[n]$, the estimate is $t[n] + (t[n] - t[n-1])$.

Usage

```
robson1964(sd, alpha = 0.05)
```

Arguments

- sd A [sighting_data](#) object.
- alpha Significance level, in (0, 1), for the approximate one-sided confidence interval.

Value

An [ede_estimate](#) object.

References

Robson, D. S., & Whitlock, J. H. (1964). Estimation of a truncation point. *Biometrika*, 51(1/2), 33-39.

sighting_data	<i>Construct a validated sighting record</i>
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Description

Builds the common input object used by every estimator in the package: a time-ordered table of sighting counts, checked for the conditions each estimator in the sighting-record literature assumes (numeric, non-negative, no duplicated times).

Usage

```
sighting_data(data, time_col = 1L, count_col = 2L)
```

Arguments

- data A data frame or matrix. By default the first column is read as time (e.g. year) and the second as the number of sightings recorded at that time. The earliest supplied time defines the observation origin; include an initial zero-count row when observation began before the first sighting.
- time_col, count_col Column name or position for time and sighting count.

Value

An object of class `sighting_data`: a data frame with columns `time` and `count`, sorted by time.

solow1993	<i>Solow (1993) constant-rate persistence test</i>
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Description

Parametric test of the null hypothesis that a species was still extant at a candidate test year, under a stationary Poisson sighting process.

Usage

```
solow1993(sd, alpha = 0.05, test_year, data_out = FALSE)
```

Arguments

sd	A sighting_data object.
alpha	Significance level, in (0, 1). Persistence is rejected for the first candidate year at which the p-value falls to or below alpha.
test_year	Latest year to test. Must be supplied as a number.
data_out	If TRUE, return the full p-value curve instead of the single first-rejection year.

Value

An [ede_estimate](#) object, or (if data_out = TRUE) a data frame with columns time and chance.

References

Solow, A. R. (1993). Inferring extinction from sighting data. *Ecology*, 74(3), 962-964.

solow1993b	<i>Solow (1993b) declining-population persistence test</i>
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Description

Conditional test of the null hypothesis that a declining species was still extant at a candidate test year, under a non-stationary Poisson process with an exponentially declining rate.

Usage

```
solow1993b(sd, alpha = 0.05, test_year, data_out = FALSE)
```

Arguments

sd	A sighting_data object.
alpha	Significance level, in (0, 1).
test_year	Latest year to test. Must be later than the last sighting.
data_out	If TRUE, return the full p-value curve instead of the single first-rejection year.

Value

An [ede_estimate](#) object, or (if `data_out = TRUE`) a data frame with columns `time` and `chance`.

References

Solow, A. R. (1993b). Inferring extinction in a declining population. *Journal of Mathematical Biology*, 32(1), 79-82.

solow2005

Solow (2005) Weibull extreme-value persistence test

Description

Tests persistence using the Weibull extreme-value model for the k most recent sighting events. This is the hypothesis-test counterpart of [ole\(\)](#). For a candidate time T , the p-value is equation 16 of Solow (2005). Earlier EDE versions incorrectly described a Fisher-gap calculation as a sighting-effort-weighted method from this paper.

Usage

```
solow2005(sd, alpha = 0.05, test_year, data_out = FALSE, k = NULL)
```

Arguments

<code>sd</code>	A sighting_data object.
<code>alpha</code>	Significance level, in $(0, 1)$. Persistence is rejected for the first candidate year at which the p-value falls to or below <code>alpha</code> .
<code>test_year</code>	Latest year to test. Must be supplied as a number.
<code>data_out</code>	If <code>TRUE</code> , return the full p-value curve instead of the single first-rejection year.
<code>k</code>	Number of most recent sighting events to use. Counts greater than one are treated as independent events at the recorded time. By default, all sighting events are used. Must be at least 3.

Value

An [ede_estimate](#) object, or (if `data_out = TRUE`) a data frame with columns `time` and `chance`.

References

Solow, A. R. (2005). Inferring extinction from a sighting record. *Mathematical Biosciences*, 195(1), 47-55.

solow_roberts2003	<i>Solow & Roberts (2003) nonparametric persistence test</i>
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Description

Tests the null hypothesis that a species persisted to a candidate time using only the two most recent distinct sighting times. For candidate time T , the p-value is $(t[n] - t[n-1]) / (T - t[n-1])$.

Usage

```
solow_roberts2003(sd, alpha = 0.05, test_year, data_out = FALSE)
```

Arguments

sd	A sighting_data object.
alpha	Significance level, in (0, 1). Persistence is rejected for the first candidate year at which the p-value falls to or below alpha.
test_year	Latest year to test. Must be supplied as a number.
data_out	If TRUE, return the full p-value curve instead of the single first-rejection year.

Value

An [ede_estimate](#) object, or (if data_out = TRUE) a data frame with columns time and chance. The latter contains p-values; the column name is retained for compatibility with EDE 0.1.0.

References

Solow, A. R., & Roberts, D. L. (2003). A nonparametric test for extinction based on a sighting record. *Ecology*, 84(5), 1329-1332.

strauss1989	<i>Strauss & Sadler (1989) confidence interval for the end of a range</i>
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Description

Unbiased point estimator and classical confidence interval for the true endpoint of a temporal range, derived from the distribution of the sample range under a uniform occurrence model.

Usage

```
strauss1989(sd, alpha = 0.05)
```

Arguments

sd	A sighting_data object.
alpha	Significance level, in (0, 1).

Value

An [ede_estimate](#) object containing the unbiased point estimate and a one-sided confidence interval.

References

Strauss, D., & Sadler, P. M. (1989). Classical confidence intervals and Bayesian probability estimates for ends of local taxon ranges. *Mathematical Geology*, 21(4), 411-427.

strauss1989_curve	<i>Full confidence curve for the Strauss & Sadler (1989) estimator</i>
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Description

Same estimator as [strauss1989\(\)](#), evaluated over a grid of alpha values from 0.01 to 1, for plotting the confidence curve instead of a single bound.

Usage

```
strauss1989_curve(sd)
```

Arguments

sd A [sighting_data](#) object.

Value

A data frame with columns time and chance (1 - alpha).

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