**Supplementary Material**

Reduction of organic waste in a landfill lowers the visitation probability but not the local abundance of a long-lived scavenger species

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**Appendix S1**

Table S1.Capture-recapture effort (days) of Griffon Vultures *Gyps fulvus* each month and year at the Orís landfill in Catalunya, Spain (NE Iberian Peninsula).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Months | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
| Jan |  |  |  | 1 |  | 2 | 1 | 4 |
| Feb |  | 1 | 1 |  | 1 | 1 | 2 | 6 |
| Mar |  | 4 |  | 1 | 2 | 1 | 1 | 9 |
| Apr | 1 | 2 | 5 | 2 | 1 | 3 | 1 | 15 |
| May | 1 | 1 | 2 | 3 | 2 | 2 | 2 | 13 |
| Jun | 2 | 3 |  | 3 | 1 | 1 | 1 | 11 |
| Jul | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 11 |
| Aug |  | 2 | 1 | 3 | 2 | 4 |  | 12 |
| Sep |  | 2 | 1 | 2 |  | 2 | 2 | 9 |
| Oct |  | 2 | 1 | 3 | 3 | 3 |  | 12 |
| Nov | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 9 |
| Dec | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 9 |
|  |  |  |  |  |  |  |  |  |
| Total | 9 | 22 | 15 | 23 | 16 | 22 | 13 | 120 |

**Appendix S2**

*Annual organic matter estimates available for vultures (OMA) at Orís landfill during the 2012 to 2018 period.*

To calculate OMA for the 2012-2018 we used data of the *Consorci per a la gestió de residus urbans d'Osona* trimestral reports of 2015 to 2018 (the date were the WTC became operational) and the total entry values of waste to the Orís landfill in 2012-2018. The trimestral reports consists of waste characterizations (in percentages) of ~1000 kg samples taken before and after the WTC triage process to determine what materials the waste is composed of in each stage. The total entry values of waste are the monthly metric tons of WASTE that entered the landfill each year and as of May 2015, also the metric tons of ORGAN. Therefore, to calculate OMA for each year, we departed from the total entry values ​​of ORGAN and WASTE fraction of municipal selective collection before WTC triage, the organic residuals poured in the landfill from ORGAN after WTC triage, and annually averaged organic matter percentages of the trimestral reports of ORGAN and WASTE before and after the WTC triage. The annual value of OMA for the mid-2015 to 2018 period was calculated as follows:

$$OMA=[(TWL-R\_{ORGAN})\*\%R\_{WASTE}]+(R\_{ORGAN}\*\%R\_{ORGAN})$$

Where TWL=Metric tons of total ORGAN and WASTE, RORGAN= Metric tons of >12 cm ORGAN residual waste poured into the landfill, and metric tons of <12 cm ORGAN residual waste discarded after composting process and poured into the landfill, %RWASTE=Annual percentage of WASTE organic residuals poured into the landfill, %RORGAN= Annual percentage of ORGAN organic waste poured into the landfill and RORGAN=. For 2012 to mid-2015 OMA was estimated as follows:

 $OMA=TWL\*\%E\_{WASTE}$

Where %EWASTE= Annual percentage of WASTE organic waste poured into the landfill. The %EWASTE value calculated for the first two quarters of 2015 (before the WTC was operational) was used to calculate the 2012, 2013 and 2014 OMA’s since there is no data available for these years.

Table S2.Summary of Orís landfill waste data during the period 2012 to 2018 in central Catalonia, Spain.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | TWL | **OMA** | %OMA | RORGANpre | RORGANpost | %RWASTE | %RORGAN | %EWASTE |
| 2012 | 42,366.06 | **17,942.03** | 42.35 |  |  |  |  | 42.35 |
| 2013 | 41,115.42 | **17,412.38** | 42.35 |  |  |  |  | 42.35 |
| 2014 | 41,972.73 | **17,775.45** | 42.35 |  |  |  |  | 42.35 |
| 2015 | 30,440.51 | **8,285.73** | 27.22 | 561.42 | 428.86 | 14.28 | 9.49 | 42.35 |
| 2016 | 25,659.06 | **2,603.39** | 10.15 | 788.04 | 700.62 | 10.54 | 7.09 | 38.42 |
| 2017 | 24,217.15 | **1,510.11** | 6.24 | 732.44 | 959.3 | 6.51 | 6.07 | 27.18 |
| 2018 | 28,946.64 | **1,155.06** | 3.99 | 891.14 | 1250.54 | 4.17 | 4.26 | 26.80 |

TWL=Metric tons of total ORGAN and WASTE, RORGANpre= Metric tons of >12 cm ORGAN residual waste poured into the landfill, RORGANpost= Metric tons of <12 cm ORGAN residual waste discarded after composting process and poured into the landfill, %RWASTE=Annual percentage of WASTE organic waste poured into the landfill, %RORGAN= Annual percentage of ORGAN organic waste poured into the landfill, %EWASTE= Annual percentage of WASTE organic waste poured into the landfill. Data used for analysis in bold.

**Appendix S3. Estimates of half-year pooling models**

Here, we used the half-year of captures and omitted the other part of the data to create the capture histories (following Peach *et al.* 2001 and Boys *et al.* 2019). In order to decrease the effect of transients in our analysis, we considered the data obtained from July to December of each year (from 2012 to 2018) because it represented an interval with fewer individuals that were captured only once (ca. 80 %), and we discarded the data from January to June, when individuals captured only once were almost 90% of the total. The U-CARE goodness-of-fit test using a Cormack-Jolly-Seber-type (CJS) structure detected the presence of transients (Test3.SR: χ2 = 51.48, df = 5, p-value < 0.001) and trap-response (Test2.CT: χ2 = 15.12, df = 4, p-value = 0.004). Therefore, we proceeded the same way as the one-year pooling models to account both sources of heterogeneity (See Methods).

The best fitted models were (ΔQAICc < 2): φ(PriorCapL+LE+t)p(PriorCapL)pent(t) and φ(PriorCapL+LE+t)p(PriorCapL+LE)pent(t). Averaged estimates of both models are shown in the table below (Table S3).

Table S3. Real and derived averaged estimates from the best fitted models (ΔQAICc<2) using half-year pooling observations.

|  |  |
| --- | --- |
| **Parameter** | **Estimate±ISE (Low 95%CI – Upper 95%CI)** |
| ϕ (newly marked vultures) | 0.37±0.06 (0.27 – 0.49) |
| ϕ (after WTC) | 0.83±0.04 (0.75 – 0.89) to 0.82±0.05 (0.71 – 0.89) |
| ϕ (before WTC) | 0.77±0.05 (0.65 – 0.86) to 0.67±0.05 (0.57 – 0.76) |
| p (not captured at previous period) | 0.20±0.03 (0.14 – 0.28) |
| p (captured at previous period and after WTC) | 0.30±0.03 (0.25 – 0.35) |
| p (captured at previous period and before WTC) | 0.31±0.03 (0.25 – 0.36) |
| Pent (2013) | 0.27±0.03(0.21 – 0.34) |
| Pent (2014) | 0 |
| Pent (2015) | 0.11±0.02 (0.07 – 0.15) |
| Pent (2016) | 0.11±0.03 (0.07 – 0.17) |
| Pent (2017) | 0.20±0.02 (0.16 – 0.24) |
| Pent (2018) | 0 |
| Nsuper | 3379.80±198.31 (2991.10 – 3768.49) |
| N2012 | 1071.51±194.04 (691.20 –1451.83) |
| N2013 | 1308.60±113.26 (1086.61 – 1530.59) |
| N2014 | 1094.51±92.43 (913.35 – 1275.67) |
| N2015 | 1261.00±94.87 (1075.04 – 1446.95) |
| N2016 | 1407.37±109.29 (1193.16 – 1621.59) |
| N2017 | 1745.39±128.96 (1492.63 – 1998.15) |
| N2018 | 1168.64±118.37 (936.62 – 1400.65) |

Model parameters are: ϕ, landfill visitation probability; *p*, capture probability, *pent*, probability of entry; Nsuper=Super-population size, Ni=abundance in year *i*. ISE=Inconditional Standard Error.

Newly-marked vultures’ visitation probability is estimated at 0.37 and is time-dependent before and after the waste treatment centre (WTC) with values ranging from 0.83 to 0.67, which are lower compared to one-year pooling models. Capture probabilities decreased 0.05 compared to one-year pooling models (See Table S7) and two Pent estimates are equal to “0” (2014 and 2018), which suggests that we lose information of entrant individuals using half the year of captures. Variances of the visitation, capture and entry probabilities are greater than the 1-year pooling (i.e. higher standard errors), which suggests that we also lose precision when using capture-recapture histories where part of the data was omitted. Finally, and considering that the whole dataset consists in c.3,000 ringed individuals, and that an important fraction of vultures did not wear rings in each ringing session, the estimate of 3,377 individuals for the super-population is clearly unreliable and biased, since we omitted data from vultures captured only once in January to June, and that were an important fraction of the population that attended the landfill during the study period.

**Appendix S4. Description of candidate POPAN models**

Table S4. Candidate structures for variability in each parameter type in the POPAN model, used to estimate the demographic parameters of the Griffon Vultures *Gyps fulvus* population at Orís landfill during the study period (2012-2018).

|  |  |
| --- | --- |
| Notation | Description |
| ϕ(PriorCapL+LE) | Landfill visitation probability is differentiated between transients and residents. Residents’ visitation is explained by the additive effect of before and after the WTC. |
| ϕ(PriorCapL+LE+t) | Landfill visitation probability is differentiated between transients and residents. Residents’ visitation is explained by the additive effect of before and after the WTC and is time-dependent within both. |
| ϕ(PriorCapL+OMA) | Landfill visitation probability is differentiated between transients and residents. Residents’ visitation is explained by additive effect of the amount of OMA poured into the landfill. |
| ϕ(PriorCapL+.) | Landfill visitation probability is constant over time for both transients and residents. |
| ϕ(PriorCapL+t) | Landfill visitation probability is differentiated between transients and residents. Residents’ visitation is time-dependent. |
| ϕ(LE) | Landfill visitation probability is explained by the periods before and after the WTC was installed. |
| ϕ(OMA) | Landfill visitation probability is explained by the effect of the OMA poured into the landfill. |
| ϕ(.) | Landfill visitation probability is constant over time. |
| ϕ(t) | Landfill visitation probability is time-dependent. |
| *p*(PriorCapL+Effort) | Capture probability accounts for immediate trap response. Capture probability is explained by the additive effect of sampling effort each year for individuals previously caught. |
| *p*(PriorCapL+LE) | Capture probability accounts for immediate trap response. Capture probability is explained by the additive effect of the periods before and after the WTC and is constant within both periods for individuals previously caught. |
| *p*(PriorCapL+LE+t) | Capture probability accounts for immediate trap response. Capture probability is explained by the additive effect of the periods before and after the WTC and is time-dependent within both periods for individuals previously caught. |
| *p*(PriorCapL+OMA) | Capture probability accounts for immediate trap response. Capture probability is explained by the amount additive effect of OMA poured into the landfill for individuals previously caught. |
| *p*(PriorCapL+LE+Effort) | Capture probability accounts for immediate trap response. Capture probability is explained by the additive effects of the periods before and after the WTC and sampling effort each year for individuals previously caught. |
| *p*(PriorCapL+OMA+Effort) | Capture probability accounts for immediate trap response. Capture probability is explained by the amount additive effects of OMA poured into the landfill and sampling effort each year for individuals previously caught. |
| *p*(PriorCapL+.) | Capture probability accounts for immediate trap response and is constant over time for individuals previously caught. |
| *p*(PriorCapL+t) | Capture probability accounts for immediate trap response and is time-dependent for individuals previously caught. |
| *p*(LE+Effort) | Capture probability is explained by the periods before and after the WTC and the additive effect of sampling effort each year.  |
| *p*(OMA+Effort) | Capture probability is explained by the amount of OMA poured into the landfill and the additive effect of sampling effort each year. |
| *p*(Effort) | Capture probability is explained by the sampling effort each year. |
| *p*(LE) | Capture probability is explained by the periods before and after the WTC and is constant within both periods. |
| *p*(LE+t) | Capture probability is explained by the periods before and after the WTC and is time-dependent within both periods. |
| *p*(OMA) | Capture probability is explained by the amount of OMA poured into the landfill. |
| *p*(.) | Capture probability is constant over time. |
| *p*(t) | Capture probability is time-dependent. |
| *pent*(.) | The probability that individuals from the super-population enter the study site is constant. |
| *pent*(t) | The probability that individuals from the super-population enter the study site is time-dependent. |
| *pent*(LE) | The probability that individuals from the super-population enter the study site is explained by the periods before and after the WTC was installed. |
| *pent*(LE+t) | The probability that individuals from the super-population enter the study site is explained by the period before and after the WTC was installed, and is time-dependent within both. |
| *pent*(OMA) | The probability that individuals from the super-population enter the study site is explained by the effect of the OMA poured into the landfill. |

Model parameters are: ϕ, landfill visitation probability; *p*, capture probability, *pent*, probability of entry; *t*, variation over time; ., constant over time; PriorCapL, previous capture function to account for transience and trap-response; Effort, days of sampling effort per year; LE, effect in time due to change landfill waste management (period 1: 2012 to 2015 and period 2: 2015 to 2018); and OMA, organic matter available for consumption.

**Appendix S5**

Table S5. Goodness of fit (GOF) test for assessing homogeneity assumptions of the Cormack-Jolly-Seber (CJS) model.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| GOF components and models assessed | χ2 | df | *ĉ* | p-value |
| Test3.SR | 106.66 | 5 |  | <0.001 |
| Test3.SM | 11.42 | 9 |  | 0.24 |
| Test2.CT | 25.76 | 4 |  | <0.001 |
| Test2.CL | 7.33 | 6 |  | 0.29 |
| Full time-dependent CJS model (ϕt pt) | 151.17 | 24 | 6.29 | <0.001 |
| Transience and trap-response treated model (ϕɑ2\*t pt+m) | 18.75 | 15 | 1.25 | 0.22 |

Model parameters are: ϕt, time-dependent apparent survival probability; ϕɑ2\*t, two age-class time-dependent apparent survival probability; *p*t, time-dependent capture probability; and *p*t+m, capture probabilitytime-dependent with an additive effect of trap dependence. Apparent survival probability is renamed at the manuscript as ‘landfill visitation probability’ (See Introduction).

**Appendix S6**

Table S6. Whole set of POPAN models using the Griffon Vultures *Gyps fulvus* capture-recapture data of Orís landfill during the study period (2012-2018) at Catalonia, Spain (NE Iberian Peninsula). In bold the models that represent the total quasi-likelihood Akaike’s information criterion corrected for effective sample sizes (QAICc) weight.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Model | QAICc | ΔQAICc | wi | Model Likelihood | *k* | QDeviance |
| **ϕ(PriorCapL+LE)p(PriorCapL)pent(t)** | **4306.35** | **0.00** | **0.43** | **1.00** | **12.00** | **-8878.70** |
| **ϕ(PriorCapL+LE)p(PriorCapL+LE)pent(t)** | **4308.15** | **1.80** | **0.17** | **0.41** | **13.00** | **-8878.91** |
| **ϕ(PriorCapL+LE+t)p(PriorCapL)pent(t)** | **4308.91** | **2.56** | **0.12** | **0.28** | **15.00** | **-8882.18** |
| **ϕ(PriorCapL+LE+t)p(PriorCapL+t)pent(.)** | **4310.18** | **3.83** | **0.06** | **0.15** | **15.00** | **-8880.91** |
| **ϕ(PriorCapL+LE+t)p(PriorCapL+LE)pent(t)** | **4310.88** | **4.53** | **0.04** | **0.10** | **16.00** | **-8882.23** |
| **ϕ(PriorCapL+LE)p(PriorCapL+t)pent(t)** | **4311.09** | **4.74** | **0.04** | **0.09** | **17.00** | **-8884.04** |
| **ϕ(PriorCapL)p(PriorCapL)pent(t)** | **4311.45** | **5.10** | **0.03** | **0.08** | **11.00** | **-8871.58** |
| **ϕ(PriorCapL+OMA)p(PriorCapL)pent(t)** | **4312.93** | **6.59** | **0.02** | **0.04** | **15.00** | **-8878.16** |
| **ϕ(PriorCapL+LE)p(PriorCapL+LE+Effort)pent(t)** | **4313.05** | **6.70** | **0.02** | **0.04** | **17.00** | **-8882.08** |
| **ϕ(PriorCapL+LE)p(PriorCapL+Effort)pent(t)** | **4313.05** | **6.70** | **0.02** | **0.04** | **17.00** | **-8882.07** |
| **ϕ(PriorCapL+LE+t)p(PriorCapL+t)pent(t)** | **4314.05** | **7.70** | **0.01** | **0.02** | **19.00** | **-8885.12** |
| **ϕ(PriorCapL)p(PriorCapL+Effort)pent(t)** | **4314.06** | **7.71** | **0.01** | **0.02** | **16.00** | **-8879.05** |
| **ϕ(PriorCapL+LE)p(t)pent(LE)** | **4314.12** | **7.78** | **0.01** | **0.02** | **13.00** | **-8872.94** |
| **ϕ(PriorCapL+LE)p(.)pent(t)** | **4314.72** | **8.37** | **0.01** | **0.02** | **11.00** | **-8868.32** |
| ϕ(PriorCapL+LE)p(PriorCapL+Effort)pent(LE) | 4315.78 | 9.44 | 0.00 | 0.01 | 13.00 | -8871.28 |
| ϕ(PriorCapL+LE+t)p(PriorCapL+LE+Effort)pent(t) | 4317.52 | 11.17 | 0.00 | 0.00 | 20.00 | -8883.66 |
| ϕ(PriorCapL+LE+t)p(PriorCapL+Effort)pent(t) | 4317.52 | 11.17 | 0.00 | 0.00 | 20.00 | -8883.66 |
| ϕ(PriorCapL+OMA)p(PriorCapL+t)pent(t) | 4317.62 | 11.28 | 0.00 | 0.00 | 20.00 | -8883.56 |
| ϕ(PriorCapL+LE)p(t)pent(LE+t) | 4318.08 | 11.73 | 0.00 | 0.00 | 16.00 | -8875.03 |
| ϕ(PriorCapL+LE)p(t)pent(t) | 4318.08 | 11.73 | 0.00 | 0.00 | 16.00 | -8875.03 |
| ϕ(PriorCapL+LE)p(LE+t)pent(t) | 4318.08 | 11.73 | 0.00 | 0.00 | 16.00 | -8875.03 |
| ϕ(PriorCapL+LE)p(LE+t)pent(LE+t) | 4318.08 | 11.73 | 0.00 | 0.00 | 16.00 | -8875.03 |
| ϕ(PriorCapL+OMA)p(PriorCapL+OMA+Effort)pent(t) | 4319.08 | 12.73 | 0.00 | 0.00 | 20.00 | -8882.11 |
| ϕ(PriorCapL+OMA)p(PriorCapL+Effort)pent(t) | 4319.10 | 12.75 | 0.00 | 0.00 | 20.00 | -8882.09 |
| ϕ(PriorCapL)p(t)pent(t) | 4319.39 | 13.04 | 0.00 | 0.00 | 15.00 | -8871.70 |
| ϕ(PriorCapL)p(.)pent(t) | 4319.97 | 13.63 | 0.00 | 0.00 | 10.00 | -8861.05 |
| ϕ(PriorCapL+OMA)p(.)pent(t) | 4321.45 | 15.11 | 0.00 | 0.00 | 14.00 | -8867.62 |
| ϕ(PriorCapL+OMA)p(PriorCapL+OMA)pent(t) | 4323.06 | 16.72 | 0.00 | 0.00 | 20.00 | -8878.12 |
| ϕ(PriorCapL+t)p(t)pent(t) | 4323.11 | 16.76 | 0.00 | 0.00 | 19.00 | -8876.06 |
| ϕ(PriorCapL+LE)p(Effort)pent(t) | 4324.37 | 18.03 | 0.00 | 0.00 | 17.00 | -8870.75 |
| ϕ(PriorCapL+LE)p(Effort)pent(LE+t) | 4324.37 | 18.03 | 0.00 | 0.00 | 17.00 | -8870.75 |
| ϕ(PriorCapL+OMA)p(t)pent(t) | 4324.93 | 18.58 | 0.00 | 0.00 | 19.00 | -8874.23 |
| ϕ(PriorCapL)p(Effort)pent(t) | 4326.01 | 19.67 | 0.00 | 0.00 | 16.00 | -8867.09 |
| ϕ(PriorCapL+t)p(Effort)pent(t) | 4328.16 | 21.81 | 0.00 | 0.00 | 20.00 | -8873.03 |
| ϕ(PriorCapL+OMA)p(t)pent(OMA) | 4329.29 | 22.95 | 0.00 | 0.00 | 20.00 | -8871.89 |
| ϕ(PriorCapL+LE)p(PriorCapL+LE+Effort)pent(.) | 4329.54 | 23.19 | 0.00 | 0.00 | 12.00 | -8855.51 |
| ϕ(PriorCapL)p(PriorCapL+Effort)pent(.) | 4330.31 | 23.96 | 0.00 | 0.00 | 11.00 | -8852.73 |
| ϕ(PriorCapL+OMA)p(Effort)pent(t) | 4330.80 | 24.45 | 0.00 | 0.00 | 20.00 | -8870.39 |
| ϕ(PriorCapL+LE)p(PriorCapL+Effort)pent(.) | 4332.23 | 25.89 | 0.00 | 0.00 | 12.00 | -8852.81 |
| ϕ(PriorCapL+OMA)p(PriorCapL+OMA+Effort)pent(OMA) | 4332.55 | 26.21 | 0.00 | 0.00 | 20.00 | -8868.63 |
| ϕ(PriorCapL+LE+t)p(PriorCapL+Effort)pent(.) | 4333.03 | 26.68 | 0.00 | 0.00 | 15.00 | -8858.06 |
| ϕ(PriorCapL+OMA)p(PriorCapL+OMA+Effort)pent(.) | 4335.75 | 29.40 | 0.00 | 0.00 | 15.00 | -8855.35 |
| ϕ(PriorCapL+OMA)p(PriorCapL+Effort)pent(.) | 4338.12 | 31.77 | 0.00 | 0.00 | 15.00 | -8852.98 |
| ϕ(PriorCapL+LE)p(PriorCapL)pent(LE) | 4352.13 | 45.78 | 0.00 | 0.00 | 8.00 | -8824.88 |
| ϕ(PriorCapL+LE)p(PriorCapL+LE)pent(LE) | 4354.06 | 47.72 | 0.00 | 0.00 | 9.00 | -8824.95 |
| ϕ(PriorCapL+LE)p(PriorCapL)pent(.) | 4360.40 | 54.06 | 0.00 | 0.00 | 7.00 | -8814.59 |
| ϕ(PriorCapL+LE)p(PriorCapL+LE)pent(.) | 4362.10 | 55.75 | 0.00 | 0.00 | 8.00 | -8814.91 |
| ϕ(PriorCapL)p(PriorCapL)pent(.) | 4362.84 | 56.50 | 0.00 | 0.00 | 6.00 | -8810.14 |
| ϕ(PriorCapL+OMA)p(PriorCapL)pent(.) | 4366.28 | 59.93 | 0.00 | 0.00 | 10.00 | -8814.74 |
| ϕ(PriorCapL+OMA)p(PriorCapL)pent(OMA) | 4366.82 | 60.48 | 0.00 | 0.00 | 15.00 | -8824.27 |
| ϕ(PriorCapL+OMA)p(PriorCapL+OMA)pent(OMA) | 4373.62 | 67.27 | 0.00 | 0.00 | 20.00 | -8827.57 |
| ϕ(PriorCapL+OMA)p(PriorCapL+OMA)pent(.) | 4376.33 | 69.99 | 0.00 | 0.00 | 15.00 | -8814.76 |
| ϕ(PriorCapL+LE)p(LE+Effort)pent(LE) | 4379.62 | 73.27 | 0.00 | 0.00 | 13.00 | -8807.44 |
| ϕ(PriorCapL)p(Effort)pent(.) | 4380.59 | 74.24 | 0.00 | 0.00 | 11.00 | -8802.45 |
| ϕ(PriorCapL+LE)p(Effort)pent(LE) | 4381.54 | 75.19 | 0.00 | 0.00 | 13.00 | -8805.52 |
| ϕ(PriorCapL+LE)p(Effort)pent(.) | 4382.54 | 76.19 | 0.00 | 0.00 | 12.00 | -8802.51 |
| ϕ(LE)p(PriorCapL)pent(t) | 4384.01 | 77.66 | 0.00 | 0.00 | 11.00 | -8799.02 |
| ϕ(PriorCapL+OMA)p(Effort)pent(.) | 4388.07 | 81.73 | 0.00 | 0.00 | 15.00 | -8803.02 |
| ϕ(PriorCapL+OMA)p(OMA+Effort)pent(OMA) | 4388.22 | 81.87 | 0.00 | 0.00 | 20.00 | -8812.97 |
| ϕ(LE)p(PriorCapL+Effort)pent(t) | 4389.19 | 82.85 | 0.00 | 0.00 | 16.00 | -8803.91 |
| ϕ(.)p(.)pent(t) | 4389.46 | 83.12 | 0.00 | 0.00 | 9.00 | -8789.55 |
| ϕ(LE)p(.)pent(t) | 4391.37 | 85.02 | 0.00 | 0.00 | 10.00 | -8789.65 |
| ϕ(OMA)p(PriorCapL)pent(t) | 4392.18 | 85.83 | 0.00 | 0.00 | 15.00 | -8798.91 |
| ϕ(LE)p(PriorCapL+Effort)pent(.) | 4392.28 | 85.93 | 0.00 | 0.00 | 11.00 | -8790.75 |
| ϕ(LE)p(LE)pent(LE+t) | 4393.29 | 86.94 | 0.00 | 0.00 | 11.00 | -8789.74 |
| ϕ(t)p(.)pent(t) | 4393.51 | 87.16 | 0.00 | 0.00 | 14.00 | -8795.56 |
| ϕ(.)p(t)pent(t) | 4394.50 | 88.15 | 0.00 | 0.00 | 14.00 | -8794.58 |
| ϕ(t)p(LE)pent(t) | 4395.53 | 89.18 | 0.00 | 0.00 | 15.00 | -8795.56 |
| ϕ(LE)p(t)pent(t) | 4396.51 | 90.17 | 0.00 | 0.00 | 15.00 | -8794.58 |
| ϕ(LE)p(LE+t)pent(LE+t) | 4396.51 | 90.17 | 0.00 | 0.00 | 15.00 | -8794.58 |
| ϕ(OMA)p(PriorCapL+Effort)pent(t) | 4396.97 | 90.62 | 0.00 | 0.00 | 20.00 | -8804.22 |
| ϕ(LE+t)p(LE+t)pent(LE) | 4396.98 | 90.64 | 0.00 | 0.00 | 16.00 | -8796.12 |
| ϕ(PriorCapL+OMA)p(Effort)pent(OMA) | 4397.63 | 91.28 | 0.00 | 0.00 | 20.00 | -8803.56 |
| ϕ(.)p(Effort)pent(t) | 4397.88 | 91.53 | 0.00 | 0.00 | 15.00 | -8793.22 |
| ϕ(LE+t)p(LE+t)pent(t) | 4399.35 | 93.01 | 0.00 | 0.00 | 18.00 | -8797.79 |
| ϕ(t)p(LE+t)pent(t) | 4399.35 | 93.01 | 0.00 | 0.00 | 18.00 | -8797.79 |
| ϕ(LE+t)p(LE+t)pent(LE+t) | 4399.35 | 93.01 | 0.00 | 0.00 | 18.00 | -8797.79 |
| ϕ(LE+t)p(t)pent(LE+t) | 4399.35 | 93.01 | 0.00 | 0.00 | 18.00 | -8797.79 |
| ϕ(t)p(t)pent(t) | 4399.35 | 93.01 | 0.00 | 0.00 | 18.00 | -8797.79 |
| ϕ(LE+t)p(t)pent(t) | 4399.35 | 93.01 | 0.00 | 0.00 | 18.00 | -8797.79 |
| ϕ(t)p(t)pent(LE+t) | 4399.35 | 93.01 | 0.00 | 0.00 | 18.00 | -8797.79 |
| ϕ(OMA)p(.)pent(t) | 4399.52 | 93.17 | 0.00 | 0.00 | 14.00 | -8789.55 |
| ϕ(LE)p(LE+Effort)pent(LE+t) | 4399.60 | 93.26 | 0.00 | 0.00 | 16.00 | -8793.50 |
| ϕ(OMA)p(PriorCapL+Effort)pent(.) | 4400.48 | 94.13 | 0.00 | 0.00 | 15.00 | -8790.61 |
| ϕ(OMA)p(t)pent(t) | 4404.47 | 98.12 | 0.00 | 0.00 | 19.00 | -8794.70 |
| ϕ(t)p(OMA+Effort)pent(t) | 4405.40 | 99.06 | 0.00 | 0.00 | 20.00 | -8795.78 |
| ϕ(t)p(LE+Effort)pent(t) | 4405.57 | 99.22 | 0.00 | 0.00 | 20.00 | -8795.62 |
| ϕ(LE+t)p(LE+Effort)pent(t) | 4405.57 | 99.22 | 0.00 | 0.00 | 20.00 | -8795.62 |
| ϕ(LE+t)p(LE+Effort)pent(LE+t) | 4405.57 | 99.22 | 0.00 | 0.00 | 20.00 | -8795.62 |
| ϕ(t)p(Effort)pent(t) | 4405.58 | 99.23 | 0.00 | 0.00 | 20.00 | -8795.61 |
| ϕ(t)p(Effort)pent(LE+t) | 4405.58 | 99.23 | 0.00 | 0.00 | 20.00 | -8795.61 |
| ϕ(LE+t)p(Effort)pent(t) | 4405.58 | 99.23 | 0.00 | 0.00 | 20.00 | -8795.61 |
| ϕ(LE+t)p(Effort)pent(LE+t) | 4405.58 | 99.23 | 0.00 | 0.00 | 20.00 | -8795.61 |
| ϕ(OMA)p(Effort)pent(t) | 4407.46 | 101.11 | 0.00 | 0.00 | 20.00 | -8793.73 |
| ϕ(t)p(LE+Effort)pent(LE) | 4410.10 | 103.76 | 0.00 | 0.00 | 16.00 | -8783.01 |
| ϕ(LE+t)p(LE+Effort)pent(LE) | 4410.10 | 103.76 | 0.00 | 0.00 | 16.00 | -8783.01 |
| ϕ(t)p(LE+Effort)pent(.) | 4411.39 | 105.04 | 0.00 | 0.00 | 15.00 | -8779.70 |
| ϕ(.)p(LE+Effort)pent(.) | 4411.73 | 105.38 | 0.00 | 0.00 | 10.00 | -8769.30 |
| ϕ(LE)p(LE+Effort)pent(LE) | 4412.13 | 105.78 | 0.00 | 0.00 | 12.00 | -8772.92 |
| ϕ(LE)p(Effort)pent(LE) | 4412.75 | 106.40 | 0.00 | 0.00 | 12.00 | -8772.30 |
| ϕ(LE)p(LE+Effort)pent(.) | 4413.15 | 106.81 | 0.00 | 0.00 | 11.00 | -8769.88 |
| ϕ(LE)p(PriorCapL)pent(.) | 4414.09 | 107.74 | 0.00 | 0.00 | 6.00 | -8758.90 |
| ϕ(t)p(OMA+Effort)pent(.) | 4414.86 | 108.51 | 0.00 | 0.00 | 15.00 | -8776.23 |
| ϕ(LE)p(Effort)pent(.) | 4414.93 | 108.58 | 0.00 | 0.00 | 11.00 | -8768.11 |
| ϕ(t)p(Effort)pent(.) | 4415.42 | 109.07 | 0.00 | 0.00 | 15.00 | -8775.67 |
| ϕ(.)p(Effort)pent(.) | 4418.48 | 112.14 | 0.00 | 0.00 | 10.00 | -8762.54 |
| ϕ(OMA)p(OMA+Effort)pent(.) | 4420.64 | 114.29 | 0.00 | 0.00 | 15.00 | -8770.46 |
| ϕ(OMA)p(PriorCapL)pent(.) | 4421.40 | 115.05 | 0.00 | 0.00 | 10.00 | -8759.62 |
| ϕ(t)p(OMA+Effort)pent(OMA) | 4422.20 | 115.85 | 0.00 | 0.00 | 20.00 | -8778.98 |
| ϕ(OMA)p(Effort)pent(.) | 4424.41 | 118.06 | 0.00 | 0.00 | 15.00 | -8766.68 |
| ϕ(t)p(OMA)pent(t) | 4424.74 | 118.40 | 0.00 | 0.00 | 19.00 | -8774.42 |
| ϕ(OMA)p(OMA+Effort)pent(OMA) | 4428.51 | 122.16 | 0.00 | 0.00 | 20.00 | -8772.68 |
| ϕ(OMA)p(Effort)pent(OMA) | 4432.56 | 126.21 | 0.00 | 0.00 | 20.00 | -8768.62 |
| ϕ(t)p(.)pent(.) | 4436.60 | 130.25 | 0.00 | 0.00 | 9.00 | -8742.42 |
| ϕ(t)p(LE)pent(.) | 4438.55 | 132.20 | 0.00 | 0.00 | 10.00 | -8742.47 |
| ϕ(t)p(LE)pent(LE) | 4439.95 | 133.60 | 0.00 | 0.00 | 11.00 | -8743.09 |
| ϕ(t)p(OMA)pent(.) | 4448.51 | 142.16 | 0.00 | 0.00 | 15.00 | -8742.59 |
| ϕ(t)p(OMA)pent(OMA) | 4456.70 | 150.35 | 0.00 | 0.00 | 19.00 | -8742.47 |
| ϕ(PriorCapL+LE)p(.)pent(LE) | 4458.12 | 151.77 | 0.00 | 0.00 | 7.00 | -8716.87 |
| ϕ(PriorCapL+LE)p(LE)pent(LE) | 4458.89 | 152.54 | 0.00 | 0.00 | 8.00 | -8718.11 |
| ϕ(PriorCapL+LE)p(.)pent(.) | 4464.00 | 157.65 | 0.00 | 0.00 | 6.00 | -8708.99 |
| ϕ(PriorCapL+OMA)p(OMA)pent(OMA) | 4464.92 | 158.57 | 0.00 | 0.00 | 20.00 | -8736.27 |
| ϕ(PriorCapL+OMA)p(.)pent(OMA) | 4465.11 | 158.76 | 0.00 | 0.00 | 14.00 | -8723.97 |
| ϕ(PriorCapL+OMA)p(.)pent(.) | 4468.46 | 162.11 | 0.00 | 0.00 | 9.00 | -8710.55 |
| ϕ(PriorCapL)p(.)pent(.) | 4473.02 | 166.68 | 0.00 | 0.00 | 5.00 | -8697.96 |
| ϕ(.)p(.)pent(LE) | 4476.07 | 169.72 | 0.00 | 0.00 | 5.00 | -8694.91 |
| ϕ(.)p(LE)pent(.) | 4476.21 | 169.87 | 0.00 | 0.00 | 5.00 | -8694.77 |
| ϕ(LE)p(.)pent(LE) | 4477.93 | 171.58 | 0.00 | 0.00 | 6.00 | -8695.06 |
| ϕ(LE)p(.)pent(.) | 4478.20 | 171.86 | 0.00 | 0.00 | 5.00 | -8692.78 |
| ϕ(LE)p(LE)pent(.) | 4478.20 | 171.86 | 0.00 | 0.00 | 6.00 | -8694.78 |
| ϕ(.)p(.)pent(.) | 4478.37 | 172.02 | 0.00 | 0.00 | 4.00 | -8690.61 |
| ϕ(LE)p(LE)pent(LE) | 4479.11 | 172.76 | 0.00 | 0.00 | 7.00 | -8695.89 |
| ϕ(OMA)p(.)pent(.) | 4485.96 | 179.61 | 0.00 | 0.00 | 9.00 | -8693.05 |
| ϕ(OMA)p(.)pent(OMA) | 4491.49 | 185.14 | 0.00 | 0.00 | 14.00 | -8697.58 |
| ϕ(OMA)p(OMA)pent(.) | 4492.89 | 186.54 | 0.00 | 0.00 | 15.00 | -8698.20 |
| ϕ(OMA)p(OMA)pent(OMA) | 4499.55 | 193.20 | 0.00 | 0.00 | 20.00 | -8701.64 |

wi = QAICc weight, *k* = number of parameters. Model parameters are: ϕ, landfill visitation probability; *p*, capture probability, *pent*, probability of entry; *t*, variation over time; ., constant over time; PriorCapL, previous capture function; Effort, days of sampling effort per year; LE, effect in time due to change landfill waste management (period 1: 2012 to 2015 and period 2: 2015 to 2018); and OMA, organic matter available for vultures consumption.

**Appendix 7**

Table S7. Real and derived averaged estimates from the first two models with ΔQAICc<2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **Estimate** | **Inconditional SE** | **Low 95%CI** | **Upper 95%CI** |
| ϕ (newly marked vultures) | 0.45 | 0.03 | 0.40 | 0.51 |
| ϕ (after WTC) | 0.82 | 0.02 | 0.76 | 0.86 |
| ϕ (before WTC) | 0.76 | 0.03 | 0.69 | 0.82 |
| p (not captured at previous period) | 0.26 | 0.03 | 0.20 | 0.33 |
| p (captured at previous period) | 0.35 | 0.02 | 0.31 | 0.39 |
| Pent (2013) | 0.25 | 0.02 | 0.21 | 0.30 |
| Pent (2014) | 0.03 | 0.02 | 0.01 | 0.09 |
| Pent (2015) | 0.10 | 0.01 | 0.07 | 0.13 |
| Pent (2016) | 0.10 | 0.02 | 0.07 | 0.13 |
| Pent (2017) | 0.16 | 0.01 | 0.13 | 0.19 |
| Pent (2018) | 0.06 | 0.01 | 0.04 | 0.09 |
| Nsuper | 5034.90 | 179.25 | 4683.56 | 5386.24 |
| N2012 | 1520.48 | 211.65 | 1105.64 | 1935.32 |
| N2013 | 1970.56 | 135.64 | 1704.71 | 2236.42 |
| N2014 | 1755.65 | 98.14 | 1563.30 | 1948.01 |
| N2015 | 1933.56 | 106.29 | 1725.22 | 2141.90 |
| N2016 | 1958.90 | 132.48 | 1699.23 | 2218.56 |
| N2017 | 2303.55 | 172.26 | 1965.92 | 2641.18 |
| N2018 | 2066.96 | 173.45 | 1725.99 | 2405.92 |

Model parameters are: ϕ, landfill visitation probability; *p*, capture probability, *pent*, probability of entry; Nsuper=Super-population size, Ni=abundance in year *i*.

**Appendix S8**

Table S8. Summary of newly mark-released cohorts and first recaptures per year. Previously marked individuals are not included in each cohort released per year column.

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Newly captured/released | Time of first recapture | Total |
| 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |  |
| 2012 | 393 | 76 | 19 | 14 | 11 | 3 | 3 | 126 |
| 2013 | 634 |  | 93 | 47 | 14 | 14 | 7 | 175 |
| 2014 | 386 |  |  | 53 | 19 | 26 | 5 | 103 |
| 2015 | 380 |  |  |  | 56 | 15 | 6 | 77 |
| 2016 | 353 |  |  |  |  | 46 | 21 | 67 |
| 2017 | 457 |  |  |  |  |  | 11 | 11 |
| 2018 | 334 |  |  |  |  |  |  |  |
| Total | 2,937 | 76 | 112 | 114 | 100 | 104 | 53 | 559 |

Table S9. Reduced m-array table of batch released cohorts and first recaptures per year. Previously and newly marked individuals are both included in each cohort released per year.

|  |  |  |  |
| --- | --- | --- | --- |
| Year | Batch released | Recaptures per year | Total |
| 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| 2012 | 393 | 76 | 19 | 14 | 11 | 3 | 3 | 126 |
| 2013 | 710 |  | 116 | 53 | 18 | 18 | 10 | 215 |
| 2014 | 521 |  |  | 98 | 29 | 32 | 9 | 168 |
| 2015 | 545 |  |  |  | 99 | 31 | 11 | 141 |
| 2016 | 510 |  |  |  |  | 93 | 44 | 137 |
| 2017 | 634 |  |  |  |  |  | 94 | 94 |
| Total |  | 76 | 135 | 165 | 157 | 177 | 171 | 881 |