Package ‘SightabilityModel’

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Description

Uses logistic regression to model the probability of detection as a function of covariates. This model is then used with observational survey data to estimate population size, while accounting for uncertain detection. See Steinhorst and Samuel (1989).

Details

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Author(s)

John Fieberg

Maintainer: John Fieberg <jfieberg@umn.edu>

References


covtheta

Estimates var/cov matrix of inflation factors (1/prob detection) using a non-parametric bootstrap.

Description

Estimates var/cov matrix of inflation factors (1/prob detection) using a non-parametric bootstrap. Called by function Sight.Est if Vm.boot = TRUE.
exp.m

Usage

covtheta(total, srates, stratum, subunit, covars, betas, varbetas, nboots)

Arguments

total Number of animals in each independently sighted group
srates Plot sampling probability (associated with the independently observed animal groups)
stratum Stratum identifiers (associated with the independently observed animal groups)
subunit Plot ID (associated with the independently observed animal groups)
covars Matrix of sightability covariates (associated with the independently observed animal groups)
betas Logistic regression parameter estimates (from fitted sightability model)
varbetas Estimated variance-covariance matrix for the logistic regression parameter estimates (from fitted sightability model)
nboots Number of bootstrap resamples.

Value

smat Estimated variance-covariance matrix for the inflation factors theta = (1/probability of detection). This is an n.animal x n.animal matrix.

Author(s)

John Fieberg

See Also

Sight.Est

exp.m                  Experimental (test trials) data set used to estimate detection probabilities for moose in MN

Description

Experimental (test trials) data set used to estimate detection probabilities for moose in MN

Usage

data(exp.m)
Format
A data frame with 124 observations on the following 4 variables.

- **year**: year of the experimental survey (test trial)
- **observed**: Boolean variable (=1 if moose was observed and 0 otherwise)
- **voc**: measurement of visual obstruction
- **grpsize**: group size (number of observed moose in each independently sighted group)

References

Examples
data(exp.m)
exp.m[1:5]

---

**g.fit**

Mountain Goat Sightability Model Information

Description
Model averaged regression parameters and unconditional variance-covariance matrix for mountain goat sightability model (Rice et al. 2009)

Usage
data(g.fit)

Format
The format is: beta.g = list of regression parameters (intercept and parameters associated with GroupSize, Terrain, and X.VegCover) varbeta.g = variance-covariance matrix (associated with beta.g)

References

Examples
data(g.fit)
Mountain Goat Survey Data from Olympic National park

Description

Mountain Goat Survey Data from Olympic National park collected in 2004

Usage

data(gdat)

Format

A data frame with 113 observations on the following 9 variables.

GroupSize  number of animals observed in each independently sighted group [cluster size]
Terrain   measure of terrain obstruction
pct.VegCover  measure of vegetative obstruction
stratum  stratum identifier
total   number of animals observed in each independently sighted group [same as GroupSize]
subunit a numeric vector, Plot ID

Source

Patti Happe (Patti_Happe@nps.gov)

References


Examples

data(gdat)
MN moose survey data

Description
Operational survey data for moose in MN (during years 2004-2007). Each record corresponds to an independently sighted group of moose, with variables that capture individual covariates (used in the detection model) as well as plot-level information (stratum identifier, sampling probability, etc).

Usage
data(obs.m)

Format
A data frame with 805 observations on the following 11 variables.

- year: year of survey
- stratum: stratum identifier
- subunit: sample plot ID
- total: number of moose observed
- cows: number of cows observed
- calves: number of calves observed
- bulls: number of bulls observed
- unclass: number of unclassified animals observed (could not identify sex/age class)
- voc: measurement of visual obstruction
- grpsize: group size (cluster size)

References

Examples
data(obs.m)
obs.m[1:5,]
print.sightest

Print method for sightability estimator

Description
Prints fitted sightability model, sampling information, and sightability estimate (with confidence interval)

Usage
## S3 method for class 'sightest'
print(x, ...)

Arguments
x Sightability object, output from call to Sight.Est function.
... arguments to be passed to or from other methods

Author(s)
John Fieberg

See Also
Sight.Est, summary.sightest

sampinfo.m

Data set containing sampling information for observation survey of moose in MN

Description
Data set containing sampling information from a survey of moose in MN (during years 2004-2007)

Usage
data(sampinfo.m)

Format
A data frame with 12 observations on the following 5 variables.

year year of survey
stratum stratum identifier
Nh number of population units in stratum h
nh number of sample units in stratum h
References


Examples

data(sampinfo.m)
sampinfo.m

---

Sight.Est

Sightability Model Estimator

Description

Estimates population abundance by 1) fitting a sightability (logistic regression) model to "test trial" data; 2) applying the fitted model to independent (operational) survey data to correct for detection rates < 1.

Usage

Sight.Est(form, sdat, odat, sampinfo, method = "Wong",
          logCI = TRUE, alpha = 0.05, Vm.boot = FALSE, nboot = 1000,
          bet = NULL, varbet = NULL)

Arguments

form a symbolic description of the sightability model to be fit (e.g., "y ~ x1 + x2 + ..."), where y is a binary response variable (= 1 if the animal is seen and 0 otherwise) and x1, x2, ... are a set of predictor variables thought to influence detection

sdat 'sightability’ data frame. Each row represents an independent sightability trial, and columns contain the response (a binary random variable = 1 if the animal was observed and 0 otherwise) and the covariates used to model detection probabilities.

odat 'observational survey’ data frame containing the following variable names (stratum, subunit, total) along with the same covariates used to model detection probabilities (each record corresponds to an independently sighted group of animals). stratum = stratum identifier (will take on a single value for non-stratified surveys); subunit = numeric plot unit identifier; total = total number of observed animals (for each independently sighted group of animals).

sampinfo data frame containing sampling information pertaining to the observational survey. Must include the following variables (stratum, nh, Nh). stratum = stratum identifier (must take on the same values as stratum variable in observational data set), nh = number of sampled units in stratum h, Nh = number of population units in stratum h; note (this dataset will contain a single record for non-stratified designs).
method  method for estimating variance of the abundance estimator. Should be one of
("Wong", "SS"). See details for more information.

logCI  Boolean variable, default (= TRUE), indicates the confidence interval should
be constructed under the assumption that (tau^ - T) is lognormally distributed,
where T is the total number of animals observed (see details)

alpha  type I error rate for confidence interval construction

Vm.boot  Boolean variable, when = TRUE indicates a bootstrap should be used to estimate
cov(theta[i,j],theta[i',j']), var/cov matrix of the expansion factors (1/detection
prob)

nboot  number of bootstrap replicates to use if Vm.boot = TRUE

bet  regression parameters (if the sightability model is not to be fit by Sight.Est).
Make sure the order is consistent with the specification in the "form" argument.

varbet  variance-covariance matrix for beta^ (if the sightability model is not to be fit by
Sight.Est). Make sure the order is consistent with the specification in the "form"
argument.

Details

Variance estimation methods: method = Wong implements the variance estimator from Wong
(1996) and is the recommended approach. Method = SS implements the variance estimator of

Estimates of the variance may be biased low when the number of test trials used to estimate model
parameters is small (see Wong 1996, Fieberg and Guidice 2008). A bootstrap can be used to aid
the estimation process by specifying Vm.boot = TRUE [note: this method is experimental, and can be
time intensive].

Confidence interval construction: often the sampling distribution of tau^ is skewed right. If logCI
= TRUE, the confidence interval for tau^ will be constructed under an assumption that (tau^ - T) is
lognormally distributed, where T is the total number of animals seen. In this case, the upper and
lower limits are constructed as follows [see Wong(1996, p. 64-67)]:

LCL = T + [(tau^-T)/C]*sqrt(1+cv^2), UCL = T+[(tau^-T)*C]*sqrt(1+cv^2),
where cv^2 = var(tau^)/(tau^-T)^2 and C = exp[z[alpha/2]*sqrtln(1+cv^2)].

Value

An object of class sightest, a list that includes the following elements:
sight.model  the fitted sightability model
est  abundance estimate [tau.hat] and its estimate of uncertainty [Vartot] as well
as variance components due to sampling [Varsamp], detection [VarSight], and
model uncertainty [VarMod]

The list also includes the original test trial and operational survey data, sampling information, and
information needed to construct a confidence interval for the population estimate.

Author(s)

John Fieberg, Wildlife Biometrician, Minnesota Department of Natural Resources
References


Examples

```r
# Load data frames
data(obs.m) # observational survey data frame
data(exp.m) # experimental survey data frame
data(sampinfo.m) # information on sampling rates (contained in a data frame)

# Estimate population size in 2007 only
sampinfo <- sampinfo.m[sampinfo.m$year == 2007,]
Sight.Est(estimated ~ voc, odat = obs.m[obs.m$year == 2007,],
sdat = exp.m, sampinfo, method = "Wong",
logCI = TRUE, alpha = 0.05, Vm.boot = FALSE)

# BELOW CODE IS SOMEWHAT TIME INTENSIVE (fits models using 2 variance estimators to 3 years of data)
# Estimate population size for 2004-2007
# Compare Wong’s and Steinhorst and Samuel variance estimators
tau.Wong <- tau.SS <- matrix(NA,4,3)
count <- 1
for(i in 2004:2007){
sampinfo <- sampinfo.m[sampinfo.m$year == i,]
Wong's variance estimator
  temp <- Sight.Est(estimated ~ voc, odat = obs.m[obs.m$year == i,],
    sdat = exp.m, sampinfo, method = "Wong",
    logCI = TRUE, alpha = 0.05, Vm.boot = FALSE)
  tau.Wong[count, ] <- unlist(summary(temp))

Steinhorst and Samuel (with Samuel et al. 1992 modification)
  temp <- Sight.Est(estimated ~ voc, odat = obs.m[obs.m$year == i,],
    sdat = exp.m, sampinfo, method = "SS")
  tau.SS[count, ] <- unlist(summary(temp))
count<-count+1
}
rownames(tau.Wong) <- rownames(tau.SS) <- 2004:2007
colnames(tau.Wong) <- colnames(tau.SS) <- c("tau.hat","LCL","UCL")
(tau.Wong <- apply(tau.Wong, 1:2,
```
SS.est

Sightability estimate with variance components estimator from Steinhorst and Samuel (1989) and Samuel et al. (1992).

Description

Estimates population size, with variance estimated using Steinhorst and Samuel (1989) and Samuel et al.'s (1992) estimator. Usually, this function will be called by Sight.Est

Usage

SS.est(total, srates, nh, Nh, stratum, subunit, covars, beta, varbeta, smat = NULL)

Arguments

total Number of animals in each independently sighted group
srates Plot-level sampling probability
nh Number of sample plots in each stratum
Nh Number of population plots in each stratum
stratum Stratum identifiers (associated with the independently observed animal groups)
subunit Plot ID (associated with the independently observed animal groups)
covars Matrix of sightability covariates (associated with the independently observed animal groups)
beta Logistic regression parameter estimates (from fitted sightability model)
varbeta Estimated variance-covariance matrix for the logistic regression parameter estimates (from fitted sightability model)
smat Estimated variance-covariance matrix for the inflation factors (1/probability of detection). This is an n.animal x n.animal matrix, and is usually calculated within the SS.est function. Non-null values can be passed to the function (e.g., if a bootstrap is used to estimate uncertainty due to the estimated detection parameters).
Value

- tau.hat: Sightability estimate of population size, \( \tau^* \)
- Vartot: Estimated variance of \( \tau^* \)
- VarSamp: Estimated variance component due to sampling aerial units
- VarSight: Estimated variance component due to sighting process (i.e., series of binomial \( \text{rv} \) for each animal group)
- Varmod: Estimated variance component due to estimating detection probabilities using test trial data

Author(s)

John Fieberg

References


See Also

- `summaryNest`
- `summaryNsightest`

Description

Calculates confidence interval (based on asymptotic [normal or log-normal assumption])

Usage

```r
## S3 method for class 'sightest'
summary(object, ...)
```

Arguments

- `object`: Sightability object, output from call to `Sight.Est` function.
- `...`: arguments to be passed to or from other methods

Value

- `nhat`: Sightability population estimate
- `lcl`: Lower confidence limit
- `ucl`: Upper confidence limit
**vardiff**

**Author(s)**

John Fieberg

**See Also**

*Sight.Est*

---

| vardiff | Function to estimate the variance of the difference between two population estimates |

**Description**

Function to estimate the variance of the difference between two population estimates formed using the same sightability model (to correct for detection).

**Usage**

vardiff(sight1, sight2)

**Arguments**

- **sight1**: Sightability model object for the first population estimate (formed by calling Sight.Est function)
- **sight2**: Sightability model object for the second population estimate (formed by calling Sight.Est function)

**Details**

Population estimates constructed using the same sightability model will NOT be independent (they will typically exhibit positive covariance). This function estimates the covariance due to using the same sightability model and subtracts it from the summed variance.

**Value**

vardiff numeric = var(tau^[1])+var(tau^[2])-2*Cov(tau^[1],tau^[2])

**Author(s)**

John Fieberg
Examples

# Example using moose survey data
data(obs.m) # observational moose survey data
data(exp.m) # experimental moose survey data
data(sampinfo.m) # information on sampling rates

# Estimate population size in 2006 and 2007
sampinfo <- sampinfo.m[sampinfo.m$year == 2007,]
tau.2007 <- Sight.Est(observed ~ voc, odat = obs.m[obs.m$year == 2007,],
                          sdat = exp.m, sampinfo.m[sampinfo.m$year == 2007,],
                          method = "Wong", logCI = TRUE, alpha = 0.05, Vm.boot = FALSE)
tau.2006 <- Sight.Est(observed ~ voc, odat = obs.m[obs.m$year == 2006,],
                          sdat = exp.m, sampinfo.m[sampinfo.m$year == 2006,],
                          method = "Wong", logCI = TRUE, alpha = 0.05, Vm.boot = FALSE)

# naive variance

# variance after subtracting positive covariance
vardiff(tau.2007, tau.2006)

---

**Description**

Calculates the variance of the log rate of change between 2 population estimates that rely on the same sightability model.

**Usage**

```r
varlog.lam(sight1, sight2)
```

**Arguments**

- `sight1`  
  Sightability model object for the first population estimate (formed by calling `Sight.Est` function)

- `sight2`  
  Sightability model object for the second population estimate (formed by calling `Sight.Est` function)

**Details**

This function uses the delta method to calculate an approximate variance for the log rate of change, \( \log(\tau^{t+1}) - \log(\tau^t) \), while accounting for the positive covariance between the two estimates (as a result of using the same sightability model to correct for detection).
Value

- `loglambda` - log rate of change = log(\(\tau^{t+1}/\tau^t\))
- `varloglamda` - approximate variance of `loglambda`

Author(s)

John Fieberg

See Also

- `vardiff`

Examples

```r
# Example using moose survey data
data(obs.m) # observational moose survey data
data(exp.m) # experimental moose survey data
data(sampinfo.m) # information on sampling rates

# Estimate population size in 2006 and 2007
sampinfo <- sampinfo.m[sampinfo.m$year == 2007, ]
tau.2007 <- Sight.Est(observed ~ voc, odat = obs.m[obs.m$year == 2007, ],
                      sdat = exp.m, sampinfo.m[sampinfo.m$year == 2007, ],
                      method = "Wong", logCI = TRUE, alpha = 0.05, Vm.boot = FALSE)
tau.2006 <- Sight.Est(observed ~ voc, odat = obs.m[obs.m$year == 2006, ],
                      sdat = exp.m, sampinfo.m[sampinfo.m$year == 2006, ],
                      method = "Wong", logCI = TRUE, alpha = 0.05, Vm.boot = FALSE)

# Log rate of change
varlog.lam(tau.2006, tau.2007)
```

Wong.est

*Sightability estimate with variance components estimator from Wong (1996)*

Description

Estimates population size, with variance estimated using Wong’s (1996) estimator. This function will usually be called by `Sight.Est` function (but see details).

Usage

`Wong.est(total, srates, nh, Nh, stratum, subunit, covars, beta, varbeta, smat = NULL)`
Arguments

- `total` Number of animals in each independently sighted group
- `srates` Vector of plot-level sampling probabilities (same dimension as `total`).
- `nh` Number of sample plots in each stratum
- `Nh` Number of population plots in each stratum
- `stratum` Stratum identifiers (associated with the independently observed animal groups)
- `subunit` Plot ID (associated with the independently observed animal groups)
- `covars` Matrix of sightability covariates (associated with the independently observed animal groups)
- `beta` Logistic regression parameter estimates (from fitted sightability model)
- `varbeta` Estimated variance-covariance matrix for the logistic regression parameter estimates (from fitted sightability model)
- `smat` Estimated variance-covariance matrix for the inflation factors (1/probability of detection). This is an n.animal x n.animal matrix, and is usually calculated within the Wong.est function. Non-null values can be passed to the function (e.g., if a bootstrap is used to estimate uncertainty due to the estimated detection parameters).

Details

This function is called by Sight.Est, but may also be called directly by the user (e.g., in cases where the original sightability [test trial] data are not available, but the parameters and var/cov matrix from the logistic regression model is available in the literature).

Value

- `tau.hat` Sightability estimate of population size, \( \hat{\tau} \)
- `Vartot` Estimated variance of \( \hat{\tau} \)
- `VarSamp` Estimated variance component due to sampling aerial units
- `VarSight` Estimated variance component due to sighting process (i.e., series of binomial rv for each animal group)
- `Varmod` Estimated variance component due to estimating detection probabilities using test trial data

Author(s)

John Fieberg

References


See Also

Sight.Est, SS.est
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