Mixed models to determine the relationship between urbanization and turtle behaviour

R code to determine the relationship between urbanization and turtle behaviour (active defensive behaviours (Aggression), shell emergence time (Shell), time of initial movement (Start), total time spent moving (Move)).

Packages

```
library(Hmisc)
library(writexl)
library(ggplot2)
library(dplyr)
library(lmerTest)
library(optimx)
library(lme4)
library(PerformanceAnalytics)
library(effects)
library(ggeffects)
library(splines)
library(glmtoolbox)
library(afex)
library(nloptr)
library(dfoptim)
library(psych)
library(ordinal)
library(ggpubr)
library(terra)
library(AICcmodavg)
library(visreg)
library(MuMIn)
```

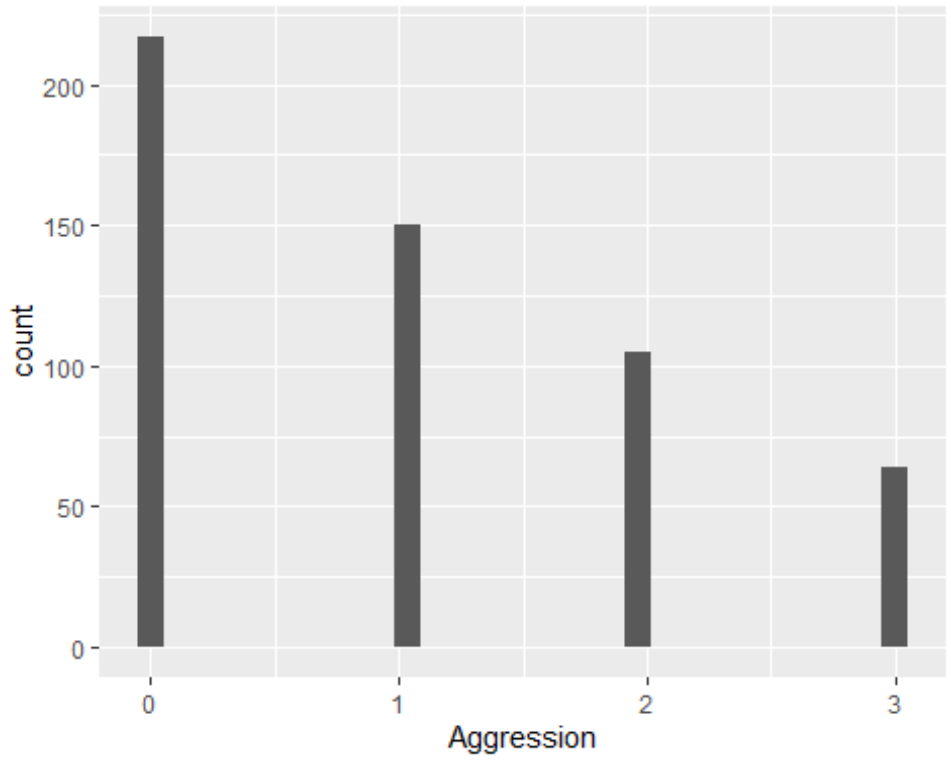
Upload the dataset to use

```
MixedData<-read.csv("C:/Users/sebas/Desktop/Masters Work/Masters
Work/Stats/Bin.Shell.600/Mixed Model Correlation Data.600.csv")
```

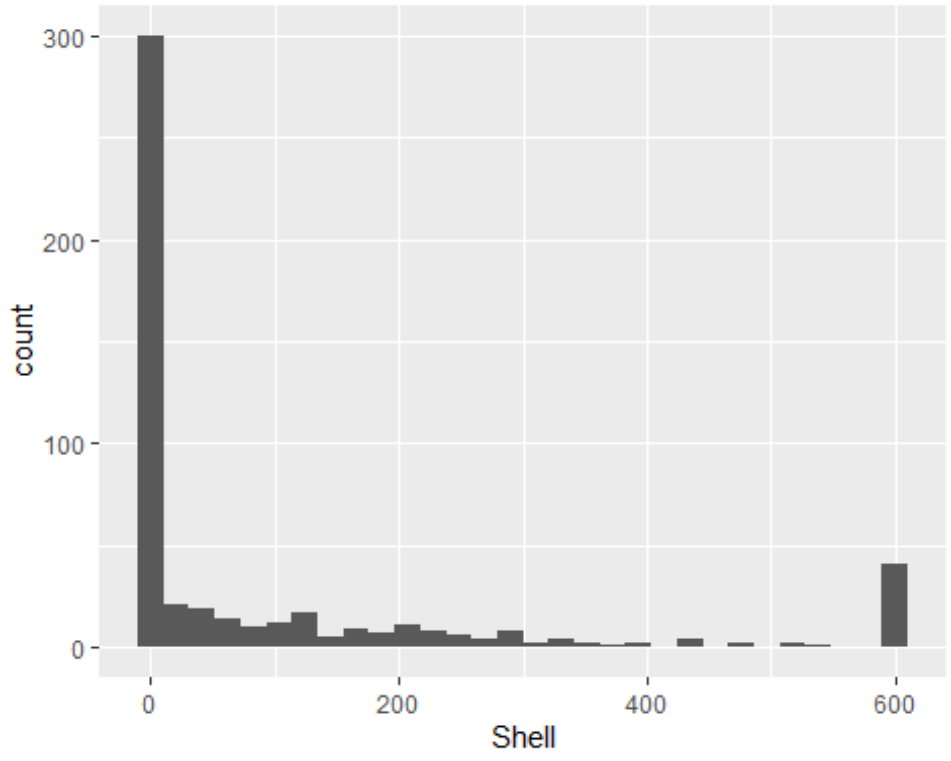
Plot Data

I am doing this step to make sure I use the right data distribution for my models later on. If I do need to transform any of the data distributions, I will need to recalculate the distance at which each land cover class has a maximum impact on the transformed behaviour.

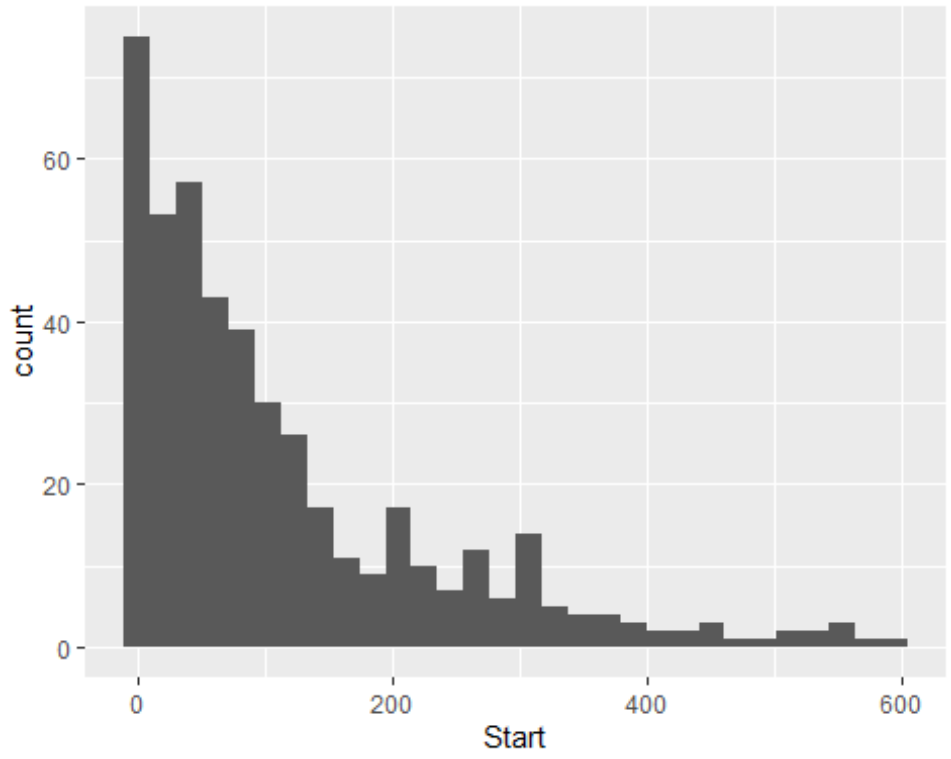
```
ggplot(MixedData, aes(x=Aggression)) + geom_histogram()
```



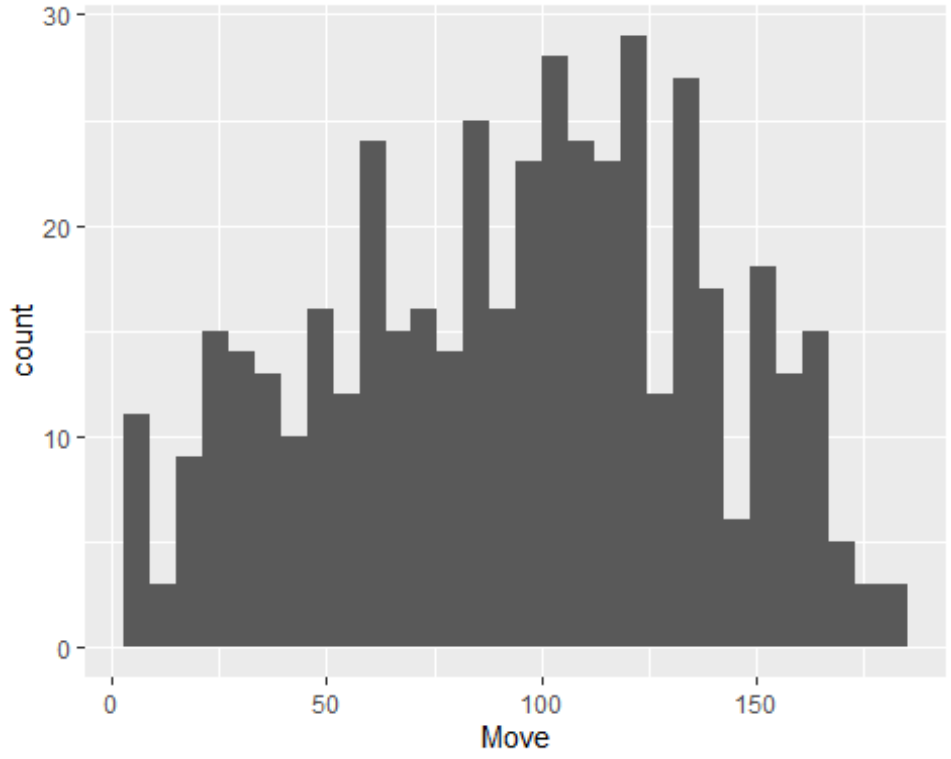

```
ggplot(MixedData, aes(x=Shell)) + geom_histogram()
```




```
ggplot(MixedData, aes(x=Start)) + geom_histogram()
```



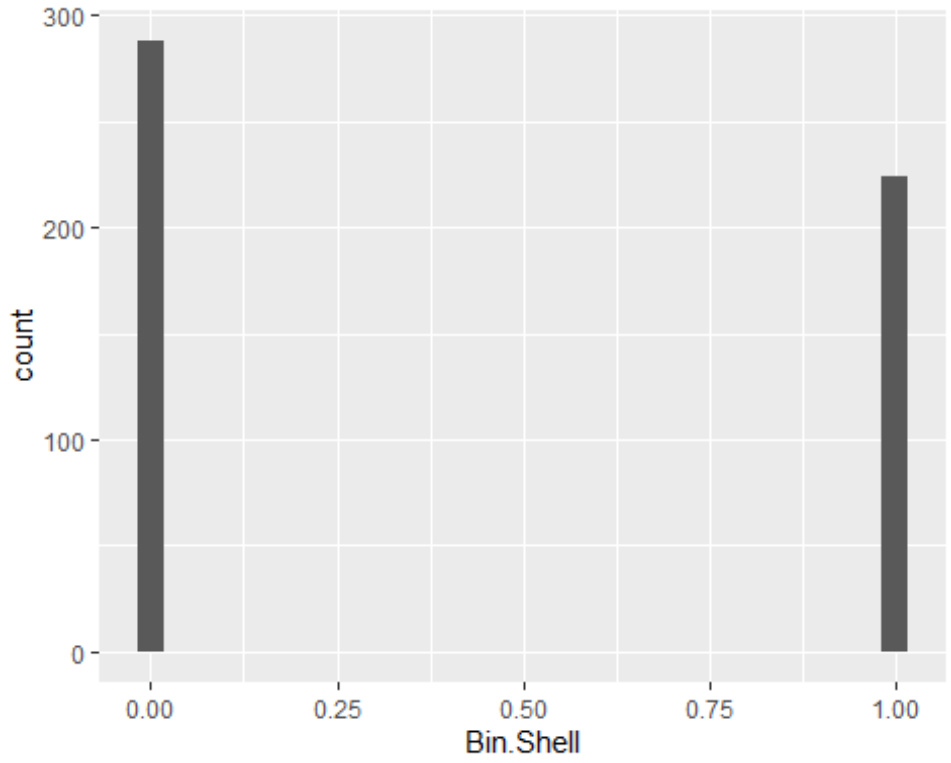

```
ggplot(MixedData, aes(x=Move)) + geom_histogram()
```



Shell emergence time has a skewed distribution, so I will use a binary version of it instead, where "0" means a turtle emerged from its shell at 0 seconds, and "1" means a turtle did not emerge from its shell at 0 seconds.

Plot binary version of shell emergence time data

```
ggplot(MixedData, aes(x=Bin.Shell)) + geom_histogram()
```



Preparing Data

```
# Response variables

MixedData$Aggression <- as.numeric(MixedData$Aggression)
MixedData$Bin.Shell <- as.numeric(MixedData$Bin.Shell)
MixedData$Start <- as.numeric(MixedData$Start)
MixedData$Move <- as.numeric(MixedData$Move)

# Predictor variables

MixedData$Site <- as.factor(MixedData$Site)
MixedData$Sex <- as.factor(MixedData$Sex)
MixedData$Code <- as.factor(MixedData$Code)
MixedData$A.Temp <- as.numeric(MixedData$A.Temp)
MixedData$W.Temp <- as.numeric(MixedData$W.Temp)
MixedData$Time <- as.numeric(MixedData$Time)
MixedData$Mass<- as.numeric(MixedData$Mass)
```

```
MixedData$PL <- as.numeric(MixedData$PL)
MixedData$CalendarDate <- as.numeric(MixedData$CalendarDate)
MixedData$for.veg.200 <- as.numeric(MixedData$for.veg.200)
MixedData$for.veg.300 <- as.numeric(MixedData$for.veg.300)
MixedData$for.veg.1000 <- as.numeric(MixedData$for.veg.1000)
MixedData$wet.200 <- as.numeric(MixedData$wet.200)
MixedData$wet.300 <- as.numeric(MixedData$wet.300)
MixedData$wet.400 <- as.numeric(MixedData$wet.400)
MixedData$wet.600 <- as.numeric(MixedData$wet.600)
MixedData$wet.1000 <- as.numeric(MixedData$wet.1000)
MixedData$agri.100 <- as.numeric(MixedData$agri.100)
MixedData$agri.200 <- as.numeric(MixedData$agri.200)
MixedData$agri.400 <- as.numeric(MixedData$agri.400)
MixedData$agri.500 <- as.numeric(MixedData$agri.500)
MixedData$agri.600 <- as.numeric(MixedData$agri.600)
MixedData$agri.1000 <- as.numeric(MixedData$agri.1000)
MixedData$urban.1000 <- as.numeric(MixedData$urban.1000)
MixedData$water.100 <- as.numeric(MixedData$water.100)
MixedData$water.400 <- as.numeric(MixedData$water.400)
MixedData$water.500 <- as.numeric(MixedData$water.500)
MixedData$water.900 <- as.numeric(MixedData$water.900)
MixedData$water.1000 <- as.numeric(MixedData$water.1000)
```

Standardization of the predictor variables

```
### All continuous numeric predictor variables were standardized (mean zero,
unit variance) before model selection.

MixedData$A.Temp.Scaled <- scale(MixedData$A.Temp, center=TRUE, scale=TRUE)
MixedData$W.Temp.Scaled <- scale(MixedData$W.Temp, center=TRUE, scale=TRUE)
MixedData$Time.Scaled <- scale(MixedData$Time, center=TRUE, scale=TRUE)
MixedData$Mass.Scaled <- scale(MixedData$Mass, center=TRUE, scale=TRUE)
MixedData$PL.Scaled <- scale(MixedData$PL, center=TRUE, scale=TRUE)
MixedData$CalendarDate.Scaled <- scale(MixedData$CalendarDate, center=TRUE,
scale=TRUE)
MixedData$for.veg.200.Scaled <- scale(MixedData$for.veg.200, center=TRUE,
scale=TRUE)
MixedData$for.veg.300.Scaled <- scale(MixedData$for.veg.300, center=TRUE,
scale=TRUE)
MixedData$for.veg.1000.Scaled <- scale(MixedData$for.veg.1000, center=TRUE,
scale=TRUE)
MixedData$wet.200.Scaled <- scale(MixedData$wet.200, center=TRUE, scale=TRUE)
MixedData$wet.300.Scaled <- scale(MixedData$wet.300, center=TRUE, scale=TRUE)
MixedData$wet.400.Scaled <- scale(MixedData$wet.400, center=TRUE, scale=TRUE)
MixedData$wet.600.Scaled <- scale(MixedData$wet.600, center=TRUE, scale=TRUE)
MixedData$wet.1000.Scaled <- scale(MixedData$wet.1000, center=TRUE,
scale=TRUE)
MixedData$agri.100.Scaled <- scale(MixedData$agri.100, center=TRUE,
scale=TRUE)
```

```
MixedData$agri.200.Scaled <- scale(MixedData$agri.200, center=TRUE,
scale=TRUE)
MixedData$agri.400.Scaled <- scale(MixedData$agri.400, center=TRUE,
scale=TRUE)
MixedData$agri.500.Scaled <- scale(MixedData$agri.500, center=TRUE,
scale=TRUE)
MixedData$agri.600.Scaled <- scale(MixedData$agri.600, center=TRUE,
scale=TRUE)
MixedData$agri.1000.Scaled <- scale(MixedData$agri.1000, center=TRUE,
scale=TRUE)
MixedData$urban.1000.Scaled <- scale(MixedData$urban.1000, center=TRUE,
scale=TRUE)
MixedData$water.100.Scaled <- scale(MixedData$water.100, center=TRUE,
scale=TRUE)
MixedData$water.400.Scaled <- scale(MixedData$water.400, center=TRUE,
scale=TRUE)
MixedData$water.500.Scaled <- scale(MixedData$water.500, center=TRUE,
scale=TRUE)
MixedData$water.900.Scaled <- scale(MixedData$water.900, center=TRUE,
scale=TRUE)
MixedData$water.1000.Scaled <- scale(MixedData$water.1000, center=TRUE,
scale=TRUE)
```

Make scaled variables numeric

```
MixedData$A.Temp.Scaled <- as.numeric(MixedData$A.Temp.Scaled)
MixedData$W.Temp.Scaled <- as.numeric(MixedData$W.Temp.Scaled)
MixedData$Time.Scaled <- as.numeric(MixedData$Time.Scaled)
MixedData$Mass.Scaled<- as.numeric(MixedData$Mass.Scaled)
MixedData$PL.Scaled <- as.numeric(MixedData$PL.Scaled)
MixedData$CalendarDate.Scaled <- as.numeric(MixedData$CalendarDate.Scaled)
MixedData$for.veg.200.Scaled <- as.numeric(MixedData$for.veg.200.Scaled)
MixedData$for.veg.300.Scaled <- as.numeric(MixedData$for.veg.300.Scaled)
MixedData$for.veg.1000.Scaled <- as.numeric(MixedData$for.veg.1000.Scaled)
MixedData$wet.200.Scaled <- as.numeric(MixedData$wet.200.Scaled)
MixedData$wet.300.Scaled <- as.numeric(MixedData$wet.300.Scaled)
MixedData$wet.400.Scaled <- as.numeric(MixedData$wet.400.Scaled)
MixedData$wet.600.Scaled <- as.numeric(MixedData$wet.600.Scaled)
MixedData$wet.1000.Scaled <- as.numeric(MixedData$wet.1000.Scaled)
MixedData$agri.100.Scaled <- as.numeric(MixedData$agri.100.Scaled)
MixedData$agri.200.Scaled <- as.numeric(MixedData$agri.200.Scaled)
MixedData$agri.400.Scaled <- as.numeric(MixedData$agri.400.Scaled)
MixedData$agri.500.Scaled <- as.numeric(MixedData$agri.500.Scaled)
MixedData$agri.600.Scaled <- as.numeric(MixedData$agri.600.Scaled)
MixedData$agri.1000.Scaled <- as.numeric(MixedData$agri.1000.Scaled)
MixedData$urban.1000.Scaled <- as.numeric(MixedData$urban.1000.Scaled)
MixedData$water.100.Scaled <- as.numeric(MixedData$water.100.Scaled)
MixedData$water.400.Scaled <- as.numeric(MixedData$water.400.Scaled)
MixedData$water.500.Scaled <- as.numeric(MixedData$water.500.Scaled)
```

```
MixedData$water.900.Scaled <- as.numeric(MixedData$water.900.Scaled)
MixedData$water.1000.Scaled <- as.numeric(MixedData$water.1000.Scaled)
```

Verification of model assumptions

Active defensive behaviours (Aggression)

Multicollinearity: Generalized variance inflation factor (GVIF^(1/(2*df)))

GVIF^(1/(2*df)) > 2 indicates the presence of multicollinearity, so I will remove variables with values over 2, starting with the highest value.

```
mod.Aggression.vif <- lm(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
W.Temp.Scaled + Time.Scaled + Mass.Scaled + PL.Scaled + Sex +
for.veg.1000.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled +
water.400.Scaled, data = MixedData, na.action=na.exclude)
gvif(mod.Aggression.vif)

##                       GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 3.0926  1          1.7586
## A.Temp.Scaled       3.8408  1          1.9598
## W.Temp.Scaled       5.7294  1          2.3936
## Time.Scaled         1.1397  1          1.0676
## Mass.Scaled         9.0761  1          3.0127
## PL.Scaled           8.2574  1          2.8736
## Sex                 1.5100  1          1.2288
## for.veg.1000.Scaled 5.9695  1          2.4433
## wet.200.Scaled      1.3717  1          1.1712
## agri.100.Scaled     1.7661  1          1.3289
## urban.1000.Scaled   4.3219  1          2.0789
## water.400.Scaled    2.5555  1          1.5986
```

Turtle mass (Mass) has the highest GVIF^(1/(2*df)) > 2, so I will remove it and recalculate the factors.

```
mod.Aggression.vif <- lm(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
W.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + for.veg.1000.Scaled +
wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled + water.400.Scaled, data
= MixedData, na.action=na.exclude)
gvif(mod.Aggression.vif)

##                       GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 3.0921  1          1.7584
## A.Temp.Scaled       3.7862  1          1.9458
## W.Temp.Scaled       5.7100  1          2.3896
## Time.Scaled         1.1248  1          1.0606
## PL.Scaled           1.4024  1          1.1842
## Sex                 1.4118  1          1.1882
## for.veg.1000.Scaled 5.9694  1          2.4432
## wet.200.Scaled      1.3707  1          1.1708
```

```
## agri.100.Scaled     1.7654  1          1.3287
## urban.1000.Scaled   4.2665  1          2.0656
## water.400.Scaled    2.5162  1          1.5863
```

Proportion of forest and vegetation area at 1000m (for.veg.1000) has the highest GVIF^(1/(2*df)) > 2, so I will remove it and recalculate the factors.

```
mod.Aggression.vif <- lm(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
W.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.200.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.400.Scaled, data = MixedData,
na.action=na.exclude)
gvif(mod.Aggression.vif)
```

```
##                       GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 2.7130  1          1.6471
## A.Temp.Scaled       3.7182  1          1.9283
## W.Temp.Scaled       5.6994  1          2.3873
## Time.Scaled         1.1062  1          1.0518
## PL.Scaled           1.3879  1          1.1781
## Sex                 1.4090  1          1.1870
## wet.200.Scaled      1.3592  1          1.1658
## agri.100.Scaled     1.2301  1          1.1091
## urban.1000.Scaled   1.2841  1          1.1332
## water.400.Scaled    1.3704  1          1.1706
```

Water temperature (W.Temp) has the highest GVIF^(1/(2*df)) > 2, so I will remove it and recalculate the factors.

```
mod.Aggression.vif <- lm(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled, data = MixedData, na.action=na.exclude)
gvif(mod.Aggression.vif)
```

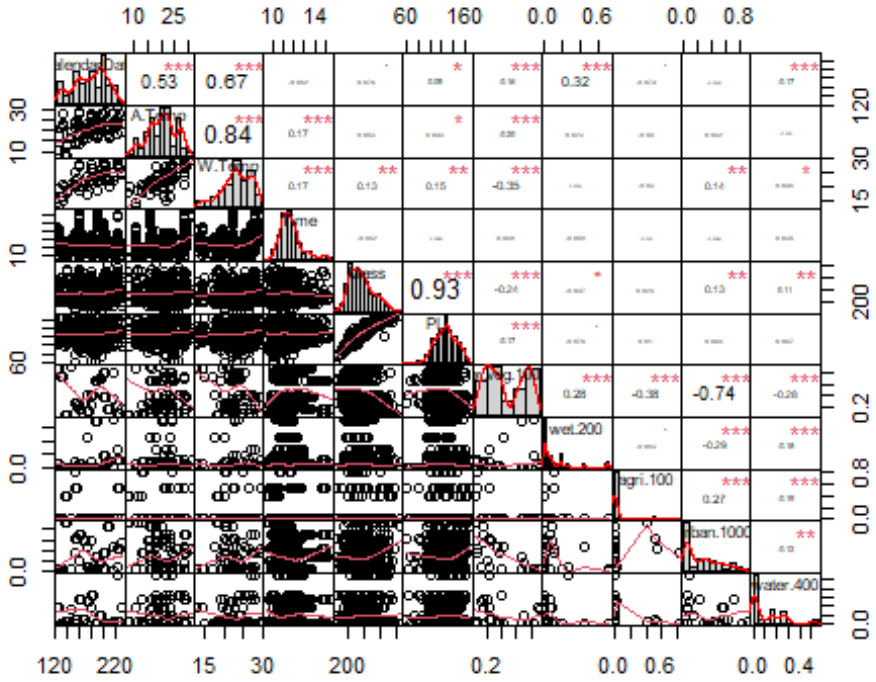
```
##                       GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 1.7005  1          1.3040
## A.Temp.Scaled       1.5191  1          1.2325
## Time.Scaled         1.0828  1          1.0406
## PL.Scaled           1.4046  1          1.1852
## Sex                 1.4112  1          1.1879
## wet.200.Scaled      1.3285  1          1.1526
## agri.100.Scaled     1.1437  1          1.0694
## urban.1000.Scaled   1.2163  1          1.1029
## water.400.Scaled    1.1445  1          1.0698
```

All of the GVIF^(1/(2*df)) < 2, so I will not remove any more variables.

Calculation of Pearson and Spearman correlation coefficients

Pearson correlation coefficients

```
# Visualization of the correlations
cor.pearson.Aggression <- MixedData[, c(3,4,5,6,7,8,26,28,37,56,60)]
chart.Correlation(cor.pearson.Aggression, histogram=TRUE, pch=19)
```




```
# Creation of the correlation table
table.corr.pearson.Aggression <-
rcorr(as.matrix(MixedData[,c(3,4,5,6,7,8,26,28,37,56,60)]), type="pearson")
table.cor.pearson.Aggression.r <- table.corr.pearson.Aggression$r # Pearson
correlation coefficients
table.cor.pearson.Aggression.p <- table.corr.pearson.Aggression$P # P values
of the correlations
table.cor.pearson.Aggression.r
```

```
##              CalendarDate      A.Temp       W.Temp          Time
Mass
## CalendarDate  1.000000000  0.52662360  0.668683098 -0.051688682
0.07560208
## A.Temp        0.526623600  1.00000000  0.838871081  0.171967476
0.05252964
## W.Temp        0.668683098  0.83887108  1.000000000  0.166126059
0.13221505
## Time         -0.051688682  0.17196748  0.166126059  1.000000000 -
0.05245171
## Mass          0.075602082  0.05252964  0.132215053 -0.052451709
```

```
1.00000000
## PL            0.089516177  0.09250283  0.146064749  0.009461487
0.93311455
## for.veg.1000 -0.159757526 -0.20286665 -0.354421886  0.048125471 -
0.23967087
## wet.200       0.319118112  0.02344567  0.002124113 -0.057823266 -
0.09719429
## agri.100     -0.078714526 -0.03995312 -0.030225708 -0.013077109
0.02406704
## urban.1000   -0.003462429  0.04205111  0.143942429 -0.006102219
0.12738974
## water.400    -0.169078991 -0.02278033  0.093636191  0.035069081
0.11260470
##                         PL for.veg.1000      wet.200    agri.100
urban.1000
## CalendarDate  0.089516177  -0.15975753  0.319118112 -0.07871453 -
0.003462429
## A.Temp        0.092502829  -0.20286665  0.023445668 -0.03995312
0.042051110
## W.Temp        0.146064749  -0.35442189  0.002124113 -0.03022571
0.143942429
## Time          0.009461487   0.04812547 -0.057823266 -0.01307711 -
0.006102219
## Mass          0.933114554  -0.23967087 -0.097194285  0.02406704
0.127389743
## PL            1.000000000  -0.17433634 -0.076087500  0.01037365
0.063945149
## for.veg.1000 -0.174336336   1.00000000  0.276458046 -0.38318444 -
0.743798223
## wet.200      -0.076087500   0.27645805  1.000000000 -0.08318312 -
0.294829446
## agri.100      0.010373653  -0.38318444 -0.083183118  1.00000000
0.271994655
## urban.1000    0.063945149  -0.74379822 -0.294829446  0.27199465
1.000000000
## water.400     0.067406397  -0.28142967 -0.183447101 -0.19070486 -
0.117362738
##                water.400
## CalendarDate -0.16907899
## A.Temp       -0.02278033
## W.Temp        0.09363619
## Time          0.03506908
## Mass          0.11260470
## PL            0.06740640
## for.veg.1000 -0.28142967
## wet.200      -0.18344710
## agri.100     -0.19070486
## urban.1000   -0.11736274
## water.400     1.00000000
```

```
table.cor.pearson.Aggression.p

##              CalendarDate       A.Temp       W.Temp         Time
Mass
## CalendarDate           NA 0.000000e+00 0.000000e+00 2.322103e-01
8.033738e-02
## A.Temp       0.000000e+00           NA 0.000000e+00 6.283828e-05
2.246911e-01
## W.Temp       0.000000e+00 0.000000e+00           NA 2.346306e-04
3.499660e-03
## Time         2.322103e-01 6.283828e-05 2.346306e-04           NA
2.253805e-01
## Mass         8.033738e-02 2.246911e-01 3.499660e-03 2.253805e-01
NA
## PL           3.846835e-02 3.242105e-02 1.256393e-03 8.271659e-01
0.000000e+00
## for.veg.1000 2.040904e-04 2.189891e-06 8.881784e-16 2.660399e-01
1.932793e-08
## wet.200      3.730349e-14 5.880847e-01 9.627472e-01 1.813210e-01
2.443073e-02
## agri.100     6.861526e-02 3.559077e-01 5.061950e-01 7.626040e-01
5.782300e-01
## urban.1000   9.362578e-01 3.311946e-01 1.464223e-03 8.879110e-01
3.132312e-03
## water.400    8.365543e-05 5.987216e-01 3.906820e-02 4.177898e-01
9.075308e-03
##                        PL for.veg.1000      wet.200     agri.100
urban.1000
## CalendarDate 3.846835e-02 2.040904e-04 3.730349e-14 6.861526e-02
9.362578e-01
## A.Temp       3.242105e-02 2.189891e-06 5.880847e-01 3.559077e-01
3.311946e-01
## W.Temp       1.256393e-03 8.881784e-16 9.627472e-01 5.061950e-01
1.464223e-03
## Time         8.271659e-01 2.660399e-01 1.813210e-01 7.626040e-01
8.879110e-01
## Mass         0.000000e+00 1.932793e-08 2.443073e-02 5.782300e-01
3.132312e-03
## PL                     NA 5.033503e-05 7.868930e-02 8.108043e-01
1.396467e-01
## for.veg.1000 5.033503e-05           NA 7.372303e-11 0.000000e+00
0.000000e+00
## wet.200      7.868930e-02 7.372303e-11           NA 5.427077e-02
3.277600e-12
## agri.100     8.108043e-01 0.000000e+00 5.427077e-02           NA
1.518086e-10
## urban.1000   1.396467e-01 0.000000e+00 3.277600e-12 1.518086e-10
NA
## water.400    1.194137e-01 3.246692e-11 1.924186e-05 8.760883e-06
6.524110e-03
```

```
##                  water.400
## CalendarDate 8.365543e-05
## A.Temp       5.987216e-01
## W.Temp       3.906820e-02
## Time         4.177898e-01
## Mass         9.075308e-03
## PL           1.194137e-01
## for.veg.1000 3.246692e-11
## wet.200      1.924186e-05
## agri.100     8.760883e-06
## urban.1000   6.524110e-03
## water.400              NA
```

Spearman correlation coefficients

```
# Creation of the correlation table
table.corr.spearman.Aggression <-
rcorr(as.matrix(MixedData[,c(3,4,5,6,7,8,26,28,37,56,60)]), type="spearman")
table.cor.spearman.Aggression.r <- table.corr.spearman.Aggression$r # Pearson
correlation coefficients
table.cor.spearman.Aggression.p <- table.corr.spearman.Aggression$P # P
values of the correlations
table.cor.spearman.Aggression.r
```

```
##              CalendarDate      A.Temp      W.Temp         Time        Mass
## CalendarDate   1.00000000  0.45842169  0.56884913 -0.098920865  0.08038929
## A.Temp         0.45842169  1.00000000  0.83718368  0.138498905  0.06589666
## W.Temp         0.56884913  0.83718368  1.00000000  0.173659029  0.13270468
## Time          -0.09892087  0.13849890  0.17365903  1.000000000 -0.04025948
## Mass           0.08038929  0.06589666  0.13270468 -0.040259479  1.00000000
## PL             0.08898378  0.10442546  0.15193967 -0.013644546  0.94856246
## for.veg.1000  -0.13614271 -0.17001898 -0.28928407  0.119570436 -0.19217208
## wet.200        0.38993834  0.04537204  0.12470905  0.022468674 -0.04181263
## agri.100      -0.08934127 -0.02430981 -0.06768594 -0.063059962  0.04983615
## urban.1000     0.05728527  0.13104537  0.21782810 -0.071452190  0.10868203
## water.400     -0.30298704 -0.10238175 -0.01252963  0.007177042  0.09129109
##                       PL for.veg.1000     wet.200    agri.100  urban.1000
## CalendarDate  0.08898378   -0.1361427  0.38993834 -0.08934127  0.05728527
## A.Temp        0.10442546   -0.1700190  0.04537204 -0.02430981  0.13104537
## W.Temp        0.15193967   -0.2892841  0.12470905 -0.06768594  0.21782810
## Time         -0.01364455    0.1195704  0.02246867 -0.06305996 -0.07145219
## Mass          0.94856246   -0.1921721 -0.04181263  0.04983615  0.10868203
## PL            1.00000000   -0.1623624 -0.06444220  0.05678992  0.07998962
## for.veg.1000 -0.16236237    1.0000000  0.16925793 -0.47395684 -0.82572013
## wet.200      -0.06444220    0.1692579  1.00000000 -0.06033822 -0.23397742
## agri.100      0.05678992   -0.4739568 -0.06033822  1.00000000  0.27938984
## urban.1000    0.07998962   -0.8257201 -0.23397742  0.27938984  1.00000000
## water.400     0.06318439   -0.2190942 -0.19135539 -0.03550963  0.02511729
##                  water.400
## CalendarDate -0.302987043
## A.Temp       -0.102381748
```

```
## W.Temp       -0.012529631
## Time          0.007177042
## Mass          0.091291089
## PL            0.063184387
## for.veg.1000 -0.219094175
## wet.200      -0.191355393
## agri.100     -0.035509628
## urban.1000    0.025117287
## water.400     1.000000000

table.cor.spearman.Aggression.p

##              CalendarDate       A.Temp       W.Temp         Time
Mass
## CalendarDate           NA 0.000000e+00 0.000000e+00 0.0219948308
6.291206e-02
## A.Temp       0.000000e+00           NA 0.000000e+00 0.0013067179
1.275805e-01
## W.Temp       0.000000e+00 0.000000e+00           NA 0.0001191832
3.379071e-03
## Time         2.199483e-02 1.306718e-03 1.191832e-04           NA
3.522285e-01
## Mass         6.291206e-02 1.275805e-01 3.379071e-03 0.3522284632
NA
## PL           3.964107e-02 1.567793e-02 7.879312e-04 0.7528559899
0.000000e+00
## for.veg.1000 1.581516e-03 7.625616e-05 8.007350e-11 0.0055757019
7.445223e-06
## wet.200      0.000000e+00 2.943962e-01 5.906328e-03 0.6037338847
3.339467e-01
## agri.100     3.866754e-02 5.744009e-01 1.362161e-01 0.1448442211
2.493981e-01
## urban.1000   1.854229e-01 2.366128e-03 1.246624e-06 0.0984350178
1.181043e-02
## water.400    7.642775e-13 1.773963e-02 7.829165e-01 0.8683342163
3.459895e-02
##                        PL for.veg.1000      wet.200     agri.100
urban.1000
## CalendarDate 0.0396410665 1.581516e-03 0.000000e+00 3.866754e-02
1.854229e-01
## A.Temp       0.0156779333 7.625616e-05 2.943962e-01 5.744009e-01
2.366128e-03
## W.Temp       0.0007879312 8.007350e-11 5.906328e-03 1.362161e-01
1.246624e-06
## Time         0.7528559899 5.575702e-03 6.037339e-01 1.448442e-01
9.843502e-02
## Mass         0.0000000000 7.445223e-06 3.339467e-01 2.493981e-01
1.181043e-02
## PL                     NA 1.621239e-04 1.365892e-01 1.896750e-01
6.448653e-02
```

```
## for.veg.1000 0.0001621239           NA 8.219673e-05 0.000000e+00
0.000000e+00
## wet.200      0.1365891515 8.219673e-05           NA 1.630337e-01
4.239393e-08
## agri.100     0.1896750465 0.000000e+00 1.630337e-01           NA
4.554446e-11
## urban.1000   0.0644865292 0.000000e+00 4.239393e-08 4.554446e-11
NA
## water.400    0.1444276999 3.008301e-07 8.152307e-06 4.119614e-01
5.617520e-01
##                 water.400
## CalendarDate 7.642775e-13
## A.Temp       1.773963e-02
## W.Temp       7.829165e-01
## Time         8.683342e-01
## Mass         3.459895e-02
## PL           1.444277e-01
## for.veg.1000 3.008301e-07
## wet.200      8.152307e-06
## agri.100     4.119614e-01
## urban.1000   5.617520e-01
## water.400              NA
```

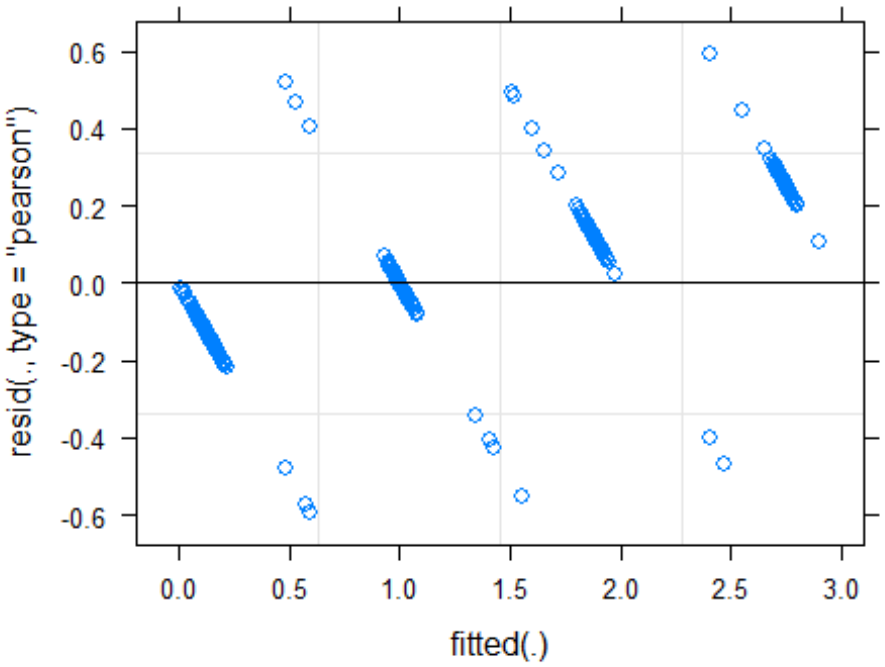
The Pearson correlation coefficient of 0.93 between Mass and PL, 0.84 between W.Temp and A.Temp and -0.74 between urban.for.veg.1000 and urban.1000 confirmed the deletion of Mass, W.Temp, and for.veg.1000 with the calculation of the GVIF^(1/(2*df)).

Verification of the assumptions with the initial model

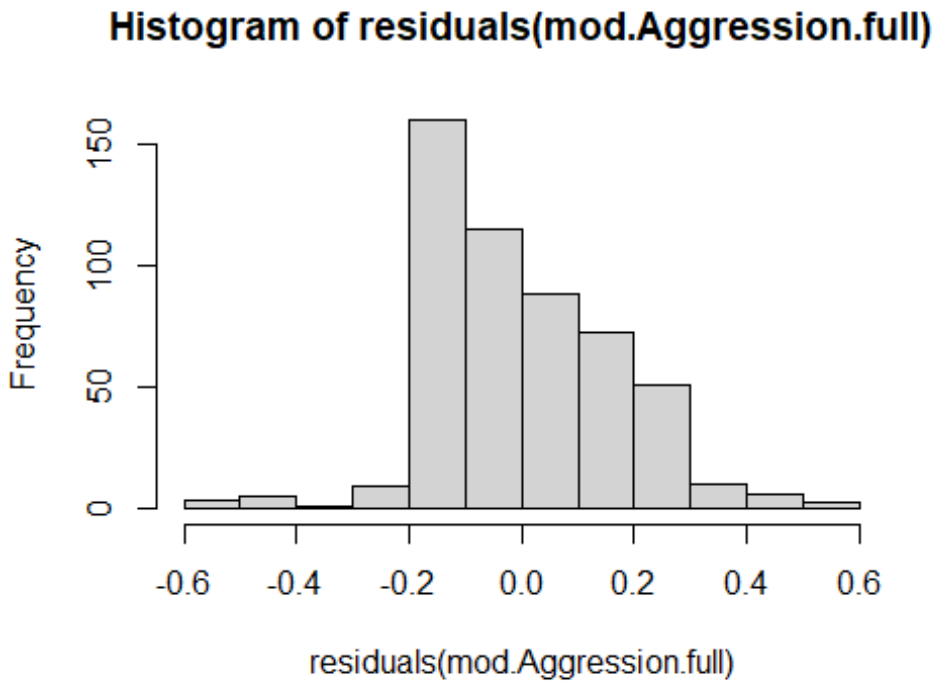
```
mod.Aggression.full <- lmer(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code) + (1|Site), data = MixedData,
REML = TRUE, na.action=na.exclude)

summary(mod.Aggression.full)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled
+
##     water.400.Scaled + (1 | Code) + (1 | Site)
##    Data: MixedData
##
## REML criterion at convergence: 1500.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.55498 -0.31577 -0.06114  0.28952  1.55232
##
## Random effects:
```

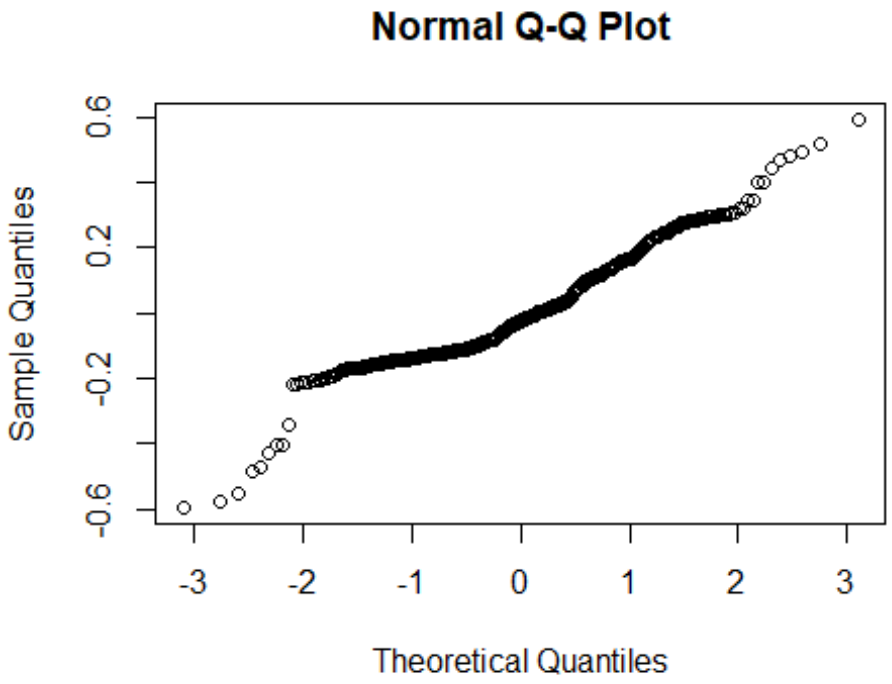
```
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 0.89340  0.9452
##  Site     (Intercept) 0.03487  0.1867
##  Residual             0.14606  0.3822
## Number of obs: 522, groups:  Code, 492; Site, 24
##
## Fixed effects:
##                      Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)           1.00148    0.08420  31.50789  11.895 3.46e-13 ***
## CalendarDate.Scaled  -0.05395    0.07452  17.14086  -0.724   0.4788
## A.Temp.Scaled         0.14378    0.06375  45.47667   2.255   0.0290 *
## Time.Scaled          -0.04752    0.04417 253.92511  -1.076   0.2831
## PL.Scaled            -0.05307    0.05647 474.75813  -0.940   0.3478
## SexM                  0.04213    0.09554 247.28036   0.441   0.6596
## wet.200.Scaled       -0.03924    0.06700  12.36223  -0.586   0.5686
## agri.100.Scaled      -0.05992    0.05884  23.67696  -1.018   0.3188
## urban.1000.Scaled     0.09694    0.06763  10.82073   1.433   0.1800
## water.400.Scaled      0.13923    0.06576  10.79946   2.117   0.0583 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.200. a.100. u.1000
## ClndrDt.Scl -0.048
## A.Temp.Scld  0.073 -0.467
## Time.Scaled  0.025  0.135 -0.253
## PL.Scaled   -0.336 -0.051 -0.046 -0.021
## SexM        -0.670  0.044 -0.066 -0.022  0.455
## wt.200.Scld -0.066 -0.326  0.122 -0.012  0.084  0.022
## agr.100.Scl  0.001  0.114 -0.023  0.016 -0.067 -0.086  0.024
## urbn.1000.S -0.098 -0.126  0.065  0.014  0.017  0.067  0.349 -0.228
## wtr.400.Scl -0.011  0.038 -0.015 -0.012 -0.101 -0.050  0.234  0.202  0.194

plot(mod.Aggression.full)
```




```
hist(residuals(mod.Aggression.full))
```




```
qqnorm(resid(mod.Aggression.full))
```



Time of initial movement (Start)

Multicollinearity: Generalized variance inflation factor (GVIF^(1/(2*df)))

GVIF^(1/(2*df)) > 2 indicates the presence of multicollinearity, so I will remove variables with values over 2, starting with the highest value.

```
mod.Start.vif <- lm(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
W.Temp.Scaled + Time.Scaled + Mass.Scaled + PL.Scaled + Sex +
for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled + urban.1000.Scaled +
water.500.Scaled, data = MixedData, na.action=na.exclude)
gvif(mod.Start.vif)
```

```
##                       GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 2.2956  1          1.5151
## A.Temp.Scaled       4.2591  1          2.0638
## W.Temp.Scaled       5.6476  1          2.3765
## Time.Scaled         1.1199  1          1.0583
## Mass.Scaled         8.8715  1          2.9785
## PL.Scaled           7.9423  1          2.8182
## Sex                 1.4811  1          1.2170
## for.veg.200.Scaled  3.3965  1          1.8430
## wet.400.Scaled      2.6633  1          1.6320
## agri.600.Scaled     1.3300  1          1.1533
## urban.1000.Scaled   2.9008  1          1.7032
## water.500.Scaled    2.0301  1          1.4248
```

Turtle mass (Mass) has the highest GVIF^(1/(2*df)) > 2, so I will remove it and recalculate the factors.

```
mod.Start.vif <- lm(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
W.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled +
wet.400.Scaled + agri.600.Scaled + urban.1000.Scaled + water.500.Scaled, data
= MixedData, na.action=na.exclude)
gvif(mod.Start.vif)
```

```
##                        GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 2.2953  1          1.5150
## A.Temp.Scaled       4.2167  1          2.0535
## W.Temp.Scaled       5.6371  1          2.3743
## Time.Scaled         1.1054  1          1.0514
## PL.Scaled           1.3687  1          1.1699
## Sex                 1.3664  1          1.1689
## for.veg.200.Scaled  3.3965  1          1.8430
## wet.400.Scaled      2.6633  1          1.6320
## agri.600.Scaled     1.3279  1          1.1523
## urban.1000.Scaled   2.8466  1          1.6872
## water.500.Scaled    1.9759  1          1.4057
```

Water temperature (W.Temp) has the highest GVIF^(1/(2*df)) > 2, so I will remove it and recalculate the factors.

```
mod.Start.vif <- lm(Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled +
urban.1000.Scaled + water.500.Scaled, data = MixedData, na.action=na.exclude)
gvif(mod.Start.vif)
```

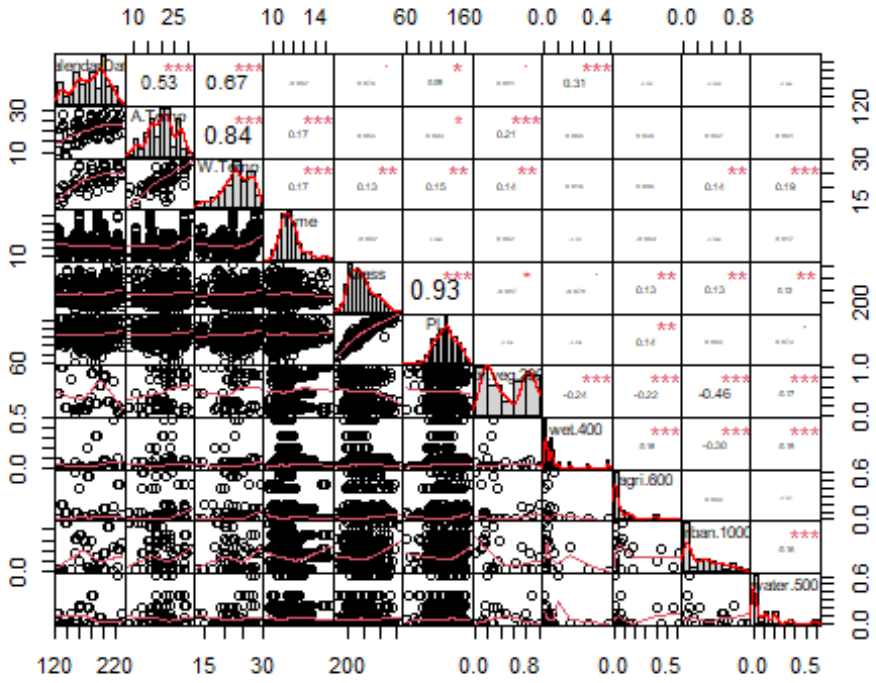
```
##                        GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 1.6219  1          1.2735
## A.Temp.Scaled       1.7465  1          1.3216
## Time.Scaled         1.0943  1          1.0461
## PL.Scaled           1.3825  1          1.1758
## Sex                 1.3683  1          1.1697
## for.veg.200.Scaled  3.2244  1          1.7957
## wet.400.Scaled      2.5927  1          1.6102
## agri.600.Scaled     1.4225  1          1.1927
## urban.1000.Scaled   2.6813  1          1.6375
## water.500.Scaled    1.7734  1          1.3317
```

All of the GVIF^(1/(2*df)) < 2, so I will not remove any more variables.

Calculation of Pearson and Spearman correlation coefficients

Pearson correlation coefficients

```
# Visualization of the correlations
cor.pearson.Start <- MixedData[, c(3,4,5,6,7,8,18,30,42,56,61)]
chart.Correlation(cor.pearson.Start, histogram=TRUE, pch=19)
```




```
# Creation of the correlation table
table.corr.pearson.Start <-
rcorr(as.matrix(MixedData[,c(3,4,5,6,7,8,18,30,42,56,61)]), type="pearson")
table.cor.pearson.Start.r <- table.corr.pearson.Start$r # Pearson correlation
coefficients
table.cor.pearson.Start.p <- table.corr.pearson.Start$P # P values of the
correlations
table.cor.pearson.Start.r
```

```
##                CalendarDate     A.Temp      W.Temp         Time         Mass
## CalendarDate  1.000000000 0.52662360 0.668683098 -0.051688682  0.07560208
## A.Temp        0.526623600 1.00000000 0.838871081  0.171967476  0.05252964
## W.Temp        0.668683098 0.83887108 1.000000000  0.166126059  0.13221505
## Time         -0.051688682 0.17196748 0.166126059  1.000000000 -0.05245171
## Mass          0.075602082 0.05252964 0.132215053 -0.052451709  1.00000000
## PL            0.089516177 0.09250283 0.146064749  0.009461487  0.93311455
## for.veg.200   0.081109497 0.21284818 0.135718201  0.062119056 -0.08740432
## wet.400       0.306093497 0.06431535 0.015608535 -0.036551862 -0.07810264
## agri.600     -0.035110853 0.03604656 0.006005415 -0.069402894  0.13163938
## urban.1000   -0.003462429 0.04205111 0.143942429 -0.006102219  0.12738974
## water.500    -0.044004133 0.06070427 0.192147258  0.016514392  0.11851616
##                        PL for.veg.200     wet.400     agri.600
urban.1000
## CalendarDate  0.089516177  0.08110950  0.30609350 -0.035110853 -
0.003462429
## A.Temp        0.092502829  0.21284818  0.06431535  0.036046563
0.042051110
```

```
## W.Temp        0.146064749  0.13571820  0.01560853  0.006005415
0.143942429
## Time          0.009461487  0.06211906 -0.03655186 -0.069402894 -
0.006102219
## Mass          0.933114554 -0.08740432 -0.07810264  0.131639380
0.127389743
## PL            1.000000000 -0.03366684 -0.03941912  0.137973397
0.063945149
## for.veg.200  -0.033666836  1.00000000 -0.24135779 -0.219409133 -
0.460382656
## wet.400      -0.039419118 -0.24135779  1.00000000 -0.178579433 -
0.297525027
## agri.600      0.137973397 -0.21940913 -0.17857943  1.000000000
0.043890365
## urban.1000    0.063945149 -0.46038266 -0.29752503  0.043890365
1.000000000
## water.500     0.072939414 -0.17138084 -0.18871224 -0.017252283 -
0.155373576
##                water.500
## CalendarDate -0.04400413
## A.Temp        0.06070427
## W.Temp        0.19214726
## Time          0.01651439
## Mass          0.11851616
## PL            0.07293941
## for.veg.200  -0.17138084
## wet.400      -0.18871224
## agri.600     -0.01725228
## urban.1000   -0.15537358
## water.500     1.00000000

table.cor.pearson.Start.p

##              CalendarDate       A.Temp       W.Temp         Time
Mass
## CalendarDate           NA 0.000000e+00 0.000000e+00 2.322103e-01
0.080337384
## A.Temp       0.000000e+00           NA 0.000000e+00 6.283828e-05
0.224691088
## W.Temp       0.000000e+00 0.000000e+00           NA 2.346306e-04
0.003499660
## Time         2.322103e-01 6.283828e-05 2.346306e-04           NA
0.225380534
## Mass         8.033738e-02 2.246911e-01 3.499660e-03 2.253805e-01
NA
## PL           3.846835e-02 3.242105e-02 1.256393e-03 8.271659e-01
0.000000000
## for.veg.200  6.058262e-02 6.579274e-07 2.716312e-03 1.509483e-01
0.043103630
## wet.400      4.334311e-13 1.369959e-01 7.314244e-01 3.983658e-01
```

```
0.070801885
## agri.600     4.172351e-01 4.049233e-01 8.949431e-01 1.084987e-01
0.002259201
## urban.1000   9.362578e-01 3.311946e-01 1.464223e-03 8.879110e-01
0.003132312
## water.500    3.092088e-01 1.604920e-01 2.000264e-05 7.028551e-01
0.006011935
##                        PL  for.veg.200      wet.400     agri.600
urban.1000
## CalendarDate 0.038468345 6.058262e-02 4.334311e-13 4.172351e-01 9.362578e-
01
## A.Temp       0.032421052 6.579274e-07 1.369959e-01 4.049233e-01 3.311946e-
01
## W.Temp       0.001256393 2.716312e-03 7.314244e-01 8.949431e-01 1.464223e-
03
## Time         0.827165890 1.509483e-01 3.983658e-01 1.084987e-01 8.879110e-
01
## Mass         0.000000000 4.310363e-02 7.080188e-02 2.259201e-03 3.132312e-
03
## PL                    NA 4.370909e-01 3.628289e-01 1.378178e-03 1.396467e-
01
## for.veg.200  0.437090868           NA 1.525600e-08 2.890116e-07
0.000000e+00
## wet.400      0.362828857 1.525600e-08           NA 3.207206e-05 2.036149e-
12
## agri.600     0.001378178 2.890116e-07 3.207206e-05           NA 3.104625e-
01
## urban.1000   0.139646656 0.000000e+00 2.036149e-12 3.104625e-01
NA
## water.500    0.091912781 6.662331e-05 1.090597e-05 6.902496e-01 3.053590e-
04
##                 water.500
## CalendarDate 3.092088e-01
## A.Temp       1.604920e-01
## W.Temp       2.000264e-05
## Time         7.028551e-01
## Mass         6.011935e-03
## PL           9.191278e-02
## for.veg.200  6.662331e-05
## wet.400      1.090597e-05
## agri.600     6.902496e-01
## urban.1000   3.053590e-04
## water.500             NA
```

Spearman correlation coefficients

```
# Creation of the correlation table
table.corr.spearman.Start <-
rcorr(as.matrix(MixedData[,c(3,4,5,6,7,8,18,30,42,56,61)]), type="spearman")
table.cor.spearman.Start.r <- table.corr.spearman.Start$r # Pearson
correlation coefficients
```

```
table.cor.spearman.Start.p <- table.corr.spearman.Start$P # P values of the
correlations
table.cor.spearman.Start.r

##               CalendarDate      A.Temp     W.Temp         Time        Mass
## CalendarDate   1.00000000  0.45842169 0.56884913 -0.098920865  0.08038929
## A.Temp         0.45842169  1.00000000 0.83718368  0.138498905  0.06589666
## W.Temp         0.56884913  0.83718368 1.00000000  0.173659029  0.13270468
## Time          -0.09892087  0.13849890 0.17365903  1.000000000 -0.04025948
## Mass           0.08038929  0.06589666 0.13270468 -0.040259479  1.00000000
## PL             0.08898378  0.10442546 0.15193967 -0.013644546  0.94856246
## for.veg.200    0.07590530  0.18670931 0.17243577  0.072682965 -0.05303332
## wet.400        0.41005248  0.11243977 0.19326625  0.146391742 -0.04217241
## agri.600      -0.06694664  0.22598407 0.11700410 -0.093444945  0.16767037
## urban.1000     0.05728527  0.13104537 0.21782810 -0.071452190  0.10868203
## water.500     -0.27348685 -0.05671475 0.03613419  0.002018679  0.09506451
##                       PL for.veg.200     wet.400     agri.600  urban.1000
## CalendarDate  0.08898378  0.07590530  0.41005248 -0.066946640  0.05728527
## A.Temp        0.10442546  0.18670931  0.11243977  0.225984071  0.13104537
## W.Temp        0.15193967  0.17243577  0.19326625  0.117004100  0.21782810
## Time         -0.01364455  0.07268297  0.14639174 -0.093444945 -0.07145219
## Mass          0.94856246 -0.05303332 -0.04217241  0.167670371  0.10868203
## PL            1.00000000 -0.01916834 -0.04821271  0.181622684  0.07998962
## for.veg.200  -0.01916834  1.00000000 -0.14248989 -0.184907521 -0.41380576
## wet.400      -0.04821271 -0.14248989  1.00000000 -0.300029610 -0.23226774
## agri.600      0.18162268 -0.18490752 -0.30002961  1.000000000  0.48970284
## urban.1000    0.07998962 -0.41380576 -0.23226774  0.489702837  1.00000000
## water.500     0.06924256 -0.27799035 -0.42187319  0.005477243  0.05503142
##                 water.500
## CalendarDate -0.273486853
## A.Temp       -0.056714750
## W.Temp        0.036134191
## Time          0.002018679
## Mass          0.095064505
## PL            0.069242556
## for.veg.200  -0.277990353
## wet.400      -0.421873192
## agri.600      0.005477243
## urban.1000    0.055031416
## water.500     1.000000000

table.cor.spearman.Start.p

##               CalendarDate       A.Temp       W.Temp         Time
Mass
## CalendarDate           NA 0.000000e+00 0.000000e+00 0.0219948308
6.291206e-02
## A.Temp       0.000000e+00           NA 0.000000e+00 0.0013067179
1.275805e-01
## W.Temp       0.000000e+00 0.000000e+00           NA 0.0001191832
```

```
3.379071e-03
## Time         2.199483e-02 1.306718e-03 1.191832e-04           NA
3.522285e-01
## Mass         6.291206e-02 1.275805e-01 3.379071e-03 0.3522284632
NA
## PL           3.964107e-02 1.567793e-02 7.879312e-04 0.7528559899
0.000000e+00
## for.veg.200  7.912840e-02 1.356056e-05 1.332995e-04 0.0927575303
2.202715e-01
## wet.400      0.000000e+00 9.177827e-03 1.785318e-05 0.0006747625
3.298003e-01
## agri.600     1.216114e-01 1.234880e-07 9.833391e-03 0.0305341790
9.602068e-05
## urban.1000   1.854229e-01 2.366128e-03 1.246624e-06 0.0984350178
1.181043e-02
## water.500    1.194147e-10 1.898472e-01 4.267291e-01 0.9628107149
2.775370e-02
##                        PL  for.veg.200      wet.400     agri.600
urban.1000
## CalendarDate 3.964107e-02 7.912840e-02 0.000000e+00 1.216114e-01
1.854229e-01
## A.Temp       1.567793e-02 1.356056e-05 9.177827e-03 1.234880e-07
2.366128e-03
## W.Temp       7.879312e-04 1.332995e-04 1.785318e-05 9.833391e-03
1.246624e-06
## Time         7.528560e-01 9.275753e-02 6.747625e-04 3.053418e-02
9.843502e-02
## Mass         0.000000e+00 2.202715e-01 3.298003e-01 9.602068e-05
1.181043e-02
## PL                     NA 6.582225e-01 2.656216e-01 2.375451e-05
6.448653e-02
## for.veg.200  6.582225e-01           NA 9.394054e-04 1.646414e-05
0.000000e+00
## wet.400      2.656216e-01 9.394054e-04           NA 1.302514e-12
5.346181e-08
## agri.600     2.375451e-05 1.646414e-05 1.302514e-12           NA
0.000000e+00
## urban.1000   6.448653e-02 0.000000e+00 5.346181e-08 0.000000e+00
NA
## water.500    1.096520e-01 5.735767e-11 0.000000e+00 8.993265e-01
2.033521e-01
##                   water.500
## CalendarDate 1.194147e-10
## A.Temp       1.898472e-01
## W.Temp       4.267291e-01
## Time         9.628107e-01
## Mass         2.775370e-02
## PL           1.096520e-01
## for.veg.200  5.735767e-11
## wet.400      0.000000e+00
```

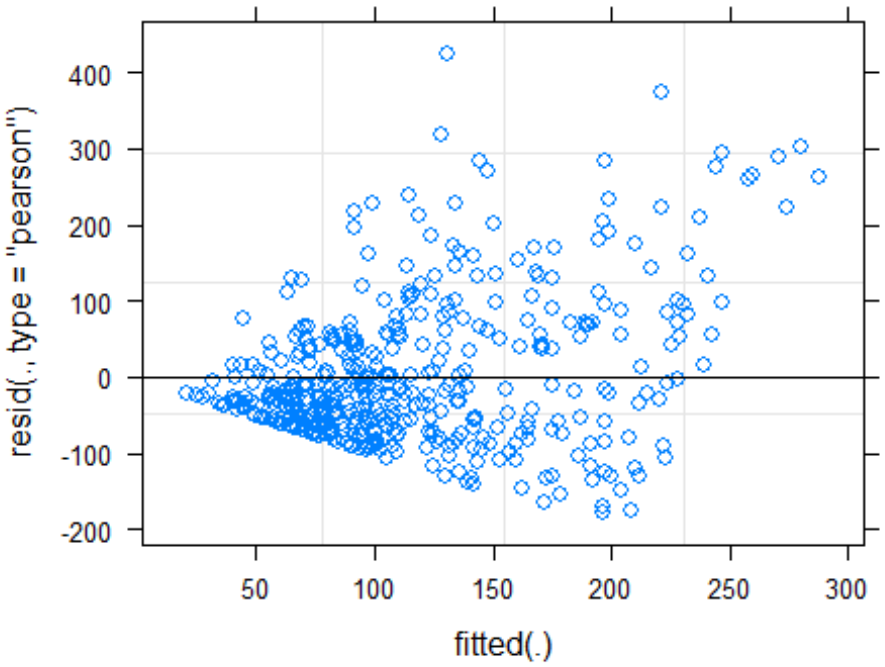
```
## agri.600     8.993265e-01
## urban.1000   2.033521e-01
## water.500              NA
```

The Pearson correlation coefficient of 0.93 between Mass and PL and 0.84 between W.Temp and A.Temp confirmed the deletion of Mass and W.Temp with the calculation of the GVIF^(1/(2*df)).

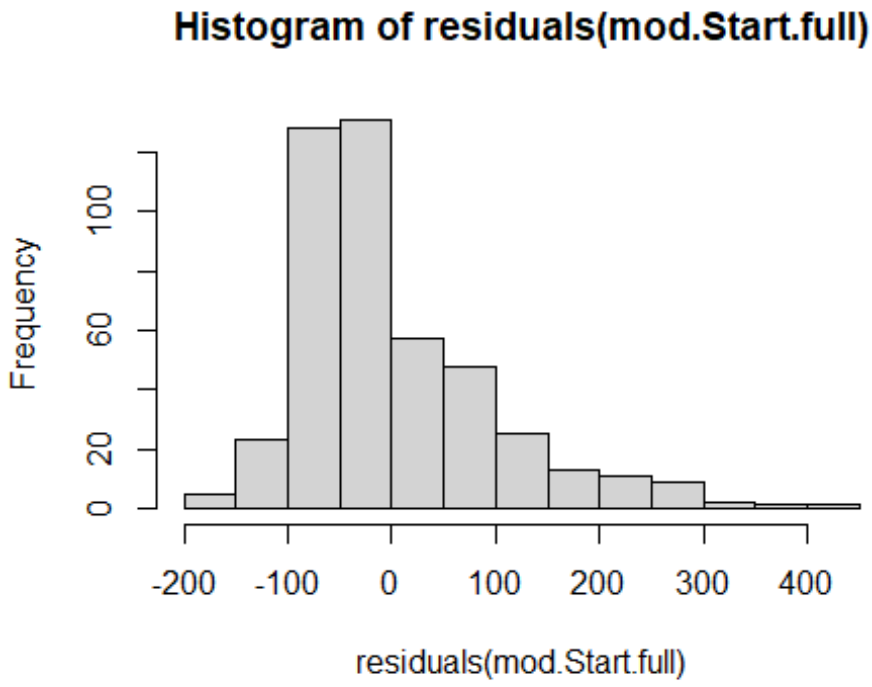
Verification of the assumptions with the initial model

```
mod.Start.full <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1|Code) + (1|Site),
data = MixedData, REML = TRUE, na.action=na.exclude)

summary(mod.Start.full)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scaled +
##     Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled +
##     urban.1000.Scaled + water.500.Scaled + (1 | Code) + (1 |      Site)
##    Data: MixedData
##
## REML criterion at convergence: 5522.9
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.7051 -0.5974 -0.2511  0.4462  4.0698
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept)  1711     41.37
##  Site     (Intercept)  2377     48.75
##  Residual             10853    104.18
## Number of obs: 454, groups:  Code, 430; Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          121.855     14.207  25.474   8.577 5.53e-09 ***
## CalendarDate.Scaled  -19.886     13.450  18.438  -1.478  0.15616
## A.Temp.Scaled         -4.217     10.057 148.565  -0.419  0.67559
## Time.Scaled           -4.557      5.925 440.328  -0.769  0.44221
## PL.Scaled             18.995      6.949 418.253   2.734  0.00653 **
## SexM                   5.277     12.823 439.387   0.412  0.68089
## for.veg.200.Scaled   -15.564     20.757  14.567  -0.750  0.46531
## wet.400.Scaled        17.301     18.906  13.880   0.915  0.37575
## agri.600.Scaled        1.036     12.655  15.764   0.082  0.93575
## urban.1000.Scaled    -15.886     19.774  13.777  -0.803  0.43539
## water.500.Scaled     -12.429     15.241  13.489  -0.816  0.42895
```

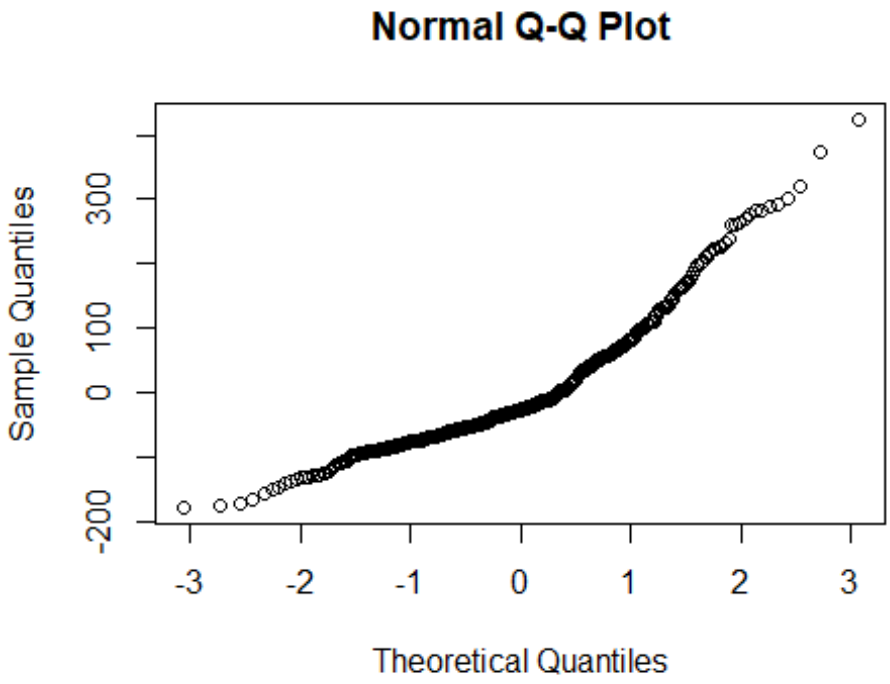
```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl SexM   f..200 w.400. a.600.
## ClndrDt.Scl -0.057
## A.Temp.Scld  0.100 -0.358
## Time.Scaled  0.045  0.086 -0.235
## PL.Scaled   -0.264 -0.021 -0.031 -0.039
## SexM        -0.522  0.042 -0.116 -0.050  0.469
## fr.vg.200.S  0.009 -0.122 -0.219  0.044 -0.015  0.051
## wt.400.Scld -0.058 -0.323 -0.093  0.030  0.010  0.039  0.704
## agr.600.Scl -0.106 -0.070 -0.146  0.056 -0.048  0.009  0.591  0.553
## urbn.1000.S -0.071 -0.230 -0.090  0.049 -0.014  0.057  0.751  0.730  0.512
## wtr.500.Scl -0.043 -0.204 -0.117  0.017 -0.059  0.011  0.575  0.599  0.426
##             u.1000
## ClndrDt.Scl
## A.Temp.Scld
## Time.Scaled
## PL.Scaled
## SexM
## fr.vg.200.S
## wt.400.Scld
## agr.600.Scl
## urbn.1000.S
## wtr.500.Scl  0.624

plot(mod.Start.full)
```




```
hist(residuals(mod.Start.full))
```




```
qqnorm(resid(mod.Start.full))
```



Time of shell emergence (Bin.Shell)

Multicollinearity: Generalized variance inflation factor (GVIF^(1/(2*df)))

GVIF^(1/(2*df)) > 2 indicates the presence of multicollinearity, so I will remove variables with values over 2, starting with the highest value.

```
mod.Bin.Shell.vif <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
W.Temp.Scaled + Time.Scaled + Mass.Scaled + PL.Scaled + Sex +
for.veg.1000.Scaled + wet.300.Scaled + agri.1000.Scaled + urban.1000.Scaled +
water.900.Scaled, data = MixedData, family = binomial, na.action=na.exclude)
gvif(mod.Bin.Shell.vif)
```

```
##                         GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled   2.2335  1          1.4945
## A.Temp.Scaled         3.2566  1          1.8046
## W.Temp.Scaled         4.6305  1          2.1519
## Time.Scaled           1.0978  1          1.0478
## Mass.Scaled           9.4050  1          3.0668
## PL.Scaled             8.4056  1          2.8992
## Sex                   1.4693  1          1.2121
## for.veg.1000.Scaled  76.3505  1          8.7379
## wet.300.Scaled        3.7945  1          1.9479
## agri.1000.Scaled     24.1413  1          4.9134
## urban.1000.Scaled    60.1982  1          7.7587
## water.900.Scaled     12.7235  1          3.5670
```

Proportion of forest and vegetation area at 1000m (for.veg.1000) has the highest GVIF^(1/(2*df)) > 2, so I will remove it and recalculate the factors.

```
mod.Bin.Shell.vif <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
W.Temp.Scaled + Time.Scaled + Mass.Scaled + PL.Scaled + Sex + wet.300.Scaled
+ agri.1000.Scaled + urban.1000.Scaled + water.900.Scaled, data = MixedData,
family = binomial, na.action=na.exclude)
gvif(mod.Bin.Shell.vif)
```

```
##                       GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 2.2084  1          1.4861
## A.Temp.Scaled       3.2449  1          1.8014
## W.Temp.Scaled       4.5909  1          2.1426
## Time.Scaled         1.0962  1          1.0470
## Mass.Scaled         9.3543  1          3.0585
## PL.Scaled           8.3520  1          2.8900
## Sex                 1.4499  1          1.2041
## wet.300.Scaled      1.4939  1          1.2223
## agri.1000.Scaled    1.1970  1          1.0941
## urban.1000.Scaled   1.3446  1          1.1596
## water.900.Scaled    1.2665  1          1.1254
```

Turtle mass (Mass) has the highest GVIF^(1/(2*df)) > 2, so I will remove it and recalculate the factors.

```
mod.Bin.Shell.vif <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
W.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.300.Scaled +
agri.1000.Scaled + urban.1000.Scaled + water.900.Scaled, data = MixedData,
family = binomial, na.action=na.exclude)
gvif(mod.Bin.Shell.vif)
```

```
##                       GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 2.1874  1          1.4790
## A.Temp.Scaled       3.2392  1          1.7998
## W.Temp.Scaled       4.5708  1          2.1379
## Time.Scaled         1.0857  1          1.0420
## PL.Scaled           1.4000  1          1.1832
## Sex                 1.3525  1          1.1630
## wet.300.Scaled      1.4926  1          1.2217
## agri.1000.Scaled    1.1971  1          1.0941
## urban.1000.Scaled   1.2621  1          1.1234
## water.900.Scaled    1.2191  1          1.1041
```

Water temperature (W.Temp) has the highest GVIF^(1/(2*df)) > 2, so I will remove it and recalculate the factors.

```
mod.Bin.Shell.vif <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled, data = MixedData, family = binomial,
na.action=na.exclude)
gvif(mod.Bin.Shell.vif)
```

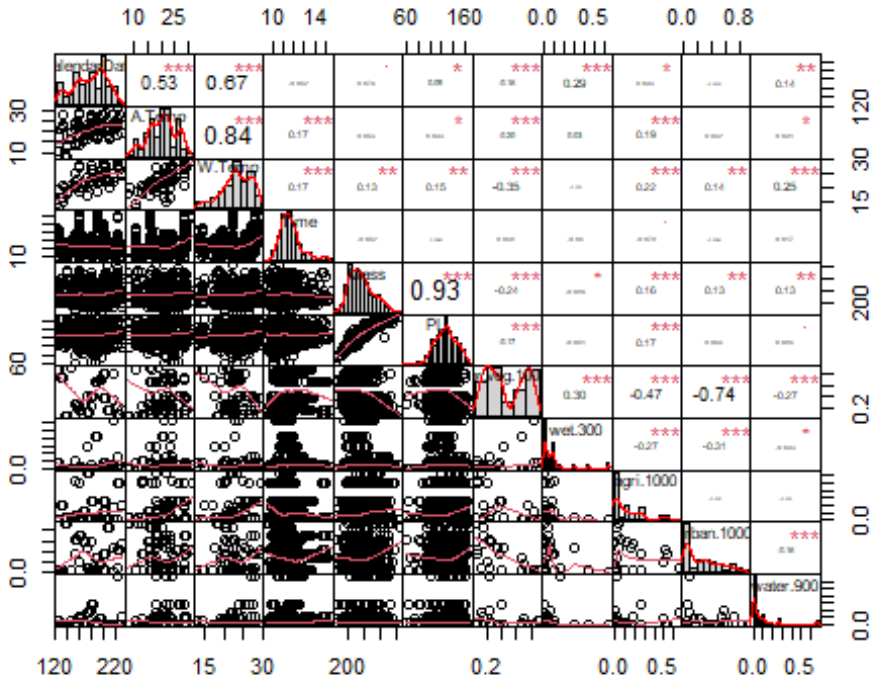
```
##                         GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 1.6023  1          1.2658
## A.Temp.Scaled       1.4137  1          1.1890
## Time.Scaled         1.0726  1          1.0357
## PL.Scaled           1.4134  1          1.1889
## Sex                 1.3611  1          1.1667
## wet.300.Scaled      1.4687  1          1.2119
## agri.1000.Scaled    1.2172  1          1.1033
## urban.1000.Scaled   1.2138  1          1.1017
## water.900.Scaled    1.1263  1          1.0613
```

All of the GVIF^(1/(2*df)) < 2, so I will not remove any more variables.

Calculation of Pearson and Spearman correlation coefficients

Pearson correlation coefficients

```
# Visualization of the correlations
cor.pearson.Bin.Shell <- MixedData[, c(3,4,5,6,7,8,26,29,46,56,65)]
chart.Correlation(cor.pearson.Bin.Shell, histogram=TRUE, pch=19)
```




```
# Creation of the correlation table
table.corr.pearson.Bin.Shell <-
rcorr(as.matrix(MixedData[,c(3,4,5,6,7,8,26,29,46,56,65)]), type="pearson")
table.cor.pearson.Bin.Shell.r <- table.corr.pearson.Bin.Shell$r # Pearson
correlation coefficients
table.cor.pearson.Bin.Shell.p <- table.corr.pearson.Bin.Shell$P # P values of
```

```
the correlations
table.cor.pearson.Bin.Shell.r

##               CalendarDate      A.Temp      W.Temp         Time        Mass
## CalendarDate  1.000000000  0.52662360  0.66868310 -0.051688682  0.07560208
## A.Temp        0.526623600  1.00000000  0.83887108  0.171967476  0.05252964
## W.Temp        0.668683098  0.83887108  1.00000000  0.166126059  0.13221505
## Time         -0.051688682  0.17196748  0.16612606  1.000000000 -0.05245171
## Mass          0.075602082  0.05252964  0.13221505 -0.052451709  1.00000000
## PL            0.089516177  0.09250283  0.14606475  0.009461487  0.93311455
## for.veg.1000 -0.159757526 -0.20286665 -0.35442189  0.048125471 -0.23967087
## wet.300       0.285505234  0.02957879 -0.02150728 -0.039628347 -0.08629485
## agri.1000     0.093070389  0.19452574  0.21528845 -0.078150322  0.15949820
## urban.1000   -0.003462429  0.04205111  0.14394243 -0.006102219  0.12738974
## water.900     0.140565598  0.09143754  0.25309673  0.016579901  0.13233284
##                        PL for.veg.1000     wet.300   agri.1000
urban.1000
## CalendarDate  0.089516177  -0.15975753  0.28550523  0.09307039 -
0.003462429
## A.Temp        0.092502829  -0.20286665  0.02957879  0.19452574
0.042051110
## W.Temp        0.146064749  -0.35442189 -0.02150728  0.21528845
0.143942429
## Time          0.009461487   0.04812547 -0.03962835 -0.07815032 -
0.006102219
## Mass          0.933114554  -0.23967087 -0.08629485  0.15949820
0.127389743
## PL            1.000000000  -0.17433634 -0.05147288  0.16850474
0.063945149
## for.veg.1000 -0.174336336   1.00000000  0.30140143 -0.47018472 -
0.743798223
## wet.300      -0.051472876   0.30140143  1.00000000 -0.27005276 -
0.307775684
## agri.1000     0.168504745  -0.47018472 -0.27005276  1.00000000 -
0.035135268
## urban.1000    0.063945149  -0.74379822 -0.30777568 -0.03513527
1.000000000
## water.900     0.083709114  -0.26815368 -0.09294993 -0.02285347 -
0.162490358
##                water.900
## CalendarDate  0.14056560
## A.Temp        0.09143754
## W.Temp        0.25309673
## Time          0.01657990
## Mass          0.13233284
## PL            0.08370911
## for.veg.1000 -0.26815368
## wet.300      -0.09294993
## agri.1000    -0.02285347
```

```
## urban.1000   -0.16249036
## water.900     1.00000000

table.cor.pearson.Bin.Shell.p

##              CalendarDate       A.Temp       W.Temp         Time
Mass
## CalendarDate           NA 0.000000e+00 0.000000e+00 2.322103e-01
8.033738e-02
## A.Temp       0.000000e+00           NA 0.000000e+00 6.283828e-05
2.246911e-01
## W.Temp       0.000000e+00 0.000000e+00           NA 2.346306e-04
3.499660e-03
## Time         2.322103e-01 6.283828e-05 2.346306e-04           NA
2.253805e-01
## Mass         8.033738e-02 2.246911e-01 3.499660e-03 2.253805e-01
NA
## PL           3.846835e-02 3.242105e-02 1.256393e-03 8.271659e-01
0.000000e+00
## for.veg.1000 2.040904e-04 2.189891e-06 8.881784e-16 2.660399e-01
1.932793e-08
## wet.300      1.637268e-11 4.943861e-01 6.362342e-01 3.598346e-01
4.583253e-02
## agri.1000    3.121016e-02 5.719872e-06 1.666280e-06 7.062947e-02
2.090744e-04
## urban.1000   9.362578e-01 3.311946e-01 1.464223e-03 8.879110e-01
3.132312e-03
## water.900    1.102607e-03 3.430866e-02 1.534812e-08 7.017326e-01
2.139968e-03
##                        PL for.veg.1000      wet.300    agri.1000
urban.1000
## CalendarDate 3.846835e-02 2.040904e-04 1.637268e-11 3.121016e-02
9.362578e-01
## A.Temp       3.242105e-02 2.189891e-06 4.943861e-01 5.719872e-06
3.311946e-01
## W.Temp       1.256393e-03 8.881784e-16 6.362342e-01 1.666280e-06
1.464223e-03
## Time         8.271659e-01 2.660399e-01 3.598346e-01 7.062947e-02
8.879110e-01
## Mass         0.000000e+00 1.932793e-08 4.583253e-02 2.090744e-04
3.132312e-03
## PL                     NA 5.033503e-05 2.346072e-01 8.986288e-05
1.396467e-01
## for.veg.1000 5.033503e-05           NA 1.017852e-12 0.000000e+00
0.000000e+00
## wet.300      2.346072e-01 1.017852e-12           NA 2.070131e-10
3.179679e-13
## agri.1000    8.986288e-05 0.000000e+00 2.070131e-10           NA
4.169111e-01
## urban.1000   1.396467e-01 0.000000e+00 3.179679e-13 4.169111e-01
```

```
NA
## water.900    5.298219e-02 2.797003e-10 3.143027e-02 5.975481e-01
1.579156e-04
##                  water.900
## CalendarDate 1.102607e-03
## A.Temp       3.430866e-02
## W.Temp       1.534812e-08
## Time         7.017326e-01
## Mass         2.139968e-03
## PL           5.298219e-02
## for.veg.1000 2.797003e-10
## wet.300      3.143027e-02
## agri.1000    5.975481e-01
## urban.1000   1.579156e-04
## water.900              NA
```

Spearman correlation coefficients

```
# Creation of the correlation table
table.corr.spearman.Bin.Shell <-
rcorr(as.matrix(MixedData[,c(3,4,5,6,7,8,26,29,46,56,65)]), type="spearman")
table.cor.spearman.Bin.Shell.r <- table.corr.spearman.Bin.Shell$r # Pearson
correlation coefficients
table.cor.spearman.Bin.Shell.p <- table.corr.spearman.Bin.Shell$P # P values
of the correlations
table.cor.spearman.Bin.Shell.r
```

```
##              CalendarDate       A.Temp      W.Temp        Time        Mass
## CalendarDate   1.00000000  0.458421690  0.56884913 -0.09892087  0.08038929
## A.Temp         0.45842169  1.000000000  0.83718368  0.13849890  0.06589666
## W.Temp         0.56884913  0.837183684  1.00000000  0.17365903  0.13270468
## Time          -0.09892087  0.138498905  0.17365903  1.00000000 -0.04025948
## Mass           0.08038929  0.065896659  0.13270468 -0.04025948  1.00000000
## PL             0.08898378  0.104425464  0.15193967 -0.01364455  0.94856246
## for.veg.1000  -0.13614271 -0.170018984 -0.28928407  0.11957044 -0.19217208
## wet.300        0.32499215 -0.007493503  0.05630636  0.12226733 -0.07340554
## agri.1000      0.14975219  0.307433887  0.33671601 -0.12473748  0.18211450
## urban.1000     0.05728527  0.131045369  0.21782810 -0.07145219  0.10868203
## water.900     -0.23064372 -0.101001782 -0.01834662  0.03769977  0.04847697
##                       PL for.veg.1000      wet.300  agri.1000  urban.1000
## CalendarDate  0.08898378   -0.1361427  0.324992150  0.1497522  0.05728527
## A.Temp        0.10442546   -0.1700190 -0.007493503  0.3074339  0.13104537
## W.Temp        0.15193967   -0.2892841  0.056306361  0.3367160  0.21782810
## Time         -0.01364455    0.1195704  0.122267329 -0.1247375 -0.07145219
## Mass          0.94856246   -0.1921721 -0.073405540  0.1821145  0.10868203
## PL            1.00000000   -0.1623624 -0.088758890  0.1885881  0.07998962
## for.veg.1000 -0.16236237    1.0000000  0.291174883 -0.5429549 -0.82572013
## wet.300      -0.08875889    0.2911749  1.000000000 -0.3173058 -0.32221448
## agri.1000     0.18858810   -0.5429549 -0.317305773  1.0000000  0.33862008
## urban.1000    0.07998962   -0.8257201 -0.322214475  0.3386201  1.00000000
## water.900     0.03358886   -0.2295566 -0.387776581 -0.1408985  0.06336506
```

```
##                water.900
## CalendarDate -0.23064372
## A.Temp       -0.10100178
## W.Temp       -0.01834662
## Time          0.03769977
## Mass          0.04847697
## PL            0.03358886
## for.veg.1000 -0.22955661
## wet.300      -0.38777658
## agri.1000    -0.14089853
## urban.1000    0.06336506
## water.900     1.00000000

table.cor.spearman.Bin.Shell.p

##              CalendarDate       A.Temp       W.Temp         Time
Mass
## CalendarDate           NA 0.000000e+00 0.000000e+00 0.0219948308
6.291206e-02
## A.Temp       0.000000e+00           NA 0.000000e+00 0.0013067179
1.275805e-01
## W.Temp       0.000000e+00 0.000000e+00           NA 0.0001191832
3.379071e-03
## Time         2.199483e-02 1.306718e-03 1.191832e-04           NA
3.522285e-01
## Mass         6.291206e-02 1.275805e-01 3.379071e-03 0.3522284632
NA
## PL           3.964107e-02 1.567793e-02 7.879312e-04 0.7528559899
0.000000e+00
## for.veg.1000 1.581516e-03 7.625616e-05 8.007350e-11 0.0055757019
7.445223e-06
## wet.300      1.199041e-14 8.625850e-01 2.153146e-01 0.0045864816
8.954843e-02
## agri.1000    5.041266e-04 3.388401e-13 2.398082e-14 0.0038225745
2.216001e-05
## urban.1000   1.854229e-01 2.366128e-03 1.246624e-06 0.0984350178
1.181043e-02
## water.900    6.652959e-08 1.934139e-02 6.866163e-01 0.3837078901
2.625597e-01
##                        PL for.veg.1000      wet.300    agri.1000
urban.1000
## CalendarDate 3.964107e-02 1.581516e-03 1.199041e-14 5.041266e-04
1.854229e-01
## A.Temp       1.567793e-02 7.625616e-05 8.625850e-01 3.388401e-13
2.366128e-03
## W.Temp       7.879312e-04 8.007350e-11 2.153146e-01 2.398082e-14
1.246624e-06
## Time         7.528560e-01 5.575702e-03 4.586482e-03 3.822575e-03
9.843502e-02
## Mass         0.000000e+00 7.445223e-06 8.954843e-02 2.216001e-05
```

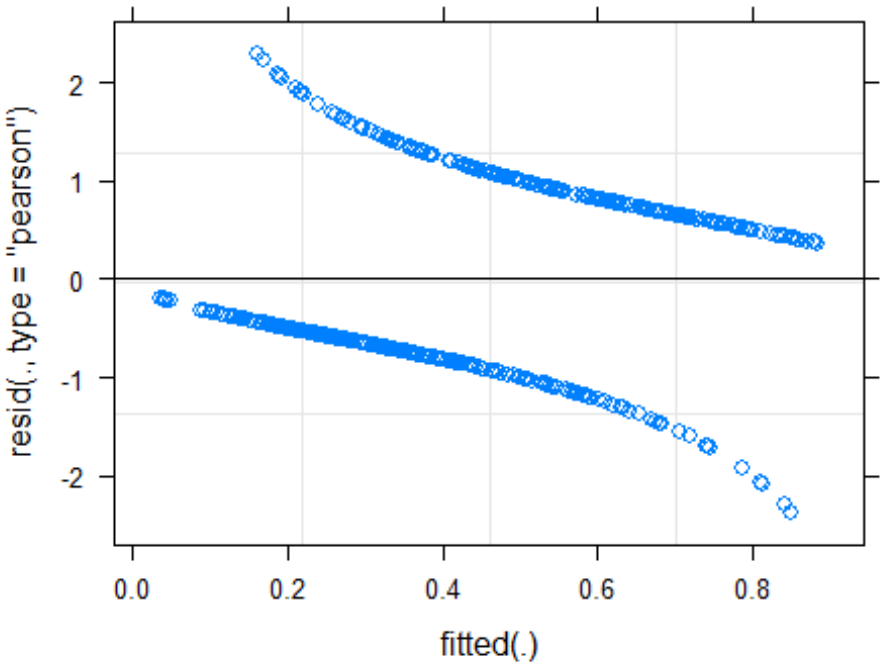
```
1.181043e-02
## PL                    NA 1.621239e-04 4.014546e-02 1.126664e-05
6.448653e-02
## for.veg.1000 1.621239e-04           NA 6.200374e-12 0.000000e+00
0.000000e+00
## wet.300      4.014546e-02 6.200374e-12           NA 5.284662e-14
2.042810e-14
## agri.1000    1.126664e-05 0.000000e+00 5.284662e-14           NA
8.881784e-16
## urban.1000   6.448653e-02 0.000000e+00 2.042810e-14 8.881784e-16
NA
## water.900    4.381540e-01 7.694788e-08 0.000000e+00 1.072620e-03
1.429059e-01
##                 water.900
## CalendarDate 6.652959e-08
## A.Temp       1.934139e-02
## W.Temp       6.866163e-01
## Time         3.837079e-01
## Mass         2.625597e-01
## PL           4.381540e-01
## for.veg.1000 7.694788e-08
## wet.300      0.000000e+00
## agri.1000    1.072620e-03
## urban.1000   1.429059e-01
## water.900              NA
```

The Pearson correlation coefficient of -0.74 between for.veg.1000 and urban.1000, 0.93 between Mass and PL,and 0.84 between W.Temp and A.Temp confirmed the deletion of for.veg.1000, Mass, and W.Temp with the calculation of the GVIF^(1/(2*df)).

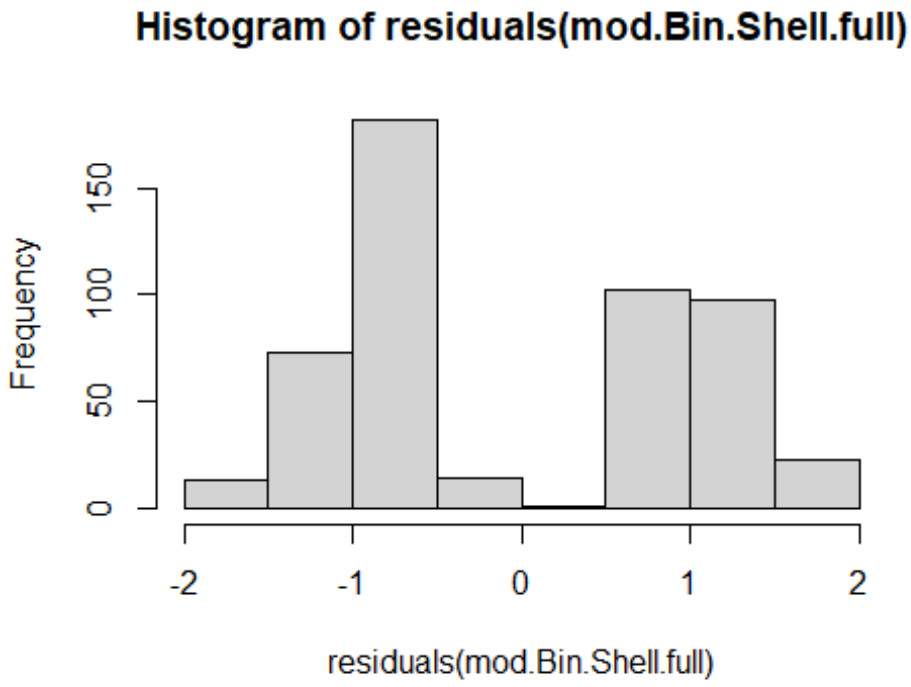
Verification of the assumptions with the initial model

```
mod.Bin.Shell.full <- glmer(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1|Site) + (1|Code), data = MixedData,
family = binomial, na.action=na.exclude)

summary(mod.Bin.Shell.full)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled +
##     water.900.Scaled + (1 | Site) + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##    637.6    688.3   -306.8    613.6      494
##
```

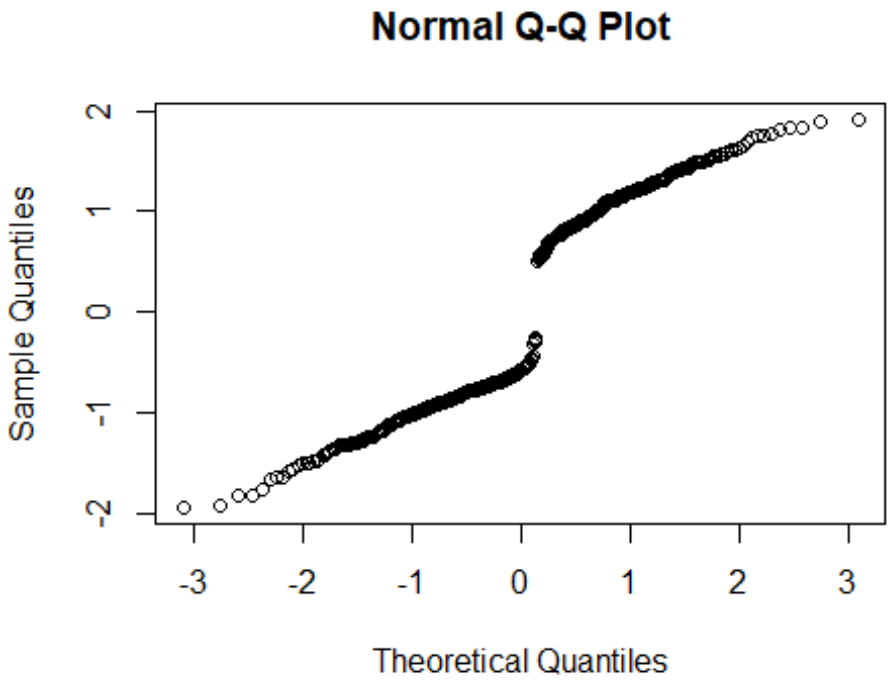
```
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.3731 -0.6924 -0.4231  0.7804  2.2883
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  Code   (Intercept) 0.394958 0.62846
##  Site   (Intercept) 0.002675 0.05172
## Number of obs: 506, groups:  Code, 478; Site, 23
##
## Fixed effects:
##                       Estimate Std. Error z value Pr(>|z|)
## (Intercept)         -0.273471   0.188311  -1.452 0.146437
## CalendarDate.Scaled -0.519502   0.147058  -3.533 0.000411 ***
## A.Temp.Scaled       -0.444253   0.143668  -3.092 0.001987 **
## Time.Scaled         -0.308826   0.121947  -2.532 0.011326 *
## PL.Scaled            0.225610   0.138687   1.627 0.103787
## SexM                -0.074558   0.248956  -0.299 0.764571
## wet.300.Scaled       0.244893   0.125513   1.951 0.051041 .
## agri.1000.Scaled     0.001697   0.116766   0.015 0.988404
## urban.1000.Scaled   -0.264439   0.121799  -2.171 0.029924 *
## water.900.Scaled    -0.016795   0.112129  -0.150 0.880939
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.300. a.1000 u.1000
## ClndrDt.Scl -0.079
## A.Temp.Scld  0.177 -0.369
## Time.Scaled  0.166  0.159 -0.058
## PL.Scaled   -0.464 -0.038 -0.170 -0.099
## SexM        -0.779  0.119 -0.074 -0.090  0.476
## wt.300.Scld -0.084 -0.366 -0.016  0.010  0.094  0.028
## agr.1000.Sc -0.014 -0.035 -0.141  0.150 -0.109  0.003  0.341
## urbn.1000.S -0.027 -0.035  0.071  0.122 -0.062  0.086  0.330  0.184
## wtr.900.Scl  0.024 -0.151 -0.001 -0.016 -0.129 -0.044  0.221  0.105  0.232
## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model failed to converge with max|grad| = 0.025219 (tol = 0.002, component
1)

plot(mod.Bin.Shell.full)
```




```
hist(residuals(mod.Bin.Shell.full))
```




```
qqnorm(resid(mod.Bin.Shell.full))
```



Total time spent moving (Move)

Multicollinearity: Generalized variance inflation factor (GVIF^(1/(2*df)))

GVIF^(1/(2*df)) > 2 indicates the presence of multicollinearity, so I will remove variables with values over 2, starting with the highest value.

```
mod.Move.vif <- lm(Move ~ CalendarDate.Scaled + A.Temp.Scaled + W.Temp.Scaled
+ Time.Scaled + Mass.Scaled + PL.Scaled + Sex + for.veg.300.Scaled +
wet.600.Scaled + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled,
data = MixedData, na.action=na.exclude)
gvif(mod.Move.vif)
```

```
##                       GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 2.1511  1          1.4667
## A.Temp.Scaled       4.0975  1          2.0242
## W.Temp.Scaled       5.8063  1          2.4096
## Time.Scaled         1.1339  1          1.0648
## Mass.Scaled         9.0248  1          3.0041
## PL.Scaled           7.9817  1          2.8252
## Sex                 1.4918  1          1.2214
## for.veg.300.Scaled  3.7113  1          1.9265
## wet.600.Scaled      1.9893  1          1.4104
## agri.100.Scaled     1.5977  1          1.2640
## urban.1000.Scaled   3.1887  1          1.7857
## water.1000.Scaled   2.2055  1          1.4851
```

Turtle mass (Mass) has the highest GVIF^(1/(2*df)) > 2, so I will remove it and recalculate the factors.

```
mod.Move.vif <- lm(Move ~ CalendarDate.Scaled + A.Temp.Scaled + W.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled, data = MixedData,
na.action=na.exclude)
gvif(mod.Move.vif)
```

```
##                        GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 2.1479  1          1.4656
## A.Temp.Scaled       4.0531  1          2.0132
## W.Temp.Scaled       5.7873  1          2.4057
## Time.Scaled         1.1162  1          1.0565
## PL.Scaled           1.3618  1          1.1670
## Sex                 1.3759  1          1.1730
## for.veg.300.Scaled  3.7113  1          1.9265
## wet.600.Scaled      1.9893  1          1.4104
## agri.100.Scaled     1.5920  1          1.2617
## urban.1000.Scaled   3.1226  1          1.7671
## water.1000.Scaled   2.1404  1          1.4630
```

Water temperature (W.Temp) has the highest GVIF^(1/(2*df)) > 2, so I will remove it and recalculate the factors.

```
mod.Move.vif <- lm(Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled, data = MixedData,
na.action=na.exclude)
gvif(mod.Move.vif)
```

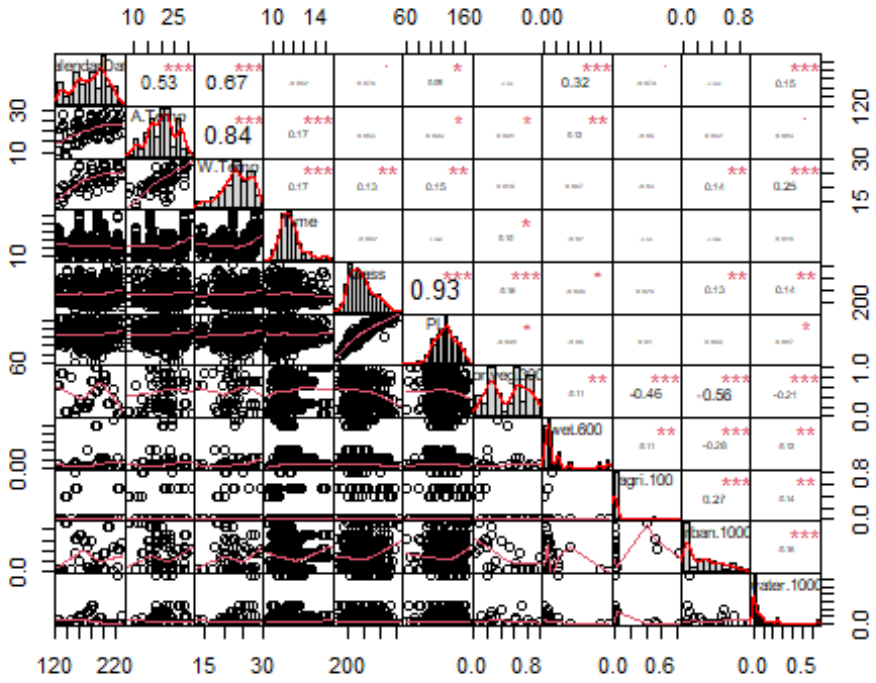
```
##                        GVIF df GVIF^(1/(2*df))
## CalendarDate.Scaled 1.6927  1          1.3010
## A.Temp.Scaled       1.5492  1          1.2447
## Time.Scaled         1.1070  1          1.0521
## PL.Scaled           1.3734  1          1.1719
## Sex                 1.3747  1          1.1725
## for.veg.300.Scaled  3.2982  1          1.8161
## wet.600.Scaled      1.8972  1          1.3774
## agri.100.Scaled     1.5658  1          1.2513
## urban.1000.Scaled   2.5930  1          1.6103
## water.1000.Scaled   1.8443  1          1.3581
```

All of the GVIF^(1/(2*df)) < 2, so I will not remove any more variables.

Calculation of Pearson and Spearman correlation coefficients

Pearson correlation coefficients

```
# Visualization of the correlations
cor.pearson.Move <- MixedData[, c(3,4,5,6,7,8,19,32,37,56,66)]
chart.Correlation(cor.pearson.Move, histogram=TRUE, pch=19)
```




```
# Creation of the correlation table
table.corr.pearson.Move <-
rcorr(as.matrix(MixedData[,c(3,4,5,6,7,8,19,32,37,56,66)]), type="pearson")
table.cor.pearson.Move.r <- table.corr.pearson.Move$r # Pearson correlation
coefficients
table.cor.pearson.Move.p <- table.corr.pearson.Move$P # P values of the
correlations
table.cor.pearson.Move.r
```

```
##                CalendarDate      A.Temp      W.Temp        Time        Mass
## CalendarDate   1.000000000  0.52662360  0.66868310 -0.051688682  0.07560208
## A.Temp         0.526623600  1.00000000  0.83887108  0.171967476  0.05252964
## W.Temp         0.668683098  0.83887108  1.00000000  0.166126059  0.13221505
## Time          -0.051688682  0.17196748  0.16612606  1.000000000 -0.05245171
## Mass           0.075602082  0.05252964  0.13221505 -0.052451709  1.00000000
## PL             0.089516177  0.09250283  0.14606475  0.009461487  0.93311455
## for.veg.300   -0.013496855  0.09108232  0.01541856  0.100593611 -0.15655831
## wet.600        0.317315461  0.12209698  0.06743185 -0.020258434 -0.09392134
## agri.100      -0.078714526 -0.03995312 -0.03022571 -0.013077109  0.02406704
## urban.1000    -0.003462429  0.04205111  0.14394243 -0.006102219  0.12738974
## water.1000     0.149646573  0.08311559  0.24535011  0.015131887  0.13576043
##                        PL for.veg.300     wet.600    agri.100   urban.1000
## CalendarDate   0.089516177 -0.01349685  0.31731546 -0.07871453 -0.003462429
## A.Temp         0.092502829  0.09108232  0.12209698 -0.03995312  0.042051110
## W.Temp         0.146064749  0.01541856  0.06743185 -0.03022571  0.143942429
## Time           0.009461487  0.10059361 -0.02025843 -0.01307711 -0.006102219
## Mass           0.933114554 -0.15655831 -0.09392134  0.02406704  0.127389743
```

```
## PL            1.000000000 -0.09827262 -0.04979076  0.01037365  0.063945149
## for.veg.300  -0.098272621  1.00000000 -0.11488524 -0.46193445 -0.559879830
## wet.600      -0.049790756 -0.11488524  1.00000000 -0.11309548 -0.277413533
## agri.100      0.010373653 -0.46193445 -0.11309548  1.00000000  0.271994655
## urban.1000    0.063945149 -0.55987983 -0.27741353  0.27199465  1.000000000
## water.1000    0.086809165 -0.20733260 -0.11525621 -0.13673053 -0.163064570
##                water.1000
## CalendarDate  0.14964657
## A.Temp        0.08311559
## W.Temp        0.24535011
## Time          0.01513189
## Mass          0.13576043
## PL            0.08680917
## for.veg.300  -0.20733260
## wet.600      -0.11525621
## agri.100     -0.13673053
## urban.1000   -0.16306457
## water.1000    1.00000000

table.cor.pearson.Move.p

##              CalendarDate       A.Temp       W.Temp         Time
Mass
## CalendarDate           NA 0.000000e+00 0.000000e+00 2.322103e-01
0.0803373837
## A.Temp       0.000000e+00           NA 0.000000e+00 6.283828e-05
0.2246910877
## W.Temp       0.000000e+00 0.000000e+00           NA 2.346306e-04
0.0034996595
## Time         2.322103e-01 6.283828e-05 2.346306e-04           NA
0.2253805335
## Mass         8.033738e-02 2.246911e-01 3.499660e-03 2.253805e-01
NA
## PL           3.846835e-02 3.242105e-02 1.256393e-03 8.271659e-01
0.0000000000
## for.veg.300  7.552233e-01 3.501640e-02 7.345696e-01 1.983870e-02
0.0002741392
## wet.600      5.284662e-14 4.643928e-03 1.376963e-01 6.398062e-01
0.0296925449
## agri.100     6.861526e-02 3.559077e-01 5.061950e-01 7.626040e-01
0.5782299989
## urban.1000   9.362578e-01 3.311946e-01 1.464223e-03 8.879110e-01
0.0031323118
## water.1000   5.088140e-04 5.446734e-02 4.280305e-08 7.266910e-01
0.0016308042
##                        PL  for.veg.300      wet.600     agri.100
urban.1000
## CalendarDate 0.038468345 7.552233e-01 5.284662e-14 6.861526e-02 9.362578e-
01
## A.Temp       0.032421052 3.501640e-02 4.643928e-03 3.559077e-01 3.311946e-
```

```
01
## W.Temp       0.001256393 7.345696e-01 1.376963e-01 5.061950e-01 1.464223e-
03
## Time         0.827165890 1.983870e-02 6.398062e-01 7.626040e-01 8.879110e-
01
## Mass         0.000000000 2.741392e-04 2.969254e-02 5.782300e-01 3.132312e-
03
## PL                    NA 2.301169e-02 2.502745e-01 8.108043e-01 1.396467e-
01
## for.veg.300  0.023011686           NA 7.758640e-03 0.000000e+00
0.000000e+00
## wet.600      0.250274454 7.758640e-03           NA 8.776242e-03 6.305312e-
11
## agri.100     0.810804345 0.000000e+00 8.776242e-03           NA 1.518086e-
10
## urban.1000   0.139646656 0.000000e+00 6.305312e-11 1.518086e-10
NA
## water.1000   0.044750150 1.287993e-06 7.561412e-03 1.508389e-03 1.495518e-
04
##                water.1000
## CalendarDate 5.088140e-04
## A.Temp       5.446734e-02
## W.Temp       4.280305e-08
## Time         7.266910e-01
## Mass         1.630804e-03
## PL           4.475015e-02
## for.veg.300  1.287993e-06
## wet.600      7.561412e-03
## agri.100     1.508389e-03
## urban.1000   1.495518e-04
## water.1000             NA
```

Spearman correlation coefficients

```
# Creation of the correlation table
table.corr.spearman.Move <-
rcorr(as.matrix(MixedData[,c(3,4,5,6,7,8,19,32,37,56,66)]), type="spearman")
table.cor.spearman.Move.r <- table.corr.spearman.Move$r # Pearson correlation
coefficients
table.cor.spearman.Move.p <- table.corr.spearman.Move$P # P values of the
correlations
table.cor.spearman.Move.r
```

```
##              CalendarDate      A.Temp      W.Temp        Time        Mass
## CalendarDate  1.000000000  0.45842169  0.56884913 -0.09892087  0.08038929
## A.Temp        0.458421690  1.00000000  0.83718368  0.13849890  0.06589666
## W.Temp        0.568849127  0.83718368  1.00000000  0.17365903  0.13270468
## Time         -0.098920865  0.13849890  0.17365903  1.00000000 -0.04025948
## Mass          0.080389290  0.06589666  0.13270468 -0.04025948  1.00000000
## PL            0.088983783  0.10442546  0.15193967 -0.01364455  0.94856246
## for.veg.300   0.009875034  0.10037382  0.08247229  0.08653131 -0.11905658
```

```
## wet.600       0.408715978  0.18072693  0.24428729  0.16690425 -0.12345744
## agri.100     -0.089341274 -0.02430981 -0.06768594 -0.06305996  0.04983615
## urban.1000    0.057285275  0.13104537  0.21782810 -0.07145219  0.10868203
## water.1000   -0.228592159 -0.10346354 -0.01803073  0.03380113  0.05068902
##                        PL  for.veg.300     wet.600    agri.100  urban.1000
## CalendarDate  0.08898378  0.009875034  0.40871598 -0.08934127  0.05728527
## A.Temp        0.10442546  0.100373821  0.18072693 -0.02430981  0.13104537
## W.Temp        0.15193967  0.082472291  0.24428729 -0.06768594  0.21782810
## Time         -0.01364455  0.086531310  0.16690425 -0.06305996 -0.07145219
## Mass          0.94856246 -0.119056577 -0.12345744  0.04983615  0.10868203
## PL            1.00000000 -0.085385576 -0.11558586  0.05678992  0.07998962
## for.veg.300  -0.08538558  1.000000000  0.08511604 -0.49468619 -0.54813534
## wet.600      -0.11558586  0.085116043  1.00000000 -0.19656797 -0.28542464
## agri.100      0.05678992 -0.494686189 -0.19656797  1.00000000  0.27938984
## urban.1000    0.07998962 -0.548135336 -0.28542464  0.27938984  1.00000000
## water.1000    0.03595837 -0.233574219 -0.48557676 -0.07369328  0.06274805
##                water.1000
## CalendarDate -0.22859216
## A.Temp       -0.10346354
## W.Temp       -0.01803073
## Time          0.03380113
## Mass          0.05068902
## PL            0.03595837
## for.veg.300  -0.23357422
## wet.600      -0.48557676
## agri.100     -0.07369328
## urban.1000    0.06274805
## water.1000    1.00000000

table.cor.spearman.Move.p

##              CalendarDate       A.Temp       W.Temp         Time
Mass
## CalendarDate           NA 0.000000e+00 0.000000e+00 0.0219948308
0.062912061
## A.Temp       0.000000e+00           NA 0.000000e+00 0.0013067179
0.127580483
## W.Temp       0.000000e+00 0.000000e+00           NA 0.0001191832
0.003379071
## Time         2.199483e-02 1.306718e-03 1.191832e-04           NA
0.352228463
## Mass         6.291206e-02 1.275805e-01 3.379071e-03 0.3522284632
NA
## PL           3.964107e-02 1.567793e-02 7.879312e-04 0.7528559899
0.000000000
## for.veg.300  8.195721e-01 2.011107e-02 6.928619e-02 0.0452390586
0.005784635
## wet.600      0.000000e+00 2.564232e-05 4.913921e-08 0.0001034490
0.004202712
## agri.100     3.866754e-02 5.744009e-01 1.362161e-01 0.1448442211
```

```
0.249398114
## urban.1000   1.854229e-01 2.366128e-03 1.246624e-06 0.0984350178
0.011810430
## water.1000   8.749580e-08 1.656624e-02 6.917336e-01 0.4348325411
0.241378152
##                        PL  for.veg.300      wet.600     agri.100
urban.1000
## CalendarDate 0.0396410665 8.195721e-01 0.000000e+00 3.866754e-02
1.854229e-01
## A.Temp       0.0156779333 2.011107e-02 2.564232e-05 5.744009e-01
2.366128e-03
## W.Temp       0.0007879312 6.928619e-02 4.913921e-08 1.362161e-01
1.246624e-06
## Time         0.7528559899 4.523906e-02 1.034490e-04 1.448442e-01
9.843502e-02
## Mass         0.0000000000 5.784635e-03 4.202712e-03 2.493981e-01
1.181043e-02
## PL                     NA 4.838620e-02 7.445541e-03 1.896750e-01
6.448653e-02
## for.veg.300  0.0483861978           NA 4.888954e-02 0.000000e+00
0.000000e+00
## wet.600      0.0074455412 4.888954e-02           NA 4.538554e-06
1.659783e-11
## agri.100     0.1896750465 0.000000e+00 4.538554e-06           NA
4.554446e-11
## urban.1000   0.0644865292 0.000000e+00 1.659783e-11 4.554446e-11
NA
## water.1000   0.4065146753 4.478494e-08 0.000000e+00 8.829560e-02
1.468465e-01
##                water.1000
## CalendarDate 8.749580e-08
## A.Temp       1.656624e-02
## W.Temp       6.917336e-01
## Time         4.348325e-01
## Mass         2.413782e-01
## PL           4.065147e-01
## for.veg.300  4.478494e-08
## wet.600      0.000000e+00
## agri.100     8.829560e-02
## urban.1000   1.468465e-01
## water.1000             NA
```

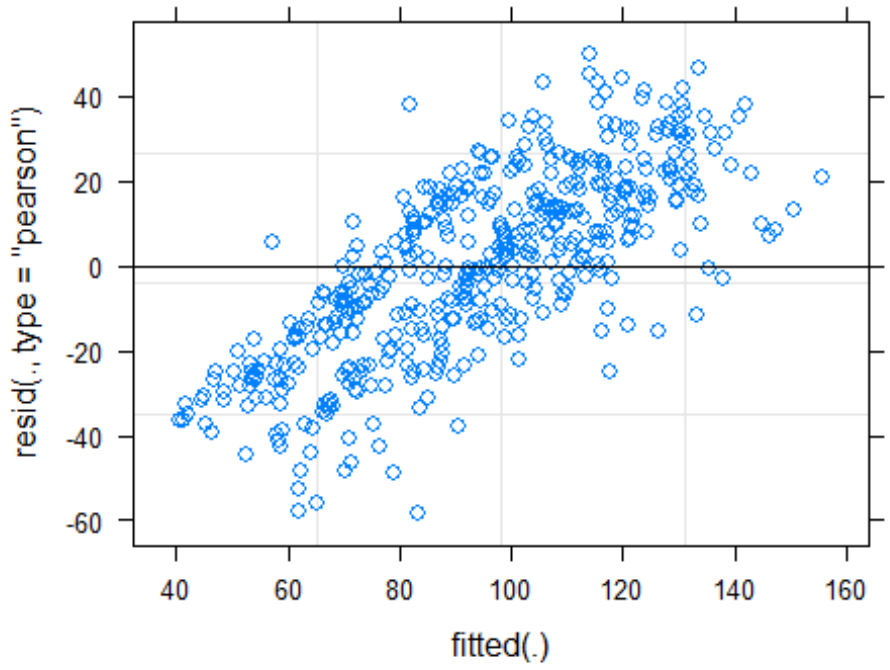
The Pearson correlation coefficient of 0.93 between Mass and PL and 0.84 between W.Temp and A.Temp confirmed the deletion of Mass and W.Temp with the calculation of the GVIF^(1/(2*df)).

Verification of the assumptions with the initial model

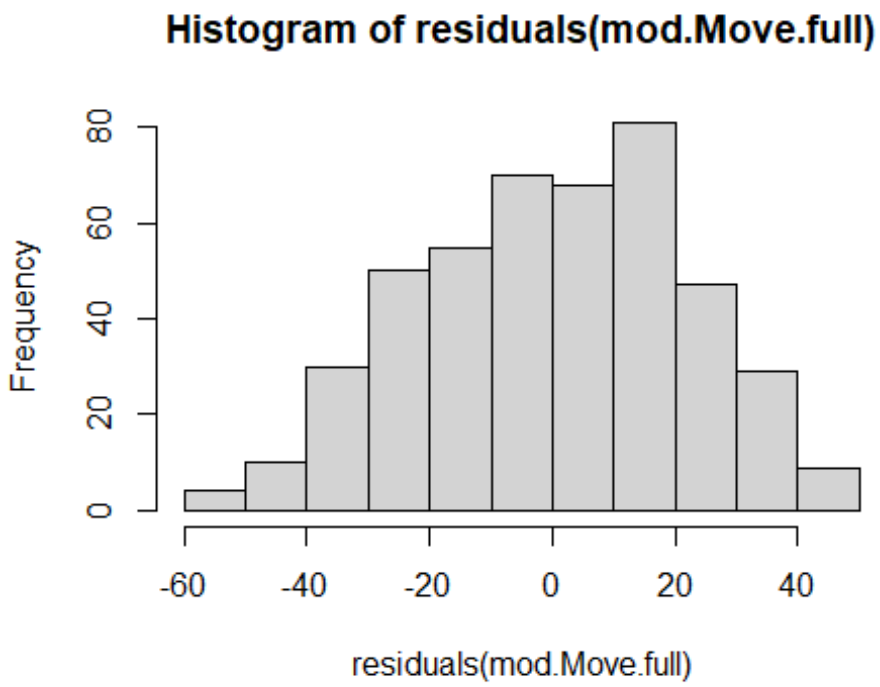
```
mod.Move.full <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Code) +
```

```
(1|Site), data = MixedData, REML = TRUE, na.action=na.exclude)

summary(mod.Move.full)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scaled +
##     Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled +
##     urban.1000.Scaled + water.1000.Scaled + (1 | Code) + (1 |      Site)
##    Data: MixedData
##
## REML criterion at convergence: 4604.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.94964 -0.52458  0.06559  0.55080  1.67014
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 756.5    27.50
##  Site     (Intercept) 231.9    15.23
##  Residual             894.8    29.91
## Number of obs: 453, groups:  Code, 429; Site, 23
##
## Fixed effects:
##                     Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)          89.7725     4.7506  29.2985  18.897   <2e-16 ***
## CalendarDate.Scaled   2.8778     4.5793  19.6989   0.628   0.5369
## A.Temp.Scaled        -1.6130     3.4232 105.3638  -0.471   0.6385
## Time.Scaled           1.2102     2.1178 432.5464   0.571   0.5680
## PL.Scaled            -0.6353     2.5282 429.7145  -0.251   0.8017
## SexM                  4.9045     4.5844 422.3354   1.070   0.2853
## for.veg.300.Scaled    0.3362     6.6030  15.7704   0.051   0.9600
## wet.600.Scaled       -0.8010     4.8360  16.8054  -0.166   0.8704
## agri.100.Scaled       7.6336     4.2909  19.6989   1.779   0.0907 .
## urban.1000.Scaled     5.9955     5.8880  16.6737   1.018   0.3231
## water.1000.Scaled    -3.2380     4.6730  15.5003  -0.693   0.4986
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl SexM   f..300 w.600. a.100.
## ClndrDt.Scl -0.056
## A.Temp.Scld  0.090 -0.404
## Time.Scaled  0.045  0.101 -0.227
## PL.Scaled   -0.280 -0.022 -0.050 -0.038
## SexM        -0.557  0.050 -0.108 -0.053  0.467
## fr.vg.300.S  0.110 -0.022 -0.127 -0.024  0.039  0.011
## wt.600.Scld -0.005 -0.329  0.005 -0.017  0.064  0.012  0.498
```

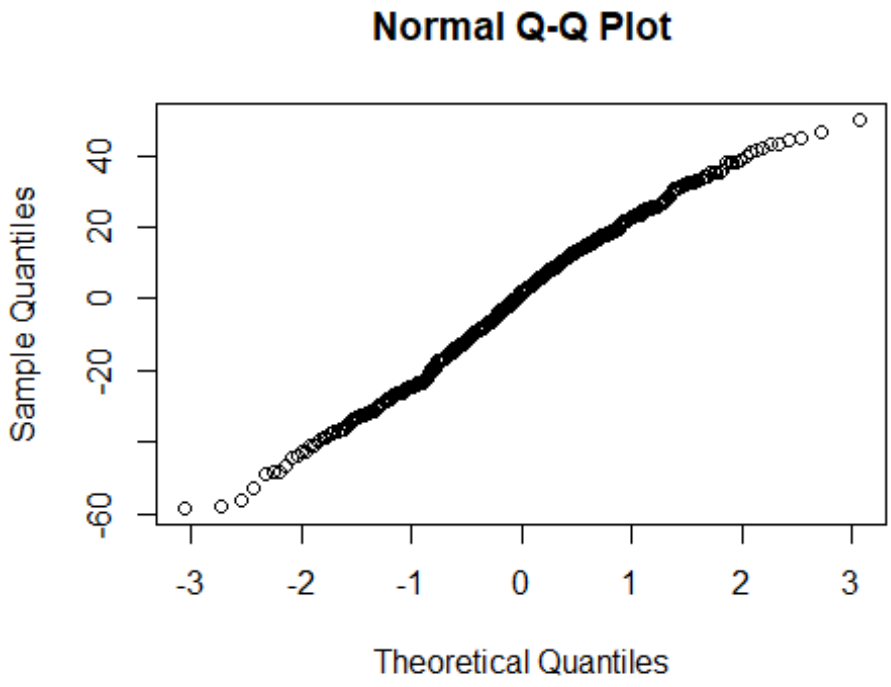
```
## agr.100.Scl  0.032  0.008 -0.057  0.011  0.012 -0.034  0.592  0.343
## urbn.1000.S  0.003 -0.194 -0.007 -0.004  0.034  0.043  0.686  0.591  0.308
## wtr.1000.Sc  0.010 -0.260 -0.023 -0.029 -0.028 -0.015  0.553  0.489  0.413
##              u.1000
## ClndrDt.Scl
## A.Temp.Scld
## Time.Scaled
## PL.Scaled
## SexM
## fr.vg.300.S
## wt.600.Scld
## agr.100.Scl
## urbn.1000.S
## wtr.1000.Sc  0.558

plot(mod.Move.full)
```




```
hist(residuals(mod.Move.full))
```




```
qqnorm(resid(mod.Move.full))
```



Model selection

Active defensive behaviours

Random variable

I am testing the significance of turtle ID and site identity by using likelihood ratio tests to see if the addition of these random variables has a significant effect on the initial model. I am using a dummy variable (the same value for all the observations) to create a null mixed model to compared with the different combinations of mixed models.

Creation of the different mixed models

```
## Null mixed model
mod.Aggression.null <- lmer(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Dummy), data = MixedData,
na.action=na.exclude, control=lmerControl(check.nlev.gtr.1="ignore"), REML =
FALSE)

## only site identity as random variable
mod.Aggression.dummy.site <- lmer(Aggression ~ CalendarDate.Scaled +
A.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.200.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.400.Scaled + (1|Dummy) +
(1|Site), data = MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

## only turtle ID as random variable
mod.Aggression.dummy.code <- lmer(Aggression ~ CalendarDate.Scaled +
A.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.200.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.400.Scaled + (1|Dummy) +
(1|Code), data = MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)
```

Likelihood ratio tests between the mixed models

```
#anova with null model and dummy + site model
anova(mod.Aggression.null, mod.Aggression.dummy.site)

## Data: MixedData
## Models:
## mod.Aggression.null: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1 | Dummy)
## mod.Aggression.dummy.site: Aggression ~ CalendarDate.Scaled +
A.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.200.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.400.Scaled + (1 | Dummy) + (1 |
Site)
##                           npar    AIC    BIC  logLik deviance  Chisq Df
## mod.Aggression.null         12 1519.2 1570.3 -747.61   1495.2
```

```
## mod.Aggression.dummy.site   13 1521.2 1576.5 -747.59   1495.2 0.0522  1
##                            Pr(>Chisq)
## mod.Aggression.null
## mod.Aggression.dummy.site     0.8192

#anova with null model and dummy + code model
anova(mod.Aggression.null, mod.Aggression.dummy.code)

## Data: MixedData
## Models:
## mod.Aggression.null: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1 | Dummy)
## mod.Aggression.dummy.code: Aggression ~ CalendarDate.Scaled +
A.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.200.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.400.Scaled + (1 | Dummy) + (1 |
Code)
##                            npar    AIC    BIC  logLik deviance  Chisq Df
## mod.Aggression.null          12 1519.2 1570.3 -747.61   1495.2
## mod.Aggression.dummy.code    13 1486.8 1542.2 -730.41   1460.8 34.397  1
##                            Pr(>Chisq)
## mod.Aggression.null
## mod.Aggression.dummy.code  4.494e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

If a test has a significant p-value (less than 0.05) then the random effect is significant.Turtle ID (Code) is significant by itself but site identity (Site) is not. I will see if Code and Site together are more significant then Code by itself.

```
## turtle ID without the dummy variable
mod.Aggression.code <- lmer(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData,
na.action=na.exclude, control=lmerControl(check.nlev.gtr.1="ignore"), REML =
FALSE)

## turtle ID and site identity without the dummy variable
mod.Aggression.code.site <- lmer(Aggression ~ CalendarDate.Scaled +
A.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.200.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.400.Scaled + (1|Code) + (1|Site),
data = MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

#anova with code model and code + site model
anova(mod.Aggression.code, mod.Aggression.code.site)

## Data: MixedData
## Models:
## mod.Aggression.code: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
```

```
urban.1000.Scaled + water.400.Scaled + (1 | Code)
## mod.Aggression.code.site: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1 | Code) + (1 | Site)
##                          npar    AIC    BIC  logLik deviance Chisq Df
## mod.Aggression.code        12 1484.8 1535.9 -730.41   1460.8
## mod.Aggression.code.site   13 1486.8 1542.2 -730.41   1460.8 8e-04  1
##                          Pr(>Chisq)
## mod.Aggression.code
## mod.Aggression.code.site     0.9772
```

Code and Site together are not more significant then Code by itself ($p > 0.05$), so I will only keep Code.

Predictor variables

I am selecting the final model with a backward selection procedure. At each step, I deleted the fixed effect with the highest p value. I confirmed the deletion of each fixed effect with a likelihood ratio test. I created a new dataset at each step to use only the rows with complete observations for all the fixed effects, so that the likelihood ratio tests do not run between two models with a different number of observations.

```
mod.Aggression.full <- lmer(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData,
na.action=na.exclude, REML = FALSE)
summary(mod.Aggression.full)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled
+
##     water.400.Scaled + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1484.8   1535.9   -730.4   1460.8      510
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.60879 -0.32199 -0.05001  0.31016  1.57965
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 0.8978   0.9475
##  Residual             0.1433   0.3785
## Number of obs: 522, groups:  Code, 492
##
```

```
## Fixed effects:
##                       Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)            0.99134    0.07176 416.06835  13.815  < 2e-16 ***
## CalendarDate.Scaled   -0.06446    0.05923 513.61544  -1.088  0.27698
## A.Temp.Scaled          0.14055    0.05411 490.26081   2.597  0.00968 **
## Time.Scaled           -0.03584    0.04230 328.28211  -0.847  0.39746
## PL.Scaled             -0.03876    0.05547 492.74772  -0.699  0.48508
## SexM                   0.05669    0.09405 251.64085   0.603  0.54720
## wet.200.Scaled        -0.04635    0.05135 495.02947  -0.903  0.36713
## agri.100.Scaled       -0.06135    0.04946 493.06408  -1.240  0.21538
## urban.1000.Scaled      0.09016    0.04996 492.73077   1.805  0.07172 .
## water.400.Scaled       0.13219    0.04929 492.59868   2.682  0.00757 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.200. a.100. u.1000
## ClndrDt.Scl -0.073
## A.Temp.Scld  0.069 -0.523
## Time.Scaled  0.030  0.162 -0.242
## PL.Scaled   -0.378 -0.051 -0.068 -0.014
## SexM        -0.767  0.068 -0.059 -0.051  0.461
## wt.200.Scld -0.042 -0.312  0.109  0.011  0.097  0.025
## agr.100.Scl  0.084  0.090 -0.015  0.033 -0.088 -0.104  0.013
## urbn.1000.S -0.074 -0.045 -0.023  0.017  0.015  0.077  0.319 -0.223
## wtr.400.Scl  0.048  0.154 -0.074  0.005 -0.138 -0.074  0.173  0.198  0.117
```

I deleted turtle sex (Sex).

```
mod.Aggression.1 <- lmer(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData,
na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Aggression,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$Sex,
MixedData$wet.200.Scaled, MixedData$agri.100.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.400.Scaled),]

mod.full.adjust <- lmer(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

mod.Aggression.1.adjust <- lmer(Aggression ~ CalendarDate.Scaled +
A.Temp.Scaled + Time.Scaled + PL.Scaled + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)
```

```
anova(mod.Aggression.1.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Aggression.1.adjust: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1 | Code)
## mod.full.adjust: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1 | Code)
##                          npar    AIC    BIC  logLik deviance  Chisq Df
## mod.Aggression.1.adjust   11 1483.2 1530.0 -730.59   1461.2
## mod.full.adjust           12 1484.8 1535.9 -730.41   1460.8 0.3555  1
##                          Pr(>Chisq)
## mod.Aggression.1.adjust
## mod.full.adjust              0.551
```

```
summary(mod.Aggression.1)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled +
##     water.400.Scaled + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1528.6   1575.7   -753.3   1506.6      524
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.93844 -0.39021 -0.05932  0.37266  2.46919
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 0.8257   0.9087
##  Residual             0.2124   0.4608
## Number of obs: 535, groups:  Code, 504
##
## Fixed effects:
##                      Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)           1.02630    0.04530 500.68223  22.653  < 2e-16 ***
## CalendarDate.Scaled  -0.05129    0.05874 518.60051  -0.873  0.38300
## A.Temp.Scaled         0.13273    0.05427 531.82399   2.446  0.01478 *
## Time.Scaled          -0.01832    0.04320 427.49445  -0.424  0.67171
## PL.Scaled            -0.06187    0.04531 530.22999  -1.365  0.17271
## wet.200.Scaled       -0.05092    0.05084 508.59182  -1.002  0.31700
## agri.100.Scaled      -0.04561    0.04831 501.97540  -0.944  0.34559
## urban.1000.Scaled     0.08383    0.04924 504.46854   1.702  0.08929 .
```

```
## water.400.Scaled      0.14028    0.04786 503.15370   2.931  0.00353 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl w.200. a.100. u.1000
## ClndrDt.Scl -0.033
## A.Temp.Scld  0.021 -0.529
## Time.Scaled  0.001  0.168 -0.235
## PL.Scaled    0.021 -0.096 -0.012 -0.022
## wt.200.Scld -0.021 -0.317  0.123  0.002  0.065
## agr.100.Scl -0.002  0.101 -0.025  0.026 -0.017  0.016
## urbn.1000.S -0.021 -0.042 -0.019  0.012 -0.035  0.313 -0.225
## wtr.400.Scl -0.031  0.154 -0.091  0.010 -0.089  0.181  0.187  0.133
```

I deleted time of testing (Time).

```
mod.Aggression.2 <- lmer(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
PL.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled +
water.400.Scaled + (1|Code), data = MixedData, na.action=na.exclude, REML =
FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Aggression,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$wet.200.Scaled,
MixedData$agri.100.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.400.Scaled),]

mod.full.adjust <- lmer(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

mod.Aggression.2.adjust <- lmer(Aggression ~ CalendarDate.Scaled +
A.Temp.Scaled + PL.Scaled + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

anova(mod.Aggression.2.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Aggression.2.adjust: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled
+ PL.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled +
water.400.Scaled + (1 | Code)
## mod.full.adjust: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + wet.200.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.400.Scaled + (1 | Code)
##                         npar    AIC    BIC  logLik deviance  Chisq Df
## mod.Aggression.2.adjust   10 1526.8 1569.6 -753.38   1506.8
```

```
## mod.full.adjust           11 1528.6 1575.7 -753.29   1506.6 0.1798  1
##                          Pr(>Chisq)
## mod.Aggression.2.adjust
## mod.full.adjust             0.6715
```

```
summary(mod.Aggression.2)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled + PL.Scaled +
##     wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled +
water.400.Scaled +
##     (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1526.8   1569.6   -753.4   1506.8      525
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.90627 -0.39311 -0.06746  0.37682  2.42856
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 0.8259   0.9088
##  Residual             0.2125   0.4610
## Number of obs: 535, groups:  Code, 504
##
## Fixed effects:
##                      Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)           1.02632    0.04531 500.63443  22.650  < 2e-16 ***
## CalendarDate.Scaled  -0.04711    0.05792 519.45485  -0.813  0.41638
## A.Temp.Scaled         0.12731    0.05276 529.72570   2.413  0.01616 *
## PL.Scaled            -0.06229    0.04531 530.44429  -1.375  0.16976
## wet.200.Scaled       -0.05088    0.05085 508.54422  -1.001  0.31744
## agri.100.Scaled      -0.04508    0.04830 501.83505  -0.933  0.35111
## urban.1000.Scaled     0.08408    0.04924 504.42215   1.707  0.08837 .
## water.400.Scaled      0.14048    0.04786 503.19256   2.935  0.00349 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S PL.Scl w.200. a.100. u.1000
## ClndrDt.Scl -0.033
## A.Temp.Scld  0.022 -0.511
## PL.Scaled    0.021 -0.094 -0.017
## wt.200.Scld -0.021 -0.321  0.127  0.065
## agr.100.Scl -0.002  0.098 -0.020 -0.016  0.016
## urbn.1000.S -0.021 -0.045 -0.016 -0.035  0.313 -0.226
## wtr.400.Scl -0.031  0.154 -0.092 -0.089  0.181  0.187  0.133
```

I deleted Calendar date of testing (CalendarDate).

```
mod.Aggression.3 <- lmer(Aggression ~ A.Temp.Scaled + PL.Scaled +
wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled + water.400.Scaled +
(1|Code), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Aggression,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled, MixedData$PL.Scaled,
MixedData$wet.200.Scaled, MixedData$agri.100.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.400.Scaled),]

mod.full.adjust <- lmer(Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
PL.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled +
water.400.Scaled + (1|Code), data = MixedData.adjust, na.action=na.exclude,
REML = FALSE)

mod.Aggression.3.adjust <- lmer(Aggression ~ A.Temp.Scaled + PL.Scaled +
wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled + water.400.Scaled +
(1|Code), data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

anova(mod.Aggression.3.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Aggression.3.adjust: Aggression ~ A.Temp.Scaled + PL.Scaled +
wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled + water.400.Scaled + (1
| Code)
## mod.full.adjust: Aggression ~ CalendarDate.Scaled + A.Temp.Scaled +
PL.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled +
water.400.Scaled + (1 | Code)
##                          npar    AIC    BIC  logLik deviance  Chisq Df
## mod.Aggression.3.adjust    9 1525.4 1564.0 -753.71   1507.4
## mod.full.adjust           10 1526.8 1569.6 -753.38   1506.8 0.6609  1
##                          Pr(>Chisq)
## mod.Aggression.3.adjust
## mod.full.adjust             0.4162
```

```
summary(mod.Aggression.3)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Aggression ~ A.Temp.Scaled + PL.Scaled + wet.200.Scaled + agri.100.Scaled
+
##     urban.1000.Scaled + water.400.Scaled + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1525.4   1564.0   -753.7   1507.4      526
##
```

```
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.89243 -0.39528 -0.07591  0.38030  2.43447
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 0.8258   0.9088
##  Residual             0.2137   0.4622
## Number of obs: 535, groups:  Code, 504
##
## Fixed effects:
##                    Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         1.02509    0.04531 500.81975  22.625  < 2e-16 ***
## A.Temp.Scaled       0.10532    0.04536 534.99437   2.322  0.02063 *
## PL.Scaled          -0.06569    0.04513 530.40418  -1.456  0.14611
## wet.200.Scaled     -0.06418    0.04817 504.98435  -1.332  0.18340
## agri.100.Scaled    -0.04122    0.04809 501.88280  -0.857  0.39178
## urban.1000.Scaled   0.08227    0.04922 503.91281   1.672  0.09522 .
## water.400.Scaled    0.14648    0.04731 503.27379   3.096  0.00207 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) A.Tm.S PL.Scl w.200. a.100. u.1000
## A.Temp.Scld  0.006
## PL.Scaled    0.018 -0.076
## wt.200.Scld -0.033 -0.046  0.037
## agr.100.Scl  0.001  0.036 -0.007  0.050
## urbn.1000.S -0.023 -0.046 -0.039  0.316 -0.223
## wtr.400.Scl -0.026 -0.015 -0.076  0.246  0.175  0.142
```

I deleted proportion of agricultural area at 100m (agri.100).

```
mod.Aggression.4 <- lmer(Aggression ~ A.Temp.Scaled + PL.Scaled +
wet.200.Scaled + urban.1000.Scaled + water.400.Scaled + (1|Code), data =
MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Aggression,
MixedData$A.Temp.Scaled, MixedData$PL.Scaled, MixedData$wet.200.Scaled,
MixedData$agri.100.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.400.Scaled),]

mod.full.adjust <- lmer(Aggression ~ A.Temp.Scaled + PL.Scaled +
wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled + water.400.Scaled +
(1|Code), data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Aggression.4.adjust <- lmer(Aggression ~ A.Temp.Scaled + PL.Scaled +
wet.200.Scaled + urban.1000.Scaled + water.400.Scaled + (1|Code), data =
MixedData.adjust, na.action=na.exclude, REML = FALSE)
```

```
anova(mod.Aggression.4.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Aggression.4.adjust: Aggression ~ A.Temp.Scaled + PL.Scaled +
wet.200.Scaled + urban.1000.Scaled + water.400.Scaled + (1 | Code)
## mod.full.adjust: Aggression ~ A.Temp.Scaled + PL.Scaled + wet.200.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.400.Scaled + (1 | Code)
##                         npar    AIC    BIC  logLik deviance Chisq Df
Pr(>Chisq)
## mod.Aggression.4.adjust    8 1524.2 1558.4 -754.07   1508.2
## mod.full.adjust            9 1525.4 1564.0 -753.71   1507.4 0.734  1
0.3916
```

```
summary(mod.Aggression.4)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Aggression ~ A.Temp.Scaled + PL.Scaled + wet.200.Scaled +
urban.1000.Scaled +
##     water.400.Scaled + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1524.1   1558.4   -754.1   1508.1      527
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.89448 -0.38885 -0.07051  0.38111  2.43647
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 0.8279   0.9099
##  Residual             0.2133   0.4618
## Number of obs: 535, groups:  Code, 504
##
## Fixed effects:
##                    Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         1.02512    0.04534 500.93942  22.608  < 2e-16 ***
## A.Temp.Scaled       0.10675    0.04537 534.99140   2.353  0.01898 *
## PL.Scaled          -0.06600    0.04517 530.47415  -1.461  0.14453
## wet.200.Scaled     -0.06210    0.04815 505.23814  -1.290  0.19776
## urban.1000.Scaled   0.07288    0.04802 503.27997   1.518  0.12973
## water.400.Scaled    0.15356    0.04662 503.63761   3.294  0.00106 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
```

```
##             (Intr) A.Tm.S PL.Scl w.200. u.1000
## A.Temp.Scld  0.006
## PL.Scaled    0.018 -0.076
## wt.200.Scld -0.033 -0.048  0.038
## urbn.1000.S -0.023 -0.039 -0.042  0.336
## wtr.400.Scl -0.027 -0.022 -0.076  0.241  0.189
```

I deleted proportion of wetland area at 200m (wet.200).

```
mod.Aggression.5 <- lmer(Aggression ~ A.Temp.Scaled + PL.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData,
na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Aggression,
MixedData$A.Temp.Scaled, MixedData$PL.Scaled, MixedData$wet.200.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.400.Scaled),]

mod.full.adjust <- lmer(Aggression ~ A.Temp.Scaled + PL.Scaled +
wet.200.Scaled + urban.1000.Scaled + water.400.Scaled + (1|Code), data =
MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Aggression.5.adjust <- lmer(Aggression ~ A.Temp.Scaled + PL.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

anova(mod.Aggression.5.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Aggression.5.adjust: Aggression ~ A.Temp.Scaled + PL.Scaled +
urban.1000.Scaled + water.400.Scaled + (1 | Code)
## mod.full.adjust: Aggression ~ A.Temp.Scaled + PL.Scaled + wet.200.Scaled +
urban.1000.Scaled + water.400.Scaled + (1 | Code)
##                          npar    AIC    BIC  logLik deviance  Chisq Df
## mod.Aggression.5.adjust    7 1523.8 1553.8 -754.90   1509.8
## mod.full.adjust            8 1524.2 1558.4 -754.07   1508.2 1.6606  1
##                          Pr(>Chisq)
## mod.Aggression.5.adjust
## mod.full.adjust             0.1975
```

```
summary(mod.Aggression.5)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Aggression ~ A.Temp.Scaled + PL.Scaled + urban.1000.Scaled +
##     water.400.Scaled + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1523.8   1553.8   -754.9   1509.8      528
##
```

```
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.88555 -0.38883 -0.06362  0.39251  2.44042
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 0.8306   0.9114
##  Residual             0.2137   0.4623
## Number of obs: 535, groups:  Code, 504
##
## Fixed effects:
##                    Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         1.02318    0.04539 501.20871  22.542  < 2e-16 ***
## A.Temp.Scaled       0.10395    0.04538 534.99225   2.290 0.022383 *
## PL.Scaled          -0.06381    0.04520 530.40562  -1.412 0.158673
## urban.1000.Scaled   0.09366    0.04530 504.79137   2.067 0.039204 *
## water.400.Scaled    0.16806    0.04532 504.82354   3.708 0.000232 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) A.Tm.S PL.Scl u.1000
## A.Temp.Scld  0.004
## PL.Scaled    0.019 -0.074
## urbn.1000.S -0.013 -0.024 -0.058
## wtr.400.Scl -0.019 -0.011 -0.088  0.118
```

I deleted plastron length (PL).

```
mod.Aggression.6 <- lmer(Aggression ~ A.Temp.Scaled + urban.1000.Scaled +
water.400.Scaled + (1|Code), data = MixedData, na.action=na.exclude, REML =
FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Aggression,
MixedData$A.Temp.Scaled, MixedData$PL.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.400.Scaled),]

mod.full.adjust <- lmer(Aggression ~ A.Temp.Scaled + PL.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

mod.Aggression.6.adjust <- lmer(Aggression ~ A.Temp.Scaled +
urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

anova(mod.Aggression.6.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Aggression.6.adjust: Aggression ~ A.Temp.Scaled + urban.1000.Scaled +
```

```
water.400.Scaled + (1 | Code)
## mod.full.adjust: Aggression ~ A.Temp.Scaled + PL.Scaled +
urban.1000.Scaled + water.400.Scaled + (1 | Code)
##                          npar    AIC    BIC logLik deviance Chisq Df
Pr(>Chisq)
## mod.Aggression.6.adjust    6 1523.8 1549.5 -755.9   1511.8
## mod.full.adjust            7 1523.8 1553.8 -754.9   1509.8 1.983  1
0.1591

summary(mod.Aggression.6)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Aggression ~ A.Temp.Scaled + urban.1000.Scaled + water.400.Scaled
+
##     (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1525.7   1551.4   -756.8   1513.7      530
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.84490 -0.38534 -0.05837  0.39662  2.43163
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 0.8264   0.9091
##  Residual             0.2187   0.4677
## Number of obs: 536, groups:  Code, 505
##
## Fixed effects:
##                    Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         1.02412    0.04535 502.37553  22.583  < 2e-16 ***
## A.Temp.Scaled       0.09838    0.04513 535.87535   2.180 0.029684 *
## urban.1000.Scaled   0.08987    0.04524 505.62984   1.987 0.047510 *
## water.400.Scaled    0.16271    0.04514 506.00437   3.605 0.000344 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) A.Tm.S u.1000
## A.Temp.Scld  0.002
## urbn.1000.S -0.012 -0.030
## wtr.400.Scl -0.016 -0.015  0.114
```

All of the fixed effects are statistically significant, so I will stop the backwards selection process.

Final model

Summary statistics

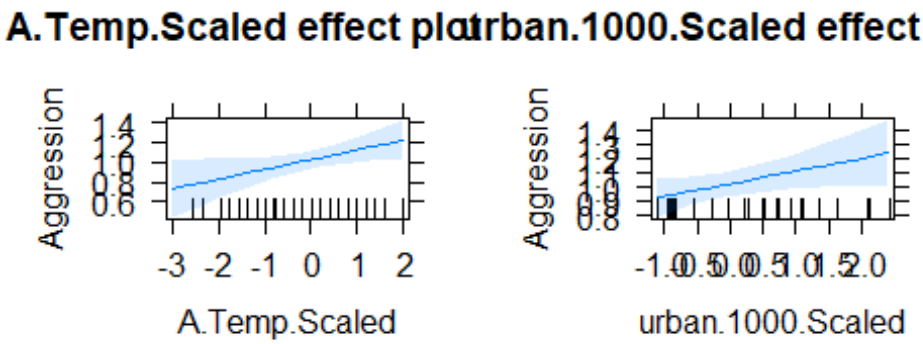
I changed the REML to TRUE to calculate the summary statistics of the final model.

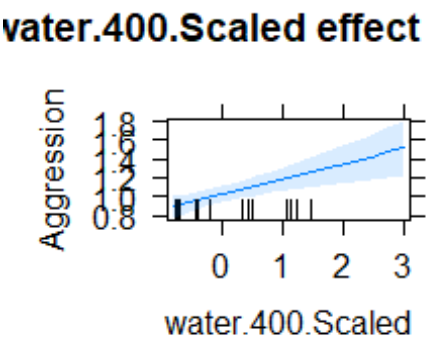
```
mod.Aggression.final <- lmer(Aggression ~ A.Temp.Scaled + urban.1000.Scaled +
water.400.Scaled + (1|Code), data = MixedData, na.action=na.exclude, REML =
TRUE)
summary(mod.Aggression.final)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Aggression ~ A.Temp.Scaled + urban.1000.Scaled + water.400.Scaled
+
##     (1 | Code)
##    Data: MixedData
##
## REML criterion at convergence: 1531.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.84545 -0.38266 -0.05814  0.39317  2.42771
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 0.8343   0.9134
##  Residual             0.2191   0.4680
## Number of obs: 536, groups:  Code, 505
##
## Fixed effects:
##                    Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         1.02412    0.04553 498.54384  22.495  < 2e-16 ***
## A.Temp.Scaled       0.09844    0.04530 531.88334   2.173 0.030203 *
## urban.1000.Scaled   0.08987    0.04542 501.74100   1.979 0.048389 *
## water.400.Scaled    0.16269    0.04532 502.10846   3.590 0.000363 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) A.Tm.S u.1000
## A.Temp.Scld  0.002
## urbn.1000.S -0.012 -0.030
## wtr.400.Scl -0.016 -0.015  0.114
```

Visualization of the predictor effects

```
plot(allEffects(mod.Aggression.final))
```





Calculation of the marginal and conditional variance explained by the final model

```
r.squaredGLMM(mod.Aggression.final)

##              R2m       R2c
## [1,] 0.03730533 0.7997945
```

Marginal R2: fixed effects R2. Conditional R2: fixed and random effects R2.

Calculation of the 95% confidence intervals

```
confint(mod.Aggression.final, level = 0.95, method = "Wald")

##                             2.5 %    97.5 %
## .sig01                         NA        NA
## .sigma                         NA        NA
## (Intercept)         0.9348892047 1.1133529
## A.Temp.Scaled       0.0096607255 0.1872179
## urban.1000.Scaled   0.0008539708 0.1788790
## water.400.Scaled    0.0738757498 0.2515142
```

Creation of the prediction figure for urban area at 1000m

```
pred.con.model.Aggression.urban.1000 <- ggpredict(mod.Aggression.final, terms
= "urban.1000.Scaled")
pred.con.model.Aggression.urban.1000
```

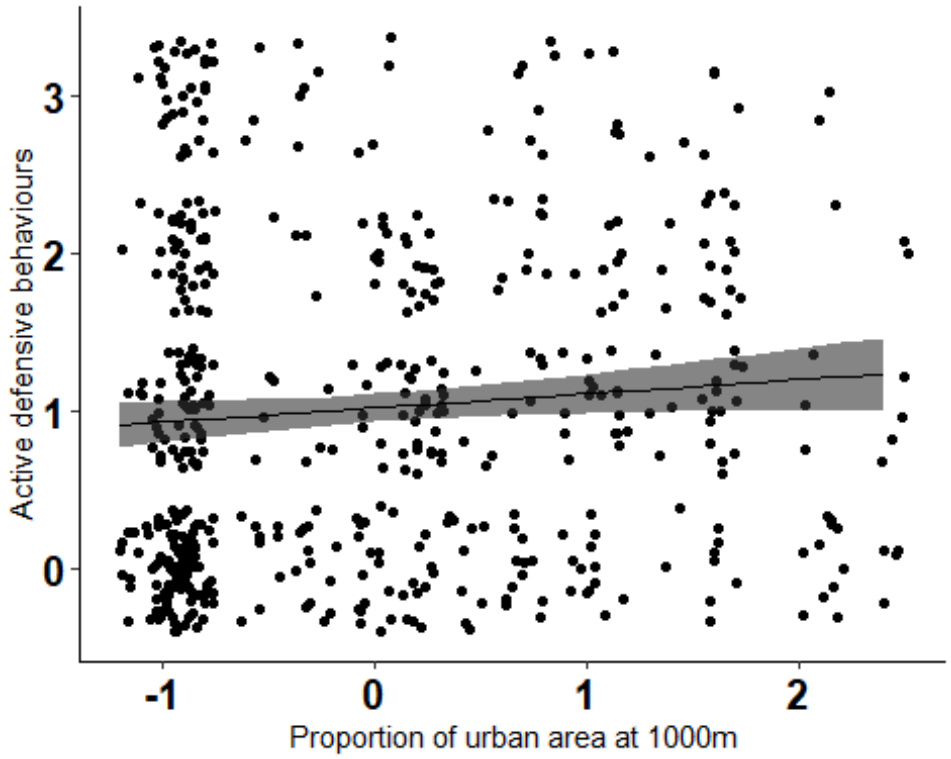
```
## # Predicted values of Aggression
##
## urban.1000.Scaled | Predicted |       95% CI
## ------------------------------------------
##             -1.20 |      0.92 | [0.78, 1.06]
##             -0.80 |      0.95 | [0.84, 1.07]
##             -0.20 |      1.01 | [0.91, 1.10]
##              0.20 |      1.04 | [0.95, 1.13]
##              0.60 |      1.08 | [0.97, 1.18]
##              1.00 |      1.11 | [0.99, 1.24]
##              1.40 |      1.15 | [1.00, 1.30]
##              2.40 |      1.24 | [1.01, 1.47]
##
## Adjusted for:
## *    A.Temp.Scaled = 0.00
## * water.400.Scaled = 0.00
## *             Code = 0 (population-level)
```

```
# New dataset to only have complete observations for all the variables
MixedData.adjust.final.model.Aggression <-
MixedData[complete.cases(MixedData$A.Temp.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.400.Scaled),]
```

Figure for proportion of urban area at 1000m

Data was jittered.

```
graph.con.Aggression.urban.1000 <-
ggplot(data=pred.con.model.Aggression.urban.1000, aes(x, predicted)) +
geom_point(data=MixedData, aes(urban.1000.Scaled, Aggression), position =
position_jitter(width = 0.1)) +
  geom_ribbon(data=pred.con.model.Aggression.urban.1000, aes(ymin=conf.low,
ymax= conf.high), alpha=0.6) +
  geom_line(data=pred.con.model.Aggression.urban.1000, color="black")+
    theme_bw() + theme(panel.border = element_blank(),
                       panel.grid.major = element_blank(),
                       panel.grid.minor = element_blank(),
                       axis.line = element_line(colour = "black")) +
  theme(axis.text=element_text(size=15, colour="black",face = "bold")) +
  ylab("Active defensive behaviours") +
  xlab("Proportion of urban area at 1000m")

graph.con.Aggression.urban.1000
```



Model selection

Time of shell emergence (binary)

Random variable

I am testing the significance of turtle ID and site identity by using likelihood ratio tests to see if the addition of these random variables make a significant effect on the initial model. I am using a dummy variable (same value for all the observations) to create a null mixed model to compared with the different combinations of mixed models.

Creation of the different mixed models

```
## Null mixed model
mod.Bin.Shell.null <- glmer(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1|Dummy), data = MixedData, family =
binomial, control=glmerControl(check.nlev.gtr.1="ignore"),
na.action=na.exclude)

## only site identity as random variable
mod.Bin.Shell.dummy.site <- glmer(Bin.Shell ~ CalendarDate.Scaled +
A.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.300.Scaled +
agri.1000.Scaled + urban.1000.Scaled + water.900.Scaled + (1|Dummy) +
(1|Site), data = MixedData, family = binomial,
control=glmerControl(check.nlev.gtr.1="ignore"), na.action=na.exclude)
```

```
## only turtle ID as random variable
mod.Bin.Shell.dummy.code <- glmer(Bin.Shell ~ CalendarDate.Scaled +
A.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.300.Scaled +
agri.1000.Scaled + urban.1000.Scaled + water.900.Scaled + (1|Dummy) +
(1|Code), data = MixedData, family = binomial,
control=glmerControl(check.nlev.gtr.1="ignore"), na.action=na.exclude)
```

Likelihood ratio tests between the mixed models

```
#anova with null model and dummy + site model
anova(mod.Bin.Shell.null, mod.Bin.Shell.dummy.site)

## Data: MixedData
## Models:
## mod.Bin.Shell.null: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1 | Dummy)
## mod.Bin.Shell.dummy.site: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1 | Dummy) + (1 | Site)
##                          npar    AIC    BIC  logLik deviance  Chisq Df
## mod.Bin.Shell.null         11 636.60 683.09 -307.30   614.60
## mod.Bin.Shell.dummy.site   12 638.52 689.24 -307.26   614.52 0.0737  1
##                          Pr(>Chisq)
## mod.Bin.Shell.null
## mod.Bin.Shell.dummy.site      0.786

#anova with null model and dummy + code model
anova(mod.Bin.Shell.null, mod.Bin.Shell.dummy.code)

## Data: MixedData
## Models:
## mod.Bin.Shell.null: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1 | Dummy)
## mod.Bin.Shell.dummy.code: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1 | Dummy) + (1 | Code)
##                          npar    AIC    BIC  logLik deviance  Chisq Df
## mod.Bin.Shell.null         11 636.60 683.09 -307.30   614.60
## mod.Bin.Shell.dummy.code   12 637.56 688.28 -306.78   613.56 1.0357  1
##                          Pr(>Chisq)
## mod.Bin.Shell.null
## mod.Bin.Shell.dummy.code     0.3088
```

If a test has a significant p-value (less than 0.05) then the random effect is significant. Turtle ID (Code) and site identity (Site) are not significant by themselves so I will see if they are more significant together.

```r
## Turtle ID without the dummy variable
mod.Bin.Shell.code <- glmer(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1|Code), data = MixedData, family =
binomial, control=glmerControl(check.nlev.gtr.1="ignore"),
na.action=na.exclude)

## Site identity without the dummy variable
mod.Bin.Shell.site <- glmer(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1|Site), data = MixedData, family =
binomial, control=glmerControl(check.nlev.gtr.1="ignore"),
na.action=na.exclude)

## Turtle and site identity without the dummy variable
mod.Bin.Shell.code.site <- glmer(Bin.Shell ~ CalendarDate.Scaled +
A.Temp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.300.Scaled +
agri.1000.Scaled + urban.1000.Scaled + water.900.Scaled + (1|Code) +
(1|Site), data = MixedData, family = binomial,
control=glmerControl(check.nlev.gtr.1="ignore"), na.action=na.exclude)

#anova with code model and code + site model
anova(mod.Bin.Shell.code, mod.Bin.Shell.code.site)

## Data: MixedData
## Models:
## mod.Bin.Shell.code: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1 | Code)
## mod.Bin.Shell.code.site: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1 | Code) + (1 | Site)
##                         npar    AIC    BIC  logLik deviance Chisq Df
Pr(>Chisq)
## mod.Bin.Shell.code        11 635.56 682.05 -306.78   613.56
## mod.Bin.Shell.code.site   12 637.56 688.28 -306.78   613.56 9e-04  1
0.9758

#anova with site model and code + site model
anova(mod.Bin.Shell.site, mod.Bin.Shell.code.site)

## Data: MixedData
## Models:
## mod.Bin.Shell.site: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1 | Site)
## mod.Bin.Shell.code.site: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled + (1 | Code) + (1 | Site)
##                         npar    AIC    BIC  logLik deviance  Chisq Df
## mod.Bin.Shell.site        11 636.52 683.01 -307.26   614.52
```

```
## mod.Bin.Shell.code.site   12 637.56 688.28 -306.78   613.56 0.9623  1
##                          Pr(>Chisq)
## mod.Bin.Shell.site
## mod.Bin.Shell.code.site     0.3266
```

Site and Code are not more significant together ($p > 0.05$), so I will not keep any of the random effects.

Predictor variables

I am selecting the final model with a backward selection procedure. At each step, I deleted the fixed effect with the highest p value. I confirmed the deletion of each fixed effect with a likelihood ratio test. I created a new dataset at each step to use only the rows with complete observations for all the fixed effects, so that the likelihood ratio tests do not run between two models with a different number of observations.

```
mod.Bin.Shell.full <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled, data = MixedData, family = binomial,
na.action=na.exclude)

summary(mod.Bin.Shell.full)

##
## Call:
## glm(formula = Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
##     Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
##     urban.1000.Scaled + water.900.Scaled, family = binomial,
##     data = MixedData, na.action = na.exclude)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.0259  -0.9577  -0.6259   1.0474   2.0174
##
## Coefficients:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)         -0.25033    0.16361  -1.530 0.126007
## CalendarDate.Scaled -0.48214    0.12832  -3.757 0.000172 ***
## A.Temp.Scaled       -0.40595    0.12447  -3.261 0.001108 **
## Time.Scaled         -0.28796    0.11140  -2.585 0.009743 **
## PL.Scaled            0.20347    0.12329   1.650 0.098851 .
## SexM                -0.06964    0.22757  -0.306 0.759583
## wet.300.Scaled       0.22514    0.11105   2.027 0.042618 *
## agri.1000.Scaled    -0.00587    0.10625  -0.055 0.955941
## urban.1000.Scaled   -0.24275    0.10823  -2.243 0.024906 *
## water.900.Scaled    -0.01244    0.10186  -0.122 0.902753
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 694.8  on 505  degrees of freedom
## Residual deviance: 614.6  on 496  degrees of freedom
##   (30 observations deleted due to missingness)
## AIC: 634.6
##
## Number of Fisher Scoring iterations: 4
```

I deleted proportion of agricultural area at 1000m (agri.1000).

```
mod.Bin.Shell.1 <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled +
water.900.Scaled, data = MixedData, family = binomial, na.action=na.exclude)

MixedData.adjust <- MixedData[complete.cases(MixedData$Bin.Shell,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$Sex,
MixedData$wet.300.Scaled, MixedData$agri.1000.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.900.Scaled),]

mod.full.adjust <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled + water.900.Scaled, data = MixedData.adjust, family =
binomial, na.action=na.exclude)

mod.Bin.Shell.1.adjust <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled +
water.900.Scaled, data = MixedData.adjust, family = binomial,
na.action=na.exclude)

anova(mod.Bin.Shell.1.adjust, mod.full.adjust, test="Chisq")
```

```
## Analysis of Deviance Table
##
## Model 1: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled +
water.900.Scaled
## Model 2: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled +
urban.1000.Scaled +
##     water.900.Scaled
##   Resid. Df Resid. Dev Df  Deviance Pr(>Chi)
## 1       497      614.6
## 2       496      614.6  1 0.0030514   0.9559
```

```
summary(mod.Bin.Shell.1)
```

```
##
## Call:
## glm(formula = Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
```

```
##     Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled +
##     water.900.Scaled, family = binomial, data = MixedData, na.action =
na.exclude)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.0238  -0.9571  -0.6261   1.0475   2.0150
##
## Coefficients:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)         -0.25013    0.16358  -1.529 0.126249
## CalendarDate.Scaled -0.48226    0.12829  -3.759 0.000171 ***
## A.Temp.Scaled       -0.40671    0.12371  -3.288 0.001010 **
## Time.Scaled         -0.28691    0.10974  -2.615 0.008935 **
## PL.Scaled            0.20250    0.12203   1.659 0.097019 .
## SexM                -0.06972    0.22760  -0.306 0.759356
## wet.300.Scaled       0.22714    0.10497   2.164 0.030468 *
## urban.1000.Scaled   -0.24161    0.10623  -2.274 0.022949 *
## water.900.Scaled    -0.01189    0.10138  -0.117 0.906634
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 694.8  on 505  degrees of freedom
## Residual deviance: 614.6  on 497  degrees of freedom
##   (30 observations deleted due to missingness)
## AIC: 632.6
##
## Number of Fisher Scoring iterations: 4
```

I deleted proportion of open water at 900m (water.900).

```
mod.Bin.Shell.2 <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled, data =
MixedData, family = binomial, na.action=na.exclude)

MixedData.adjust <- MixedData[complete.cases(MixedData$Bin.Shell,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$Sex,
MixedData$wet.300.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.900.Scaled),]

mod.full.adjust <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled +
water.900.Scaled, data = MixedData.adjust, family = binomial,
na.action=na.exclude)

mod.Bin.Shell.2.adjust <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled, data =
```

```
MixedData.adjust, family = binomial, na.action=na.exclude)

anova(mod.Bin.Shell.2.adjust, mod.full.adjust, test="Chisq")
```

```
## Analysis of Deviance Table
##
## Model 1: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled
## Model 2: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled +
water.900.Scaled
##   Resid. Df Resid. Dev Df Deviance Pr(>Chi)
## 1       498     614.61
## 2       497     614.60  1 0.013799   0.9065
```

```
summary(mod.Bin.Shell.2)
```

```
##
## Call:
## glm(formula = Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
##     Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled,
##     family = binomial, data = MixedData, na.action = na.exclude)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.0239  -0.9561  -0.6238   1.0490   2.0177
##
## Coefficients:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)         -0.24913    0.16337  -1.525 0.127276
## CalendarDate.Scaled -0.48497    0.12614  -3.845 0.000121 ***
## A.Temp.Scaled       -0.40646    0.12365  -3.287 0.001012 **
## Time.Scaled         -0.28742    0.10970  -2.620 0.008792 **
## PL.Scaled            0.20064    0.12100   1.658 0.097284 .
## SexM                -0.07128    0.22721  -0.314 0.753732
## wet.300.Scaled       0.22964    0.10279   2.234 0.025486 *
## urban.1000.Scaled   -0.23916    0.10415  -2.296 0.021655 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 694.80  on 505  degrees of freedom
## Residual deviance: 614.61  on 498  degrees of freedom
##   (30 observations deleted due to missingness)
## AIC: 630.61
##
## Number of Fisher Scoring iterations: 4
```

I deleted turtle sex (Sex).

```r
mod.Bin.Shell.3 <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + wet.300.Scaled + urban.1000.Scaled, data =
MixedData, family = binomial, na.action=na.exclude)

MixedData.adjust <- MixedData[complete.cases(MixedData$Bin.Shell,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$Sex,
MixedData$wet.300.Scaled, MixedData$urban.1000.Scaled),]

mod.full.adjust <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled, data =
MixedData.adjust, family = binomial, na.action=na.exclude)

mod.Bin.Shell.3.adjust <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + wet.300.Scaled + urban.1000.Scaled, data =
MixedData.adjust, family = binomial, na.action=na.exclude)

anova(mod.Bin.Shell.3.adjust, mod.full.adjust, test="Chisq")
```

```
## Analysis of Deviance Table
##
## Model 1: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + wet.300.Scaled + urban.1000.Scaled
## Model 2: Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled
##   Resid. Df Resid. Dev Df Deviance Pr(>Chi)
## 1       499     614.71
## 2       498     614.61  1 0.098397   0.7538
```

```r
summary(mod.Bin.Shell.3)
```

```
##
## Call:
## glm(formula = Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
##     Time.Scaled + PL.Scaled + wet.300.Scaled + urban.1000.Scaled,
##     family = binomial, data = MixedData, na.action = na.exclude)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.0034  -0.9421  -0.6419   1.0446   2.0357
##
## Coefficients:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)         -0.30912    0.09807  -3.152 0.001621 **
## CalendarDate.Scaled -0.47153    0.12449  -3.788 0.000152 ***
## A.Temp.Scaled       -0.40945    0.12254  -3.341 0.000834 ***
## Time.Scaled         -0.28586    0.10878  -2.628 0.008590 **
## PL.Scaled            0.24691    0.10480   2.356 0.018475 *
## wet.300.Scaled       0.23790    0.10254   2.320 0.020334 *
## urban.1000.Scaled   -0.22537    0.10310  -2.186 0.028823 *
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 700.61  on 510  degrees of freedom
## Residual deviance: 620.61  on 504  degrees of freedom
##   (25 observations deleted due to missingness)
## AIC: 634.61
##
## Number of Fisher Scoring iterations: 4
```

All of the fixed effects are statistically significant, so I will stop the backwards selection process.

Final model

Summary statistics

Data was jittered.

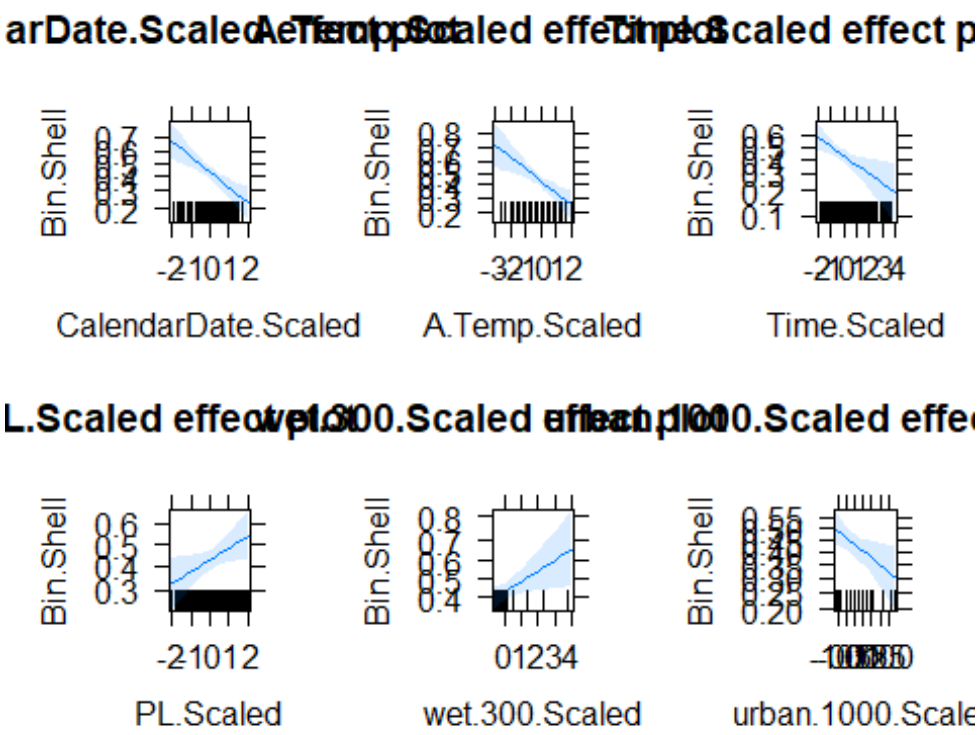
```
mod.Bin.Shell.final <- glm(Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + wet.300.Scaled + urban.1000.Scaled, data =
MixedData.adjust, family = binomial, na.action=na.exclude)
summary(mod.Bin.Shell.final)
```

```
##
## Call:
## glm(formula = Bin.Shell ~ CalendarDate.Scaled + A.Temp.Scaled +
##     Time.Scaled + PL.Scaled + wet.300.Scaled + urban.1000.Scaled,
##     family = binomial, data = MixedData.adjust, na.action = na.exclude)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.0117  -0.9527  -0.6273   1.0516   2.0170
##
## Coefficients:
##                     Estimate Std. Error z value Pr(>|z|)
## (Intercept)          -0.2900     0.0986  -2.942 0.003263 **
## CalendarDate.Scaled  -0.4807     0.1253  -3.837 0.000124 ***
## A.Temp.Scaled        -0.4093     0.1233  -3.320 0.000901 ***
## Time.Scaled          -0.2906     0.1092  -2.662 0.007777 **
## PL.Scaled             0.2189     0.1063   2.060 0.039428 *
## wet.300.Scaled        0.2307     0.1027   2.245 0.024744 *
## urban.1000.Scaled    -0.2364     0.1037  -2.279 0.022651 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
```

```
##
##     Null deviance: 694.80  on 505  degrees of freedom
## Residual deviance: 614.71  on 499  degrees of freedom
## AIC: 628.71
##
## Number of Fisher Scoring iterations: 4
```

Visualization of the predictor effects

```
plot(allEffects(mod.Bin.Shell.final,))
```



Calculation of the marginal and conditional variance explained by the final model

```
r.squaredGLMM(mod.Bin.Shell.final)

##                   R2m       R2c
## theoretical 0.1955055 0.1955055
## delta       0.1647505 0.1647505
```

Marginal R2: fixed effects R2. Conditional R2: fixed and random effects R2. The delta method can be used with all distributions and link functions.

Calculation of the 95% confidence intervals

```
confint(mod.Bin.Shell.final, level = 0.95, method = "Wald")

##                              2.5 %      97.5 %
## (Intercept)          -0.48486594 -0.09791228
```

```
## CalendarDate.Scaled -0.72953960 -0.23753990
## A.Temp.Scaled       -0.65442480 -0.17004497
## Time.Scaled         -0.51113185 -0.08181381
## PL.Scaled            0.01175867  0.42895858
## wet.300.Scaled       0.03024778  0.43466269
## urban.1000.Scaled   -0.44148747 -0.03422159
```

Creation of the prediction figure for urban area at 1000m

```
pred.con.model.Bin.Shell.final <- ggpredict(mod.Bin.Shell.final, terms =
"urban.1000.Scaled")
pred.con.model.Bin.Shell.final
```

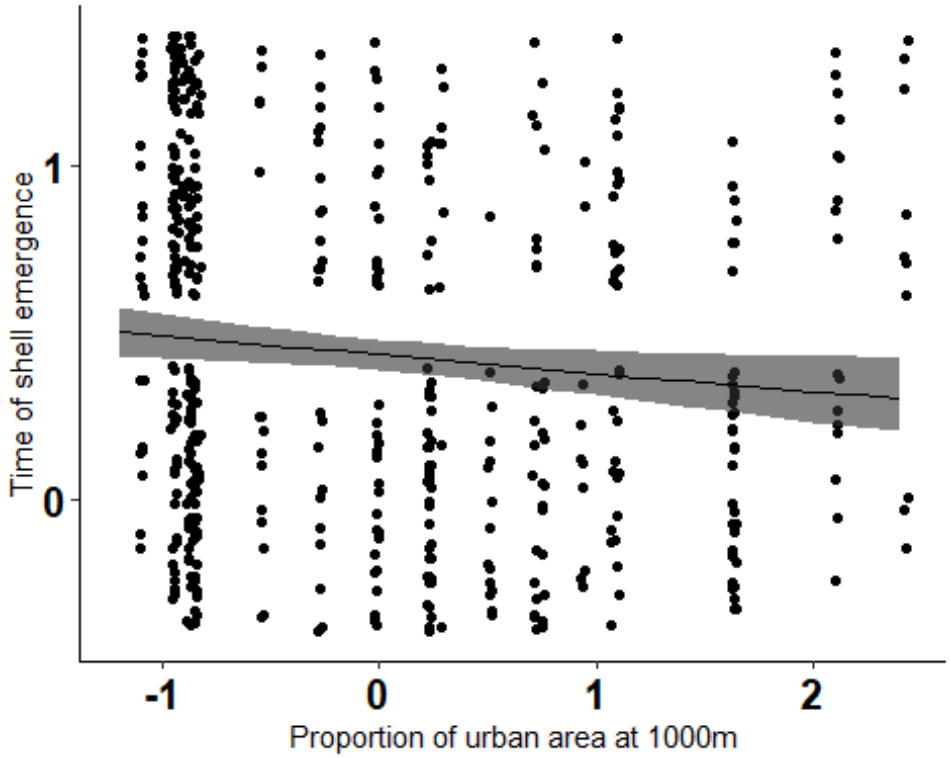
```
## # Predicted probabilities of Bin.Shell
##
## urban.1000.Scaled | Predicted |       95% CI
## ----------------------------------------------
##             -1.20 |      0.50 | [0.43, 0.58]
##             -0.80 |      0.48 | [0.42, 0.54]
##             -0.20 |      0.44 | [0.40, 0.49]
##              0.20 |      0.42 | [0.37, 0.47]
##              0.60 |      0.40 | [0.34, 0.46]
##              1.00 |      0.38 | [0.31, 0.45]
##              1.40 |      0.35 | [0.28, 0.44]
##              2.40 |      0.30 | [0.20, 0.43]
##
## Adjusted for:
## * CalendarDate.Scaled =  0.02
## *       A.Temp.Scaled = -0.02
## *         Time.Scaled = -0.02
## *           PL.Scaled =  0.06
## *      wet.300.Scaled =  0.01
```

Figure for proportion of urban area at 1000m

Data was jittered.

```
graph.con.Bin.Shell.urban.1000 <- ggplot(data=pred.con.model.Bin.Shell.final,
aes(x, predicted)) + geom_point(data=MixedData, aes(urban.1000.Scaled,
Bin.Shell), position = position_jitter(width = 0.01)) +
  geom_ribbon(data=pred.con.model.Bin.Shell.final, aes(ymin=conf.low, ymax=
conf.high), alpha=0.6) +
  geom_line(data=pred.con.model.Bin.Shell.final, color="black")+
    theme_bw() + theme(panel.border = element_blank(),
                       panel.grid.major = element_blank(),
                       panel.grid.minor = element_blank(),
                       axis.line = element_line(colour = "black")) +
  theme(axis.text=element_text(size=15, colour="black",face = "bold")) +
  ylab("Time of shell emergence") +
  xlab("Proportion of urban area at 1000m") +
```

```
  scale_y_continuous(breaks = c(0, 1))

graph.con.Bin.Shell.urban.1000
```



Model selection

Time of initial movement

Random variable

I am testing the significance of turtle ID and site identity by using likelihood ratio tests to see if the addition of these random variables make a significant effect on the initial model. I am using a dummy variable (same value for all the observations) to create a null mixed model to compared with the different combinations of mixed models.

Creation of the different mixed models

```
## Null mixed model
mod.Start.null <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1|Dummy), data =
MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

## only site identity as random variable
mod.Start.dummy.site <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
```

```
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1|Dummy) +
(1|Site), data = MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

## only turtle ID as random variable
mod.Start.dummy.code <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1|Dummy) +
(1|Code), data = MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)
```

Likelihood ratio tests between the mixed models

```
#anova with null model and dummy + site model
anova(mod.Start.null, mod.Start.dummy.site)

## Data: MixedData
## Models:
## mod.Start.null: Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled +
urban.1000.Scaled + water.500.Scaled + (1 | Dummy)
## mod.Start.dummy.site: Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1 | Dummy) + (1 |
Site)
##                      npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Start.null         13 5633.0 5686.6 -2803.5   5607.0
## mod.Start.dummy.site   14 5622.5 5680.2 -2797.2   5594.5 12.539  1
0.0003985
##
## mod.Start.null
## mod.Start.dummy.site ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#anova with null model and dummy + code model
anova(mod.Start.null, mod.Start.dummy.code)

## Data: MixedData
## Models:
## mod.Start.null: Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled +
urban.1000.Scaled + water.500.Scaled + (1 | Dummy)
## mod.Start.dummy.code: Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1 | Dummy) + (1 |
Code)
##                      npar    AIC    BIC  logLik deviance  Chisq Df
```

```
Pr(>Chisq)
## mod.Start.null         13 5633.0 5686.6 -2803.5   5607.0
## mod.Start.dummy.code   14 5633.2 5690.9 -2802.6   5605.2 1.8135  1
0.1781
```

If a test has a significant p-value (less than 0.05) then the random effect is significant. Site identity (Site) is significant by itself but turtle identity (Code) is not. I will see if Site and Code together are more significant then Site by itself.

```
## Site identity without the dummy variable
mod.Start.site <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1|Site), data =
MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

## Turtle and site identity without the dummy variable
mod.Start.code.site <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1|Code) + (1|Site),
data = MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

#anova with site model and code + site model
anova(mod.Start.site, mod.Start.code.site)

## Data: MixedData
## Models:
## mod.Start.site: Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled +
urban.1000.Scaled + water.500.Scaled + (1 | Site)
## mod.Start.code.site: Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1 | Code) + (1 |
Site)
##                     npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Start.site        13 5620.5 5674.0 -2797.2   5594.5
## mod.Start.code.site   14 5621.6 5679.2 -2796.8   5593.6 0.9154  1
0.3387
```

Site and Code together are not more significant then Site by itself ($p > 0.05$), so I will only keep Site.

Predictor variables

I am selecting the final model with a backward selection procedure. At each step, I deleted the fixed effect with the highest p value. I confirmed the deletion of each fixed effect with a likelihood ratio test. I created a new dataset at each step to use only the rows with

complete observations for all the fixed effects, so that the likelihood ratio tests do not run between two models with a different number of observations.

```
mod.Start.full <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1|Site), data =
MixedData, na.action=na.exclude, REML = FALSE)

summary(mod.Start.full)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scaled +
##     Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled +
##     urban.1000.Scaled + water.500.Scaled + (1 | Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5620.5   5674.0  -2797.3   5594.5      441
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.7795 -0.6498 -0.2979  0.4847  4.2002
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  1300     36.05
##  Residual             12480    111.71
## Number of obs: 454, groups:  Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          121.563     12.188  42.712   9.974 1.01e-12 ***
## CalendarDate.Scaled  -18.702     11.118  24.906  -1.682  0.10504
## A.Temp.Scaled         -3.933      9.352 115.551  -0.421  0.67485
## Time.Scaled           -5.669      5.832 447.861  -0.972  0.33151
## PL.Scaled             18.916      6.836 451.192   2.767  0.00589 **
## SexM                   3.427     12.723 449.098   0.269  0.78779
## for.veg.200.Scaled   -15.890     16.774  19.514  -0.947  0.35506
## wet.400.Scaled        17.139     15.218  18.677   1.126  0.27435
## agri.600.Scaled        1.413     10.337  22.144   0.137  0.89250
## urban.1000.Scaled    -16.261     15.873  18.101  -1.024  0.31912
## water.500.Scaled     -12.932     12.231  18.034  -1.057  0.30432
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl SexM   f..200 w.400. a.600.
## ClndrDt.Scl -0.066
```

```
## A.Temp.Scld  0.110 -0.399
## Time.Scaled  0.053  0.095 -0.233
## PL.Scaled   -0.307 -0.020 -0.041 -0.035
## SexM        -0.604  0.049 -0.113 -0.059  0.472
## fr.vg.200.S -0.013 -0.109 -0.257  0.048 -0.016  0.059
## wt.400.Scld -0.063 -0.315 -0.116  0.036  0.011  0.046  0.704
## agr.600.Scl -0.092 -0.060 -0.172  0.067 -0.060  0.009  0.579  0.541
## urbn.1000.S -0.077 -0.218 -0.120  0.055 -0.018  0.067  0.750  0.725  0.495
## wtr.500.Scl -0.042 -0.179 -0.146  0.019 -0.072  0.011  0.581  0.595  0.418
##             u.1000
## ClndrDt.Scl
## A.Temp.Scld
## Time.Scaled
## PL.Scaled
## SexM
## fr.vg.200.S
## wt.400.Scld
## agr.600.Scl
## urbn.1000.S
## wtr.500.Scl  0.619
```

I deleted proportion of agricultural area at 600m (agri.600).

```
mod.Start.1 <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled +
water.500.Scaled + (1|Site), data = MixedData, na.action=na.exclude, REML =
FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$Sex,
MixedData$for.veg.200.Scaled, MixedData$wet.400.Scaled,
MixedData$agri.600.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.500.Scaled),]

mod.full.adjust <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
agri.600.Scaled + urban.1000.Scaled + water.500.Scaled + (1|Site), data =
MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Start.1.adjust <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
urban.1000.Scaled + water.500.Scaled + (1|Site), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

anova(mod.Start.1.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Start.1.adjust: Start ~ CalendarDate.Scaled + A.Temp.Scaled +
```

```
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
urban.1000.Scaled + water.500.Scaled + (1 | Site)
## mod.full.adjust: Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled +
urban.1000.Scaled + water.500.Scaled + (1 | Site)
##                    npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Start.1.adjust   12 5618.5 5667.9 -2797.3   5594.5
## mod.full.adjust      13 5620.5 5674.0 -2797.2   5594.5 0.0186  1
0.8914

summary(mod.Start.1)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scaled +
##     Sex + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled +
##     water.500.Scaled + (1 | Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5618.5   5667.9  -2797.3   5594.5      442
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.7825 -0.6512 -0.2920  0.4800  4.2021
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  1305     36.12
##  Residual             12479    111.71
## Number of obs: 454, groups:  Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          121.725     12.146  43.855  10.022 6.47e-13 ***
## CalendarDate.Scaled  -18.619     11.109  25.189  -1.676  0.10612
## A.Temp.Scaled         -3.713      9.216 105.768  -0.403  0.68786
## Time.Scaled           -5.716      5.819 446.144  -0.982  0.32644
## PL.Scaled             18.963      6.823 452.210   2.779  0.00568 **
## SexM                   3.413     12.722 449.091   0.268  0.78864
## for.veg.200.Scaled   -17.212     13.691  22.126  -1.257  0.22178
## wet.400.Scaled        16.014     12.810  20.789   1.250  0.22514
## urban.1000.Scaled    -17.332     13.808  20.578  -1.255  0.22345
## water.500.Scaled     -13.628     11.122  18.941  -1.225  0.23548
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
```

```
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl SexM   f..200 w.400. u.1000
## ClndrDt.Scl -0.072
## A.Temp.Scld  0.096 -0.416
## Time.Scaled  0.060  0.099 -0.226
## PL.Scaled   -0.314 -0.024 -0.052 -0.031
## SexM        -0.606  0.050 -0.113 -0.060  0.473
## fr.vg.200.S  0.050 -0.092 -0.195  0.011  0.023  0.066
## wt.400.Scld -0.016 -0.336 -0.027 -0.001  0.052  0.050  0.570
## urbn.1000.S -0.037 -0.217 -0.041  0.026  0.013  0.072  0.654  0.626
## wtr.500.Scl -0.004 -0.170 -0.083 -0.010 -0.051  0.008  0.458  0.483  0.522
```

I deleted turtle sex (Sex).

```
mod.Start.2 <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled +
water.500.Scaled + (1|Site), data = MixedData, na.action=na.exclude, REML =
FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$Sex,
MixedData$for.veg.200.Scaled, MixedData$wet.400.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.500.Scaled),]

mod.full.adjust <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled +
urban.1000.Scaled + water.500.Scaled + (1|Site), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

mod.Start.2.adjust <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + for.veg.200.Scaled + wet.400.Scaled +
urban.1000.Scaled + water.500.Scaled + (1|Site), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

anova(mod.Start.2.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Start.2.adjust: Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + for.veg.200.Scaled + wet.400.Scaled +
urban.1000.Scaled + water.500.Scaled + (1 | Site)
## mod.full.adjust: Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled +
water.500.Scaled + (1 | Site)
##                   npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Start.2.adjust   11 5616.6 5661.9 -2797.3   5594.6
## mod.full.adjust      12 5618.5 5667.9 -2797.3   5594.5 0.0719  1
0.7885
```

```
summary(mod.Start.2)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scaled +
##     for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled +
##     water.500.Scaled + (1 | Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5673.8   5719.2  -2825.9   5651.8      448
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.7853 -0.6524 -0.3028  0.4765  4.2409
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  1326     36.41
##  Residual             12354    111.15
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          123.672      9.686  18.364  12.768 1.42e-10 ***
## CalendarDate.Scaled  -18.545     11.105  25.227  -1.670  0.10729
## A.Temp.Scaled         -3.860      9.103 111.426  -0.424  0.67239
## Time.Scaled           -5.444      5.773 449.706  -0.943  0.34621
## PL.Scaled             18.144      5.860 458.871   3.096  0.00208 **
## for.veg.200.Scaled   -16.984     13.674  22.029  -1.242  0.22729
## wet.400.Scaled        15.834     12.834  20.853   1.234  0.23101
## urban.1000.Scaled    -17.532     13.806  20.520  -1.270  0.21836
## water.500.Scaled     -13.818     11.085  18.582  -1.247  0.22806
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl f..200 w.400. u.1000
## ClndrDt.Scl -0.053
## A.Temp.Scld  0.036 -0.411
## Time.Scaled  0.032  0.102 -0.236
## PL.Scaled   -0.029 -0.050 -0.003 -0.012
## fr.vg.200.S  0.112 -0.098 -0.186  0.016  0.000
## wt.400.Scld  0.017 -0.340 -0.022  0.003  0.035  0.569
## urbn.1000.S  0.008 -0.222 -0.033  0.031 -0.020  0.652  0.625
## wtr.500.Scl -0.004 -0.176 -0.081 -0.007 -0.041  0.458  0.485  0.525
```

I deleted air temperature (A.Temp).

```r
mod.Start.3 <- lmer(Start ~ CalendarDate.Scaled + Time.Scaled + PL.Scaled +
for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled +
(1|Site), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$for.veg.200.Scaled,
MixedData$wet.400.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.500.Scaled),]

mod.full.adjust <- lmer(Start ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + for.veg.200.Scaled + wet.400.Scaled +
urban.1000.Scaled + water.500.Scaled + (1|Site), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

mod.Start.3.adjust <- lmer(Start ~ CalendarDate.Scaled + Time.Scaled +
PL.Scaled + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled +
water.500.Scaled + (1|Site), data = MixedData.adjust, na.action=na.exclude,
REML = FALSE)

anova(mod.Start.3.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Start.3.adjust: Start ~ CalendarDate.Scaled + Time.Scaled + PL.Scaled
+ for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled
+ (1 | Site)
## mod.full.adjust: Start ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled +
water.500.Scaled + (1 | Site)
##                    npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Start.3.adjust   10 5672.0 5713.3 -2826.0   5652.0
## mod.full.adjust      11 5673.8 5719.2 -2825.9   5651.8 0.1797  1
0.6716
```

```r
summary(mod.Start.3)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Start ~ CalendarDate.Scaled + Time.Scaled + PL.Scaled + for.veg.200.Scaled
+
##     wet.400.Scaled + urban.1000.Scaled + water.500.Scaled + (1 |
Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5672.0   5713.3  -2826.0   5652.0      449
##
```

```
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.7806 -0.6478 -0.2925  0.4666  4.2266
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  1331     36.49
##  Residual             12357    111.16
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          123.830      9.692  18.514  12.776 1.26e-10 ***
## CalendarDate.Scaled  -20.486     10.139  20.873  -2.021   0.0563 .
## Time.Scaled           -6.015      5.611 452.475  -1.072   0.2843
## PL.Scaled             18.129      5.862 458.881   3.093   0.0021 **
## for.veg.200.Scaled   -18.054     13.454  21.081  -1.342   0.1939
## wet.400.Scaled        15.719     12.847  20.991   1.224   0.2347
## urban.1000.Scaled    -17.721     13.817  20.525  -1.283   0.2139
## water.500.Scaled     -14.197     11.064  18.379  -1.283   0.2154
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S Tm.Scl PL.Scl f..200 w.400. u.1000
## ClndrDt.Scl -0.042
## Time.Scaled  0.041  0.006
## PL.Scaled   -0.029 -0.056 -0.013
## fr.vg.200.S  0.121 -0.194 -0.029  0.000
## wt.400.Scld  0.018 -0.383 -0.003  0.035  0.575
## urbn.1000.S  0.009 -0.258  0.024 -0.020  0.658  0.625
## wtr.500.Scl -0.001 -0.231 -0.027 -0.041  0.452  0.484  0.524
```

I deleted time of testing (Time).

```
mod.Start.4 <- lmer(Start ~ CalendarDate.Scaled + PL.Scaled +
for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled +
(1|Site), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start,
MixedData$CalendarDate.Scaled, MixedData$Time.Scaled, MixedData$PL.Scaled,
MixedData$for.veg.200.Scaled, MixedData$wet.400.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.500.Scaled),]

mod.full.adjust <- lmer(Start ~ CalendarDate.Scaled + Time.Scaled + PL.Scaled
+ for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled
+ (1|Site), data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Start.4.adjust <- lmer(Start ~ CalendarDate.Scaled + PL.Scaled +
for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled +
```

```
(1|Site), data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

anova(mod.Start.4.adjust, mod.full.adjust)

## Data: MixedData.adjust
## Models:
## mod.Start.4.adjust: Start ~ CalendarDate.Scaled + PL.Scaled +
for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled +
(1 | Site)
## mod.full.adjust: Start ~ CalendarDate.Scaled + Time.Scaled + PL.Scaled +
for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled +
(1 | Site)
##                    npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Start.4.adjust    9 5671.1 5708.3 -2826.6   5653.1
## mod.full.adjust      10 5672.0 5713.3 -2826.0   5652.0 1.1215  1
0.2896

summary(mod.Start.4)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ CalendarDate.Scaled + PL.Scaled + for.veg.200.Scaled +
##     wet.400.Scaled + urban.1000.Scaled + water.500.Scaled + (1 |
Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5671.1   5708.3  -2826.5   5653.1      450
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.8000 -0.6361 -0.2864  0.4597  4.2948
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  1439     37.94
##  Residual             12356    111.16
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          124.468      9.945  19.395  12.516 9.68e-11 ***
## CalendarDate.Scaled  -20.603     10.396  21.741  -1.982  0.06028 .
## PL.Scaled             17.880      5.867 458.649   3.047  0.00244 **
## for.veg.200.Scaled   -18.337     13.788  21.868  -1.330  0.19725
## wet.400.Scaled        15.734     13.173  21.805   1.194  0.24513
## urban.1000.Scaled    -17.283     14.166  21.472  -1.220  0.23568
## water.500.Scaled     -14.425     11.359  19.172  -1.270  0.21930
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S PL.Scl f..200 w.400. u.1000
## ClndrDt.Scl -0.042
## PL.Scaled   -0.028 -0.054
## fr.vg.200.S  0.126 -0.191 -0.001
## wt.400.Scld  0.019 -0.382  0.035  0.574
## urbn.1000.S  0.009 -0.258 -0.019  0.658  0.625
## wtr.500.Scl  0.001 -0.232 -0.041  0.450  0.485  0.525
```

I removed proportion of wetland area at 400m (wet.400).

```
mod.Start.5 <- lmer(Start ~ CalendarDate.Scaled + PL.Scaled +
for.veg.200.Scaled + urban.1000.Scaled + water.500.Scaled + (1|Site), data =
MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start,
MixedData$CalendarDate.Scaled, MixedData$PL.Scaled,
MixedData$for.veg.200.Scaled, MixedData$wet.400.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.500.Scaled),]

mod.full.adjust <- lmer(Start ~ CalendarDate.Scaled + PL.Scaled +
for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled +
(1|Site), data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Start.5.adjust <- lmer(Start ~ CalendarDate.Scaled + PL.Scaled +
for.veg.200.Scaled + urban.1000.Scaled + water.500.Scaled + (1|Site), data =
MixedData.adjust,  na.action=na.exclude, REML = FALSE)

anova(mod.Start.5.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Start.5.adjust: Start ~ CalendarDate.Scaled + PL.Scaled +
for.veg.200.Scaled + urban.1000.Scaled + water.500.Scaled + (1 | Site)
## mod.full.adjust: Start ~ CalendarDate.Scaled + PL.Scaled +
for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled +
(1 | Site)
##                    npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Start.5.adjust    8 5670.5 5703.5 -2827.2   5654.5
## mod.full.adjust       9 5671.1 5708.3 -2826.6   5653.1 1.3923  1
0.238
```

```
summary(mod.Start.5)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ CalendarDate.Scaled + PL.Scaled + for.veg.200.Scaled +
##     urban.1000.Scaled + water.500.Scaled + (1 | Site)
```

```
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5670.5   5703.5  -2827.2   5654.5      451
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.7520 -0.6381 -0.2847  0.4564  4.3022
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  1566     39.58
##  Residual             12359    111.17
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          124.448     10.241  19.456  12.152 1.55e-10 ***
## CalendarDate.Scaled  -16.049      9.885  20.932  -1.624  0.11942
## PL.Scaled             17.468      5.872 458.468   2.975  0.00309 **
## for.veg.200.Scaled   -27.653     11.626  20.165  -2.378  0.02738 *
## urban.1000.Scaled    -27.792     11.379  21.202  -2.442  0.02343 *
## water.500.Scaled     -20.940     10.236  19.145  -2.046  0.05478 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S PL.Scl f..200 u.1000
## ClndrDt.Scl -0.036
## PL.Scaled   -0.029 -0.043
## fr.vg.200.S  0.143  0.039 -0.025
## urbn.1000.S -0.004 -0.027 -0.051  0.469
## wtr.500.Scl -0.009 -0.060 -0.064  0.238  0.326
```

I removed Calendar date of testing (CalendarDate).

```
mod.Start.6 <- lmer(Start ~ PL.Scaled + for.veg.200.Scaled +
urban.1000.Scaled + water.500.Scaled + (1|Site), data = MixedData,
na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start,
MixedData$CalendarDate.Scaled, MixedData$PL.Scaled,
MixedData$for.veg.200.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.500.Scaled),]

mod.full.adjust <- lmer(Start ~ CalendarDate.Scaled + PL.Scaled +
for.veg.200.Scaled +    urban.1000.Scaled + water.500.Scaled + (1|Site), data
= MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Start.6.adjust <- lmer(Start ~ PL.Scaled + for.veg.200.Scaled +
```

```
urban.1000.Scaled + water.500.Scaled + (1|Site), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

anova(mod.Start.6.adjust, mod.full.adjust)

## Data: MixedData.adjust
## Models:
## mod.Start.6.adjust: Start ~ PL.Scaled + for.veg.200.Scaled +
urban.1000.Scaled + water.500.Scaled + (1 | Site)
## mod.full.adjust: Start ~ CalendarDate.Scaled + PL.Scaled +
for.veg.200.Scaled + urban.1000.Scaled + water.500.Scaled + (1 | Site)
##                     npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Start.6.adjust    7 5671.1 5700.0 -2828.5   5657.1
## mod.full.adjust       8 5670.5 5703.5 -2827.2   5654.5 2.5754  1
0.1085

summary(mod.Start.6)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ PL.Scaled + for.veg.200.Scaled + urban.1000.Scaled +
##     water.500.Scaled + (1 | Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5671.1   5700.0  -2828.5   5657.1      452
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.7710 -0.6399 -0.3070  0.4709  4.2815
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  1750     41.83
##  Residual             12383    111.28
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          124.112     10.650  18.392  11.654 6.26e-10 ***
## PL.Scaled             16.875      5.882 458.345   2.869  0.00431 **
## for.veg.200.Scaled   -26.692     12.080  19.150  -2.210  0.03951 *
## urban.1000.Scaled    -28.209     11.818  19.997  -2.387  0.02699 *
## water.500.Scaled     -21.911     10.635  18.236  -2.060  0.05392 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) PL.Scl f..200 u.1000
```

```
## PL.Scaled   -0.030
## fr.vg.200.S  0.149 -0.023
## urbn.1000.S -0.005 -0.050  0.470
## wtr.500.Scl -0.010 -0.065  0.239  0.325
```

I removed proportion of open water area at 500m (water.500).

```
mod.Start.7 <- lmer(Start ~ PL.Scaled + for.veg.200.Scaled +
urban.1000.Scaled + (1|Site), data = MixedData, na.action=na.exclude, REML =
FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start,
MixedData$PL.Scaled, MixedData$for.veg.200.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.500.Scaled),]

mod.full.adjust <- lmer(Start ~ PL.Scaled + for.veg.200.Scaled +
urban.1000.Scaled + water.500.Scaled + (1|Site), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

mod.Start.7.adjust <- lmer(Start ~ PL.Scaled + for.veg.200.Scaled +
urban.1000.Scaled + (1|Site), data = MixedData.adjust,  na.action=na.exclude,
REML = FALSE)

anova(mod.Start.7.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Start.7.adjust: Start ~ PL.Scaled + for.veg.200.Scaled +
urban.1000.Scaled + (1 | Site)
## mod.full.adjust: Start ~ PL.Scaled + for.veg.200.Scaled +
urban.1000.Scaled + water.500.Scaled + (1 | Site)
##                    npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Start.7.adjust    6 5672.9 5697.6 -2830.4   5660.9
## mod.full.adjust       7 5671.1 5700.0 -2828.5   5657.1 3.8075  1
0.05102 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(mod.Start.7)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ PL.Scaled + for.veg.200.Scaled + urban.1000.Scaled +
##     (1 | Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5672.9   5697.6  -2830.4   5660.9      453
##
## Scaled residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -1.7411 -0.6467 -0.2877  0.4708  4.2924
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  2302     47.98
##  Residual             12362    111.19
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          124.575     11.799  19.883  10.558 1.34e-09 ***
## PL.Scaled             15.786      5.889 457.518   2.681  0.00761 **
## for.veg.200.Scaled   -20.325     12.985  20.168  -1.565  0.13308
## urban.1000.Scaled    -20.139     12.330  21.432  -1.633  0.11700
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) PL.Scl f..200
## PL.Scaled   -0.029
## fr.vg.200.S  0.166 -0.008
## urbn.1000.S -0.002 -0.028  0.428
```

I removed proportion of forest and vegetation area at 200m (for.veg.200).

```
mod.Start.8 <- lmer(Start ~ PL.Scaled + urban.1000.Scaled + (1|Site), data =
MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start,
MixedData$PL.Scaled, MixedData$for.veg.200.Scaled,
MixedData$urban.1000.Scaled),]

mod.full.adjust <- lmer(Start ~ PL.Scaled + for.veg.200.Scaled +
urban.1000.Scaled + (1|Site), data = MixedData.adjust, na.action=na.exclude,
REML = FALSE)

mod.Start.8.adjust <- lmer(Start ~ PL.Scaled + urban.1000.Scaled + (1|Site),
data = MixedData.adjust,  na.action=na.exclude, REML = FALSE)

anova(mod.Start.8.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Start.8.adjust: Start ~ PL.Scaled + urban.1000.Scaled + (1 | Site)
## mod.full.adjust: Start ~ PL.Scaled + for.veg.200.Scaled +
urban.1000.Scaled + (1 | Site)
##                    npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Start.8.adjust    5 5673.1 5693.8 -2831.6   5663.1
```

```
## mod.full.adjust       6 5672.9 5697.6 -2830.4   5660.9 2.2663  1
0.1322

summary(mod.Start.8)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ PL.Scaled + urban.1000.Scaled + (1 | Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5673.1   5693.8  -2831.6   5663.1      454
##
## Scaled residuals:
##    Min     1Q Median     3Q    Max
## -1.701 -0.659 -0.284  0.458  4.274
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  2715     52.11
##  Residual             12345    111.11
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                   Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)        128.072     12.401  21.744  10.327 7.59e-10 ***
## PL.Scaled           15.546      5.898 456.398   2.636  0.00868 **
## urban.1000.Scaled  -11.912     11.862  22.720  -1.004  0.32586
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) PL.Scl
## PL.Scaled   -0.027
## urbn.1000.S -0.085 -0.025
```

I removed proportion of urban area at 1000m (urban.1000).

```
mod.Start.9 <- lmer(Start ~ PL.Scaled + (1|Site), data = MixedData,
na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start,
MixedData$PL.Scaled, MixedData$urban.1000.Scaled),]

mod.full.adjust <- lmer(Start ~ PL.Scaled + urban.1000.Scaled + (1|Site),
data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Start.9.adjust <- lmer(Start ~ PL.Scaled + (1|Site), data =
MixedData.adjust,  na.action=na.exclude, REML = FALSE)
```

```
anova(mod.Start.9.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Start.9.adjust: Start ~ PL.Scaled + (1 | Site)
## mod.full.adjust: Start ~ PL.Scaled + urban.1000.Scaled + (1 | Site)
##                    npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod.Start.9.adjust    4 5672.1 5688.6 -2832.1   5664.1
## mod.full.adjust       5 5673.1 5693.8 -2831.6   5663.1 0.988  1     0.3202
```

```
summary(mod.Start.9)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ PL.Scaled + (1 | Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5672.1   5688.6  -2832.1   5664.1      455
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.6816 -0.6563 -0.2807  0.4406  4.2729
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  2867     53.55
##  Residual             12345    111.11
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##             Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)   127.13      12.62  21.94  10.070 1.09e-09 ***
## PL.Scaled      15.35       5.90 456.19   2.602  0.00957 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##           (Intr)
## PL.Scaled -0.028
```

All of the fixed effects are statistically significant, so I will stop the backwards selection process.

Final model

Summary statistics

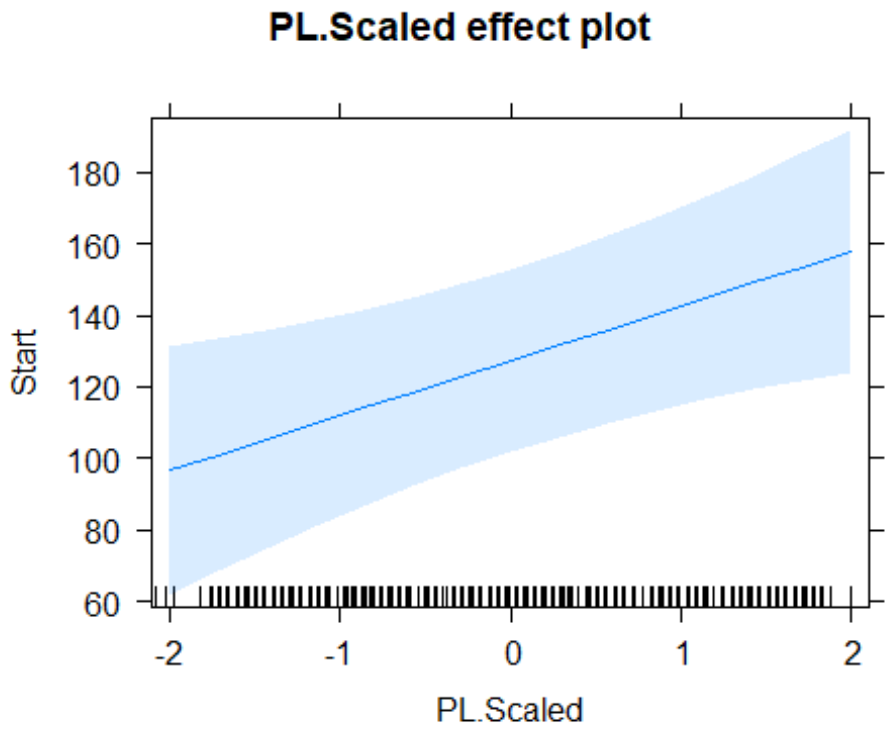
I changed the REML to TRUE to calculate the summary statistics of the final model.

```
#Creating model with just the conditional average coefficients
mod.Start.final <- lmer(Start ~ PL.Scaled + (1|Site), data = MixedData,
na.action=na.exclude, REML = TRUE)
summary(mod.Start.final)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Start ~ PL.Scaled + (1 | Site)
##    Data: MixedData
##
## REML criterion at convergence: 5651.8
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.6912 -0.6532 -0.2782  0.4459  4.2701
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  3044     55.17
##  Residual             12372    111.23
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##             Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)  127.250     12.930  21.055   9.841  2.5e-09 ***
## PL.Scaled     15.306      5.911 454.312   2.589  0.00992 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##           (Intr)
## PL.Scaled -0.028
```

Visualization of the predictor effects

```
plot(allEffects(mod.Start.final))
```



Calculation of the marginal and conditional variance explained by the final model

```
r.squaredGLMM(mod.Start.final)

##             R2m       R2c
## [1,] 0.01326099 0.2080788
```

Marginal R2: fixed effects R2. Conditional R2: fixed and random effects R2

Calculation of the 95% confidence intervals

```
confint(mod.Start.final, level = 0.95, method = "Wald")

##                   2.5 %    97.5 %
## .sig01               NA        NA
## .sigma               NA        NA
## (Intercept) 101.907609 152.59333
## PL.Scaled     3.720853  26.89185
```

Model selection

Total time spent moving

Random variable

I am testing the significance of turtle ID and site identity by using likelihood ratio tests to see if the addition of these random variables make a significant effect on the initial model. I am using a dummy variable (same value for all the observations) to create a null mixed model to compared with the different combinations of mixed models.

Creation of the different mixed models

```
#Null Mixed Model
mod.Move.null <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Dummy), data =
MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

## only site identity as random variable
mod.Move.dummy.site <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Dummy) +
(1|Site), data = MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

## only turtle ID as random variable
mod.Move.dummy.code <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Dummy) +
(1|Code), data = MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)
```

Likelihood ratio tests between the mixed models

```
#anova with null model and dummy + site model
anova(mod.Move.null, mod.Move.dummy.site)

## Data: MixedData
## Models:
## mod.Move.null: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1 | Dummy)
## mod.Move.dummy.site: Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1 | Dummy) + (1 |
Site)
##                     npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
```

```
## mod.Move.null         13 4693.0 4746.6 -2333.5   4667.0
## mod.Move.dummy.site   14 4683.4 4741.0 -2327.7   4655.4 11.665  1
0.0006368
##
## mod.Move.null
## mod.Move.dummy.site ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#anova with null model and dummy + code model
anova(mod.Move.null, mod.Move.dummy.code)
```

```
## Data: MixedData
## Models:
## mod.Move.null: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1 | Dummy)
## mod.Move.dummy.code: Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1 | Dummy) + (1 |
Code)
##                     npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Move.null         13 4693.0 4746.6 -2333.5   4667.0
## mod.Move.dummy.code   14 4690.6 4748.2 -2331.3   4662.6 4.4534  1
0.03483 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

If a test has a significant p-value (less than 0.05) then the random effect is significant. Site identity (Site) and turtle ID (Code) are significant by themselves. I will see if Site and Code together are more significant then Site and Code by themselves.

```
## Turtle ID without the dummy variable
mod.Move.code <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Code), data =
MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

## Site identity without the dummy variable
mod.Move.site <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Site), data =
MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

## Turtle and site identity without the dummy variable
mod.Move.code.site <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
```

```
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Code) +
(1|Site), data = MixedData, na.action=na.exclude,
control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

#anova with site model and code + site model
anova(mod.Move.site, mod.Move.code.site)

## Data: MixedData
## Models:
## mod.Move.site: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1 | Site)
## mod.Move.code.site: Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1 | Code) + (1 |
Site)
##                    npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Move.site        13 4681.4 4734.9 -2327.7   4655.4
## mod.Move.code.site   14 4679.5 4737.1 -2325.7   4651.5 3.9129  1
0.04792 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#anova with code model and code + site model
anova(mod.Move.code, mod.Move.code.site)

## Data: MixedData
## Models:
## mod.Move.code: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1 | Code)
## mod.Move.code.site: Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1 | Code) + (1 |
Site)
##                    npar    AIC    BIC  logLik deviance  Chisq Df
Pr(>Chisq)
## mod.Move.code        13 4688.6 4742.1 -2331.3   4662.6
## mod.Move.code.site   14 4679.5 4737.1 -2325.7   4651.5 11.125  1
0.0008518 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Site and Code together are more significant then Site and Code by themselves ($p < 0.05$), so I will keep both.

Predictor variables

I am selecting the final model with a backward selection procedure. At each step, I deleted the fixed effect with the highest p value. I confirmed the deletion of each fixed effect with a likelihood ratio test. I created a new dataset at each step to use only the rows with complete observations for all the fixed effects, so that the likelihood ratio tests do not run between two models with a different number of observations.

```
mod.Move.full <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Site) +
(1|Code), data = MixedData, na.action=na.exclude, REML = FALSE)
summary(mod.Move.full)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scaled +
##     Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled +
##     urban.1000.Scaled + water.1000.Scaled + (1 | Site) + (1 |      Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   4679.5   4737.1  -2325.7   4651.5      439
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.94945 -0.53190  0.05023  0.55901  1.59557
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 746.7    27.33
##  Site     (Intercept) 123.4    11.11
##  Residual             890.7    29.84
## Number of obs: 453, groups:  Code, 429; Site, 23
##
## Fixed effects:
##                      Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)          90.03990    4.13573  51.89653  21.771   <2e-16 ***
## CalendarDate.Scaled   2.53842    3.83232  27.68781   0.662   0.5132
## A.Temp.Scaled        -1.55475    3.13922  89.37380  -0.495   0.6216
## Time.Scaled           1.20480    2.08020 440.09897   0.579   0.5628
## PL.Scaled            -0.83400    2.49972 440.21016  -0.334   0.7388
## SexM                  4.80496    4.54104 432.01412   1.058   0.2906
## for.veg.300.Scaled    0.03984    5.41914  22.81472   0.007   0.9942
## wet.600.Scaled       -0.96779    4.00018  25.31734  -0.242   0.8108
## agri.100.Scaled       7.28995    3.61269  32.42149   2.018   0.0519 .
## urban.1000.Scaled     5.87915    4.85745  23.95407   1.210   0.2380
## water.1000.Scaled    -3.19655    3.83167  22.83416  -0.834   0.4128
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl SexM   f..300 w.600. a.100.
## ClndrDt.Scl -0.077
## A.Temp.Scld  0.102 -0.439
## Time.Scaled  0.050  0.115 -0.222
## PL.Scaled   -0.317 -0.021 -0.068 -0.037
## SexM        -0.633  0.060 -0.105 -0.064  0.470
## fr.vg.300.S  0.086 -0.047 -0.138 -0.041  0.050  0.009
## wt.600.Scld -0.005 -0.332 -0.006 -0.023  0.074  0.013  0.517
## agr.100.Scl  0.044 -0.020 -0.062  0.008  0.012 -0.044  0.586  0.352
## urbn.1000.S -0.008 -0.195 -0.029 -0.015  0.039  0.048  0.695  0.597  0.312
## wtr.1000.Sc  0.017 -0.259 -0.033 -0.041 -0.034 -0.021  0.567  0.494  0.416
##             u.1000
## ClndrDt.Scl
## A.Temp.Scld
## Time.Scaled
## PL.Scaled
## SexM
## fr.vg.300.S
## wt.600.Scld
## agr.100.Scl
## urbn.1000.S
## wtr.1000.Sc  0.563
```

I deleted proportion of forest and vegetation area at 300m (for.veg.300).

```
mod.Move.1 <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + wet.600.Scaled + agri.100.Scaled + urban.1000.Scaled +
water.1000.Scaled + (1|Site) + (1|Code), data = MixedData,
na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$Sex,
MixedData$for.veg.300.Scaled,  MixedData$wet.600.Scaled,
MixedData$agri.100.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.1000.Scaled),]

mod.full.adjust <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Site) +
(1|Code), data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Move.1.adjust <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.600.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1|Site) + (1|Code), data =
MixedData.adjust, na.action=na.exclude, REML = FALSE)
```

```
anova(mod.Move.1.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Move.1.adjust: Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.600.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1 | Site) + (1 | Code)
## mod.full.adjust: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1 | Site) + (1 | Code)
##                   npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod.Move.1.adjust   13 4677.5 4731.0 -2325.7   4651.5
## mod.full.adjust     14 4679.5 4737.1 -2325.7   4651.5 1e-04  1     0.9941
```

```
summary(mod.Move.1)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scaled +
##     Sex + wet.600.Scaled + agri.100.Scaled + urban.1000.Scaled +
##     water.1000.Scaled + (1 | Site) + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   4677.5   4731.0  -2325.7   4651.5      440
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.94939 -0.53174  0.05024  0.55910  1.59533
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 746.7    27.33
##  Site     (Intercept) 123.4    11.11
##  Residual             890.8    29.85
## Number of obs: 453, groups:  Code, 429; Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)           90.037      4.120  53.830  21.853   <2e-16 ***
## CalendarDate.Scaled    2.540      3.828  27.309   0.663   0.5126
## A.Temp.Scaled         -1.552      3.109  87.320  -0.499   0.6190
## Time.Scaled            1.205      2.079 437.021   0.580   0.5622
## PL.Scaled             -0.835      2.497 440.696  -0.334   0.7382
## SexM                   4.805      4.541 432.046   1.058   0.2906
## wet.600.Scaled        -0.983      3.425  21.684  -0.287   0.7768
## agri.100.Scaled        7.274      2.928  35.408   2.484   0.0179 *
## urban.1000.Scaled      5.854      3.493  20.559   1.676   0.1088
```

```
## water.1000.Scaled     -3.212      3.157  20.092  -1.018   0.3210
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.600. a.100. u.1000
## ClndrDt.Scl -0.073
## A.Temp.Scld  0.115 -0.451
## Time.Scaled  0.054  0.114 -0.230
## PL.Scaled   -0.323 -0.019 -0.061 -0.035
## SexM        -0.637  0.060 -0.105 -0.063  0.470
## wt.600.Scld -0.058 -0.360  0.077 -0.003  0.057  0.009
## agr.100.Scl -0.007  0.009  0.023  0.040 -0.021 -0.060  0.072
## urbn.1000.S -0.095 -0.226  0.094  0.019  0.007  0.058  0.386 -0.163
## wtr.1000.Sc -0.039 -0.283  0.056 -0.021 -0.075 -0.032  0.286  0.126  0.286
```

I deleted proportion of wetland area at 600m (wet.600).

```
mod.Move.2 <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled +
(1|Site) + (1|Code), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$Sex,
MixedData$wet.600.Scaled, MixedData$agri.100.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.1000.Scaled),]

mod.full.adjust <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.600.Scaled + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1|Site) + (1|Code), data =
MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Move.2.adjust <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + agri.100.Scaled + urban.1000.Scaled +
water.1000.Scaled + (1|Site) + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

anova(mod.Move.2.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Move.2.adjust: Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + agri.100.Scaled + urban.1000.Scaled +
water.1000.Scaled + (1 | Site) + (1 | Code)
## mod.full.adjust: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + wet.600.Scaled + agri.100.Scaled + urban.1000.Scaled +
water.1000.Scaled + (1 | Site) + (1 | Code)
##                  npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
```

```
## mod.Move.2.adjust   12 4675.6 4724.9 -2325.8   4651.6
## mod.full.adjust     13 4677.5 4731.0 -2325.7   4651.5 0.0821  1     0.7745

summary(mod.Move.2)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scaled +
##     Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled +
##     (1 | Site) + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   4675.6   4724.9  -2325.8   4651.6      441
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.94827 -0.53101  0.05176  0.56139  1.59715
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 746.2    27.32
##  Site     (Intercept) 124.6    11.16
##  Residual             891.0    29.85
## Number of obs: 453, groups:  Code, 429; Site, 23
##
## Fixed effects:
##                     Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)          89.9635     4.1200  54.5571  21.836   <2e-16 ***
## CalendarDate.Scaled   2.1491     3.5788  28.6360   0.601   0.5529
## A.Temp.Scaled        -1.4847     3.1037  89.0762  -0.478   0.6336
## Time.Scaled           1.2043     2.0789 437.4471   0.579   0.5627
## PL.Scaled            -0.7914     2.4928 440.8079  -0.317   0.7510
## SexM                  4.8188     4.5409 432.0419   1.061   0.2892
## agri.100.Scaled       7.3381     2.9269  35.3741   2.507   0.0169 *
## urban.1000.Scaled     6.2406     3.2300  21.9675   1.932   0.0663 .
## water.1000.Scaled    -2.9556     3.0334  20.9853  -0.974   0.3410
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl PL.Scl SexM   a.100. u.1000
## ClndrDt.Scl -0.101
## A.Temp.Scld  0.120 -0.454
## Time.Scaled  0.054  0.120 -0.231
## PL.Scaled   -0.321  0.002 -0.066 -0.035
## SexM        -0.636  0.068 -0.106 -0.063  0.470
## agr.100.Scl -0.004  0.038  0.018  0.040 -0.025 -0.061
```

```
## urbn.1000.S -0.079 -0.102  0.070  0.022 -0.016  0.059 -0.207
## wtr.1000.Sc -0.024 -0.201  0.035 -0.022 -0.095 -0.036  0.110  0.199
```

I deleted turtle plastron length (PL).

```
mod.Move.3 <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled +
Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Site) +
(1|Code), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$Sex,
MixedData$agri.100.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.1000.Scaled),]

mod.full.adjust <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + agri.100.Scaled + urban.1000.Scaled +
water.1000.Scaled + (1|Site) + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

mod.Move.3.adjust <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled +
(1|Site) + (1|Code), data = MixedData.adjust, na.action=na.exclude, REML =
FALSE)

anova(mod.Move.3.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Move.3.adjust: Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled +
(1 | Site) + (1 | Code)
## mod.full.adjust: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled +
(1 | Site) + (1 | Code)
##                   npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod.Move.3.adjust   11 4673.7 4718.9 -2325.8   4651.7
## mod.full.adjust     12 4675.6 4724.9 -2325.8   4651.6 0.1004  1     0.7514
```

```
summary(mod.Move.3)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled + Sex +
##     agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled +
##     (1 | Site) + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   4683.9   4729.2  -2331.0   4661.9      443
##
```

```
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.93328 -0.53864  0.05394  0.55345  1.59614
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 746.7    27.33
##  Site     (Intercept) 128.6    11.34
##  Residual             889.6    29.83
## Number of obs: 454, groups:  Code, 430; Site, 23
##
## Fixed effects:
##                     Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)          89.4599     3.9264  44.4263  22.784   <2e-16 ***
## CalendarDate.Scaled   2.0268     3.6044  28.5476   0.562   0.5783
## A.Temp.Scaled        -1.6561     3.1085  88.8618  -0.533   0.5955
## Time.Scaled           0.8925     2.0586 438.5359   0.434   0.6648
## SexM                  5.4202     4.0072 443.6209   1.353   0.1769
## agri.100.Scaled       7.0283     2.9319  33.9761   2.397   0.0222 *
## urban.1000.Scaled     6.2252     3.2590  21.9516   1.910   0.0693 .
## water.1000.Scaled    -2.9995     3.0476  20.5500  -0.984   0.3364
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S Tm.Scl SexM   a.100. u.1000
## ClndrDt.Scl -0.106
## A.Temp.Scld  0.104 -0.455
## Time.Scaled  0.043  0.116 -0.240
## SexM        -0.578  0.075 -0.087 -0.055
## agr.100.Scl -0.016  0.035  0.013  0.025 -0.058
## urbn.1000.S -0.089 -0.103  0.071  0.022  0.075 -0.209
## wtr.1000.Sc -0.058 -0.202  0.030 -0.023  0.011  0.111  0.199
```

I deleted time of testing (Time).

```
mod.Move.4 <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled + Sex +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Site) +
(1|Code), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled,
MixedData$Time.Scaled, MixedData$Sex, MixedData$agri.100.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.1000.Scaled),]

mod.full.adjust <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled +
Time.Scaled + Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled +
(1|Site) + (1|Code), data = MixedData.adjust, na.action=na.exclude, REML =
FALSE)
```

```
mod.Move.4.adjust <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled + Sex +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Site) +
(1|Code), data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

anova(mod.Move.4.adjust, mod.full.adjust)

## Data: MixedData.adjust
## Models:
## mod.Move.4.adjust: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Sex +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1 | Site) + (1 |
Code)
## mod.full.adjust: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Time.Scaled
+ Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1 | Site)
+ (1 | Code)
##                   npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod.Move.4.adjust   10 4682.1 4723.3 -2331.1   4662.1
## mod.full.adjust     11 4683.9 4729.2 -2331.0   4661.9 0.1877  1     0.6648

summary(mod.Move.4)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Sex +
agri.100.Scaled +
##     urban.1000.Scaled + water.1000.Scaled + (1 | Site) + (1 |      Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   4682.1   4723.3  -2331.1   4662.1      444
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.95059 -0.53848  0.05562  0.55242  1.60079
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 750.9    27.40
##  Site     (Intercept) 128.3    11.33
##  Residual             886.4    29.77
## Number of obs: 454, groups:  Code, 430; Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)           89.388      3.921  44.111  22.796   <2e-16 ***
## CalendarDate.Scaled    1.846      3.578  27.817   0.516   0.6100
## A.Temp.Scaled         -1.333      3.017  88.263  -0.442   0.6597
## SexM                   5.516      4.002 444.720   1.378   0.1688
## agri.100.Scaled        6.995      2.930  33.803   2.388   0.0227 *
## urban.1000.Scaled      6.195      3.256  21.849   1.903   0.0703 .
## water.1000.Scaled     -2.969      3.045  20.445  -0.975   0.3409
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S A.Tm.S SexM   a.100. u.1000
## ClndrDt.Scl -0.112
## A.Temp.Scld  0.118 -0.443
## SexM        -0.577  0.082 -0.103
## agr.100.Scl -0.017  0.032  0.020 -0.057
## urbn.1000.S -0.090 -0.106  0.078  0.076 -0.210
## wtr.1000.Sc -0.057 -0.201  0.025  0.009  0.111  0.199
```

I delted air temperature (A.Temp).

```
mod.Move.5 <- lmer(Move ~ CalendarDate.Scaled + Sex + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1|Site) + (1|Code), data =
MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move,
MixedData$CalendarDate.Scaled, MixedData$A.Temp.Scaled, MixedData$Sex,
MixedData$agri.100.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.1000.Scaled),]

mod.full.adjust <- lmer(Move ~ CalendarDate.Scaled + A.Temp.Scaled + Sex +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1|Site) +
(1|Code), data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Move.5.adjust <- lmer(Move ~ CalendarDate.Scaled + Sex + agri.100.Scaled
+ urban.1000.Scaled + water.1000.Scaled + (1|Site) + (1|Code), data =
MixedData.adjust, na.action=na.exclude, REML = FALSE)

anova(mod.Move.5.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Move.5.adjust: Move ~ CalendarDate.Scaled + Sex + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1 | Site) + (1 | Code)
## mod.full.adjust: Move ~ CalendarDate.Scaled + A.Temp.Scaled + Sex +
agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1 | Site) + (1 |
Code)
##                  npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## mod.Move.5.adjust    9 4680.3 4717.4 -2331.2   4662.3
## mod.full.adjust     10 4682.1 4723.3 -2331.1   4662.1 0.195  1     0.6588
```

```
summary(mod.Move.5)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Move ~ CalendarDate.Scaled + Sex + agri.100.Scaled + urban.1000.Scaled +
##     water.1000.Scaled + (1 | Site) + (1 | Code)
```

```
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   4680.3   4717.4  -2331.2   4662.3      445
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.93033 -0.52757  0.06357  0.55061  1.60079
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 747.8    27.35
##  Site     (Intercept) 128.7    11.35
##  Residual             889.8    29.83
## Number of obs: 454, groups:  Code, 430; Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)           89.591      3.897  43.305  22.989   <2e-16 ***
## CalendarDate.Scaled    1.146      3.211  21.509   0.357   0.7246
## SexM                   5.334      3.981 445.429   1.340   0.1810
## agri.100.Scaled        7.022      2.932  33.221   2.395   0.0224 *
## urban.1000.Scaled      6.307      3.250  21.924   1.941   0.0652 .
## water.1000.Scaled     -2.936      3.047  20.133  -0.963   0.3468
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) ClnD.S SexM   a.100. u.1000
## ClndrDt.Scl -0.067
## SexM        -0.571  0.041
## agr.100.Scl -0.019  0.046 -0.055
## urbn.1000.S -0.100 -0.080  0.085 -0.212
## wtr.1000.Sc -0.061 -0.212  0.012  0.111  0.198
```

I deleted Calendar date of testing (CalendarDate).

```
mod.Move.6 <- lmer(Move ~ Sex + agri.100.Scaled + urban.1000.Scaled +
water.1000.Scaled + (1|Site) + (1|Code), data = MixedData,
na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move,
MixedData$CalendarDate.Scaled, MixedData$Sex, MixedData$agri.100.Scaled,
MixedData$urban.1000.Scaled, MixedData$water.1000.Scaled),]

mod.full.adjust <- lmer(Move ~ CalendarDate.Scaled + Sex + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1|Site) + (1|Code), data =
MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Move.6.adjust <- lmer(Move ~ Sex + agri.100.Scaled + urban.1000.Scaled +
```

```
water.1000.Scaled + (1|Site) + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

anova(mod.Move.6.adjust, mod.full.adjust)

## Data: MixedData.adjust
## Models:
## mod.Move.6.adjust: Move ~ Sex + agri.100.Scaled + urban.1000.Scaled +
water.1000.Scaled + (1 | Site) + (1 | Code)
## mod.full.adjust: Move ~ CalendarDate.Scaled + Sex + agri.100.Scaled +
urban.1000.Scaled + water.1000.Scaled + (1 | Site) + (1 | Code)
##                   npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod.Move.6.adjust    8 4678.5 4711.4 -2331.2   4662.5
## mod.full.adjust      9 4680.3 4717.4 -2331.2   4662.3 0.1271  1     0.7214

summary(mod.Move.6)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Move ~ Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled +
##     (1 | Site) + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   4678.5   4711.4  -2331.2   4662.5      446
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.93595 -0.53469  0.05744  0.55361  1.59762
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 745.4    27.30
##  Site     (Intercept) 127.8    11.31
##  Residual             892.9    29.88
## Number of obs: 454, groups:  Code, 430; Site, 23
##
## Fixed effects:
##                   Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)         89.687      3.883  42.667  23.095   <2e-16 ***
## SexM                 5.277      3.979 445.904   1.326   0.1854
## agri.100.Scaled      6.971      2.924  33.643   2.384   0.0229 *
## urban.1000.Scaled    6.400      3.233  22.157   1.979   0.0603 .
## water.1000.Scaled   -2.705      2.972  20.588  -0.910   0.3732
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) SexM   a.100. u.1000
```

```
## SexM        -0.571
## agr.100.Scl -0.016 -0.057
## urbn.1000.S -0.106  0.088 -0.209
## wtr.1000.Sc -0.076  0.021  0.123  0.186
```

I deleted proportion of open water area at 1000m (water.1000).

```
mod.Move.7 <- lmer(Move ~ Sex + agri.100.Scaled + urban.1000.Scaled +
(1|Site) + (1|Code), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move, MixedData$Sex,
MixedData$agri.100.Scaled, MixedData$urban.1000.Scaled,
MixedData$water.1000.Scaled),]

mod.full.adjust <- lmer(Move ~ Sex + agri.100.Scaled + urban.1000.Scaled +
water.1000.Scaled + (1|Site) + (1|Code), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

mod.Move.7.adjust <- lmer(Move ~ Sex + agri.100.Scaled + urban.1000.Scaled +
(1|Site) + (1|Code), data = MixedData.adjust, na.action=na.exclude, REML =
FALSE)

anova(mod.Move.7.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Move.7.adjust: Move ~ Sex + agri.100.Scaled + urban.1000.Scaled + (1 |
Site) + (1 | Code)
## mod.full.adjust: Move ~ Sex + agri.100.Scaled + urban.1000.Scaled +
water.1000.Scaled + (1 | Site) + (1 | Code)
##                   npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod.Move.7.adjust    7 4677.3 4706.1 -2331.6   4663.3
## mod.full.adjust      8 4678.5 4711.4 -2331.2   4662.5 0.8139  1      0.367
```

```
summary(mod.Move.7)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Move ~ Sex + agri.100.Scaled + urban.1000.Scaled + (1 | Site) +
##     (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   4677.3   4706.1  -2331.6   4663.3      447
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.94250 -0.53395  0.06378  0.54919  1.60909
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
```

```
##  Code     (Intercept) 746.7    27.33
##  Site     (Intercept) 136.1    11.67
##  Residual             891.7    29.86
## Number of obs: 454, groups:  Code, 430; Site, 23
##
## Fixed effects:
##                   Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)         89.393      3.922  42.669  22.792   <2e-16 ***
## SexM                 5.346      3.981 445.692   1.343   0.1800
## agri.100.Scaled      7.323      2.944  33.752   2.487   0.0180 *
## urban.1000.Scaled    6.948      3.234  22.414   2.148   0.0427 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) SexM   a.100.
## SexM        -0.565
## agr.100.Scl -0.010 -0.059
## urbn.1000.S -0.093  0.085 -0.238
```

I deleted turtle sex (Sex).

```
mod.Move.8 <- lmer(Move ~ agri.100.Scaled + urban.1000.Scaled + (1|Site) +
(1|Code), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move, MixedData$Sex,
MixedData$agri.100.Scaled, MixedData$urban.1000.Scaled),]

mod.full.adjust <- lmer(Move ~ Sex + agri.100.Scaled + urban.1000.Scaled +
(1|Site) + (1|Code), data = MixedData.adjust, na.action=na.exclude, REML =
FALSE)

mod.Move.8.adjust <- lmer(Move ~ agri.100.Scaled + urban.1000.Scaled +
(1|Site) + (1|Code), data = MixedData.adjust, na.action=na.exclude, REML =
FALSE)

anova(mod.Move.8.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Move.8.adjust: Move ~ agri.100.Scaled + urban.1000.Scaled + (1 | Site)
+ (1 | Code)
## mod.full.adjust: Move ~ Sex + agri.100.Scaled + urban.1000.Scaled + (1 |
Site) + (1 | Code)
##                   npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod.Move.8.adjust    6 4677.1 4701.8 -2332.5   4665.1
## mod.full.adjust      7 4677.3 4706.1 -2331.6   4663.3 1.7987  1     0.1799
```

```
summary(mod.Move.8)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Move ~ agri.100.Scaled + urban.1000.Scaled + (1 | Site) + (1 |
##     Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   4728.9   4753.6  -2358.4   4716.9      453
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.94979 -0.51286  0.06056  0.52536  1.60654
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 793.9    28.18
##  Site     (Intercept) 142.0    11.92
##  Residual             854.7    29.24
## Number of obs: 459, groups:  Code, 434; Site, 23
##
## Fixed effects:
##                   Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)         92.524      3.279 20.374  28.216   <2e-16 ***
## agri.100.Scaled      7.494      2.974 33.220   2.520   0.0167 *
## urban.1000.Scaled    6.698      3.263 22.036   2.053   0.0522 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) a.100.
## agr.100.Scl -0.053
## urbn.1000.S -0.054 -0.235
```

I deleted proportion of urban area at 1000m (urban.1000).

```
mod.Move.9 <- lmer(Move ~ agri.100.Scaled + (1|Site) + (1|Code), data =
MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move,
MixedData$agri.100.Scaled, MixedData$urban.1000.Scaled),]

mod.full.adjust <- lmer(Move ~ agri.100.Scaled + urban.1000.Scaled + (1|Site)
+ (1|Code), data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.Move.9.adjust <- lmer(Move ~ agri.100.Scaled + (1|Site) + (1|Code), data
= MixedData.adjust, na.action=na.exclude, REML = FALSE)

anova(mod.Move.9.adjust, mod.full.adjust)
```

```
## Data: MixedData.adjust
## Models:
## mod.Move.9.adjust: Move ~ agri.100.Scaled + (1 | Site) + (1 | Code)
## mod.full.adjust: Move ~ agri.100.Scaled + urban.1000.Scaled + (1 | Site) +
(1 | Code)
##                   npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## mod.Move.9.adjust    5 4730.7 4751.4 -2360.3   4720.7
## mod.full.adjust      6 4728.9 4753.6 -2358.4   4716.9 3.8449  1     0.0499
*
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

summary(mod.Move.9)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Move ~ agri.100.Scaled + (1 | Site) + (1 | Code)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   4730.7   4751.4  -2360.4   4720.7      454
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.95044 -0.52349  0.05835  0.53308  1.63015
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 790.4    28.11
##  Site     (Intercept) 188.9    13.74
##  Residual             857.3    29.28
## Number of obs: 459, groups:  Code, 434; Site, 23
##
## Fixed effects:
##                 Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)       92.789      3.588 20.914  25.862   <2e-16 ***
## agri.100.Scaled    9.033      3.108 31.860   2.907   0.0066 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr)
## agr.100.Scl -0.079
```

As the LRT p - value suggests that mod.Move.9 is not a better fit then mod.Move.8 ($p < 0.05$), I will stop the backwards selection at mod.Move.8 and use it to create the final model.

Final model

Summary statistics

I changed the REML to TRUE to calculate the summary statistics of the final model.

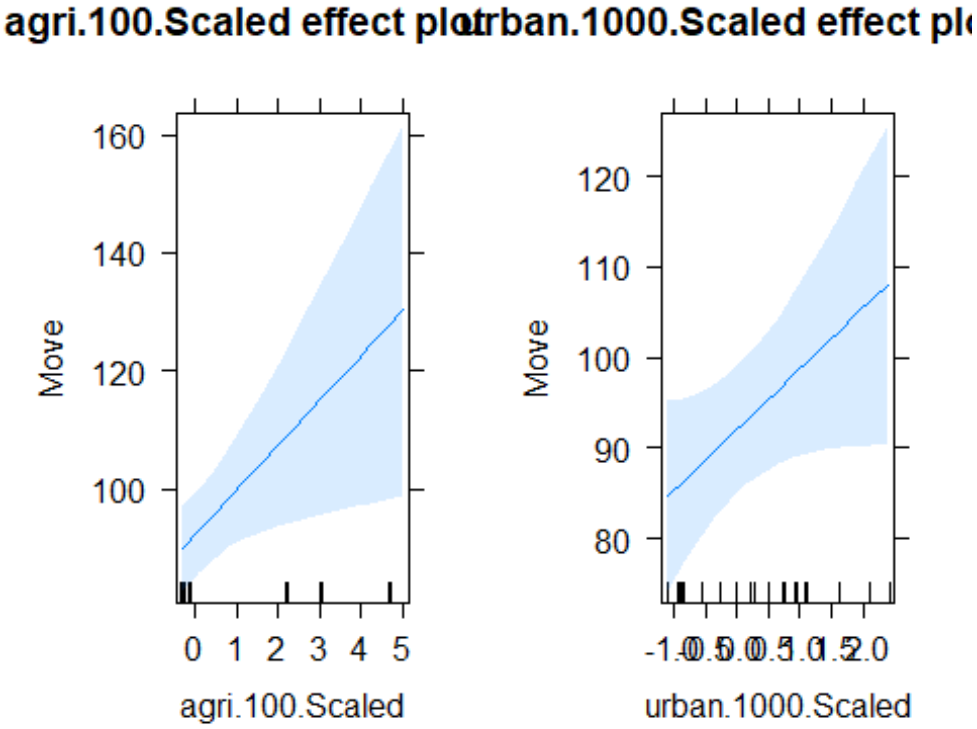
```
#Creating model with just the conditional average coefficients
mod.Move.final <- lmer(Move ~ agri.100.Scaled + urban.1000.Scaled + (1|Site)
+ (1|Code), data = MixedData, na.action=na.exclude, REML = TRUE)

summary(mod.Move.final)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Move ~ agri.100.Scaled + urban.1000.Scaled + (1 | Site) + (1 |
##     Code)
##    Data: MixedData
##
## REML criterion at convergence: 4704.3
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.95468 -0.50476  0.06275  0.52497  1.60171
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 794.8    28.19
##  Site     (Intercept) 177.8    13.33
##  Residual             854.1    29.23
## Number of obs: 459, groups:  Code, 434; Site, 23
##
## Fixed effects:
##                   Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)         92.424      3.523 17.918  26.238 9.51e-16 ***
## agri.100.Scaled      7.581      3.148 27.397   2.408   0.0230 *
## urban.1000.Scaled    6.689      3.496 19.258   1.913   0.0707 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) a.100.
## agr.100.Scl -0.061
## urbn.1000.S -0.057 -0.237
```

Proportion of urban area at 1000m does not have a statistically significant effect on total time spent moving.

Visualization of the predictor effects

```
plot(allEffects(mod.Move.final))
```



Calculation of the marginal and conditional variance explained by the final model

```
r.squaredGLMM(mod.Move.final)
```

```
##             R2m       R2c
## [1,] 0.05853838 0.5597985
```

Marginal R2: fixed effects R2. Conditional R2: fixed and random effects R2.

Calculation of the 95% confidence intervals

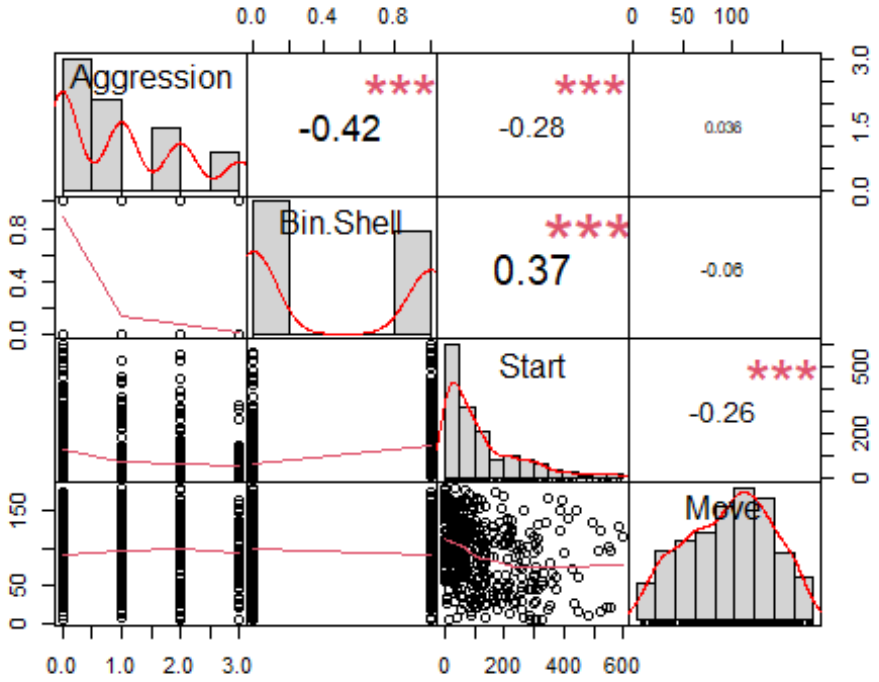
```
confint(mod.Move.final, level = 0.95, method = "Wald")
```

```
##                          2.5 %   97.5 %
## .sig01                      NA       NA
## .sig02                      NA       NA
## .sigma                      NA       NA
## (Intercept)        85.5197263 99.32801
## agri.100.Scaled     1.4108529 13.75138
## urban.1000.Scaled  -0.1628494 13.54157
```

Calculation of Pearson and Spearman correlation coefficients between behaviours

Pearson correlation coefficients

```
# Visualization of the correlations
cor.behaviour <- MixedData[,c(11,13,14,15)]
chart.Correlation(cor.behaviour, histogram=TRUE, pch=19)
```




```
# Creation of the correlation table
table.corr.pearson.behaviour <- rcorr(as.matrix(MixedData[,c(11,13,14,15)]),
type="pearson")
table.cor.pearson.behaviour.r <- table.corr.pearson.behaviour$r # Pearson
correlation coefficients
table.cor.pearson.behaviour.p <- table.corr.pearson.behaviour$P # P values of
the correlations
table.cor.pearson.behaviour.r

##             Aggression   Bin.Shell       Start        Move
## Aggression  1.00000000 -0.42367744 -0.2759465  0.03613673
## Bin.Shell  -0.42367744  1.00000000  0.3699742 -0.06016433
## Start      -0.27594651  0.36997418  1.0000000 -0.26028477
## Move        0.03613673 -0.06016433 -0.2602848  1.00000000

table.cor.pearson.behaviour.p
```

```
##              Aggression    Bin.Shell        Start         Move
## Aggression           NA 0.000000e+00 1.748938e-09 4.399102e-01
## Bin.Shell  0.000000e+00           NA 2.220446e-16 1.982237e-01
## Start      1.748938e-09 2.220446e-16           NA 1.522212e-08
## Move       4.399102e-01 1.982237e-01 1.522212e-08           NA
```

Spearman correlation coefficients

```
# Creation of the correlation table
table.corr.spearman.behaviour <- rcorr(as.matrix(MixedData[,c(11,13,14,15)]),
type="spearman")
table.cor.spearman.behaviour.r <- table.corr.spearman.behaviour$r # Pearson
correlation coefficients
table.cor.spearman.behaviour.p <- table.corr.spearman.behaviour$P # P values
of the correlations
table.cor.spearman.behaviour.r
```

```
##             Aggression  Bin.Shell      Start        Move
## Aggression  1.00000000 -0.4416514 -0.3028358  0.05072592
## Bin.Shell  -0.44165143  1.0000000  0.4269960 -0.06471060
## Start      -0.30283584  0.4269960  1.0000000 -0.28682170
## Move        0.05072592 -0.0647106 -0.2868217  1.00000000
```

```
table.cor.spearman.behaviour.p
```

```
##              Aggression Bin.Shell        Start         Move
## Aggression           NA 0.0000000 3.270673e-11 2.781425e-01
## Bin.Shell  0.000000e+00        NA 0.000000e+00 1.663435e-01
## Start      3.270673e-11 0.0000000           NA 3.844765e-10
## Move       2.781425e-01 0.1663435 3.844765e-10           NA
```