Imperfect detection - assignment

2023-12-03

Question 1: Form meaningful biological hypotheses about how Opossum's occupancy and detection probabilities might vary

Key information:

- Opossums are sensitive to temperature
- Opossums are generalist in terms of habitat preference
- Opossum activity patterns are affected by fire

Biological hypotheses:

- Hypothesis 1:
  - *Opossum occupancy increases with average yearly temperature*
- Hypothesis 2:
  - *Opossum occupancy does not vary with habitat quality*
- Hypothesis 3:
  - *Opossum detection probability increases with occurrence of fire*

Question 2: Prepare the data and run the models corresponding to your biological hypotheses from Q1

Prepare the data

```
#Load opossum data

opossum = read.csv("opossumdata.csv")
opossum
```

```
##    Site det1 det2 det3 det4 det5 det6 det7 det8 Temperature Habitat Fire1 Fire2
## 1     1    0    0    1   NA   NA    0    0    0        13.0       2     0     0
## 2     2    0    0    0    0    0    0    0    0        13.0       2     0     0
## 3     3    1    0    1    0   NA    1    0   NA        15.0       2     0     0
## 4     4    0    1   NA    0    1    1    0    1        16.0       4     0     0
## 5     5    0    0    0    0    0    1    1    0        18.0       5     0     0
## 6     6    1    0    1    1    0    0    0    1        20.0       6     0     0
## 7     7    0    1    1    0    0    1   NA    1        21.0       7     0     0
## 8     8    1    0    0    1   NA    0    0   NA        21.0       7     0     0
## 9     9    0    0    1    1    0    1    1    1        21.0       7     0     0
## 10   10    1    1    1    0    1    1    1    1        23.0       8     0     0
## 11   11    0    1    0   NA    0    0    0    1        25.0       8     0     0
## 12   12    0    0    1    0    1    0    1    0        26.0       9     0     0
## 13   13    1    0    0    0    0    0    0    1        29.0       9     0     0
## 14   14    0    1    1    1    1    0    1    0        31.0       9     0     0
## 15   15    1    0    0    0    0    1    0    1        35.0       9     0     0
## 16   16    0    1    1    1    1    1    1    0        37.0       9     0     0
## 17   17    1    1    1    0    0    1    1    1        38.0      10     0     0
## 18   18    0    1    1    1    1    0    1    0        40.6      10     0     0
## 19   19    0    1    1    1    0    0    1    1        42.0      10     0     0
## 20   20    1    1    1    1    1    1    0    1        42.3      10     0     0
##    Fire3 Fire4 Fire5 Fire6 Fire7 Fire8
## 1      1     1     0     0     1     1
## 2      1     1     0     0     1     1
## 3      1     1     0     0     1     1
## 4      1     1     0     0     1     1
## 5      1     1     0     0     1     1
## 6      1     1     0     0     1     1
## 7      1     1     0     0     1     1
## 8      1     1     0     0     1     1
## 9      1     1     0     0     1     1
## 10     1     1     0     0     1     1
## 11     1     1     0     0     1     1
## 12     1     1     0     0     1     1
## 13     1     1     0     0     1     1
## 14     1     1     0     0     1     1
## 15     1     1     0     0     1     1
## 16     1     1     0     0     1     1
## 17     1     1     0     0     1     1
## 18     1     1     0     0     1     1
## 19     1     1     0     0     1     1
## 20     1     1     0     0     1     1
```

```r
#Separate detection history

y=opossum[,2:9]
y
```

```
##    det1 det2 det3 det4 det5 det6 det7 det8
## 1     0    0    1   NA   NA    0    0    0
## 2     0    0    0    0    0    0    0    0
## 3     1    0    1    0   NA    1    0   NA
## 4     0    1   NA    0    1    1    0    1
## 5     0    0    0    0    0    1    1    0
```

```
## 6      1     0     1     1     0     0     0     1
## 7      0     1     1     0     0     1    NA     1
## 8      1     0     0     1    NA     0     0    NA
## 9      0     0     1     1     0     1     1     1
## 10     1     1     1     0     1     1     1     1
## 11     0     1     0    NA     0     0     0     1
## 12     0     0     1     0     1     0     1     0
## 13     1     0     0     0     0     0     0     1
## 14     0     1     1     1     1     0     1     0
## 15     1     0     0     0     0     1     0     1
## 16     0     1     1     1     1     1     1     0
## 17     1     1     1     0     0     1     1     1
## 18     0     1     1     1     1     0     1     0
## 19     0     1     1     1     0     0     1     1
## 20     1     1     1     1     1     1     0     1
```

```
#Organise co-variates

siteCovs = data.frame(Temperature=opossum$Temperature, Habitat=opossum$Habitat)
obsCovs = data.frame(opossum[,12:19])
obsCovs = list(obsCovs=obsCovs)
siteCovs
```

```
##    Temperature Habitat
## 1         13.0       2
## 2         13.0       2
## 3         15.0       2
## 4         16.0       4
## 5         18.0       5
## 6         20.0       6
## 7         21.0       7
## 8         21.0       7
## 9         21.0       7
## 10        23.0       8
## 11        25.0       8
## 12        26.0       9
## 13        29.0       9
## 14        31.0       9
## 15        35.0       9
## 16        37.0       9
## 17        38.0      10
## 18        40.6      10
## 19        42.0      10
## 20        42.3      10
```

```
obsCovs
```

```
## $obsCovs
##    Fire1 Fire2 Fire3 Fire4 Fire5 Fire6 Fire7 Fire8
## 1      0     0     1     1     0     0     1     1
## 2      0     0     1     1     0     0     1     1
## 3      0     0     1     1     0     0     1     1
## 4      0     0     1     1     0     0     1     1
```

```
## 5      0      0      1      1      0      0      1      1
## 6      0      0      1      1      0      0      1      1
## 7      0      0      1      1      0      0      1      1
## 8      0      0      1      1      0      0      1      1
## 9      0      0      1      1      0      0      1      1
## 10     0      0      1      1      0      0      1      1
## 11     0      0      1      1      0      0      1      1
## 12     0      0      1      1      0      0      1      1
## 13     0      0      1      1      0      0      1      1
## 14     0      0      1      1      0      0      1      1
## 15     0      0      1      1      0      0      1      1
## 16     0      0      1      1      0      0      1      1
## 17     0      0      1      1      0      0      1      1
## 18     0      0      1      1      0      0      1      1
## 19     0      0      1      1      0      0      1      1
## 20     0      0      1      1      0      0      1      1
```

```r
#Organise data using UMF

umf = unmarkedFrameOccu(y = y, siteCovs = siteCovs, obsCovs = obsCovs)
summary(umf)
```

```
## unmarkedFrame Object
##
## 20 sites
## Maximum number of observations per site: 8
## Mean number of observations per site: 7.55
## Sites with at least one detection: 19
##
## Tabulation of y observations:
##    0    1 <NA>
##   75   76    9
##
## Site-level covariates:
##   Temperature       Habitat
##  Min.   :13.00   Min.   : 2.00
##  1st Qu.:19.50   1st Qu.: 5.75
##  Median :24.00   Median : 8.00
##  Mean   :26.34   Mean   : 7.15
##  3rd Qu.:35.50   3rd Qu.: 9.00
##  Max.   :42.30   Max.   :10.00
##
## Observation-level covariates:
##     obsCovs
##  Min.   :0.0
##  1st Qu.:0.0
##  Median :0.5
##  Mean   :0.5
##  3rd Qu.:1.0
##  Max.   :1.0
```

```r
#Standardise the covariates
```

```r
umf@siteCovs$Temperature = scale(umf@siteCovs$Temperature)

umf@siteCovs$Habitat = scale(umf@siteCovs$Habitat)

umf@obsCovs$obsCovs = scale(umf@obsCovs$obsCovs)
```

Create the models

Model 1

```r
#Model 1 - no covariates

model1 = occu(formula = ~1 ~1, data = umf)

model1
```

```
##
## Call:
## occu(formula = ~1 ~ 1, data = umf)
##
## Occupancy:
##  Estimate   SE    z P(>|z|)
##      2.99 1.08 2.78 0.00537
##
## Detection:
##  Estimate    SE     z P(>|z|)
##     0.121 0.169 0.713   0.476
##
## AIC: 209.5245
```

```r
#backtransform from LOGIT scale

backTransform(model1, type="det") #(detection probability, p = 0.530)
```

```
## Backtransformed linear combination(s) of Detection estimate(s)
##
##  Estimate     SE LinComb (Intercept)
##      0.53 0.0422   0.121           1
##
## Transformation: logistic
```

```r
backTransform(model1, type="state") #(occupancy probability, p = 0.952)
```

```
## Backtransformed linear combination(s) of Occupancy estimate(s)
##
##  Estimate     SE LinComb (Intercept)
##     0.952 0.0489    2.99           1
##
## Transformation: logistic
```

Model 2

```r
#Model 2 - No detection covariate, occupancy covariate of average yearly temperature ('Temperature')

model2 = occu(formula = ~1 ~Temperature, data = umf)

model2
```

```
##
## Call:
## occu(formula = ~1 ~ Temperature, data = umf)
##
## Occupancy:
##             Estimate   SE     z P(>|z|)
## (Intercept)     32.4 70.6 0.459   0.646
## Temperature     24.0 52.4 0.458   0.647
##
## Detection:
##  Estimate    SE     z P(>|z|)
##     0.126 0.168 0.751   0.453
##
## AIC: 206.4578
```

```r
backTransform(model2, type="det") #(detection probability, p = 0.531)
```

```
## Backtransformed linear combination(s) of Detection estimate(s)
##
##  Estimate     SE LinComb (Intercept)
##     0.531 0.0418   0.126           1
##
## Transformation: logistic
```

```r
lincombA1 = linearComb(model2, coefficients = c(1,0), type = "state")
backTransform(lincombA1) #(occupancy probability (low temperature), p = 1)
```

```
## Backtransformed linear combination(s) of Occupancy estimate(s)
##
##  Estimate       SE LinComb (Intercept) Temperature
##         1 5.74e-13    32.4           1           0
##
## Transformation: logistic
```

```r
lincombB1 = linearComb(model2, coefficients = c(1,1), type = "state")
backTransform(lincombB1) #(occupancy probability (high temperature), p = 1)
```

```
## Backtransformed linear combination(s) of Occupancy estimate(s)
##
##  Estimate       SE LinComb (Intercept) Temperature
##         1 3.71e-23    56.5           1           1
##
## Transformation: logistic
```

Model 3

```r
#Model 3 - No detection covatiate, occupancy covariate of habitat quality ('Habitat')

model3 = occu(formula = ~1 ~Habitat, data = umf)

model3
```

```
##
## Call:
## occu(formula = ~1 ~ Habitat, data = umf)
##
## Occupancy:
##             Estimate   SE     z P(>|z|)
## (Intercept)    17.27 87.1 0.198   0.843
## Habitat         8.93 47.0 0.190   0.849
##
## Detection:
##  Estimate    SE     z P(>|z|)
##     0.125 0.168 0.748   0.454
##
## AIC: 207.4847
```

```r
backTransform(model3, type="det") #(detection probability, p = 0.531)
```

```
## Backtransformed linear combination(s) of Detection estimate(s)
##
##  Estimate     SE LinComb (Intercept)
##     0.531 0.0418   0.125           1
##
## Transformation: logistic
```

```r
lincombA2 = linearComb(model3, coefficients = c(1,0), type = "state")
backTransform(lincombA2) #(occupancy probability (low habitat quality), p = 1)
```

```
## Backtransformed linear combination(s) of Occupancy estimate(s)
##
##  Estimate       SE LinComb (Intercept) Habitat
##         1 2.76e-06    17.3           1       0
##
## Transformation: logistic
```

```r
lincombB2 = linearComb(model3, coefficients = c(1,1), type = "state")
backTransform(lincombB2) #(occupancy probability (high habitat quality), p = 1)
```

```
## Backtransformed linear combination(s) of Occupancy estimate(s)
##
##  Estimate       SE LinComb (Intercept) Habitat
##         1 5.61e-10    26.2           1       1
##
## Transformation: logistic
```

Model 4

```
#Model 4 - detection covariate of occurence of fire ('obsCovs'), no occupancy covariate


model4 = occu(formula = ~ obsCovs
                        ~ 1,
              data = umf)
model4
```

```
##
## Call:
## occu(formula = ~obsCovs ~ 1, data = umf)
##
## Occupancy:
##  Estimate   SE    z P(>|z|)
##      2.99 1.07 2.79 0.00527
##
## Detection:
##             Estimate    SE     z P(>|z|)
## (Intercept)    0.127 0.170 0.745   0.456
## obsCovs        0.214 0.169 1.268   0.205
##
## AIC: 209.9069
```

```
lincombA3 = linearComb(model4, coefficients = c(1,0), type = "det")
backTransform(lincombA3) #(detection probability (no fire), p = 0.532)
```

```
## Backtransformed linear combination(s) of Detection estimate(s)
##
##  Estimate     SE LinComb (Intercept) obsCovs
##     0.532 0.0424   0.127           1       0
##
## Transformation: logistic
```

```
lincombB3 = linearComb(model4, coefficients = c(1,1), type = "det")
backTransform(lincombB3) #(detection probability (fire), p = 0.584)
```

```
## Backtransformed linear combination(s) of Detection estimate(s)
##
##  Estimate     SE LinComb (Intercept) obsCovs
##     0.584 0.0593   0.341           1       1
##
## Transformation: logistic
```

```
backTransform(model4, type="state") #(occupancy probability, p = 0.952)
```

```
## Backtransformed linear combination(s) of Occupancy estimate(s)
##
##  Estimate     SE LinComb (Intercept)
##     0.952 0.0489    2.99           1
##
## Transformation: logistic
```

Compare models 1, 2, 3 and 4 using AIC

```
fit = fitList('psi(.)p(.)' = model1,
              'psi(Temperature)p(.)' = model2,
              'psi(Habitat)p(.)'=model3,
              'psi(.)p(obsCovs)' = model4)

modSel(fit)
```

```
##                      nPars    AIC delta AICwt cumltvWt
## psi(Temperature)p(.)     3 206.46  0.00 0.502     0.50
## psi(Habitat)p(.)         3 207.48  1.03 0.300     0.80
## psi(.)p(.)               2 209.52  3.07 0.108     0.91
## psi(.)p(obsCovs)         3 209.91  3.45 0.089     1.00
```

Q2 Conclusion Part 1

- The best models are Models 2 and 3:
  - Model 2 - AIC = 206.46 - No detection covariate, occupancy covariate of average yearly temperature ('Temperature')
  - Model 3 - AIC = 207.48 - No detection covatiate, occupancy covariate of habitat quality ('Habitat')
- Cannot determine which of Models 2 and 3 are more suitable, as they are within +/- 2 AIC of each other

Q2 Conclusion Part 2

- **Hypotheses:**
  - Hypothesis 1 - *Opossum occupancy increases with average yearly temperature*
    - tested by Model 2 - hypothesis **is not** supported as occupancy probability was 1 (did not vary) for both low and high average yearly temperatures.
  - Hypothesis 2 - *Opossum occupancy does not vary with habitat quality*
    - tested by Model 3 - hypothesis **is** supported as occupany probability was 1 (did not vary) for low and high habitat quality
  - Hypothesis 3 - *Opossum detection probability increases with occurrence of fire*
    - tested by Model 4 - hypothesis **is** supported as detection probability was 0.532 when there was no fire, but it was 0.584 (increased) when there was fire

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Question 3: Interpret the obtained (back transformed) values of the estimates for occupancy and detection probability from the best ranked model(s)

The best ranked models:

- Model 2:

- Occupancy probability was 1 for low and high average yearly temperatures. This shows that **these data** suggest that temperature (within the 13C to 42.3C range) does not influence Opossum occupation, the probability of occupation is the same (1) for all temperatures
- Detection probability was 0.531. This gives the probability of detecting an individual in that study (53.1%) given that that individual does occupy the region being studied.

- Model 3:
  - Occupancy probability was 1 for all habitat quality. This shows that **these data** suggest that habitat quality does not influence Opossum occupation, as the probability of occupation is the same (1) for all habitat qualities
  - Detection probability was 0.531. This gives the probability of detecting an individual in that study (53.1%) given that that individual does occupy the region being studied.

Question 4: Use the dodo data file. Add the habitat quality covariate. Build a set of single-season models to test the validity of the following hypotheses:

- *Dodo's occupancy probability is constant while detection probability varies with habitat quality*

- *Dodo's occupancy probability varies with habitat quality and detection probability varies with occurrence of flood*

Plan - Models to build:

Model A: constant occupancy probability (~1), but detection probability has habitat quality covariate

Model B: occupancy probability has habitat quality covariate and detection probability has flood covariate

- Compare Model A and Model B using AIC

Prepare Dodo data

```
# Load edited dodo data

dodo_edit = read.csv("Dodo_data_edited.csv")
dodo_edit
```

```
##    Site det1 det2 det3 det4 det5 det6 det7 det8 det9 Sun Habitat Flood1 Flood2
## 1     1    0    0    1   NA   NA    0    0    0    0  11       2      0      0
## 2     2    0    0    0    0    0    0    0    0    0  21       4      0      0
## 3     3    2    0    1    0   NA    2    0   NA    1  32       6      0      0
## 4     4    0    3   NA    0    3    0    0    2    2  43       3      0      0
## 5     5    0    0    0    0    0    0    2    0    1  54       7      0      0
## 6     6    4    0    2    4    0    0    0    0    2  65       8      0      0
## 7     7    0    2    4    0    0    3   NA    0    0  76       9      0      0
```

```
## 8      8    2    3   NA    2   NA    0    0   NA    0  87        9       0       0
## 9      9    6    4    5    3    0    0    0    2    0  88       10       0       0
## 10    10    6    5    6    0    4    0    0    0    2  98       10       0       0
##    Flood3 Flood4 Flood5 Flood6 Flood7 Flood8 Flood9
## 1       0      1      1      1      0      0      0
## 2       0      1      1      1      0      0      0
## 3       0      1      1      1      0      0      0
## 4       0      1      1      1      0      0      0
## 5       0      1      1      1      0      0      0
## 6       0      1      1      1      0      0      0
## 7       0      1      1      1      0      0      0
## 8       0      1      1      1      0      0      0
## 9       0      1      1      1      0      0      0
## 10      0      1      1      1      0      0      0
```

```r
#Separate detection histories

y=dodo_edit[,2:10]
y[y>1]=1
y
```

```
##    det1 det2 det3 det4 det5 det6 det7 det8 det9
## 1     0    0    1   NA   NA    0    0    0    0
## 2     0    0    0    0    0    0    0    0    0
## 3     1    0    1    0   NA    1    0   NA    1
## 4     0    1   NA    0    1    0    0    1    1
## 5     0    0    0    0    0    0    1    0    1
## 6     1    0    1    1    0    0    0    0    1
## 7     0    1    1    0    0    1   NA    0    0
## 8     1    1   NA    1   NA    0    0   NA    0
## 9     1    1    1    1    0    0    0    1    0
## 10    1    1    1    0    1    0    0    0    1
```

```r
#Organise covariates

siteCovs = data.frame(Habitat=dodo_edit$Habitat, Sun=dodo_edit$Sun)
obsCovs = data.frame(dodo_edit[,13:21])
obsCovs = list(obsCovs=obsCovs)
siteCovs
```

```
##    Habitat Sun
## 1        2  11
## 2        4  21
## 3        6  32
## 4        3  43
## 5        7  54
## 6        8  65
## 7        9  76
## 8        9  87
## 9       10  88
## 10      10  98
```

```r
obsCovs
```

```
## $obsCovs
##    Flood1 Flood2 Flood3 Flood4 Flood5 Flood6 Flood7 Flood8 Flood9
## 1       0      0      0      1      1      1      0      0      0
## 2       0      0      0      1      1      1      0      0      0
## 3       0      0      0      1      1      1      0      0      0
## 4       0      0      0      1      1      1      0      0      0
## 5       0      0      0      1      1      1      0      0      0
## 6       0      0      0      1      1      1      0      0      0
## 7       0      0      0      1      1      1      0      0      0
## 8       0      0      0      1      1      1      0      0      0
## 9       0      0      0      1      1      1      0      0      0
## 10      0      0      0      1      1      1      0      0      0
```

```r
#Organise data using UMF

dodo_umf = unmarkedFrameOccu(y=y, siteCovs=siteCovs, obsCovs=obsCovs)
summary(dodo_umf)
```

```
## unmarkedFrame Object
##
## 10 sites
## Maximum number of observations per site: 9
## Mean number of observations per site: 8.1
## Sites with at least one detection: 9
##
## Tabulation of y observations:
##    0    1 <NA>
##   50   31    9
##
## Site-level covariates:
##     Habitat          Sun
##  Min.   : 2.0   Min.   :11.00
##  1st Qu.: 4.5   1st Qu.:34.75
##  Median : 7.5   Median :59.50
##  Mean   : 6.8   Mean   :57.50
##  3rd Qu.: 9.0   3rd Qu.:84.25
##  Max.   :10.0   Max.   :98.00
##
## Observation-level covariates:
##     obsCovs
##  Min.   :0.0000
##  1st Qu.:0.0000
##  Median :0.0000
##  Mean   :0.3333
##  3rd Qu.:1.0000
##  Max.   :1.0000
```

```r
#Standardise covariates

dodo_umf@siteCovs$Habitat = scale(dodo_umf@siteCovs$Habitat)
```

```r
dodo_umf@siteCovs$Sun = scale(dodo_umf@siteCovs$Sun)
dodo_umf@obsCovs$obsCovs = scale(dodo_umf@obsCovs$obsCovs)
```

Create models

ModelA - constant occupancy probability (~1), but detection probability has habitat quality covariate

```r
modelA = occu(formula = ~ Habitat
                        ~ 1,
              data = dodo_umf)

modelA
```

```
##
## Call:
## occu(formula = ~Habitat ~ 1, data = dodo_umf)
##
## Occupancy:
##  Estimate   SE    z P(>|z|)
##       2.6 1.67 1.56   0.119
##
## Detection:
##             Estimate    SE     z P(>|z|)
## (Intercept)   -0.401 0.283 -1.41   0.157
## Habitat        0.392 0.313  1.25   0.210
##
## AIC: 108.9789
```

```r
lincombA4 = linearComb(modelA, coefficients = c(1,0), type = "det")
backTransform(lincombA4) #when there is low quality habitat (detection probability, p = 0.401)
```

```
## Backtransformed linear combination(s) of Detection estimate(s)
##
##  Estimate     SE LinComb (Intercept) Habitat
##     0.401 0.0681  -0.401           1       0
##
## Transformation: logistic
```

```r
lincombB4 = linearComb(modelA, coefficients = c(1,1), type = "det")
backTransform(lincombB4) #when there is high quality habitat (detection probability, p = 0.498)
```

```
## Backtransformed linear combination(s) of Detection estimate(s)
##
##  Estimate     SE  LinComb (Intercept) Habitat
##     0.498 0.0808 -0.00876           1       1
##
## Transformation: logistic
```

```r
backTransform(modelA, type="state") #(occupancy probability, p = 0.931)
```

```
## Backtransformed linear combination(s) of Occupancy estimate(s)
##
##  Estimate    SE LinComb (Intercept)
##     0.931 0.108     2.6           1
##
## Transformation: logistic
```

Detection Probability (low quality habitat) = 0.401

Detection Probability (high quality habitat) = 0.498

Occupancy Probability = 0.931

Model B - occupancy probability has habitat covariate and detection probability has flood covariate

```r
modelB = occu(formula = ~ obsCovs
                        ~ Habitat,
              data = dodo_umf)

modelB
```

```
##
## Call:
## occu(formula = ~obsCovs ~ Habitat, data = dodo_umf)
##
## Occupancy:
##             Estimate   SE     z P(>|z|)
## (Intercept)     2.79 1.65 1.691  0.0907
## Habitat         1.25 1.38 0.906  0.3651
##
## Detection:
##             Estimate    SE     z P(>|z|)
## (Intercept)   -0.309 0.246 -1.26   0.208
## obsCovs       -0.372 0.254 -1.47   0.143
##
## AIC: 109.5019
```

```r
lincombA5 = linearComb(modelB, coefficients = c(1,0), type = "det")
backTransform(lincombA5) #when there is no flood (detection probability, p =0.423)
```

```
## Backtransformed linear combination(s) of Detection estimate(s)
##
##  Estimate   SE LinComb (Intercept) obsCovs
##     0.423 0.06  -0.309           1       0
##
## Transformation: logistic
```

```r
lincombB5 = linearComb(modelB, coefficients = c(1,1), type = "det")
backTransform(lincombB5) #when there is flood (detection probability, p = 0.336)
```

```
## Backtransformed linear combination(s) of Detection estimate(s)
##
##  Estimate     SE LinComb (Intercept) obsCovs
##     0.336 0.0828  -0.681           1       1
##
## Transformation: logistic
```

```r
lincombC5 = linearComb(modelB, coefficients = c(1,0), type = "state")
backTransform(lincombC5) #when there low habitat (occupation probability, p =0.942)
```

```
## Backtransformed linear combination(s) of Occupancy estimate(s)
##
##  Estimate     SE LinComb (Intercept) Habitat
##     0.942 0.0897    2.79           1       0
##
## Transformation: logistic
```

```r
lincombD5 = linearComb(modelB, coefficients = c(1,1), type = "state")
backTransform(lincombD5) #when there high habitat (occupation probability, p = 0.983)
```

```
## Backtransformed linear combination(s) of Occupancy estimate(s)
##
##  Estimate     SE LinComb (Intercept) Habitat
##     0.983 0.0474    4.05           1       1
##
## Transformation: logistic
```

detection probability (no flood) - 0.423

detection probability (with flood) - 0.336

occupation probability (low habitat quality) - 0.942

occupation probability (high habitat quality) - 0.983

```r
fit = fitList('psi(.)p(Habitat)' = modelA,
              'psi(Habitat)p(obsCovs)' = modelB)

modSel(fit)
```

```
##                        nPars    AIC delta AICwt cumltvWt
## psi(.)p(Habitat)           3 108.98  0.00  0.56     0.56
## psi(Habitat)p(obsCovs)     4 109.50  0.52  0.44     1.00
```

Question 4 Conclusions:

- No significant difference of fit for Models A and B, as AIC scores are within +-2 of each other

Model A: **Model A shows that quality of habitat increases detection probability**

- Detection Probability (low quality habitat) = 0.401

- Detection Probability (high quality habitat) = 0.498
- Occupancy Probability = 0.931

Model B: **Model B shows that prescence of flood decreases detection probability and quality of habitat increases occupation probability**

- detection probability (no flood) = 0.423
- detection probability (with flood) = 0.336
- occupation probability (low habitat quality) = 0.942
- occupation probability (high habitat quality) = 0.983

Question 5: Build a single-season model to investigate the validity that the occurrence of flood might affect dodo's occupancy probability

Create model

Model C: detection probability covariate (~1) and occupation covariate (obsCovs)

```
#modelC = occu(formula = ~ 1
#                        ~ obsCovs,
#               data = dodo_umf)

#modelC
```

Code chunk causes error.

Why do you get an error?

You get an error as occurence of flood cannot be applied as an occupancy covariate, because the single-season imperfect detection model assumes that occupancy of a region does not vary within a season. So as the flood covariate varies within the season it causes an error as the model assumes that occupancy of a region cannot change within a season, but the flood covariate would only operate to show how occupancy probability changes within a season - this therefore opposes the model's assumptions and causes the error.