Exploratory modelling report - Tits reproduction study, PubPrivLands project (Martin *et al., in prep.*)

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Contents

1. Introduction

1.1. Regarding reproductibility

In order to facilitate any attempt at reproducing this study, here is a depiction of the system information used to prepare and analyse the data from the PubPrivLands tits reproduction study (Martin *et al.* , *in prep.*).

```
## R version 4.4.1 (2024-06-14 ucrt)
## Platform: x86_64-w64-mingw32/x64
## Running under: Windows 10 x64 (build 19045)
##
## Matrix products: default
##
##
## locale:
## [1] LC_COLLATE=French_France.utf8  LC_CTYPE=French_France.utf8
## [3] LC_MONETARY=French_France.utf8 LC_NUMERIC=C
## [5] LC_TIME=French_France.utf8
##
## time zone: Europe/Paris
## tzcode source: internal
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
## [1] magrittr_2.0.3
##
## loaded via a namespace (and not attached):
##  [1] crayon_1.5.3      vctrs_0.6.5       cli_3.6.3         knitr_1.49
##  [5] rlang_1.1.4       xfun_0.49         generics_0.1.3    glue_1.8.0
##  [9] bit_4.5.0.1       rprojroot_2.0.4   htmltools_0.5.8.1 hms_1.1.3
## [13] rmarkdown_2.29    evaluate_1.0.3    tibble_3.2.1      tzdb_0.4.0
## [17] fastmap_1.2.0     yaml_2.3.10       lifecycle_1.0.4   compiler_4.4.1
## [21] dplyr_1.1.4       pkgconfig_2.0.3   here_1.0.1        rstudioapi_0.17.1
## [25] digest_0.6.37     R6_2.5.1          readr_2.1.5       tidyselect_1.2.1
## [29] parallel_4.4.1    vroom_1.6.5       pillar_1.10.1     withr_3.0.2
## [33] tools_4.4.1       bit64_4.5.2
```

All codes and packages used in this study can furthermore be found here: https://github.com/mrelnoob/ppl.fanf_tits. All packages are availables with their correct version in the dedicated **{renv} project**.

1.2. What is this document about and how it it organised?

This report is meant to present all *exploratory modelling* that were conducted after our formal inferential modelling phase (cf. code and manuscript). These "exploratory models" were built in order to try and fine **tune some modelling components** (e.g. zero-inflation) or to **ascertain the robustness of our formal results** by using different proxies of our variables of interest: i.e. the *local patch area* and the *connectivity metric* (F metric: *log_F_metric_d2b1* in the R code).
By nature, these models have far less support than the models used fro inference as the data have already been used for formal testing (thus type-I error rates aren't properly controlled for anymore)!

This report will be organised as follow:

1. We will first present the modelling results from all the variant models for **clutch size**, **nestling survival** and **mass**. Note that all models are simple variants of the final models we retained to formally test our two hypotheses.
2. Then, we will present the results from **nestling survival** models for which we tuned the *zero-inflation* (ZI) component to see if we could explain some of the excess of zeroes (that is total brood failures = 100% mortality rates).

To keep things short, please note that we will not present models diagnostics (they were mostly good and they can easily be reproduced from our code) nor all possible combinations of models as we did not explored them all (we mostly focused on a few proxies).

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2. Switched proxies models

2.1. Models to explain tits CLUTCH SIZE

2.1.1. Using *woody_area* instead of *patch_area*

Results when we use the **total area of woody vegetation within 150 m of the nestboxes** (in m²) instead of the size of the **local patch area** (that is, the size of the patch of nesting/foraging habitat in which the nestbox is located) to explain the *size of tit clutches*:

```
##  Family: compois  ( log )
## Formula:          clutch_size ~ log_woody_area + log_F_metric_d2b1 + species +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + cumdd_30 + laying_day + year + (1 | id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1379.4   1447.1   -672.7   1345.4      379
##
## Random effects:
##
## Conditional model:
##  Groups     Name        Variance Std.Dev.
##  id_nestbox (Intercept) 0.001745 0.04178
## Number of obs: 396, groups:  id_nestbox, 230
```

```
##
## Dispersion parameter for compois family (): 0.173
##
## Conditional model:
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)      3.708850   0.380888   9.737  < 2e-16 ***
## log_woody_area  -0.368619   0.096199  -3.832 0.000127 ***
## log_F_metric_d2b1 0.084786  0.035938   2.359 0.018314 *
## speciesCC        0.322426   0.022656  14.232  < 2e-16 ***
## urban_intensity -0.002172   0.009593  -0.226 0.820844
## manag_mid1      -0.011153   0.023298  -0.479 0.632160
## manag_high1      0.032353   0.026445   1.223 0.221177
## light_pollution -0.004757   0.005435  -0.875 0.381390
## noise_m          0.053090   0.022232   2.388 0.016940 *
## traffic         -0.008413   0.004836  -1.740 0.081897 .
## cumdd_30        -0.012465   0.054665  -0.228 0.819619
## laying_day      -0.070015   0.015679  -4.466 7.99e-06 ***
## year2020        -0.053708   0.023808  -2.256 0.024076 *
## year2021        -0.018966   0.030159  -0.629 0.529422
## year2022         0.010574   0.020887   0.506 0.612674
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: compois  ( log )
## Formula:
## clutch_size ~ c.log_woody_area * c.log_F_metric_d2b1 + species +
##      urban_intensity + manag_mid + manag_high + light_pollution +
##      noise_m + traffic + cumdd_30 + laying_day + year + (1 | id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1379.3   1451.0   -671.6   1343.3      378
##
## Random effects:
##
## Conditional model:
##  Groups      Name         Variance Std.Dev.
##  id_nestbox (Intercept) 0.001327 0.03643
## Number of obs: 396, groups:  id_nestbox, 230
##
## Dispersion parameter for compois family (): 0.176
##
## Conditional model:
##                               Estimate Std. Error z value Pr(>|z|)
## (Intercept)                   2.513361   0.186852  13.451  < 2e-16 ***
## c.log_woody_area             -0.395984   0.096977  -4.083 4.44e-05 ***
## c.log_F_metric_d2b1           0.102140   0.037518   2.722  0.00648 **
## speciesCC                     0.328025   0.022784  14.397  < 2e-16 ***
## urban_intensity              -0.001414   0.009508  -0.149  0.88176
## manag_mid1                   -0.007204   0.023168  -0.311  0.75583
## manag_high1                   0.035223   0.026219   1.343  0.17915
## light_pollution              -0.003181   0.005473  -0.581  0.56108
## noise_m                       0.058324   0.022333   2.612  0.00901 **
## traffic                      -0.008120   0.004789  -1.696  0.08995 .
```

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```
## cumdd_30                                 -0.019421   0.054646  -0.355  0.72229
## laying_day                                -0.072186   0.015677  -4.604 4.14e-06 ***
## year2020                                  -0.053342   0.023856  -2.236  0.02535 *
## year2021                                  -0.017545   0.030117  -0.583  0.56018
## year2022                                   0.011578   0.020911   0.554  0.57980
## c.log_woody_area:c.log_F_metric_d2b1       0.072674   0.049521   1.468  0.14223
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.1.2. Using *woody_volume* instead of *patch_area*

Results when we use the **total volume of woody vegetation within 150 m of the nestboxes** (in m²) instead of the size of the **local patch area** (that is, the size of the patch of nesting/foraging habitat in which the nestbox is located) to explain the *size of tit clutches*:

```
##  Family: compois  ( log )
## Formula:
## clutch_size ~ log_woody_vol + log_F_metric_d2b1 + species + urban_intensity +
## 	    manag_mid + manag_high + light_pollution + noise_m + traffic +
## 	    cumdd_30 + laying_day + year + (1 | id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1383.6   1451.3   -674.8   1349.6      379
##
## Random effects:
##
## Conditional model:
##  Groups     Name        Variance Std.Dev.
##  id_nestbox (Intercept) 0.00202  0.04495
## Number of obs: 396, groups:  id_nestbox, 230
##
## Dispersion parameter for compois family (): 0.173
##
## Conditional model:
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)        2.952518   0.268660  10.990  < 2e-16 ***
## log_woody_vol     -0.132334   0.041376  -3.198  0.00138 **
## log_F_metric_d2b1  0.043520   0.031332   1.389  0.16483
## speciesCC          0.303153   0.021093  14.372  < 2e-16 ***
## urban_intensity    0.007438   0.008793   0.846  0.39756
## manag_mid1        -0.013265   0.023556  -0.563  0.57335
## manag_high1        0.027756   0.026626   1.042  0.29720
## light_pollution   -0.007911   0.005712  -1.385  0.16607
## noise_m            0.061694   0.022519   2.740  0.00615 **
## traffic           -0.009267   0.004882  -1.898  0.05768 .
## cumdd_30          -0.009590   0.055119  -0.174  0.86188
## laying_day        -0.067822   0.015783  -4.297 1.73e-05 ***
## year2020          -0.056621   0.023822  -2.377  0.01746 *
## year2021          -0.019268   0.030309  -0.636  0.52497
## year2022           0.007518   0.020980   0.358  0.72009
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

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```
##  Family: compois  ( log )
## Formula:
## clutch_size ~ c.log_woody_vol * c.log_F_metric_d2b1 + species +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + cumdd_30 + laying_day + year + (1 | id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1383.0   1454.7   -673.5   1347.0      378
##
## Random effects:
##
## Conditional model:
##  Groups      Name         Variance Std.Dev.
##  id_nestbox (Intercept) 0.001378 0.03713
## Number of obs: 396, groups:  id_nestbox, 230
##
## Dispersion parameter for compois family (): 0.177
##
## Conditional model:
##                                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)                      2.458238   0.189505  12.972  < 2e-16 ***
## c.log_woody_vol                 -0.151986   0.042473  -3.578 0.000346 ***
## c.log_F_metric_d2b1              0.060880   0.032704   1.862 0.062666 .
## speciesCC                        0.309551   0.021224  14.585  < 2e-16 ***
## urban_intensity                  0.009585   0.008760   1.094 0.273867
## manag_mid1                      -0.007618   0.023388  -0.326 0.744650
## manag_high1                      0.031180   0.026225   1.189 0.234476
## light_pollution                 -0.006964   0.005638  -1.235 0.216707
## noise_m                          0.064008   0.022284   2.872 0.004074 **
## traffic                         -0.008358   0.004838  -1.728 0.084047 .
## cumdd_30                        -0.011196   0.054889  -0.204 0.838370
## laying_day                      -0.070825   0.015799  -4.483 7.36e-06 ***
## year2020                        -0.055865   0.023916  -2.336 0.019498 *
## year2021                        -0.016232   0.030320  -0.535 0.592410
## year2022                         0.007750   0.021014   0.369 0.712283
## c.log_woody_vol:c.log_F_metric_d2b1 0.053800 0.033154   1.623 0.104650
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.1.3. Using *woody_vw* instead of *patch_area*

Results when we use the **total volume of woody vegetation within 150 m of the nestboxes (weighted with a qualitative assessment of the structural complexity of the understory vegetation)** instead of the size of the **local patch area** (that is, the size of the patch of nesting/foraging habitat in which the nestbox is located) to explain the *size of tit clutches*:

```
##  Family: compois  ( log )
## Formula:
## clutch_size ~ log_woody_vw + log_F_metric_d2b1 + species + urban_intensity +
##     manag_mid + manag_high + light_pollution + noise_m + traffic +
##     cumdd_30 + laying_day + year + (1 | id_nestbox)
## Data: ntits3
```

```
## 
##      AIC      BIC   logLik deviance df.resid
##   1383.8   1451.5   -674.9   1349.8      379
## 
## Random effects:
## 
## Conditional model:
##  Groups     Name        Variance Std.Dev.
##  id_nestbox (Intercept) 0.002168 0.04656
## Number of obs: 396, groups:  id_nestbox, 230
## 
## Dispersion parameter for compois family (): 0.172
## 
## Conditional model:
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)      2.864252   0.258356  11.086  < 2e-16 ***
## log_woody_vw    -0.113456   0.035936  -3.157  0.00159 **
## log_F_metric_d2b1 0.042308   0.031338   1.350  0.17700
## speciesCC        0.302917   0.021146  14.325  < 2e-16 ***
## urban_intensity  0.009555   0.008608   1.110  0.26703
## manag_mid1      -0.018203   0.023713  -0.768  0.44270
## manag_high1      0.018863   0.026896   0.701  0.48309
## light_pollution -0.007755   0.005727  -1.354  0.17576
## noise_m          0.058836   0.022528   2.612  0.00901 **
## traffic         -0.009787   0.004899  -1.998  0.04572 *
## cumdd_30        -0.009801   0.055150  -0.178  0.85895
## laying_day      -0.068095   0.015807  -4.308 1.65e-05 ***
## year2020        -0.054370   0.023842  -2.280  0.02258 *
## year2021        -0.016544   0.030369  -0.545  0.58592
## year2022         0.010625   0.020925   0.508  0.61161
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1


##  Family: compois  ( log )
## Formula:
## clutch_size ~ c.log_woody_vol * c.log_F_metric_d2b1 + species +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + cumdd_30 + laying_day + year + (1 | id_nestbox)
## Data: ntits3
## 
##      AIC      BIC   logLik deviance df.resid
##   1383.0   1454.7   -673.5   1347.0      378
## 
## Random effects:
## 
## Conditional model:
##  Groups     Name        Variance Std.Dev.
##  id_nestbox (Intercept) 0.001378 0.03713
## Number of obs: 396, groups:  id_nestbox, 230
## 
## Dispersion parameter for compois family (): 0.177
## 
## Conditional model:
##                                      Estimate Std. Error z value Pr(>|z|)
```

```
## (Intercept)                           2.458238   0.189505  12.972  < 2e-16 ***
## c.log_woody_vol                       -0.151986   0.042473  -3.578 0.000346 ***
## c.log_F_metric_d2b1                    0.060880   0.032704   1.862 0.062666 .
## speciesCC                              0.309551   0.021224  14.585  < 2e-16 ***
## urban_intensity                        0.009585   0.008760   1.094 0.273867
## manag_mid1                            -0.007618   0.023388  -0.326 0.744650
## manag_high1                            0.031180   0.026225   1.189 0.234476
## light_pollution                       -0.006964   0.005638  -1.235 0.216707
## noise_m                                0.064008   0.022284   2.872 0.004074 **
## traffic                               -0.008358   0.004838  -1.728 0.084047 .
## cumdd_30                              -0.011196   0.054889  -0.204 0.838370
## laying_day                            -0.070825   0.015799  -4.483 7.36e-06 ***
## year2020                              -0.055865   0.023916  -2.336 0.019498 *
## year2021                              -0.016232   0.030320  -0.535 0.592410
## year2022                               0.007750   0.021014   0.369 0.712283
## c.log_woody_vol:c.log_F_metric_d2b1   0.053800   0.033154   1.623 0.104650
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.1.4. Using *Fplus* instead of *patch_area*

Results when we use the *F_plus* variable, i.e. the **addition** of the **local patch area** and the **F-metric** to explain the *size of tit clutches*:

```
##  Family: compois  ( log )
## Formula:
## clutch_size ~ log_Fplus + species + urban_intensity + manag_mid +
##     manag_high + light_pollution + noise_m + traffic + cumdd_30 +
##     laying_day + year + (1 | id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1391.3   1455.0   -679.6   1359.3      380
##
## Random effects:
##
## Conditional model:
##  Groups      Name         Variance Std.Dev.
##  id_nestbox (Intercept) 0.002289 0.04784
## Number of obs: 396, groups:  id_nestbox, 230
##
## Dispersion parameter for compois family (): 0.176
##
## Conditional model:
##                Estimate Std. Error z value Pr(>|z|)
## (Intercept)     2.638525   0.245263  10.758  < 2e-16 ***
## log_Fplus      -0.018610   0.028048  -0.664   0.5070
## speciesCC       0.271345   0.018918  14.343  < 2e-16 ***
## urban_intensity 0.015138   0.008129   1.862   0.0625 .
## manag_mid1     -0.010989   0.023971  -0.458   0.6467
## manag_high1     0.030880   0.027148   1.137   0.2553
## light_pollution -0.002989   0.005585  -0.535   0.5925
## noise_m         0.055130   0.022938   2.403   0.0162 *
```

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```
## traffic            -0.009541   0.004962  -1.923   0.0545 .
## cumdd_30           -0.027246   0.055449  -0.491   0.6232
## laying_day         -0.068806   0.016014  -4.296 1.74e-05 ***
## year2020           -0.061240   0.023999  -2.552   0.0107 *
## year2021           -0.024710   0.030598  -0.808   0.4193
## year2022            0.011763   0.021134   0.557   0.5778
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.1.5. Using _F_metric_d2b0_ instead of _F_metric_d2b1_

Results when we use the _F_metric_d2b0_ variable, i.e. the _F-metric_ with no weighting for the size of the patches, to explain the _size of tit clutches_:

```
##  Family: compois  ( log )
## Formula:          clutch_size ~ log_patch_area + log_F_metric_d2b0 + species +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + cumdd_30 + laying_day + year + (1 | id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1384.0   1451.7   -675.0   1350.0      379
##
## Random effects:
##
## Conditional model:
##  Groups     Name        Variance Std.Dev.
##  id_nestbox (Intercept) 0.002466 0.04966
## Number of obs: 396, groups:  id_nestbox, 230
##
## Dispersion parameter for compois family (): 0.17
##
## Conditional model:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)       2.517281   0.231335  10.882  < 2e-16 ***
## log_patch_area   -0.039021   0.012511  -3.119  0.00181 **
## log_F_metric_d2b0 0.041179   0.038390   1.073  0.28342
## speciesCC         0.300618   0.024661  12.190  < 2e-16 ***
## urban_intensity   0.017015   0.007328   2.322  0.02025 *
## manag_mid1       -0.015791   0.023744  -0.665  0.50602
## manag_high1       0.027126   0.026934   1.007  0.31389
## light_pollution  -0.004359   0.005578  -0.781  0.43455
## noise_m           0.063164   0.023388   2.701  0.00692 **
## traffic          -0.010373   0.004917  -2.110  0.03490 *
## cumdd_30         -0.013812   0.054908  -0.252  0.80139
## laying_day       -0.069506   0.015875  -4.378  1.2e-05 ***
## year2020         -0.057400   0.023681  -2.424  0.01536 *
## year2021         -0.020699   0.030257  -0.684  0.49391
## year2022          0.006858   0.020989   0.327  0.74384
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: compois  ( log )
```

```
## Formula:
## clutch_size ~ c.log_patch_area * log_F_metric_d2b0 + species +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + cumdd_30 + laying_day + year + (1 | id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1385.4   1457.1   -674.7   1349.4      378
##
## Random effects:
##
## Conditional model:
##  Groups      Name         Variance Std.Dev.
##  id_nestbox (Intercept) 0.002476 0.04976
## Number of obs: 396, groups:  id_nestbox, 230
##
## Dispersion parameter for compois family (): 0.169
##
## Conditional model:
##                               Estimate Std. Error z value Pr(>|z|)
## (Intercept)                   2.421739   0.239763  10.101  < 2e-16 ***
## c.log_patch_area              0.004464   0.056729   0.079  0.93728
## log_F_metric_d2b0             0.031415   0.040282   0.780  0.43547
## speciesCC                     0.298082   0.024850  11.995  < 2e-16 ***
## urban_intensity               0.015748   0.007501   2.099  0.03579 *
## manag_mid1                   -0.020211   0.024384  -0.829  0.40717
## manag_high1                   0.022748   0.027469   0.828  0.40760
## light_pollution              -0.004905   0.005617  -0.873  0.38255
## noise_m                       0.061767   0.023424   2.637  0.00837 **
## traffic                      -0.010502   0.004917  -2.136  0.03269 *
## cumdd_30                     -0.014122   0.054866  -0.257  0.79688
## laying_day                   -0.069232   0.015872  -4.362 1.29e-05 ***
## year2020                     -0.057727   0.023660  -2.440  0.01469 *
## year2021                     -0.020940   0.030227  -0.693  0.48847
## year2022                      0.006768   0.020970   0.323  0.74688
## c.log_patch_area:log_F_metric_d2b0 -0.020597   0.026213  -0.786  0.43199
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.2. Models to explain tits NESTLING SURVIVAL

2.2.1. Using *woody_area* instead of *patch_area*

Results when we use the **total area of woody vegetation within 150 m of the nestboxes** (in m²)
instead of the size of the **local patch area** (that is, the size of the patch of nesting/foraging habitat in
which the nestbox is located) to explain the *survival of tits nestlings*:

```
##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ log_woody_area + log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year + (1 | id_nestbox)
## Zero inflation:                              ~1
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1379.6   1450.4   -671.8   1343.6      360
##
## Random effects:
##
## Conditional model:
##  Groups     Name         Variance  Std.Dev.
##  id_nestbox (Intercept) 8.686e-09 9.32e-05
## Number of obs: 378, groups:  id_nestbox, 223
##
## Dispersion parameter for betabinomial family (): 7.93
##
## Conditional model:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)       2.928232   3.253578   0.900   0.3681
## log_woody_area    0.101942   0.700717   0.145   0.8843
## log_F_metric_d2b1 0.468205   0.230259   2.033   0.0420 *
## clutch_size      -0.164341   0.038730  -4.243 2.20e-05 ***
## urban_intensity   0.108264   0.083003   1.304   0.1921
## manag_mid1       -0.234826   0.208557  -1.126   0.2602
## manag_high1      -0.491734   0.224263  -2.193   0.0283 *
## light_pollution  -0.073429   0.044049  -1.667   0.0955 .
## noise_m           0.016971   0.199208   0.085   0.9321
## traffic           0.002740   0.041712   0.066   0.9476
## min_t_between    -0.001965   0.052719  -0.037   0.9703
## laying_day       -0.314194   0.141629  -2.218   0.0265 *
## year2020          0.426214   0.238204   1.789   0.0736 .
## year2021          0.286493   0.175472   1.633   0.1025
## year2022          1.343409   0.194442   6.909 4.88e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.0152     0.1626   -12.4   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ c.log_woody_area * c.log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year + (1 | id_nestbox)
```

```
## Zero inflation:                                    ~1
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1378.2   1453.0   -670.1   1340.2      359
##
## Random effects:
##
## Conditional model:
##  Groups      Name           Variance  Std.Dev.
##  id_nestbox (Intercept) 1.219e-08 0.0001104
## Number of obs: 378, groups:  id_nestbox, 223
##
## Dispersion parameter for betabinomial family (): 7.95
##
## Conditional model:
##                                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)                     5.5467785  1.7405346   3.187  0.00144 **
## c.log_woody_area                0.2389945  0.7051227   0.339  0.73465
## c.log_F_metric_d2b1             0.3108531  0.2480220   1.253  0.21009
## clutch_size                    -0.1659770  0.0387666  -4.281 1.86e-05 ***
## urban_intensity                 0.0945308  0.0839593   1.126  0.26020
## manag_mid1                     -0.2701780  0.2096379  -1.289  0.19747
## manag_high1                    -0.5442862  0.2258715  -2.410  0.01596 *
## light_pollution                -0.0882410  0.0447986  -1.970  0.04887 *
## noise_m                        -0.0559091  0.2058573  -0.272  0.78594
## traffic                        -0.0020035  0.0420268  -0.048  0.96198
## min_t_between                  -0.0005128  0.0527854  -0.010  0.99225
## laying_day                     -0.2646170  0.1443875  -1.833  0.06685 .
## year2020                        0.4156760  0.2390451   1.739  0.08205 .
## year2021                        0.2336489  0.1778814   1.314  0.18901
## year2022                        1.3272790  0.1939837   6.842 7.80e-12 ***
## c.log_woody_area:c.log_F_metric_d2b1 -0.7329112  0.3986635  -1.838  0.06600 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##           Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.0140     0.1625    -12.4   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.2.2. Using *woody_volume* instead of *patch_area*

Results when we use the **total volume of woody vegetation within 150 m of the nestboxes** (in m²)
instead of the size of the **local patch area** (that is, the size of the patch of nesting/foraging habitat in
which the nestbox is located) to explain the *survival of tits nestlings*:

```
## Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ log_woody_vol + log_F_metric_d2b1 +
##      clutch_size + urban_intensity + manag_mid + manag_high +
```

```
##      light_pollution + noise_m + traffic + min_t_between + laying_day +
##      year + (1 | id_nestbox)
## Zero inflation:                                ~1
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1379.4   1450.2   -671.7   1343.4      360
##
## Random effects:
##
## Conditional model:
##  Groups     Name         Variance  Std.Dev.
##  id_nestbox (Intercept) 6.953e-09 8.339e-05
## Number of obs: 378, groups:  id_nestbox, 223
##
## Dispersion parameter for betabinomial family (): 7.89
##
## Conditional model:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)       3.8889652  2.4558051   1.584   0.1133
## log_woody_vol    -0.1501143  0.3268788  -0.459   0.6461
## log_F_metric_d2b1 0.5168818  0.2114356   2.445   0.0145 *
## clutch_size      -0.1616926  0.0382147  -4.231 2.32e-05 ***
## urban_intensity   0.0839655  0.0735641   1.141   0.2537
## manag_mid1       -0.2247388  0.2085344  -1.078   0.2812
## manag_high1      -0.4841772  0.2241087  -2.160   0.0307 *
## light_pollution  -0.0796162  0.0456395  -1.744   0.0811 .
## noise_m           0.0008492  0.1970818   0.004   0.9966
## traffic           0.0028021  0.0418789   0.067   0.9467
## min_t_between    -0.0040903  0.0527223  -0.078   0.9382
## laying_day       -0.3031073  0.1427504  -2.123   0.0337 *
## year2020          0.4325093  0.2375919   1.820   0.0687 .
## year2021          0.2838455  0.1757438   1.615   0.1063
## year2022          1.3276776  0.1954514   6.793 1.10e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.0159     0.1626    -12.4   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ c.log_woody_vol * c.log_F_metric_d2b1 +
##      clutch_size + urban_intensity + manag_mid + manag_high +
##      light_pollution + noise_m + traffic + min_t_between + laying_day +
##      year + (1 | id_nestbox)
## Zero inflation:                                ~1
## Data: ntits3
## Weights: brood_size
##
```

```
##      AIC      BIC   logLik deviance df.resid
##   1376.7   1451.5   -669.4   1338.7      359
##
## Random effects:
##
## Conditional model:
##  Groups      Name           Variance  Std.Dev.
##  id_nestbox (Intercept) 1.195e-08 0.0001093
## Number of obs: 378, groups:  id_nestbox, 223
##
## Dispersion parameter for betabinomial family (): 8.01
##
## Conditional model:
##                                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)                     5.322708   1.754816   3.033  0.00242 **
## c.log_woody_vol                 0.012718   0.330706   0.038  0.96932
## c.log_F_metric_d2b1             0.349057   0.227945   1.531  0.12569
## clutch_size                    -0.161848   0.038136  -4.244 2.20e-05 ***
## urban_intensity                 0.057800   0.074551   0.775  0.43816
## manag_mid1                     -0.286658   0.210912  -1.359  0.17410
## manag_high1                    -0.557198   0.226373  -2.461  0.01384 *
## light_pollution                -0.090358   0.045917  -1.968  0.04909 *
## noise_m                        -0.039277   0.201651  -0.195  0.84557
## traffic                        -0.007958   0.042408  -0.188  0.85115
## min_t_between                  -0.002357   0.052822  -0.045  0.96440
## laying_day                     -0.249095   0.145002  -1.718  0.08582 .
## year2020                        0.426529   0.238025   1.792  0.07314 .
## year2021                        0.233735   0.176908   1.321  0.18643
## year2022                        1.330088   0.194218   6.848 7.47e-12 ***
## c.log_woody_vol:c.log_F_metric_d2b1 -0.580121   0.268341  -2.162  0.03063 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.0136     0.1624  -12.39   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.2.3. Using *woody_vw* instead of *patch_area*

Results when we use the **total volume of woody vegetation within 150 m of the nestboxes (weighted with a qualitative assessment of the structural complexity of the understory vegetation)** instead of the size of the **local patch area** (that is, the size of the patch of nesting/foraging habitat in which the nestbox is located) to explain the *survival of tits nestlings*:

```
##  Family: betabinomial  ( logit )
## Formula:          fledgling_nb/brood_size ~ log_woody_vw + log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year + (1 | id_nestbox)
## Zero inflation:                        ~1
## Data: ntits3
```

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```
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1379.6   1450.4   -671.8   1343.6      360
##
## Random effects:
##
## Conditional model:
##  Groups     Name        Variance  Std.Dev.
##  id_nestbox (Intercept) 7.958e-09 8.921e-05
## Number of obs: 378, groups:  id_nestbox, 223
##
## Dispersion parameter for betabinomial family (): 7.91
##
## Conditional model:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)       3.406627   2.317900   1.470   0.1416
## log_woody_vw     -0.029790   0.268112  -0.111   0.9115
## log_F_metric_d2b1 0.492151   0.209495   2.349   0.0188 *
## clutch_size      -0.162842   0.038211  -4.262 2.03e-05 ***
## urban_intensity   0.097307   0.070469   1.381   0.1673
## manag_mid1       -0.232008   0.207802  -1.116   0.2642
## manag_high1      -0.490305   0.223969  -2.189   0.0286 *
## light_pollution  -0.075142   0.045332  -1.658   0.0974 .
## noise_m           0.008025   0.196474   0.041   0.9674
## traffic           0.002881   0.041777   0.069   0.9450
## min_t_between    -0.002804   0.052658  -0.053   0.9575
## laying_day       -0.310547   0.142229  -2.183   0.0290 *
## year2020          0.430240   0.237566   1.811   0.0701 .
## year2021          0.286607   0.175535   1.633   0.1025
## year2022          1.338241   0.194793   6.870 6.42e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.0154     0.1626   -12.4   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ c.log_woody_vw * c.log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year + (1 | id_nestbox)
## Zero inflation:                          ~1
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1376.7   1451.5   -669.4   1338.7      359
##
## Random effects:
```

```
## 
## Conditional model:
##  Groups      Name         Variance  Std.Dev.
##  id_nestbox (Intercept) 1.311e-08 0.0001145
## Number of obs: 378, groups:  id_nestbox, 223
## 
## Dispersion parameter for betabinomial family (): 7.98
## 
## Conditional model:
##                               Estimate Std. Error z value Pr(>|z|)
## (Intercept)                   5.3887235  1.7505983   3.078  0.00208 **
## c.log_woody_vw                0.0483947  0.2656729   0.182  0.85546
## c.log_F_metric_d2b1           0.3489565  0.2221061   1.571  0.11615
## clutch_size                  -0.1629199  0.0381680  -4.268 1.97e-05 ***
## urban_intensity               0.0577013  0.0727554   0.793  0.42773
## manag_mid1                   -0.2965340  0.2105382  -1.408  0.15900
## manag_high1                  -0.5644741  0.2269119  -2.488  0.01286 *
## light_pollution              -0.0892864  0.0457406  -1.952  0.05094 .
## noise_m                      -0.0350914  0.2010659  -0.175  0.86145
## traffic                      -0.0065045  0.0422671  -0.154  0.87770
## min_t_between                -0.0002782  0.0529242  -0.005  0.99581
## laying_day                   -0.2573131  0.1446617  -1.779  0.07529 .
## year2020                      0.4238739  0.2382481   1.779  0.07522 .
## year2021                      0.2393809  0.1765516   1.356  0.17514
## year2022                      1.3376264  0.1935683   6.910 4.83e-12 ***
## c.log_woody_vw:c.log_F_metric_d2b1 -0.5524956  0.2485696  -2.223  0.02624 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Zero-inflation model:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.0174     0.1628  -12.39   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.2.4. Using *Fplus* instead of *patch_area*

Results when we use the *F_plus* variable, i.e. the **addition** of the **local patch area** and the **F-metric** to explain the *survival of tits nestlings*:

```
##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ log_Fplus + clutch_size + urban_intensity +
##     manag_mid + manag_high + light_pollution + noise_m + traffic +
##     min_t_between + laying_day + year + (1 | id_nestbox)
## Zero inflation:                          ~1
## Data: ntits3
## Weights: brood_size
## 
##      AIC      BIC   logLik deviance df.resid
##   1377.6   1444.5   -671.8   1343.6      361
## 
## Random effects:
```

```
## 
## Conditional model:
##  Groups      Name           Variance  Std.Dev.
##  id_nestbox (Intercept) 1.285e-08 0.0001134
## Number of obs: 378, groups:  id_nestbox, 223
## 
## Dispersion parameter for betabinomial family (): 7.95
## 
## Conditional model:
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)      3.121246   2.108880   1.480   0.1389
## log_Fplus        0.520015   0.211780   2.455   0.0141 *
## clutch_size     -0.163651   0.037908  -4.317 1.58e-05 ***
## urban_intensity  0.096289   0.062444   1.542   0.1231
## manag_mid1      -0.231546   0.207544  -1.116   0.2646
## manag_high1     -0.483750   0.223235  -2.167   0.0302 *
## light_pollution -0.072128   0.043932  -1.642   0.1006
## noise_m          0.035469   0.195348   0.182   0.8559
## traffic          0.002245   0.041511   0.054   0.9569
## min_t_between   -0.001443   0.052710  -0.027   0.9782
## laying_day      -0.328535   0.141136  -2.328   0.0199 *
## year2020         0.422925   0.237217   1.783   0.0746 .
## year2021         0.294735   0.175791   1.677   0.0936 .
## year2022         1.351481   0.194020   6.966 3.27e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Zero-inflation model:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.0160     0.1628  -12.39   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.2.5. Using *F_metric_d2b0* instead of *F_metric_d2b1*

Results when we use the *F_metric_d2b0* variable, i.e. the *F-metric* with no weighting for the size of the patches, to explain the *nestling survival*:

```
##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ log_woody_vol + log_F_metric_d2b0 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year + (1 | id_nestbox)
## Zero inflation:                          ~1
## Data: ntits3
## Weights: brood_size
## 
##      AIC      BIC   logLik deviance df.resid
##   1381.4   1452.3   -672.7   1345.4      360
## 
## Random effects:
## 
```

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```
## Conditional model:
##  Groups      Name          Variance  Std.Dev.
##  id_nestbox (Intercept) 1.062e-08 0.0001031
## Number of obs: 378, groups:  id_nestbox, 223
##
## Dispersion parameter for betabinomial family ():  7.8
##
## Conditional model:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)       3.497980   2.568378   1.362 0.173216
## log_woody_vol     0.108371   0.306948   0.353 0.724043
## log_F_metric_d2b0 0.447411   0.224332   1.994 0.046107 *
## clutch_size      -0.156576   0.040324  -3.883 0.000103 ***
## urban_intensity   0.065149   0.072341   0.901 0.367810
## manag_mid1       -0.185333   0.209739  -0.884 0.376894
## manag_high1      -0.434706   0.224900  -1.933 0.053251 .
## light_pollution  -0.085386   0.045423  -1.880 0.060133 .
## noise_m           0.051296   0.197059   0.260 0.794625
## traffic          -0.004842   0.041532  -0.117 0.907188
## min_t_between    -0.007634   0.052653  -0.145 0.884716
## laying_day       -0.295687   0.143696  -2.058 0.039615 *
## year2020          0.408133   0.236979   1.722 0.085027 .
## year2021          0.246756   0.176129   1.401 0.161215
## year2022          1.307071   0.196066   6.666 2.62e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.0123     0.1622   -12.4   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ c.log_woody_vol * c.log_F_metric_d2b0 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year + (1 | id_nestbox)
## Zero inflation:                                ~1
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1373.0   1447.8   -667.5   1335.0      359
##
## Random effects:
##
## Conditional model:
##  Groups      Name          Variance  Std.Dev.
##  id_nestbox (Intercept) 1.501e-08 0.0001225
## Number of obs: 378, groups:  id_nestbox, 223
##
## Dispersion parameter for betabinomial family (): 8.13
```

```
## 
## Conditional model:
##                                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)                     5.861989   1.834205   3.196  0.00139 **
## c.log_woody_vol                 0.230056   0.305255   0.754  0.45106
## c.log_F_metric_d2b0             0.181943   0.240954   0.755  0.45019
## clutch_size                    -0.175060   0.040896  -4.281 1.86e-05 ***
## urban_intensity                 0.058865   0.072445   0.813  0.41648
## manag_mid1                     -0.352058   0.216631  -1.625  0.10413
## manag_high1                    -0.623416   0.231142  -2.697  0.00699 **
## light_pollution                -0.085658   0.045681  -1.875  0.06077 .
## noise_m                        -0.057696   0.203664  -0.283  0.77696
## traffic                        -0.010458   0.041840  -0.250  0.80263
## min_t_between                   0.008875   0.053028   0.167  0.86708
## laying_day                     -0.274666   0.143999  -1.907  0.05647 .
## year2020                        0.387289   0.237588   1.630  0.10308
## year2021                        0.236717   0.175752   1.347  0.17802
## year2022                        1.326310   0.194051   6.835 8.21e-12 ***
## c.log_woody_vol:c.log_F_metric_d2b0 -1.395883 0.430624  -3.242  0.00119 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Zero-inflation model:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -2.0107     0.1621   -12.4   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.3. Models to explain tits NESTLING MASS

2.3.1. Using *woody_area* instead of *patch_area*

Results when we use the **total area of woody vegetation within 150 m of the nestboxes** (in m²) instead of the size of the **local patch area** (that is, the size of the patch of nesting/foraging habitat in which the nestbox is located) to explain the *mass of tits nestlings*:

```
##  Family: gaussian  ( identity )
## Formula:
## mass ~ log_woody_area + log_F_metric_d2b1 + species + clutch_size +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + min_t_between + laying_day + year + (1 |
##     id_nestbox)
## Data: ntits3
## 
##      AIC      BIC   logLik deviance df.resid
##   1142.8   1210.5   -553.4   1106.8      299
```

```
## 
## Random effects:
## 
## Conditional model:
##  Groups      Name          Variance  Std.Dev.
##  id_nestbox (Intercept) 2.115e-08 0.0001454
##  Residual               1.922e+00 1.3865112
## Number of obs: 317, groups:  id_nestbox, 202
## 
## Dispersion estimate for gaussian family (sigma^2): 1.92
## 
## Conditional model:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)       16.246936   4.099254   3.963 7.39e-05 ***
## log_woody_area     0.714290   0.992137   0.720 0.471555
## log_F_metric_d2b1  0.545617   0.369771   1.476 0.140064
## speciesCC         -4.875727   0.289196 -16.860  < 2e-16 ***
## clutch_size       -0.235486   0.058105  -4.053 5.06e-05 ***
## urban_intensity    0.060891   0.097899   0.622 0.533961
## manag_mid1        -0.313404   0.230861  -1.358 0.174608
## manag_high1       -0.514813   0.255651  -2.014 0.044038 *
## light_pollution   -0.045706   0.052927  -0.864 0.387819
## noise_m           -0.009887   0.221980  -0.045 0.964474
## traffic            0.059553   0.048888   1.218 0.223166
## min_t_between      0.095865   0.059304   1.616 0.105989
## laying_day        -0.594192   0.174233  -3.410 0.000649 ***
## year2020           0.904366   0.287811   3.142 0.001677 **
## year2021           0.082954   0.225462   0.368 0.712927
## year2022           1.271311   0.227438   5.590 2.27e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: gaussian  ( identity )
## Formula:
## mass ~ c.log_woody_area * c.log_F_metric_d2b1 + species + clutch_size +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + min_t_between + laying_day + year + (1 |
##     id_nestbox)
## Data: ntits3
## 
##      AIC       BIC    logLik deviance df.resid
##   1144.2   1215.6   -553.1   1106.2      298
## 
## Random effects:
## 
## Conditional model:
##  Groups      Name          Variance  Std.Dev.
##  id_nestbox (Intercept) 1.476e-08 0.0001215
##  Residual               1.919e+00 1.3851166
## Number of obs: 317, groups:  id_nestbox, 202
## 
## Dispersion estimate for gaussian family (sigma^2): 1.92
## 
## Conditional model:
```

```
##                                Estimate Std. Error z value Pr(>|z|)
## (Intercept)                     21.72312    2.07788  10.454  < 2e-16 ***
## c.log_woody_area                 0.89627    1.01696   0.881  0.37814
## c.log_F_metric_d2b1              0.43775    0.39329   1.113  0.26568
## speciesCC                       -4.92489    0.29538 -16.673  < 2e-16 ***
## clutch_size                     -0.23076    0.05835  -3.955 7.66e-05 ***
## urban_intensity                  0.05293    0.09831   0.538  0.59026
## manag_mid1                      -0.32935    0.23149  -1.423  0.15481
## manag_high1                     -0.53542    0.25669  -2.086  0.03699 *
## light_pollution                 -0.05373    0.05382  -0.998  0.31814
## noise_m                         -0.04644    0.22643  -0.205  0.83749
## traffic                          0.05722    0.04893   1.169  0.24222
## min_t_between                    0.09426    0.05928   1.590  0.11180
## laying_day                      -0.56800    0.17712  -3.207  0.00134 **
## year2020                         0.89962    0.28758   3.128  0.00176 **
## year2021                         0.06159    0.22682   0.272  0.78596
## year2022                         1.25984    0.22766   5.534 3.13e-08 ***
## c.log_woody_area:c.log_F_metric_d2b1 -0.40613    0.50821  -0.799  0.42421
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.3.2. Using *woody_volume* instead of *patch_area*

Results when we use the **total volume of woody vegetation within 150 m of the nestboxes** (in m²) instead of the size of the **local patch area** (that is, the size of the patch of nesting/foraging habitat in which the nestbox is located) to explain the *mass of tits nestlings*:

```
##  Family: gaussian  ( identity )
## Formula:
## mass ~ log_woody_vol + log_F_metric_d2b1 + species + clutch_size +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + min_t_between + laying_day + year + (1 |
##     id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1142.5   1210.1   -553.2   1106.5      299
##
## Random effects:
##
## Conditional model:
##  Groups     Name        Variance  Std.Dev.
##  id_nestbox (Intercept) 1.275e-08 0.0001129
##  Residual               1.920e+00 1.3857836
## Number of obs: 317, groups:  id_nestbox, 202
##
## Dispersion estimate for gaussian family (sigma^2): 1.92
##
## Conditional model:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)      19.850562   2.859183   6.943 3.85e-12 ***
## log_woody_vol    -0.390568   0.423181  -0.923  0.35604
## log_F_metric_d2b1 0.873214   0.315160   2.771  0.00559 **
```

```
## speciesCC          -4.654892   0.268581 -17.331  < 2e-16 ***
## clutch_size         -0.255285   0.058020  -4.400 1.08e-05 ***
## urban_intensity     -0.004298   0.088209  -0.049  0.96114
## manag_mid1          -0.307708   0.230654  -1.334  0.18218
## manag_high1         -0.509572   0.255319  -1.996  0.04595 *
## light_pollution     -0.061104   0.054683  -1.117  0.26381
## noise_m             -0.008256   0.221742  -0.037  0.97030
## traffic              0.055553   0.049040   1.133  0.25730
## min_t_between        0.089993   0.059296   1.518  0.12909
## laying_day          -0.578408   0.174856  -3.308  0.00094 ***
## year2020             0.910347   0.287470   3.167  0.00154 **
## year2021             0.066487   0.225551   0.295  0.76817
## year2022             1.241410   0.228081   5.443 5.24e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: gaussian  ( identity )
## Formula:
## mass ~ c.log_woody_vol * c.log_F_metric_d2b1 + species + clutch_size +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + min_t_between + laying_day + year + (1 |
##     id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1144.3   1215.7   -553.2   1106.3      298
##
## Random effects:
##
## Conditional model:
##  Groups      Name        Variance  Std.Dev.
##  id_nestbox (Intercept) 9.696e-09 9.847e-05
##  Residual               1.920e+00 1.386e+00
## Number of obs: 317, groups:  id_nestbox, 202
##
## Dispersion estimate for gaussian family (sigma^2): 1.92
##
## Conditional model:
##                             Estimate Std. Error z value Pr(>|z|)
## (Intercept)                 21.66041    2.08170  10.405  < 2e-16 ***
## c.log_woody_vol             -0.33676    0.44868  -0.751  0.45291
## c.log_F_metric_d2b1          0.82929    0.33786   2.455  0.01411 *
## speciesCC                   -4.67876    0.27658 -16.917  < 2e-16 ***
## clutch_size                 -0.25250    0.05852  -4.315  1.6e-05 ***
## urban_intensity             -0.01148    0.09042  -0.127  0.89897
## manag_mid1                  -0.31612    0.23178  -1.364  0.17262
## manag_high1                 -0.51797    0.25633  -2.021  0.04331 *
## light_pollution             -0.06277    0.05487  -1.144  0.25260
## noise_m                     -0.01640    0.22285  -0.074  0.94134
## traffic                      0.05352    0.04935   1.085  0.27814
## min_t_between                0.08917    0.05933   1.503  0.13282
## laying_day                  -0.56687    0.17773  -3.189  0.00143 **
## year2020                     0.91046    0.28741   3.168  0.00154 **
## year2021                     0.05937    0.22637   0.262  0.79311
```

```
## year2022                                    1.23956    0.22809    5.434  5.5e-08 ***
## c.log_woody_vol:c.log_F_metric_d2b1 -0.12174    0.33792   -0.360  0.71865
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.3.3. Using *woody_vw* instead of *patch_area*

Results when we use the **total volume of woody vegetation within 150 m of the nestboxes (weighted with a qualitative assessment of the structural complexity of the understory vegetation)** instead of the size of the **local patch area** (that is, the size of the patch of nesting/foraging habitat in which the nestbox is located) to explain the *mass of tits nestlings*:

```
##  Family: gaussian  ( identity )
## Formula:
## mass ~ log_woody_vw + log_F_metric_d2b1 + species + clutch_size +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + min_t_between + laying_day + year + (1 |
##     id_nestbox)
## Data: ntits3
##
##      AIC       BIC    logLik deviance df.resid
##   1143.0    1210.6    -553.5   1107.0      299
##
## Random effects:
##
## Conditional model:
##  Groups      Name         Variance  Std.Dev.
##  id_nestbox (Intercept) 1.363e-08 0.0001167
##  Residual               1.923e+00 1.3868869
## Number of obs: 317, groups:  id_nestbox, 202
##
## Dispersion estimate for gaussian family (sigma^2): 1.92
##
## Conditional model:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)        19.228696   2.739290   7.020 2.23e-12 ***
## log_woody_vw       -0.210147   0.357078  -0.589 0.556184
## log_F_metric_d2b1   0.815277   0.311470   2.618 0.008857 **
## speciesCC          -4.696072   0.267057 -17.585  < 2e-16 ***
## clutch_size        -0.250972   0.057954  -4.330 1.49e-05 ***
## urban_intensity     0.009877   0.086140   0.115 0.908717
## manag_mid1         -0.318618   0.231437  -1.377 0.168608
## manag_high1        -0.527082   0.257698  -2.045 0.040821 *
## light_pollution    -0.056001   0.054572  -1.026 0.304803
## noise_m            -0.017689   0.221547  -0.080 0.936362
## traffic             0.056137   0.049215   1.141 0.254019
## min_t_between       0.091832   0.059288   1.549 0.121406
## laying_day         -0.586073   0.174676  -3.355 0.000793 ***
## year2020            0.913345   0.287703   3.175 0.001500 **
## year2021            0.075675   0.225430   0.336 0.737103
## year2022            1.254820   0.227493   5.516 3.47e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##  Family: gaussian  ( identity )
## Formula:
## mass ~ c.log_woody_vw * c.log_F_metric_d2b1 + species + clutch_size +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + min_t_between + laying_day + year + (1 |
##     id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1144.9   1216.4   -553.5   1106.9      298
##
## Random effects:
##
## Conditional model:
##  Groups     Name        Variance  Std.Dev.
##  id_nestbox (Intercept) 1.440e-08 0.00012
##  Residual               1.923e+00 1.38682
## Number of obs: 317, groups:  id_nestbox, 202
##
## Dispersion estimate for gaussian family (sigma^2): 1.92
##
## Conditional model:
##                                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)                     21.781413   2.080555  10.469  < 2e-16 ***
## c.log_woody_vw                  -0.195747   0.366611  -0.534  0.59338
## c.log_F_metric_d2b1              0.799633   0.324283   2.466  0.01367 *
## speciesCC                       -4.704508   0.271448 -17.331  < 2e-16 ***
## clutch_size                     -0.249922   0.058268  -4.289 1.79e-05 ***
## urban_intensity                  0.005501   0.089763   0.061  0.95113
## manag_mid1                      -0.322950   0.232774  -1.387  0.16532
## manag_high1                     -0.531120   0.258738  -2.053  0.04010 *
## light_pollution                 -0.057088   0.054929  -1.039  0.29866
## noise_m                         -0.021107   0.222414  -0.095  0.92440
## traffic                          0.055322   0.049437   1.119  0.26313
## min_t_between                    0.091429   0.059331   1.541  0.12332
## laying_day                      -0.580539   0.177566  -3.269  0.00108 **
## year2020                         0.912817   0.287706   3.173  0.00151 **
## year2021                         0.071873   0.226485   0.317  0.75098
## year2022                         1.253206   0.227673   5.504 3.70e-08 ***
## c.log_woody_vw:c.log_F_metric_d2b1 -0.053583   0.309324  -0.173  0.86247
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.3.4. Using *Fplus* instead of *patch_area*

Results when we use the *F_plus* variable, i.e. the **addition** of the **local patch area** and the **F-metric** to explain the *mass of tits nestlings*:

```
##  Family: gaussian  ( identity )
## Formula:          mass ~ log_Fplus + species + clutch_size + urban_intensity +
##     manag_mid + manag_high + light_pollution + noise_m + traffic +
##     min_t_between + laying_day + year + (1 | id_nestbox)
## Data: ntits3
```

```
##
##      AIC      BIC   logLik deviance df.resid
##    1142.3   1206.2   -554.2   1108.3      300
##
## Random effects:
##
## Conditional model:
##  Groups      Name          Variance  Std.Dev.
##  id_nestbox (Intercept) 1.656e-08 0.0001287
##  Residual               1.932e+00 1.3898796
## Number of obs: 317, groups:  id_nestbox, 202
##
## Dispersion estimate for gaussian family (sigma^2): 1.93
##
## Conditional model:
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)    18.7042097  2.5517232   7.330 2.30e-13 ***
## log_Fplus       0.6876728  0.2790422   2.464 0.013724 *
## speciesCC      -4.8185214  0.2372407 -20.311  < 2e-16 ***
## clutch_size    -0.2405804  0.0570574  -4.216 2.48e-05 ***
## urban_intensity 0.0008252  0.0800847   0.010 0.991779
## manag_mid1     -0.2994940  0.2311709  -1.296 0.195130
## manag_high1    -0.4912619  0.2557834  -1.921 0.054780 .
## light_pollution -0.0460998 0.0530259  -0.869 0.384637
## noise_m        -0.0031851  0.2227309  -0.014 0.988591
## traffic         0.0562993  0.0489695   1.150 0.250275
## min_t_between   0.0938902  0.0594148   1.580 0.114050
## laying_day     -0.6048212  0.1746053  -3.464 0.000532 ***
## year2020        0.9075252  0.2882814   3.148 0.001644 **
## year2021        0.0822354  0.2259578   0.364 0.715902
## year2022        1.2670680  0.2277167   5.564 2.63e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.3.5. Using *F_metric_d2b0* instead of *F_metric_d2b1*

Results when we use the *F_metric_d2b0* variable, i.e. the *F-metric* with no weighting for the size of the patches, to explain the *nestling mass*:

```
##  Family: gaussian  ( identity )
## Formula:
## mass ~ log_woody_vol + log_F_metric_d2b0 + species + clutch_size +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + min_t_between + laying_day + year + (1 |
##     id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##    1141.6   1209.2   -552.8   1105.6      299
##
## Random effects:
##
## Conditional model:
```

```
##   Groups       Name          Variance  Std.Dev.
##   id_nestbox (Intercept) 1.431e-08 0.0001196
##   Residual               1.915e+00 1.3838586
## Number of obs: 317, groups:  id_nestbox, 202
##
## Dispersion estimate for gaussian family (sigma^2): 1.92
##
## Conditional model:
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)      18.67651    2.94731   6.337 2.35e-10 ***
## log_woody_vol    -0.04343    0.37404  -0.116  0.90757
## log_F_metric_d2b0  1.07128    0.36571   2.929  0.00340 **
## speciesCC        -4.50511    0.29374 -15.337  < 2e-16 ***
## clutch_size      -0.24845    0.05784  -4.296 1.74e-05 ***
## urban_intensity   0.00193    0.08815   0.022  0.98253
## manag_mid1       -0.24237    0.23012  -1.053  0.29224
## manag_high1      -0.41086    0.25524  -1.610  0.10747
## light_pollution  -0.08654    0.05596  -1.547  0.12196
## noise_m           0.11311    0.22881   0.494  0.62107
## traffic           0.05380    0.04876   1.103  0.26986
## min_t_between     0.09403    0.05929   1.586  0.11273
## laying_day       -0.55995    0.17508  -3.198  0.00138 **
## year2020          0.87299    0.28689   3.043  0.00234 **
## year2021         -0.00353    0.22664  -0.016  0.98757
## year2022          1.20336    0.22846   5.267 1.38e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: gaussian  ( identity )
## Formula:
## mass ~ c.log_woody_vol * c.log_F_metric_d2b0 + species + clutch_size +
##     urban_intensity + manag_mid + manag_high + light_pollution +
##     noise_m + traffic + min_t_between + laying_day + year + (1 |
##     id_nestbox)
## Data: ntits3
##
##      AIC      BIC   logLik deviance df.resid
##   1143.6   1215.0   -552.8   1105.6      298
##
## Random effects:
##
## Conditional model:
##  Groups       Name          Variance  Std.Dev.
##  id_nestbox (Intercept) 1.728e-08 0.0001314
##  Residual               1.915e+00 1.3838588
## Number of obs: 317, groups:  id_nestbox, 202
##
## Dispersion estimate for gaussian family (sigma^2): 1.92
##
## Conditional model:
##                              Estimate Std. Error z value Pr(>|z|)
## (Intercept)                 20.745539   2.154606   9.628  < 2e-16 ***
## c.log_woody_vol             -0.042513   0.392989  -0.108  0.91385
## c.log_F_metric_d2b0          1.069814   0.413142   2.589  0.00961 **
```

```
## speciesCC                       -4.505990   0.315698 -14.273  < 2e-16 ***
## clutch_size                      -0.248414   0.058022  -4.281 1.86e-05 ***
## urban_intensity                   0.001816   0.089429   0.020  0.98380
## manag_mid1                       -0.242796   0.236688  -1.026  0.30498
## manag_high1                      -0.411347   0.263183  -1.563  0.11806
## light_pollution                  -0.086515   0.056101  -1.542  0.12304
## noise_m                           0.112632   0.237238   0.475  0.63496
## traffic                           0.053776   0.048831   1.101  0.27078
## min_t_between                     0.094037   0.059293   1.586  0.11274
## laying_day                       -0.559830   0.175735  -3.186  0.00144 **
## year2020                          0.873003   0.286900   3.043  0.00234 **
## year2021                         -0.003474   0.226762  -0.015  0.98778
## year2022                          1.203420   0.228594   5.264 1.41e-07 ***
## c.log_woody_vol:c.log_F_metric_d2b0 -0.004348   0.571863  -0.008  0.99393
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

2.4. Conclusion on switched proxies models

The variant models results presented in the above sections give **pretty similar *patterns of results*** to our final inferential models, regardless of the reproductive trait investigated. Interestingly:

- The model using *woody_area* gives slightly better results than our *inferential model* to explain **clutch size**, with the *F-metric* having a significant positive effect on tits clutch size. It could be a sign of the existence of a more complex interaction to be determined.
- Estimates, standard errors and their associated p-values jitter a bit, which is to be expected. Some parameterisations even gave "better" results (as in lower p-values, which is what many scientist run after), but that is not the point.
- Overall, results remain consistent, particularly the fact that *connectivity metrics* seem to have a positive effect on reproductive traits, whereas the *amount of local habitat* alone (e.g. patch area, woody vegetation area or volume) is not a good predictor of the traits examined here, at least not with our dataset. It should be noted that we also ran the same models but with predictors computed using other buffer radiuses, and patterns remained the same. We do not present them here for the sake of conciseness (but you can easily reproduce these results using the R files), this report is already long enough (especially for a report that nobody will ever read...).

3. Tuning the zero-inflation (ZI) component of the NESTLING SURVIVAL model

3.1. Exploratory models

```
##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ log_patch_area + log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year
## Zero inflation:                            ~min_t_between
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1374.7   1445.5   -669.3   1338.7      360
##
##
## Dispersion parameter for betabinomial family (): 7.92
##
## Conditional model:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)       3.325920   2.079379   1.599   0.1097
## log_patch_area   -0.030688   0.103178  -0.297   0.7661
## log_F_metric_d2b1 0.503648   0.207745   2.424   0.0153 *
## clutch_size      -0.162931   0.038082  -4.278 1.88e-05 ***
## urban_intensity   0.099606   0.064230   1.551   0.1210
## manag_mid1       -0.234721   0.208192  -1.127   0.2596
## manag_high1      -0.493418   0.224146  -2.201   0.0277 *
## light_pollution  -0.074475   0.043979  -1.693   0.0904 .
## noise_m           0.004834   0.195472   0.025   0.9803
## traffic           0.002479   0.041859   0.059   0.9528
## min_t_between    -0.002306   0.052577  -0.044   0.9650
## laying_day       -0.310516   0.141253  -2.198   0.0279 *
## year2020          0.436499   0.237443   1.838   0.0660 .
## year2021          0.287792   0.175629   1.639   0.1013
## year2022          1.334170   0.195591   6.821 9.03e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept)   -2.09707    0.17325 -12.104   <2e-16 ***
## min_t_between  0.16262    0.07176   2.266   0.0234 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ log_patch_area + log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
```

```
##      year
## Zero inflation:                          ~log_F_metric_d2b1
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1375.2   1446.0   -669.6   1339.2      360
##
##
## Dispersion parameter for betabinomial family ():    8
##
## Conditional model:
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)        3.299362   2.069687   1.594   0.1109
## log_patch_area    -0.029637   0.102867  -0.288   0.7733
## log_F_metric_d2b1  0.495408   0.207615   2.386   0.0170 *
## clutch_size       -0.161523   0.037916  -4.260 2.04e-05 ***
## urban_intensity    0.099464   0.064136   1.551   0.1209
## manag_mid1        -0.237382   0.207685  -1.143   0.2530
## manag_high1       -0.492069   0.223764  -2.199   0.0279 *
## light_pollution   -0.073784   0.043883  -1.681   0.0927 .
## noise_m            0.012320   0.194393   0.063   0.9495
## traffic            0.001404   0.041655   0.034   0.9731
## min_t_between     -0.003297   0.052403  -0.063   0.9498
## laying_day        -0.308381   0.140655  -2.192   0.0283 *
## year2020           0.425287   0.236276   1.800   0.0719 .
## year2021           0.277372   0.174700   1.588   0.1124
## year2022           1.325194   0.195051   6.794 1.09e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)         0.4944     1.1893   0.416   0.6776
## log_F_metric_d2b1  -0.5723     0.2734  -2.093   0.0364 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ log_patch_area + log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year
## Zero inflation:                          ~log_patch_area
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1376.8   1447.6   -670.4   1340.8      360
##
##
## Dispersion parameter for betabinomial family (): 7.95
##
```

```
## Conditional model:
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)       3.321613   2.076801   1.599   0.1097
## log_patch_area   -0.033941   0.102884  -0.330   0.7415
## log_F_metric_d2b1 0.503158   0.207712   2.422   0.0154 *
## clutch_size      -0.162689   0.038031  -4.278 1.89e-05 ***
## urban_intensity   0.099657   0.064205   1.552   0.1206
## manag_mid1       -0.235513   0.208001  -1.132   0.2575
## manag_high1      -0.494273   0.224031  -2.206   0.0274 *
## light_pollution  -0.074244   0.043924  -1.690   0.0910 .
## noise_m           0.009236   0.195181   0.047   0.9623
## traffic           0.001802   0.041733   0.043   0.9656
## min_t_between    -0.002887   0.052505  -0.055   0.9562
## laying_day       -0.310646   0.140999  -2.203   0.0276 *
## year2020          0.428606   0.237068   1.808   0.0706 .
## year2021          0.283132   0.174948   1.618   0.1056
## year2022          1.328975   0.195128   6.811 9.71e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)   -0.9759     0.6251  -1.561   0.1185
## log_patch_area -0.3267     0.1950  -1.675   0.0939 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ log_patch_area + log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year
## Zero inflation:
## ~min_t_between + urban_intensity + year
## Data: ntits3
## Weights: brood_size
##
##     AIC      BIC   logLik deviance df.resid
##   1364.9   1451.5   -660.5   1320.9      356
##
##
## Dispersion parameter for betabinomial family (): 8.1
##
## Conditional model:
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)       3.3219118 2.0604664   1.612   0.1069
## log_patch_area   -0.0313312 0.1024427  -0.306   0.7597
## log_F_metric_d2b1 0.4984734 0.2069335   2.409   0.0160 *
## clutch_size      -0.1616501 0.0377877  -4.278 1.89e-05 ***
## urban_intensity   0.1013053 0.0639852   1.583   0.1134
## manag_mid1       -0.2355419 0.2072267  -1.137   0.2557
## manag_high1      -0.4914648 0.2233824  -2.200   0.0278 *
## light_pollution  -0.0726543 0.0437446  -1.661   0.0967 .
```

```
## noise_m              0.0142242  0.1936462   0.073   0.9414
## traffic              0.0002274  0.0414596   0.005   0.9956
## min_t_between       -0.0012327  0.0521972  -0.024   0.9812
## laying_day          -0.3113089  0.1398361  -2.226   0.0260 *
## year2020             0.4136459  0.2341880   1.766   0.0773 .
## year2021             0.2668469  0.1736310   1.537   0.1243
## year2022             1.3171747  0.1941566   6.784 1.17e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)      -1.53626    0.28725  -5.348 8.88e-08 ***
## min_t_between     0.16056    0.09657   1.663  0.09639 .
## urban_intensity   0.25256    0.10076   2.507  0.01219 *
## year2020         -0.39152    0.47482  -0.825  0.40962
## year2021         -0.96344    0.47017  -2.049  0.04045 *
## year2022         -1.26766    0.48416  -2.618  0.00884 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ log_patch_area + log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year + (1 | id_nestbox)
## Zero inflation:
## ~min_t_between + urban_intensity + year
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1366.9   1457.4   -660.5   1320.9      355
##
## Random effects:
##
## Conditional model:
##  Groups     Name         Variance  Std.Dev.
##  id_nestbox (Intercept) 1.071e-08 0.0001035
## Number of obs: 378, groups:  id_nestbox, 223
##
## Dispersion parameter for betabinomial family ():  8.1
##
## Conditional model:
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)        3.3219155  2.0604665   1.612   0.1069
## log_patch_area    -0.0313312  0.1024427  -0.306   0.7597
## log_F_metric_d2b1  0.4984735  0.2069335   2.409   0.0160 *
## clutch_size       -0.1616510  0.0377877  -4.278 1.89e-05 ***
## urban_intensity    0.1013052  0.0639852   1.583   0.1134
## manag_mid1        -0.2355420  0.2072268  -1.137   0.2557
## manag_high1       -0.4914660  0.2233824  -2.200   0.0278 *
## light_pollution   -0.0726536  0.0437446  -1.661   0.0967 .
```

```
## noise_m            0.0142240  0.1936462   0.073   0.9414
## traffic            0.0002278  0.0414596   0.005   0.9956
## min_t_between     -0.0012327  0.0521972  -0.024   0.9812
## laying_day        -0.3113086  0.1398361  -2.226   0.0260 *
## year2020           0.4136453  0.2341880   1.766   0.0773 .
## year2021           0.2668482  0.1736311   1.537   0.1243
## year2022           1.3171760  0.1941566   6.784 1.17e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)     -1.53627    0.28725  -5.348 8.88e-08 ***
## min_t_between    0.16056    0.09657   1.663  0.09639 .
## urban_intensity  0.25256    0.10076   2.507  0.01219 *
## year2020        -0.39151    0.47482  -0.825  0.40963
## year2021        -0.96343    0.47017  -2.049  0.04045 *
## year2022        -1.26764    0.48416  -2.618  0.00884 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ log_patch_area + log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year
## Zero inflation:                           ~laying_day + urban_intensity + year
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1367.1   1453.7   -661.6   1323.1      356
##
##
## Dispersion parameter for betabinomial family (): 8.11
##
## Conditional model:
##                   Estimate Std. Error z value Pr(>|z|)
## (Intercept)       3.292047   2.061231   1.597   0.1102
## log_patch_area   -0.030906   0.102444  -0.302   0.7629
## log_F_metric_d2b1 0.495762   0.206999   2.395   0.0166 *
## clutch_size      -0.161527   0.037784  -4.275 1.91e-05 ***
## urban_intensity   0.100617   0.063994   1.572   0.1159
## manag_mid1       -0.235418   0.207228  -1.136   0.2559
## manag_high1      -0.489748   0.223417  -2.192   0.0284 *
## light_pollution  -0.072470   0.043736  -1.657   0.0975 .
## noise_m           0.016655   0.193638   0.086   0.9315
## traffic          -0.000174   0.041443  -0.004   0.9966
## min_t_between    -0.002425   0.052168  -0.046   0.9629
## laying_day       -0.308365   0.139775  -2.206   0.0274 *
## year2020          0.415546   0.234070   1.775   0.0758 .
## year2021          0.265236   0.173614   1.528   0.1266
## year2022          1.316113   0.194200   6.777 1.23e-11 ***
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##                 Estimate Std. Error z value Pr(>|z|)
## (Intercept)     -3.11839    2.47172  -1.262  0.20708
## laying_day       0.17408    0.26243   0.663  0.50711
## urban_intensity  0.24550    0.10078   2.436  0.01485 *
## year2020        -0.04931    0.42178  -0.117  0.90693
## year2021        -1.07897    0.46939  -2.299  0.02152 *
## year2022        -1.30343    0.48120  -2.709  0.00675 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ c.log_patch_area * c.log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year
## Zero inflation:
## ~min_t_between + urban_intensity + year
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1362.0   1452.5   -658.0   1316.0      355
##
##
## Dispersion parameter for betabinomial family (): 8.43
##
## Conditional model:
##                                Estimate Std. Error z value Pr(>|z|)
## (Intercept)                    5.455441   1.722139   3.168  0.00154 **
## c.log_patch_area              -0.065247   0.105446  -0.619  0.53607
## c.log_F_metric_d2b1            0.349176   0.217264   1.607  0.10802
## clutch_size                   -0.159340   0.037608  -4.237 2.27e-05 ***
## urban_intensity                0.047429   0.067796   0.700  0.48419
## manag_mid1                    -0.283940   0.207500  -1.368  0.17119
## manag_high1                   -0.551222   0.223696  -2.464  0.01373 *
## light_pollution               -0.096407   0.044855  -2.149  0.03161 *
## noise_m                        0.016515   0.199289   0.083  0.93396
## traffic                       -0.014250   0.042173  -0.338  0.73545
## min_t_between                  0.003452   0.052373   0.066  0.94744
## laying_day                    -0.296561   0.139421  -2.127  0.03341 *
## year2020                       0.407457   0.233071   1.748  0.08043 .
## year2021                       0.239100   0.173159   1.381  0.16734
## year2022                       1.321089   0.192005   6.881 5.96e-12 ***
## c.log_patch_area:c.log_F_metric_d2b1 -0.360782   0.163030  -2.213  0.02690 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
##                 Estimate Std. Error z value Pr(>|z|)
```

```
## (Intercept)       -1.52840    0.28650  -5.335 9.56e-08 ***
## min_t_between       0.15972    0.09641   1.657  0.09760 .
## urban_intensity  0.24851    0.10070   2.468  0.01359 *
## year2020          -0.39147    0.47400  -0.826  0.40887
## year2021          -0.96939    0.46978  -2.064  0.03906 *
## year2022          -1.27428    0.48388  -2.633  0.00845 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


##  Family: betabinomial  ( logit )
## Formula:
## fledgling_nb/brood_size ~ c.log_patch_area * c.log_F_metric_d2b1 +
##     clutch_size + urban_intensity + manag_mid + manag_high +
##     light_pollution + noise_m + traffic + min_t_between + laying_day +
##     year + (1 | id_nestbox)
## Zero inflation:
## ~min_t_between + urban_intensity + year
## Data: ntits3
## Weights: brood_size
##
##      AIC      BIC   logLik deviance df.resid
##   1364.0   1458.5   -658.0   1316.0      354
##
## Random effects:
##
## Conditional model:
##  Groups     Name         Variance  Std.Dev.
##  id_nestbox (Intercept) 1.455e-08 0.0001206
## Number of obs: 378, groups:  id_nestbox, 223
##
## Dispersion parameter for betabinomial family (): 8.43
##
## Conditional model:
##                                Estimate Std. Error z value Pr(>|z|)
## (Intercept)                    5.455443   1.722140   3.168  0.00154 **
## c.log_patch_area              -0.065247   0.105446  -0.619  0.53607
## c.log_F_metric_d2b1            0.349179   0.217264   1.607  0.10802
## clutch_size                   -0.159339   0.037608  -4.237 2.27e-05 ***
## urban_intensity                0.047429   0.067796   0.700  0.48418
## manag_mid1                    -0.283946   0.207500  -1.368  0.17118
## manag_high1                   -0.551222   0.223696  -2.464  0.01373 *
## light_pollution               -0.096406   0.044855  -2.149  0.03161 *
## noise_m                        0.016510   0.199289   0.083  0.93397
## traffic                       -0.014250   0.042173  -0.338  0.73545
## min_t_between                  0.003451   0.052373   0.066  0.94746
## laying_day                    -0.296559   0.139421  -2.127  0.03341 *
## year2020                       0.407463   0.233071   1.748  0.08042 .
## year2021                       0.239104   0.173159   1.381  0.16733
## year2022                       1.321102   0.192005   6.881 5.96e-12 ***
## c.log_patch_area:c.log_F_metric_d2b1 -0.360787   0.163031  -2.213  0.02690 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Zero-inflation model:
```

```
##                  Estimate Std. Error z value Pr(>|z|)
## (Intercept)      -1.52841    0.28650  -5.335 9.56e-08 ***
## min_t_between     0.15972    0.09641   1.657  0.09760 .
## urban_intensity   0.24851    0.10070   2.468  0.01359 *
## year2020         -0.39145    0.47400  -0.826  0.40889
## year2021         -0.96937    0.46978  -2.063  0.03907 *
## year2022         -1.27426    0.48388  -2.633  0.00845 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

3.2. Conclusion on the exploratory ZI models

As could have been expected, tuning the zero-inflation (ZI) component of the *nestling survival* models (reminder: zero-inflated beta-binomial GLM(M)s) **quite strongly improved** the predictive abilities of the models, as measured by AIC. Among these *exploratory ZI models*, the best ones we could think of were the ones using *min_t_between*, *urban_intensity*, and *years* as predictors of the ZI, which all turned out significant or almost significant with a gain of 10 to 12 points of AIC depending on model considered (i.e. the `ttFS_zibbin_glmm1h` and `ttFS_zibbin_glmm2h` models)!
Diagnostics for these models were mostly ok: there was no outliers, deviations, dispersion or distributional problems. Predictions were fairly good as well but the models still made too narrow predictions and failed to correctly predict total successes and failures (so this is quite similar to our final inferential models).

These exploration thus suggest that increased *urban intensity* and *minimal temperatures* during the rearing of nestlings lowers their chances of survival.
We also tried removing "traffic" but it didn't change things much. When we used the *F-metric* along with *urban_intensity* to model the ZI-part of the model, the effect of the former utterly disappears suggesting that connectivity does not influence total fledging failures and its effect in "F models" was actually a surrogate effect from "urban_intensity".