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)
```

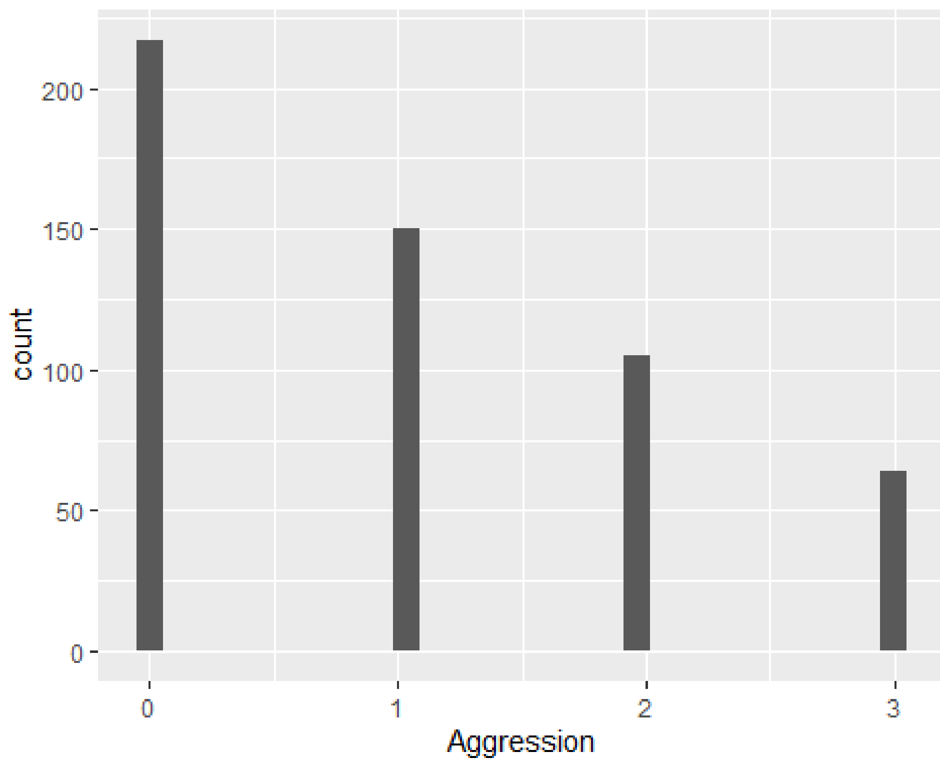
Upload the dataset to use

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

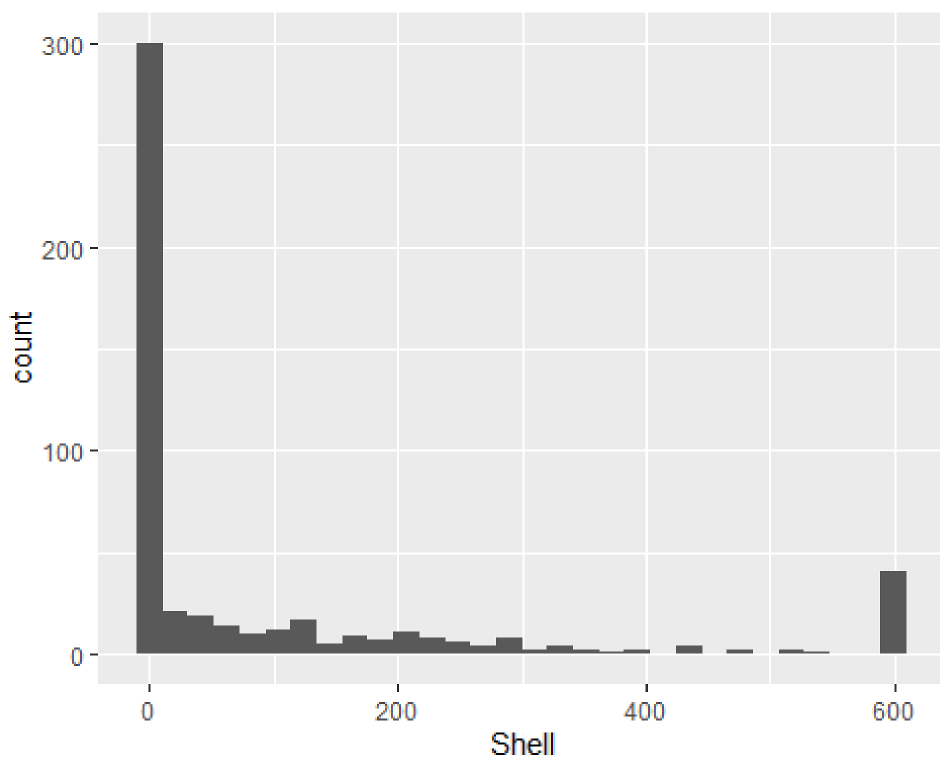
Plot Data

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.

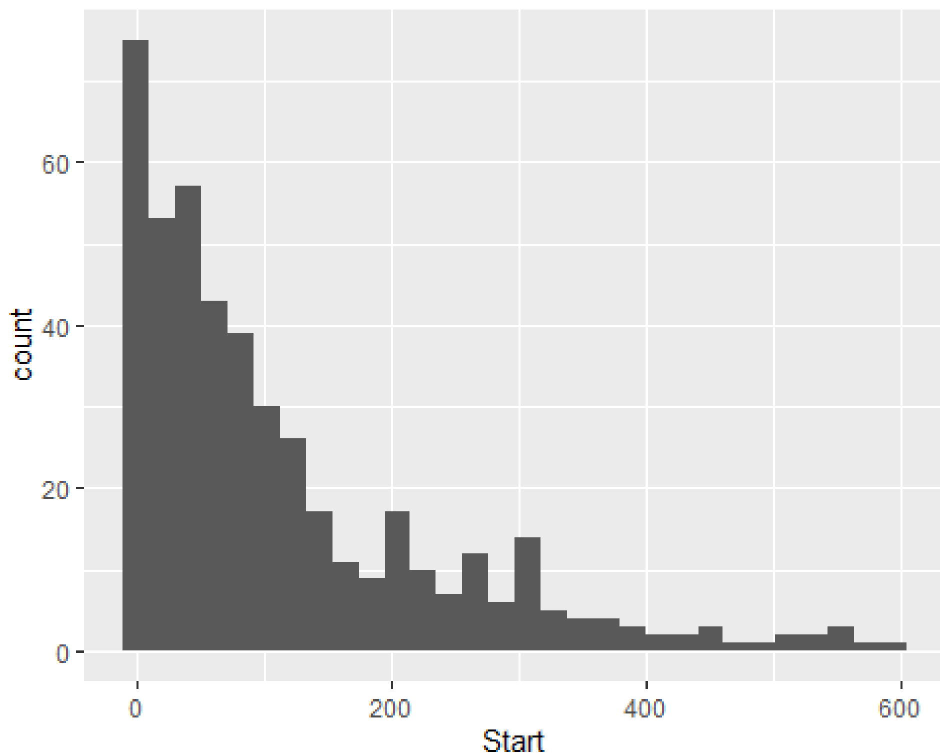
```
ggplot(MixedData, aes(x=Aggression)) + geom_histogram()
```



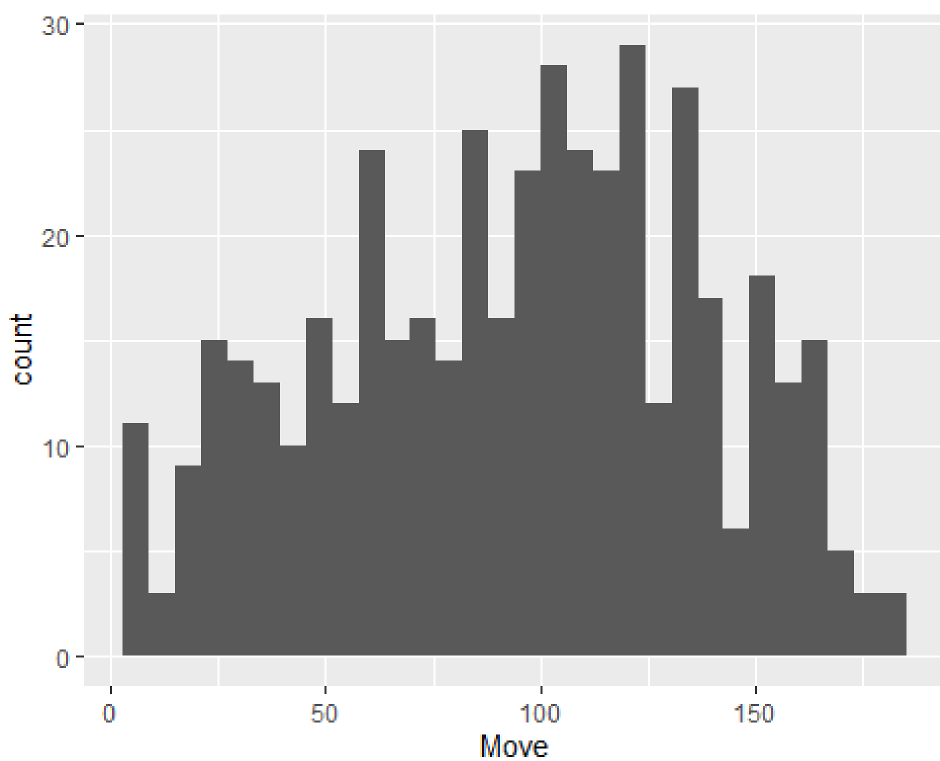

```
ggplot(MixedData, aes(x=Shell)) + geom_histogram()
```




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




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



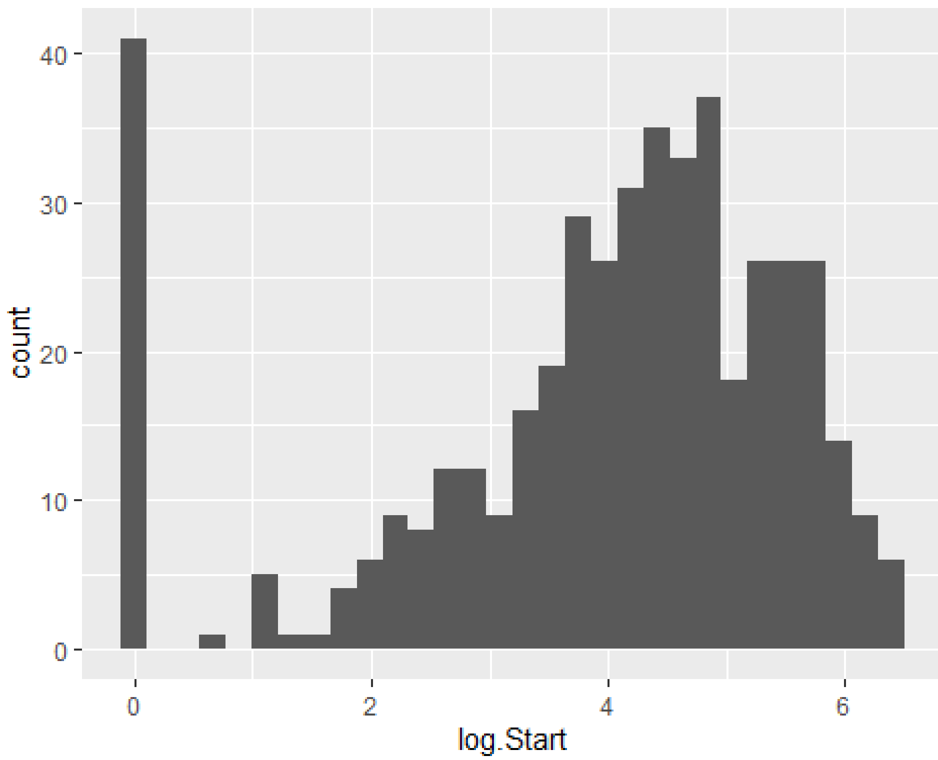
Time of initial movement has a skewed distribution so I will plot a log transformed version of it.

Log(x+1) transform time of initial movement (log.Start)

```
MixedData$log.Start <- log(MixedData$Start + 1)
```

Plot log(x+1) transformed version of time of initial movement

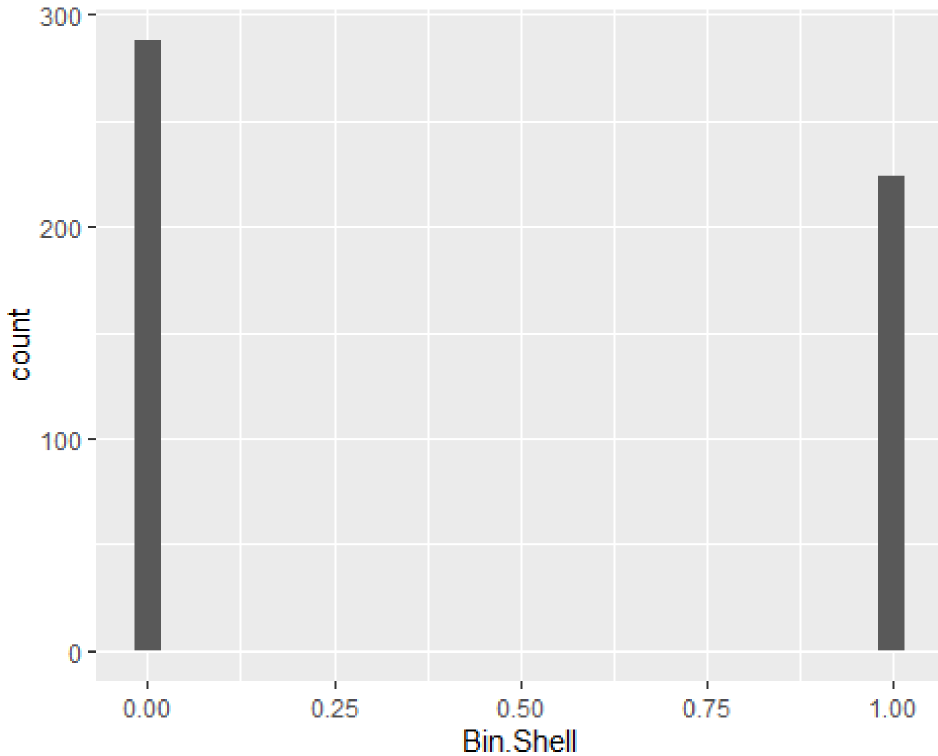
```
ggplot(MixedData, aes(x=log.Start)) + geom_histogram()
```



The log transformed version of time of initial movement is still somewhat skewed, so I will run my analysis on both versions for comparison. Shell emergence time is also skewed, 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$log.Start <- as.numeric(MixedData$log.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$JulianDate <- as.numeric(MixedData$JulianDate)
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$JulianDate.Scaled <- scale(MixedData$JulianDate, center=TRUE, scale
=TRUE)
MixedData$for.veg.200.Scaled <- scale(MixedData$for.veg.200, center=TRUE, sca
le=TRUE)
MixedData$for.veg.300.Scaled <- scale(MixedData$for.veg.300, center=TRUE, sca
le=TRUE)
MixedData$for.veg.1000.Scaled <- scale(MixedData$for.veg.1000, center=TRUE, s
cale=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=TRU
E)
MixedData$agri.100.Scaled <- scale(MixedData$agri.100, center=TRUE, scale=TRU
E)
MixedData$agri.200.Scaled <- scale(MixedData$agri.200, center=TRUE, scale=TRU
E)
MixedData$agri.400.Scaled <- scale(MixedData$agri.400, center=TRUE, scale=TRU
E)
MixedData$agri.500.Scaled <- scale(MixedData$agri.500, center=TRUE, scale=TRU
E)
MixedData$agri.600.Scaled <- scale(MixedData$agri.600, center=TRUE, scale=TRU
```

```
E)
MixedData$agri.1000.Scaled <- scale(MixedData$agri.1000, center=TRUE, scale=T
RUE)
MixedData$urban.1000.Scaled <- scale(MixedData$urban.1000, center=TRUE, scale
=TRUE)
MixedData$water.100.Scaled <- scale(MixedData$water.100, center=TRUE, scale=T
RUE)
MixedData$water.400.Scaled <- scale(MixedData$water.400, center=TRUE, scale=T
RUE)
MixedData$water.500.Scaled <- scale(MixedData$water.500, center=TRUE, scale=T
RUE)
MixedData$water.900.Scaled <- scale(MixedData$water.900, center=TRUE, scale=T
RUE)
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$JulianDate.Scaled <- as.numeric(MixedData$JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + W.T
emp.Scaled + Time.Scaled + Mass.Scaled + PL.Scaled + Sex + for.veg.1000.Scale
d + 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))
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + W.T
emp.Scaled + Time.Scaled + PL.Scaled + Sex + for.veg.1000.Scaled + wet.200.Sc
aled + agri.100.Scaled + urban.1000.Scaled + water.400.Scaled, data = MixedDa
ta, na.action=na.exclude)
gvif(mod.Aggression.vif)
```

```
##                       GVIF df GVIF^(1/(2*df))
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + W.T
emp.Scaled + Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled
+ urban.1000.Scaled + water.400.Scaled, data = MixedData, na.action=na.exclud
e)
gvif(mod.Aggression.vif)
```

```
##                     GVIF df GVIF^(1/(2*df))
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Tim
e.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled + urban.1000.Sc
aled + water.400.Scaled, data = MixedData, na.action=na.exclude)
gvif(mod.Aggression.vif)
```

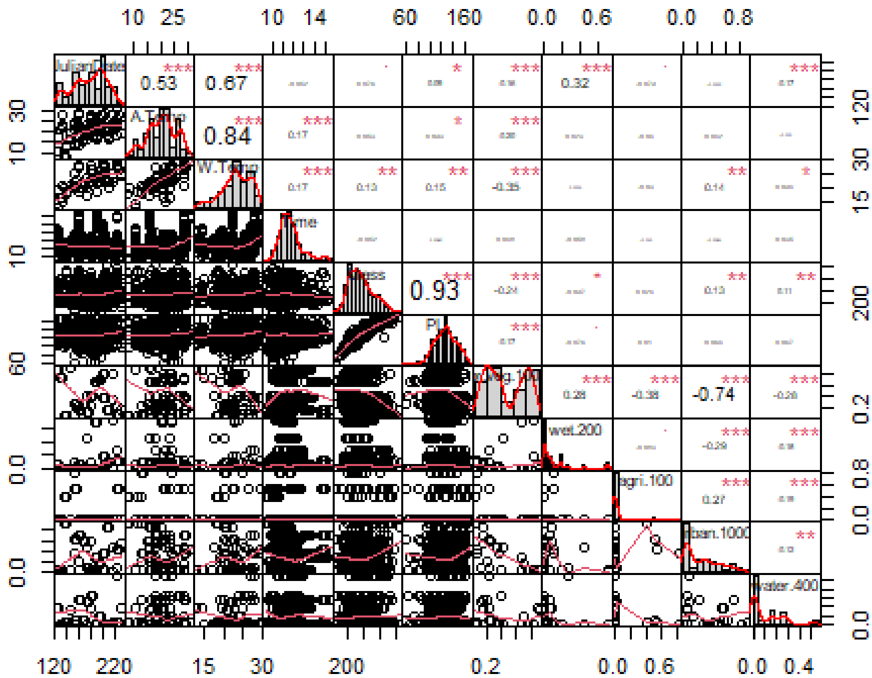
```
##                     GVIF df GVIF^(1/(2*df))
## JulianDate.Scaled 1.7005  1          1.3040
## A.Temp.Scaled     1.5191  1          1.2325
## Time.Scaled       1.0828  1          1.0406
## PL.Scaled         1.4046  1          1.1852
## Sex               1.4112  1          1.1879
## wet.200.Scaled    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$r # Pearson c
orrelation coefficients
table.cor.pearson.Aggression.p <- table.corr.pearson.Aggression$P # P values
of the correlations
table.cor.pearson.Aggression.r

##                JulianDate     A.Temp       W.Temp         Time        Mas
s
## JulianDate     1.000000000  0.52662360  0.668683098 -0.051688682  0.0756020
8
## A.Temp         0.526623600  1.00000000  0.838871081  0.171967476  0.0525296
4
## W.Temp         0.668683098  0.83887108  1.000000000  0.166126059  0.1322150
5
## Time          -0.051688682  0.17196748  0.166126059  1.000000000 -0.0524517
1
## Mass           0.075602082  0.05252964  0.132215053 -0.052451709  1.0000000
0
## PL             0.089516177  0.09250283  0.146064749  0.009461487  0.9331145
5
## for.veg.1000 -0.159757526 -0.20286665 -0.354421886  0.048125471 -0.2396708
7
## wet.200        0.319118112  0.02344567  0.002124113 -0.057823266 -0.0971942
9
```

```
## agri.100     -0.078714526 -0.03995312 -0.030225708 -0.013077109  0.0240670
4
## urban.1000   -0.003462429  0.04205111  0.143942429 -0.006102219  0.1273897
4
## water.400    -0.169078991 -0.02278033  0.093636191  0.035069081  0.1126047
0
##                        PL for.veg.1000      wet.200    agri.100   urban.10
00
## JulianDate    0.089516177  -0.15975753  0.319118112 -0.07871453 -0.0034624
29
## A.Temp        0.092502829  -0.20286665  0.023445668 -0.03995312  0.0420511
10
## W.Temp        0.146064749  -0.35442189  0.002124113 -0.03022571  0.1439424
29
## Time          0.009461487   0.04812547 -0.057823266 -0.01307711 -0.0061022
19
## Mass          0.933114554  -0.23967087 -0.097194285  0.02406704  0.1273897
43
## PL            1.000000000  -0.17433634 -0.076087500  0.01037365  0.0639451
49
## for.veg.1000 -0.174336336   1.00000000  0.276458046 -0.38318444 -0.7437982
23
## wet.200      -0.076087500   0.27645805  1.000000000 -0.08318312 -0.2948294
46
## agri.100      0.010373653  -0.38318444 -0.083183118  1.00000000  0.2719946
55
## urban.1000    0.063945149  -0.74379822 -0.294829446  0.27199465  1.0000000
00
## water.400     0.067406397  -0.28142967 -0.183447101 -0.19070486 -0.1173627
38
##                water.400
## JulianDate   -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
```

```
##                JulianDate       A.Temp       W.Temp         Time          M
ass
## JulianDate             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.1
000
## JulianDate   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
## JulianDate   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 value
s of the correlations
table.cor.spearman.Aggression.r
```

```
##               JulianDate      A.Temp      W.Temp         Time        Mass
## JulianDate    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
## JulianDate    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
## JulianDate   -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

```
##                 JulianDate       A.Temp       W.Temp         Time           M
ass
## JulianDate              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.1
000
## JulianDate   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
```

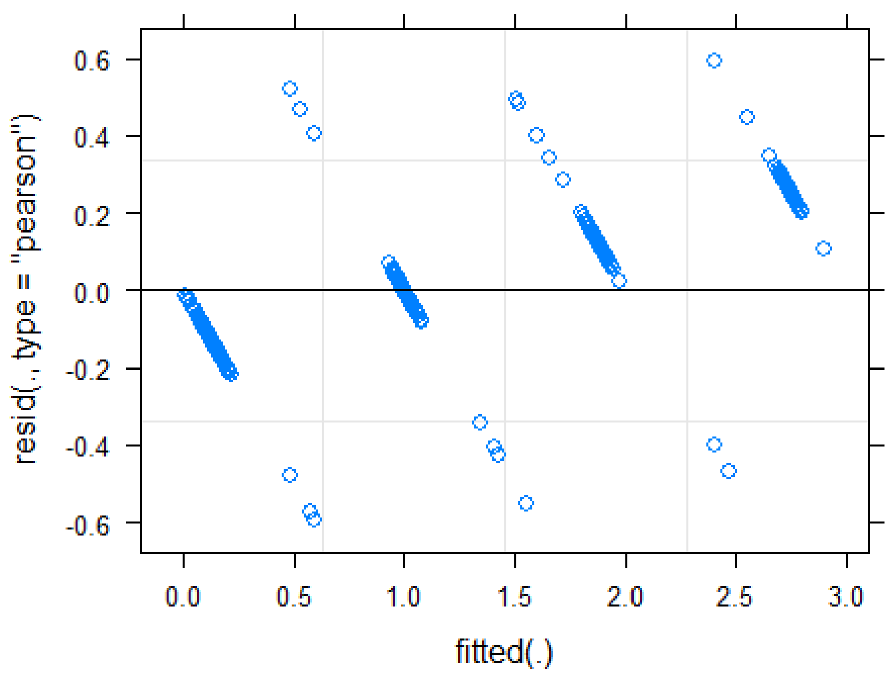
```
NA
## water.400    0.1444276999 3.008301e-07 8.152307e-06 4.119614e-01 5.617520e
-01
##                 water.400
## JulianDate   7.642775e-13
## A.Temp       1.773963e-02
## W.Temp       7.829165e-01
## Time         8.683342e-01
## Mass         3.459895e-02
## PL           1.444277e-01
## for.veg.1000 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)).

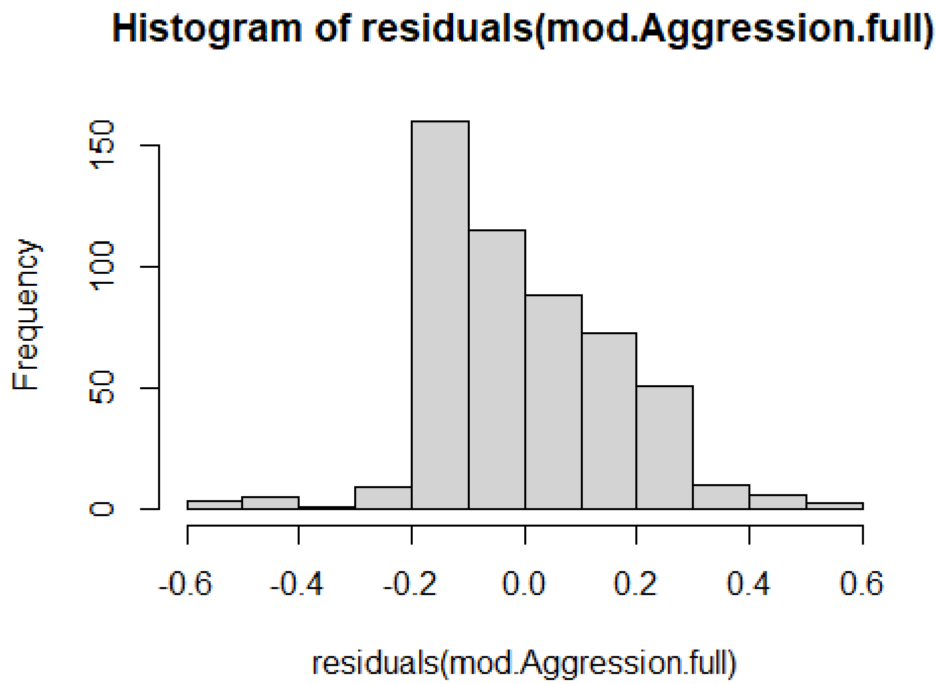
Verification of the assumptions with the initial model

```
mod.Aggression.full <- lmer(Aggression ~ JulianDate.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 = TR
UE, na.action=na.exclude)

summary(mod.Aggression.full)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Aggression ~ JulianDate.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:
```

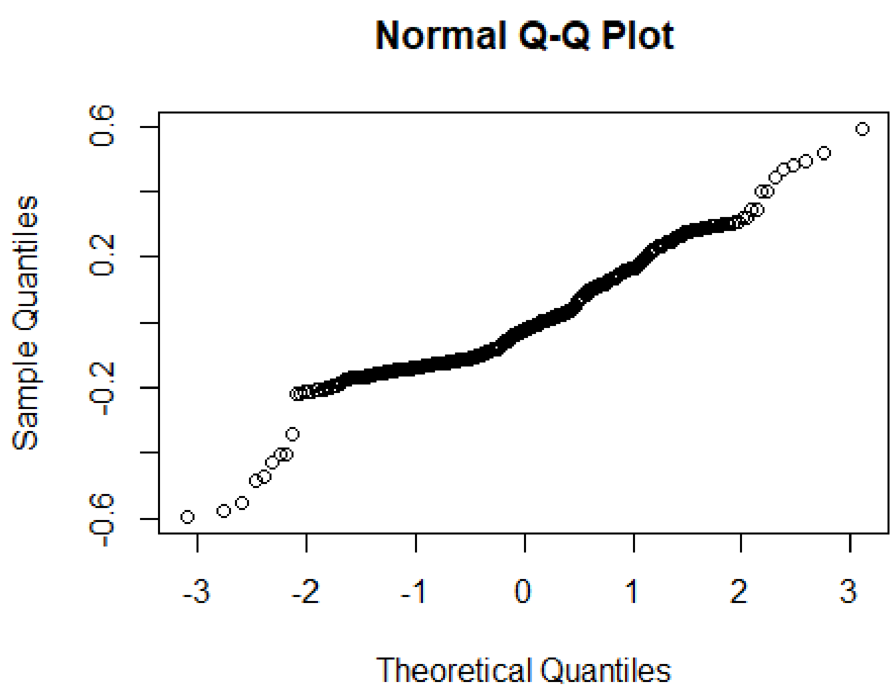
```
##                        Estimate Std. Error         df t value Pr(>|t|)    
## (Intercept)             1.00148    0.08420  31.50789  11.895 3.46e-13 ***
## JulianDate.Scaled      -0.05395    0.07452  17.14086  -0.724   0.4788    
## A.Temp.Scaled           0.14378    0.06375  45.47667   2.255   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) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.200. a.100. u.1000
## JulnDt.Scld -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 ~ JulianDate.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 = Mixed
Data, na.action=na.exclude)
gvif(mod.Start.vif)

##                     GVIF df GVIF^(1/(2*df))
## JulianDate.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 ~ JulianDate.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.actio
n=na.exclude)
gvif(mod.Start.vif)

##                     GVIF df GVIF^(1/(2*df))
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled + urb
an.1000.Scaled + water.500.Scaled, data = MixedData, na.action=na.exclude)
gvif(mod.Start.vif)
```

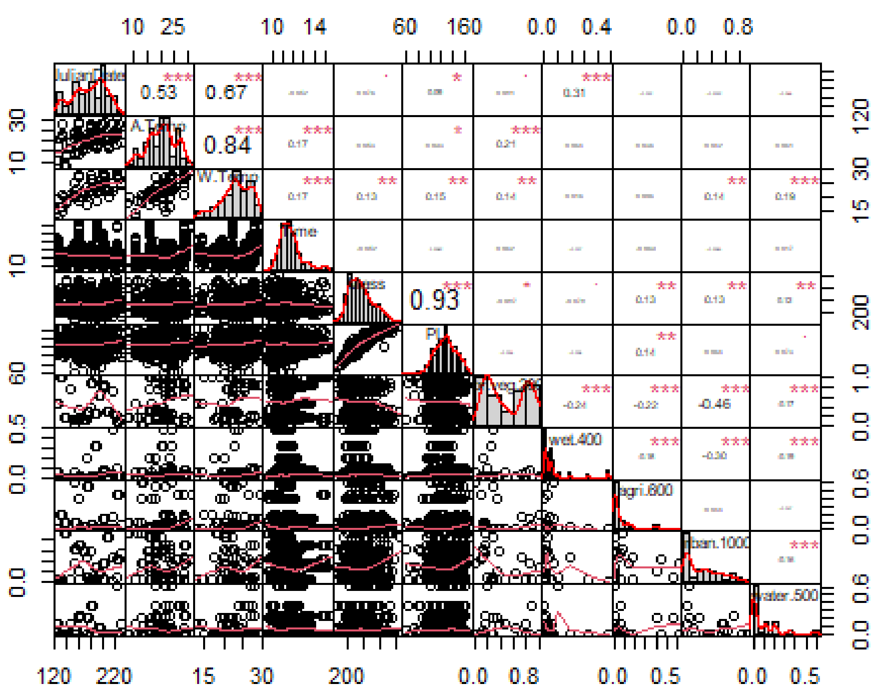
```
##                        GVIF df GVIF^(1/(2*df))
## JulianDate.Scaled  1.6219  1          1.2735
## A.Temp.Scaled      1.7465  1          1.3216
## Time.Scaled        1.0943  1          1.0461
## PL.Scaled          1.3825  1          1.1758
## Sex                1.3683  1          1.1697
## for.veg.200.Scaled 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 cor
relations
table.cor.pearson.Start.r

##               JulianDate     A.Temp     W.Temp         Time        Mass
## JulianDate   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
## JulianDate   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
## JulianDate  -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

##               JulianDate       A.Temp       W.Temp         Time         Mas
s
```

```
## JulianDate             NA 0.000000e+00 0.000000e+00 2.322103e-01 0.08033738
4
## A.Temp      0.000000e+00           NA 0.000000e+00 6.283828e-05 0.22469108
8
## W.Temp      0.000000e+00 0.000000e+00           NA 2.346306e-04 0.00349966
0
## Time        2.322103e-01 6.283828e-05 2.346306e-04           NA 0.22538053
4
## Mass        8.033738e-02 2.246911e-01 3.499660e-03 2.253805e-01           N
A
## PL          3.846835e-02 3.242105e-02 1.256393e-03 8.271659e-01 0.00000000
0
## for.veg.200 6.058262e-02 6.579274e-07 2.716312e-03 1.509483e-01 0.04310363
0
## wet.400     4.334311e-13 1.369959e-01 7.314244e-01 3.983658e-01 0.07080188
5
## agri.600    4.172351e-01 4.049233e-01 8.949431e-01 1.084987e-01 0.00225920
1
## urban.1000  9.362578e-01 3.311946e-01 1.464223e-03 8.879110e-01 0.00313231
2
## water.500   3.092088e-01 1.604920e-01 2.000264e-05 7.028551e-01 0.00601193
5
##                      PL  for.veg.200      wet.400     agri.600   urban.100
0
## JulianDate  0.038468345 6.058262e-02 4.334311e-13 4.172351e-01 9.362578e-0
1
## A.Temp      0.032421052 6.579274e-07 1.369959e-01 4.049233e-01 3.311946e-0
1
## W.Temp      0.001256393 2.716312e-03 7.314244e-01 8.949431e-01 1.464223e-0
3
## Time        0.827165890 1.509483e-01 3.983658e-01 1.084987e-01 8.879110e-0
1
## Mass        0.000000000 4.310363e-02 7.080188e-02 2.259201e-03 3.132312e-0
3
## PL                   NA 4.370909e-01 3.628289e-01 1.378178e-03 1.396467e-0
1
## for.veg.200 0.437090868           NA 1.525600e-08 2.890116e-07 0.000000e+0
0
## wet.400     0.362828857 1.525600e-08           NA 3.207206e-05 2.036149e-1
2
## agri.600    0.001378178 2.890116e-07 3.207206e-05           NA 3.104625e-0
1
## urban.1000  0.139646656 0.000000e+00 2.036149e-12 3.104625e-01           N
A
## water.500   0.091912781 6.662331e-05 1.090597e-05 6.902496e-01 3.053590e-0
4
##                water.500
## JulianDate  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(3,4,5,6,7,8,18,30,4
2,56,61)]), type="spearman")
table.cor.spearman.Start.r <- table.corr.spearman.Start$r # Pearson correlati
on coefficients
table.cor.spearman.Start.p <- table.corr.spearman.Start$P # P values of the c
orrelations
table.cor.spearman.Start.r
```

```
##              JulianDate      A.Temp     W.Temp         Time        Mass
## JulianDate   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
## JulianDate   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
## JulianDate  -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
```

```
##               JulianDate       A.Temp       W.Temp         Time          Ma
ss
## JulianDate            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.10
00
## JulianDate  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
```

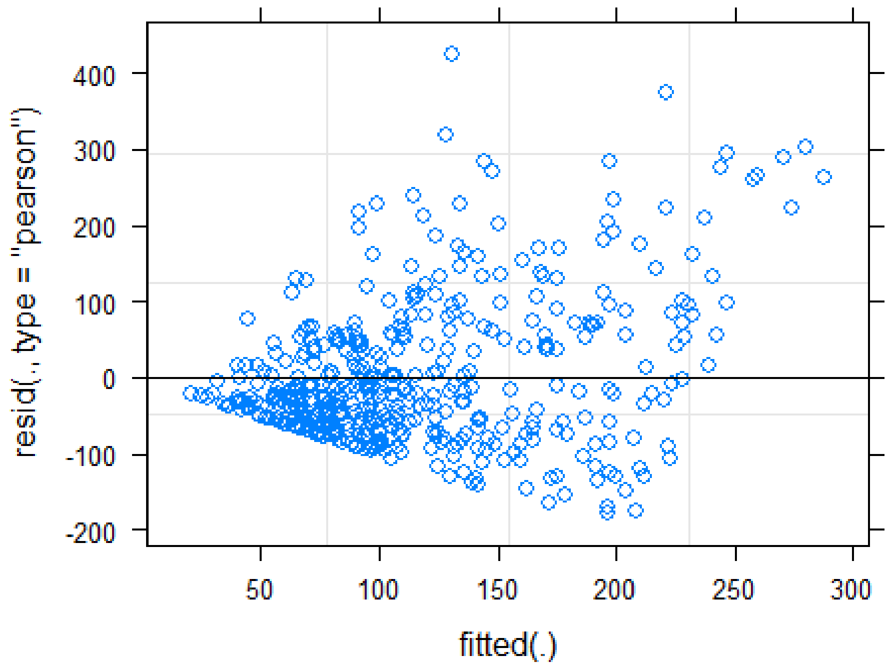
```
## agri.600    2.375451e-05 1.646414e-05 1.302514e-12           NA 0.000000e+
00
## urban.1000  6.448653e-02 0.000000e+00 5.346181e-08 0.000000e+00
NA
## water.500   1.096520e-01 5.735767e-11 0.000000e+00 8.993265e-01 2.033521e-
01
##                water.500
## JulianDate  1.194147e-10
## A.Temp      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)).

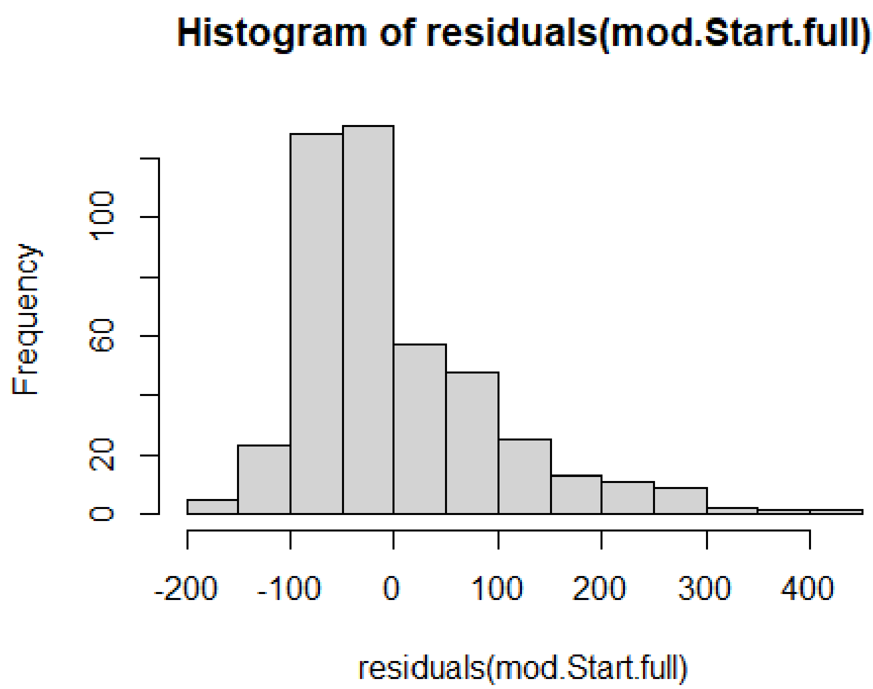
Verification of the assumptions with the initial model

```
mod.Start.full <- lmer(Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scal
ed +
##     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
```

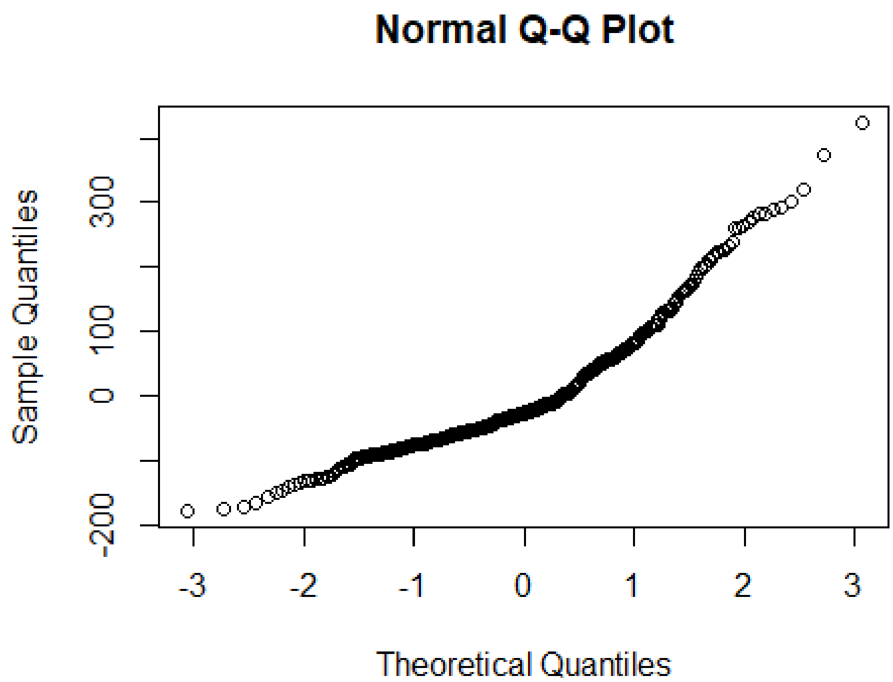
```
## Number of obs: 454, groups:  Code, 430; Site, 23
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          121.855     14.207  25.474   8.577 5.53e-09 ***
## JulianDate.Scaled    -19.886     13.450  18.438  -1.478  0.15616
## A.Temp.Scaled         -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) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   f..200 w.400. a.600.
## JulnDt.Scld -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
## JulnDt.Scld
## 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))
```



Log(x+1) transformed version of time of initial movement (log.Start)

```
MixedData$log.Start <- as.numeric(MixedData$log.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.log.Start.vif <- lm(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + W.Tem
p.Scaled + Time.Scaled + Mass.Scaled + PL.Scaled + Sex + for.veg.1000.Scaled
+ wet.400.Scaled + agri.400.Scaled + urban.1000.Scaled + water.100.Scaled, da
ta = MixedData, na.action=na.exclude)
gvif(mod.log.Start.vif)

##                       GVIF df GVIF^(1/(2*df))
## JulianDate.Scaled   2.6565  1          1.6299
## A.Temp.Scaled       4.0073  1          2.0018
## W.Temp.Scaled       5.7361  1          2.3950
## Time.Scaled         1.1459  1          1.0705
## Mass.Scaled         8.8880  1          2.9813
## PL.Scaled           7.9226  1          2.8147
## Sex                 1.4672  1          1.2113
## for.veg.1000.Scaled 6.6011  1          2.5693
## wet.400.Scaled      1.2942  1          1.1376
## agri.400.Scaled     2.3605  1          1.5364
## urban.1000.Scaled   3.8120  1          1.9524
## water.100.Scaled    1.7370  1          1.3180
```

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

```
mod.log.Start.vif <- lm(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + W.Tem
p.Scaled + Time.Scaled + PL.Scaled + Sex + for.veg.1000.Scaled + wet.400.Scal
ed + agri.400.Scaled + urban.1000.Scaled + water.100.Scaled, data = MixedData
, na.action=na.exclude)
gvif(mod.log.Start.vif)
```

```
##                       GVIF df GVIF^(1/(2*df))
## JulianDate.Scaled   2.6556  1          1.6296
## A.Temp.Scaled       3.9633  1          1.9908
## W.Temp.Scaled       5.7275  1          2.3932
## Time.Scaled         1.1307  1          1.0633
## PL.Scaled           1.3764  1          1.1732
## Sex                 1.3577  1          1.1652
## for.veg.1000.Scaled 6.4136  1          2.5325
## wet.400.Scaled      1.2936  1          1.1374
## agri.400.Scaled     2.2981  1          1.5159
## urban.1000.Scaled   3.8005  1          1.9495
## water.100.Scaled    1.7329  1          1.3164
```

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

```
##                     GVIF df GVIF^(1/(2*df))
## JulianDate.Scaled 2.5793  1          1.6060
## A.Temp.Scaled     3.9474  1          1.9868
## W.Temp.Scaled     5.2164  1          2.2839
## Time.Scaled       1.1188  1          1.0577
## PL.Scaled         1.3362  1          1.1559
## Sex               1.3547  1          1.1639
## wet.400.Scaled    1.2931  1          1.1371
## agri.400.Scaled   1.0550  1          1.0271
## urban.1000.Scaled 1.1520  1          1.0733
## water.100.Scaled  1.5273  1          1.2358
```

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

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

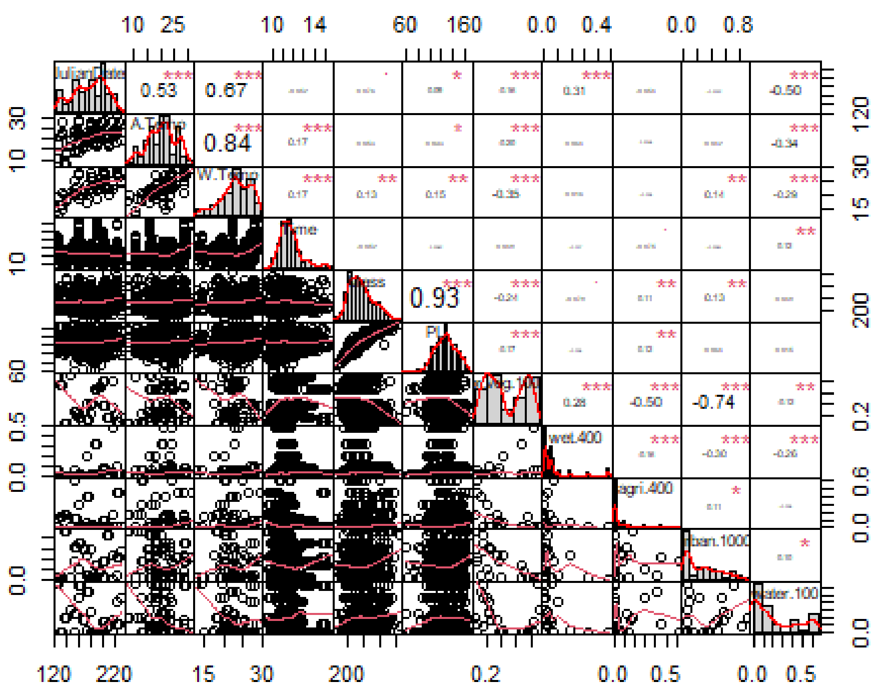
```
##                         GVIF df GVIF^(1/(2*df))
## JulianDate.Scaled 1.8283  1            1.3521
## A.Temp.Scaled     1.5302  1            1.2370
## Time.Scaled       1.1089  1            1.0530
## PL.Scaled         1.3620  1            1.1670
## Sex               1.3661  1            1.1688
## wet.400.Scaled    1.2598  1            1.1224
## agri.400.Scaled   1.0579  1            1.0285
## urban.1000.Scaled 1.1253  1            1.0608
## water.100.Scaled  1.4303  1            1.1960
```

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.log.Start <- MixedData[, c(3,4,5,6,7,8,26,30,40,56,57)]
chart.Correlation(cor.pearson.log.Start, histogram=TRUE, pch=19)
```




```
# Creation of the correlation table
table.corr.pearson.log.Start <- rcorr(as.matrix(MixedData[,c(3,4,5,6,7,8,26,3
0,40,56,57)]), type="pearson")
table.cor.pearson.log.Start.r <- table.corr.pearson.log.Start$r # Pearson cor
relation coefficients
table.cor.pearson.log.Start.p <- table.corr.pearson.log.Start$P # P values of
```

```
the correlations
table.cor.pearson.log.Start.r

##                  JulianDate       A.Temp      W.Temp         Time        Mas
s
## JulianDate    1.000000000  0.526623600  0.66868310 -0.051688682  0.0756020
8
## A.Temp        0.526623600  1.000000000  0.83887108  0.171967476  0.0525296
4
## W.Temp        0.668683098  0.838871081  1.00000000  0.166126059  0.1322150
5
## Time         -0.051688682  0.171967476  0.16612606  1.000000000 -0.0524517
1
## Mass          0.075602082  0.052529643  0.13221505 -0.052451709  1.0000000
0
## PL            0.089516177  0.092502829  0.14606475  0.009461487  0.9331145
5
## for.veg.1000 -0.159757526 -0.202866655 -0.35442189  0.048125471 -0.2396708
7
## wet.400       0.306093497  0.064315348  0.01560853 -0.036551862 -0.0781026
4
## agri.400     -0.053734482  0.001830737 -0.02805362 -0.074905763  0.1149580
0
## urban.1000   -0.003462429  0.042051110  0.14394243 -0.006102219  0.1273897
4
## water.100    -0.496260565 -0.338053897 -0.29046345  0.117991743  0.0478384
1
##                        PL for.veg.1000     wet.400     agri.400   urban.10
00
## JulianDate    0.089516177  -0.15975753  0.30609350 -0.053734482 -0.0034624
29
## A.Temp        0.092502829  -0.20286665  0.06431535  0.001830737  0.0420511
10
## W.Temp        0.146064749  -0.35442189  0.01560853 -0.028053619  0.1439424
29
## Time          0.009461487   0.04812547 -0.03655186 -0.074905763 -0.0061022
19
## Mass          0.933114554  -0.23967087 -0.07810264  0.114958001  0.1273897
43
## PL            1.000000000  -0.17433634 -0.03941912  0.116911690  0.0639451
49
## for.veg.1000 -0.174336336   1.00000000  0.28348111 -0.495333110 -0.7437982
23
## wet.400      -0.039419118   0.28348111  1.00000000 -0.161677421 -0.2975250
27
## agri.400      0.116911690  -0.49533311 -0.16167742  1.000000000  0.1086598
50
## urban.1000    0.063945149  -0.74379822 -0.29752503  0.108659850  1.0000000
00
## water.100     0.015430905  -0.12313807 -0.26458013 -0.028765465  0.1035319
```

```
38
##                water.100
## JulianDate   -0.49626056
## A.Temp       -0.33805390
## W.Temp       -0.29046345
## Time          0.11799174
## Mass          0.04783841
## PL            0.01543090
## for.veg.1000 -0.12313807
## wet.400      -0.26458013
## agri.400     -0.02876546
## urban.1000    0.10353194
## water.100     1.00000000
```

```
table.cor.pearson.log.Start.p
```

```
##                JulianDate       A.Temp       W.Temp         Time          M
ass
## JulianDate             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.400      4.334311e-13 1.369959e-01 7.314244e-01 3.983658e-01 7.080188e
-02
## agri.400     2.142232e-01 9.662709e-01 5.372464e-01 8.317038e-02 7.719600e
-03
## urban.1000   9.362578e-01 3.311946e-01 1.464223e-03 8.879110e-01 3.132312e
-03
## water.100    0.000000e+00 8.881784e-16 6.658052e-11 6.240147e-03 2.689054e
-01
##                        PL for.veg.1000      wet.400     agri.400   urban.1
000
## JulianDate   3.846835e-02 2.040904e-04 4.334311e-13 0.2142231652 9.362578e
-01
## A.Temp       3.242105e-02 2.189891e-06 1.369959e-01 0.9662709322 3.311946e
-01
## W.Temp       1.256393e-03 8.881784e-16 7.314244e-01 0.5372463677 1.464223e
-03
## Time         8.271659e-01 2.660399e-01 3.983658e-01 0.0831703770 8.879110e
-01
```

```
## Mass         0.000000e+00 1.932793e-08 7.080188e-02 0.0077195996 3.132312e
-03
## PL                     NA 5.033503e-05 3.628289e-01 0.0067865758 1.396467e
-01
## for.veg.1000 5.033503e-05           NA 2.303513e-11 0.0000000000 0.000000e
+00
## wet.400      3.628289e-01 2.303513e-11           NA 0.0001705096 2.036149e
-12
## agri.400     6.786576e-03 0.000000e+00 1.705096e-04           NA 1.182777e
-02
## urban.1000   1.396467e-01 0.000000e+00 2.036149e-12 0.0118277719
NA
## water.100    7.217625e-01 4.302738e-03 4.896181e-10 0.5063374531 1.649439e
-02
##                 water.100
## JulianDate   0.000000e+00
## A.Temp       8.881784e-16
## W.Temp       6.658052e-11
## Time         6.240147e-03
## Mass         2.689054e-01
## PL           7.217625e-01
## for.veg.1000 4.302738e-03
## wet.400      4.896181e-10
## agri.400     5.063375e-01
## urban.1000   1.649439e-02
## water.100              NA
```

Spearman correlation coefficients

```
# Creation of the correlation table
table.corr.spearman.log.Start <- rcorr(as.matrix(MixedData[,c(3,4,5,6,7,8,26,
30,40,56,57)]), type="spearman")
table.cor.spearman.log.Start.r <- table.corr.spearman.log.Start$r # Pearson c
orrelation coefficients
table.cor.spearman.log.Start.p <- table.corr.spearman.log.Start$P # P values
of the correlations
table.cor.spearman.log.Start.r
```

```
##               JulianDate      A.Temp      W.Temp        Time        Mass
## JulianDate    1.00000000  0.45842169  0.56884913 -0.09892087  0.08038929
## A.Temp        0.45842169  1.00000000  0.83718368  0.13849890  0.06589666
## W.Temp        0.56884913  0.83718368  1.00000000  0.17365903  0.13270468
## Time         -0.09892087  0.13849890  0.17365903  1.00000000 -0.04025948
## Mass          0.08038929  0.06589666  0.13270468 -0.04025948  1.00000000
## PL            0.08898378  0.10442546  0.15193967 -0.01364455  0.94856246
## for.veg.1000 -0.13614271 -0.17001898 -0.28928407  0.11957044 -0.19217208
## wet.400       0.41005248  0.11243977  0.19326625  0.14639174 -0.04217241
## agri.400     -0.13443891  0.19719332  0.07363333 -0.09493393  0.14999256
## urban.1000    0.05728527  0.13104537  0.21782810 -0.07145219  0.10868203
## water.100    -0.40716475 -0.37402320 -0.28326055  0.05606805  0.07784216
##                       PL for.veg.1000     wet.400    agri.400  urban.1000
```

```
## JulianDate    0.08898378   -0.1361427  0.41005248 -0.13443891  0.05728527
## A.Temp        0.10442546   -0.1700190  0.11243977  0.19719332  0.13104537
## W.Temp        0.15193967   -0.2892841  0.19326625  0.07363333  0.21782810
## Time         -0.01364455    0.1195704  0.14639174 -0.09493393 -0.07145219
## Mass          0.94856246   -0.1921721 -0.04217241  0.14999256  0.10868203
## PL            1.00000000   -0.1623624 -0.04821271  0.16970352  0.07998962
## for.veg.1000 -0.16236237    1.0000000  0.24464327 -0.62367762 -0.82572013
## wet.400      -0.04821271    0.2446433  1.00000000 -0.30522895 -0.23226774
## agri.400      0.16970352   -0.6236776 -0.30522895  1.00000000  0.46271885
## urban.1000    0.07998962   -0.8257201 -0.23226774  0.46271885  1.00000000
## water.100     0.03022562   -0.1316108 -0.14172001 -0.05751472  0.08587093
##                water.100
## JulianDate   -0.40716475
## A.Temp       -0.37402320
## W.Temp       -0.28326055
## Time          0.05606805
## Mass          0.07784216
## PL            0.03022562
## for.veg.1000 -0.13161079
## wet.400      -0.14172001
## agri.400     -0.05751472
## urban.1000    0.08587093
## water.100     1.00000000
```

```
table.cor.spearman.log.Start.p
```

```
##               JulianDate       A.Temp       W.Temp         Time          Ma
ss
## JulianDate            NA 0.000000e+00 0.000000e+00 0.0219948308 6.291206e-
02
## A.Temp       0.000000000           NA 0.000000e+00 0.0013067179 1.275805e-
01
## W.Temp       0.000000000 0.000000e+00           NA 0.0001191832 3.379071e-
03
## Time         0.021994831 1.306718e-03 1.191832e-04           NA 3.522285e-
01
## Mass         0.062912061 1.275805e-01 3.379071e-03 0.3522284632
NA
## PL           0.039641066 1.567793e-02 7.879312e-04 0.7528559899 0.000000e+
00
## for.veg.1000 0.001581516 7.625616e-05 8.007350e-11 0.0055757019 7.445223e-
06
## wet.400      0.000000000 9.177827e-03 1.785318e-05 0.0006747625 3.298003e-
01
## agri.400     0.001812250 4.226134e-06 1.049537e-01 0.0279695118 4.936074e-
04
## urban.1000   0.185422901 2.366128e-03 1.246624e-06 0.0984350178 1.181043e-
02
## water.100    0.000000000 0.000000e+00 2.027840e-10 0.1949553499 7.174987e-
02
```

```
##                          PL for.veg.1000      wet.400     agri.400   urban.1
000
## JulianDate   3.964107e-02 1.581516e-03 0.000000e+00 1.812250e-03 1.854229e
-01
## A.Temp       1.567793e-02 7.625616e-05 9.177827e-03 4.226134e-06 2.366128e
-03
## W.Temp       7.879312e-04 8.007350e-11 1.785318e-05 1.049537e-01 1.246624e
-06
## Time         7.528560e-01 5.575702e-03 6.747625e-04 2.796951e-02 9.843502e
-02
## Mass         0.000000e+00 7.445223e-06 3.298003e-01 4.936074e-04 1.181043e
-02
## PL                     NA 1.621239e-04 2.656216e-01 7.989296e-05 6.448653e
-02
## for.veg.1000 1.621239e-04           NA 9.574610e-09 0.000000e+00 0.000000e
+00
## wet.400      2.656216e-01 9.574610e-09           NA 5.080381e-13 5.346181e
-08
## agri.400     7.989296e-05 0.000000e+00 5.080381e-13           NA 0.000000e
+00
## urban.1000   6.448653e-02 0.000000e+00 5.346181e-08 0.000000e+00
NA
## water.100    4.853994e-01 2.264245e-03 1.001819e-03 1.836652e-01 4.691287e
-02
##                 water.100
## JulianDate   0.000000e+00
## A.Temp       0.000000e+00
## W.Temp       2.027840e-10
## Time         1.949553e-01
## Mass         7.174987e-02
## PL           4.853994e-01
## for.veg.1000 2.264245e-03
## wet.400      1.001819e-03
## agri.400     1.836652e-01
## urban.1000   4.691287e-02
## water.100              NA
```

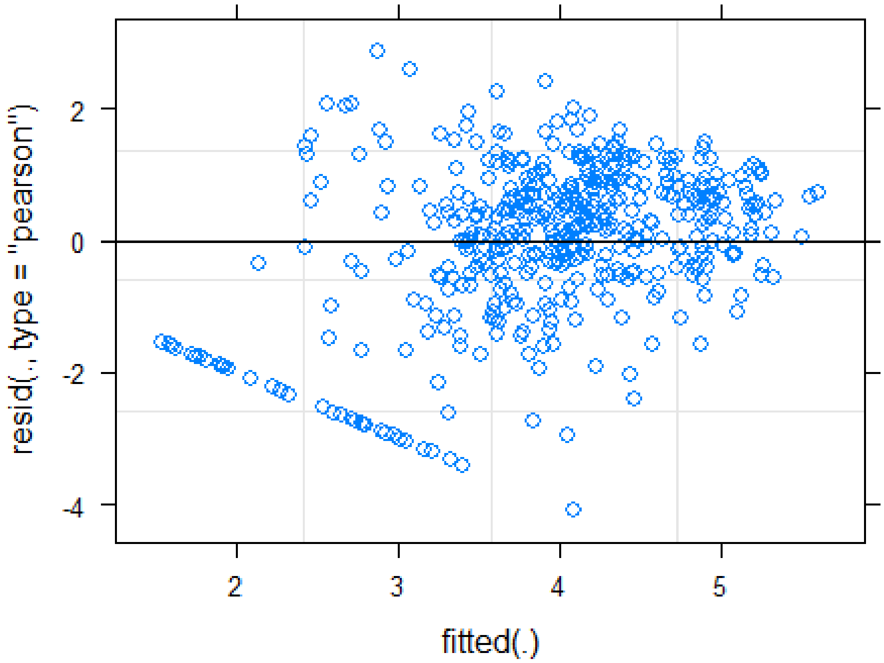
The Pearson correlation coefficient of 0.93 between Mass and PL, -0.74 between for.veg.1000 and urban.1000, and 0.84 between W.Temp and A.Temp confirmed the deletion of Mass, for.veg.1000, and W.Temp with the calculation of the GVIF^(1/(2*df)).

Verification of the assumptions with the initial model

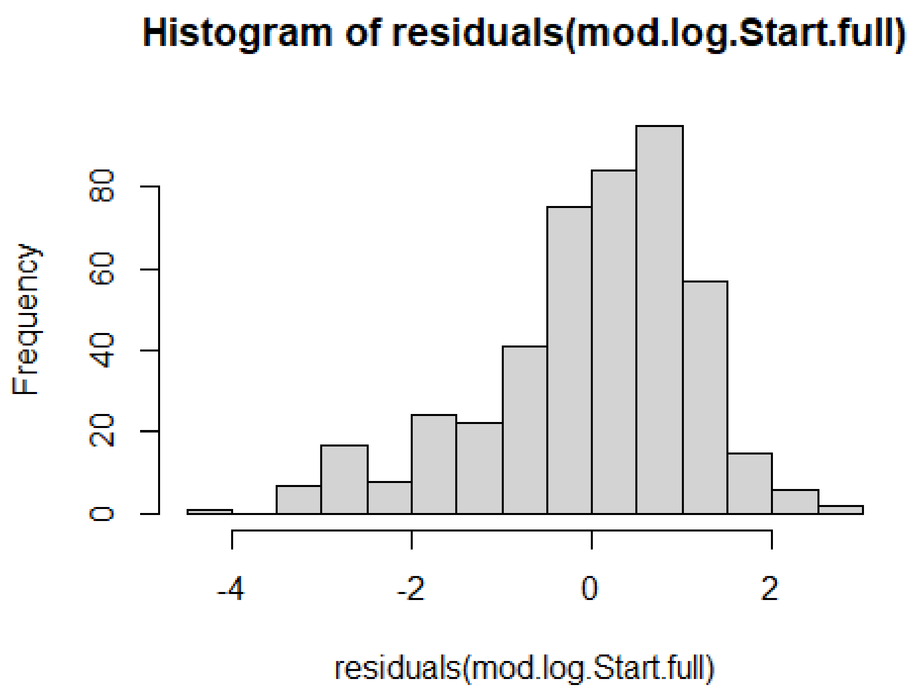
```
mod.log.Start.full <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Ti
me.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.S
caled + water.100.Scaled + (1|Code) + (1|Site), data = MixedData, REML = TRUE
, na.action=na.exclude)

summary(mod.log.Start.full)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.Scaled
+
##     water.100.Scaled + (1 | Code) + (1 | Site)
##    Data: MixedData
##
## REML criterion at convergence: 1684
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.0644 -0.3958  0.1451  0.6178  2.1520
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Code     (Intercept) 0.4099   0.6402
##  Site     (Intercept) 0.3127   0.5592
##  Residual             1.7741   1.3320
## Number of obs: 454, groups:  Code, 430; Site, 23
##
## Fixed effects:
##                    Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         4.19998    0.17362  29.34991  24.191   <2e-16 ***
## JulianDate.Scaled  -0.19806    0.16170  21.16973  -1.225   0.2341
## A.Temp.Scaled      -0.19874    0.12576 100.73408  -1.580   0.1172
## Time.Scaled         0.07622    0.07781 439.62923   0.980   0.3278
## PL.Scaled           0.21939    0.09145 410.59234   2.399   0.0169 *
## SexM               -0.24429    0.16850 441.25735  -1.450   0.1478
## wet.400.Scaled      0.22219    0.15373  14.33551   1.445   0.1699
## agri.400.Scaled     0.14719    0.11940  18.93332   1.233   0.2327
## urban.1000.Scaled  -0.11470    0.14520  15.38532  -0.790   0.4416
## water.100.Scaled   -0.25738    0.16186  14.62996  -1.590   0.1332
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.400. a.400. u.1000
## JulnDt.Scld -0.070
## A.Temp.Scld  0.112 -0.395
## Time.Scaled  0.044  0.084 -0.237
## PL.Scaled   -0.290 -0.046 -0.047 -0.034
## SexM        -0.564  0.038 -0.110 -0.053  0.472
## wt.400.Scld -0.056 -0.251  0.125 -0.016  0.045  0.004
## agr.400.Scl -0.109  0.069 -0.006  0.041 -0.044 -0.034  0.163
## urbn.1000.S -0.089 -0.165  0.122  0.028  0.024  0.046  0.329 -0.014
## wtr.100.Scl  0.030  0.166  0.123 -0.075 -0.056 -0.047  0.243  0.083  0.011
```

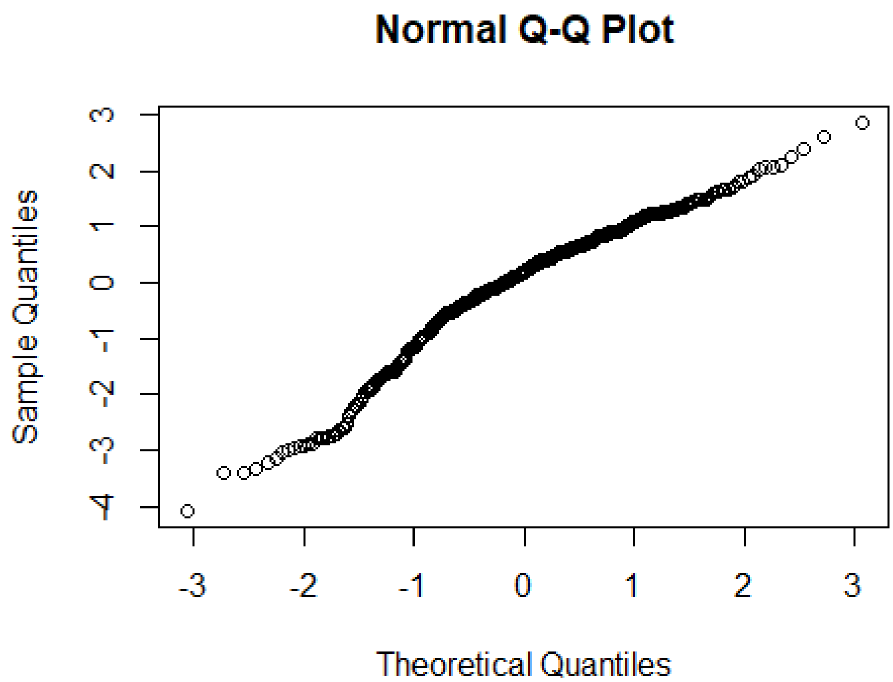
```
plot(mod.log.Start.full)
```




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




```
qqnorm(resid(mod.log.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 ~ JulianDate.Scaled + A.Temp.Scaled + W.Te
mp.Scaled + Time.Scaled + Mass.Scaled + PL.Scaled + Sex + for.veg.1000.Scaled
+ wet.300.Scaled + agri.1000.Scaled + urban.1000.Scaled + water.900.Scaled, d
ata = MixedData, family = binomial, na.action=na.exclude)
gvif(mod.Bin.Shell.vif)
```

```
##                          GVIF df GVIF^(1/(2*df))
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + W.Te
mp.Scaled + Time.Scaled + Mass.Scaled + PL.Scaled + Sex + wet.300.Scaled + ag
ri.1000.Scaled + urban.1000.Scaled + water.900.Scaled, data = MixedData, fami
ly = binomial, na.action=na.exclude)
gvif(mod.Bin.Shell.vif)
```

```
##                     GVIF df GVIF^(1/(2*df))
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + W.Te
mp.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))
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time
.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.1000.Sc
aled + water.900.Scaled, data = MixedData, family = binomial, na.action=na.ex
clude)
gvif(mod.Bin.Shell.vif)
```

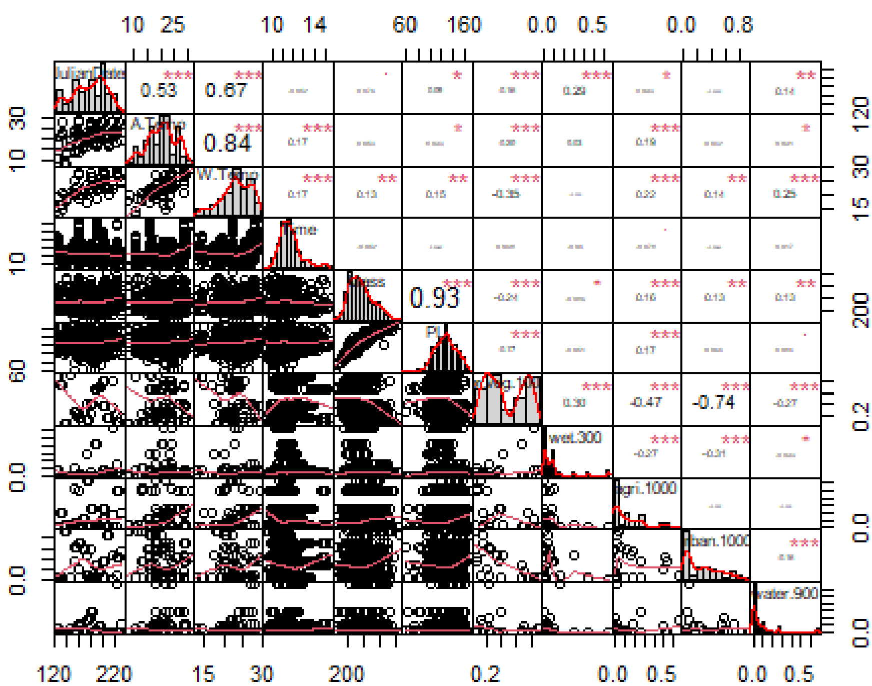
```
##                        GVIF df GVIF^(1/(2*df))
## JulianDate.Scaled 1.6023  1          1.2658
## A.Temp.Scaled     1.4137  1          1.1890
## Time.Scaled       1.0726  1          1.0357
## PL.Scaled         1.4134  1          1.1889
## Sex               1.3611  1          1.1667
## wet.300.Scaled    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(3,4,5,6,7,8,26,2
9,46,56,65)]), type="pearson")
table.cor.pearson.Bin.Shell.r <- table.corr.pearson.Bin.Shell$r # Pearson cor
relation coefficients
table.cor.pearson.Bin.Shell.p <- table.corr.pearson.Bin.Shell$P # P values of
```

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

##                JulianDate      A.Temp      W.Temp         Time        Mass
## JulianDate    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.100
0
## JulianDate    0.089516177  -0.15975753  0.28550523  0.09307039 -0.00346242
9
## A.Temp        0.092502829  -0.20286665  0.02957879  0.19452574  0.04205111
0
## W.Temp        0.146064749  -0.35442189 -0.02150728  0.21528845  0.14394242
9
## Time          0.009461487   0.04812547 -0.03962835 -0.07815032 -0.00610221
9
## Mass          0.933114554  -0.23967087 -0.08629485  0.15949820  0.12738974
3
## PL            1.000000000  -0.17433634 -0.05147288  0.16850474  0.06394514
9
## for.veg.1000 -0.174336336   1.00000000  0.30140143 -0.47018472 -0.74379822
3
## wet.300      -0.051472876   0.30140143  1.00000000 -0.27005276 -0.30777568
4
## agri.1000     0.168504745  -0.47018472 -0.27005276  1.00000000 -0.03513526
8
## urban.1000    0.063945149  -0.74379822 -0.30777568 -0.03513527  1.00000000
0
## water.900     0.083709114  -0.26815368 -0.09294993 -0.02285347 -0.16249035
8
##                 water.900
## JulianDate    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

```
##                JulianDate       A.Temp       W.Temp         Time           M
ass
## JulianDate             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.1
000
## JulianDate   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
## JulianDate   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$r # Pearson c
orrelation coefficients
table.cor.spearman.Bin.Shell.p <- table.corr.spearman.Bin.Shell$P # P values
of the correlations
table.cor.spearman.Bin.Shell.r
```

```
##               JulianDate       A.Temp      W.Temp        Time        Mass
## JulianDate    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
## JulianDate    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
## JulianDate   -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
```

```
##                JulianDate       A.Temp       W.Temp         Time          M
ass
## JulianDate             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.1
000
## JulianDate   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
## JulianDate   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
```

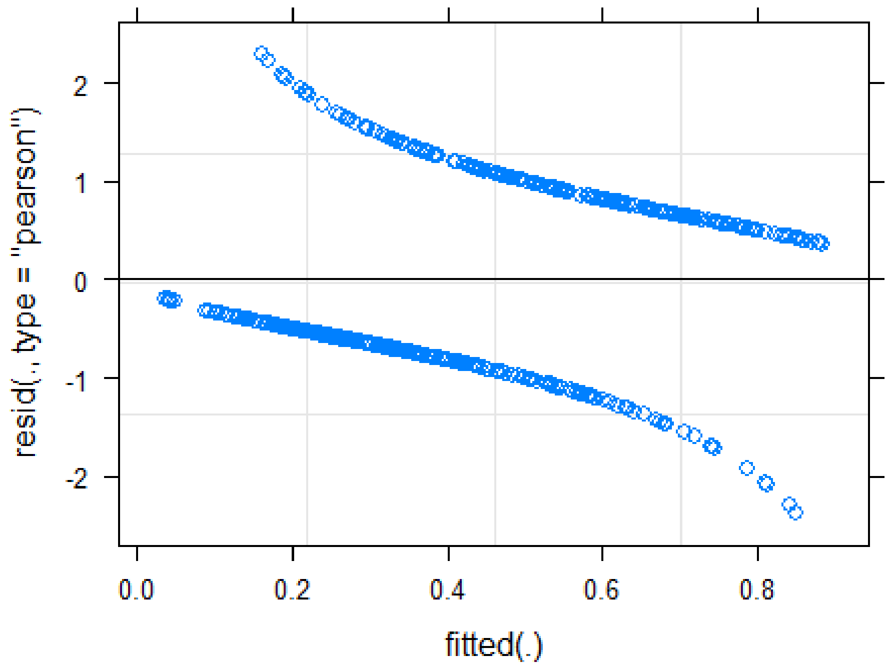
The Pearson correlation coefficient of -0.74 between for.veg.1000 and urban.1000, 0.93 between Mass and PL,and 0.84 between W.Temp and A.Temp confirmed the deletion of for.veg.1000, Mass, and W.Temp with the calculation of the GVIF^(1/(2*df)).

Verification of the assumptions with the initial model

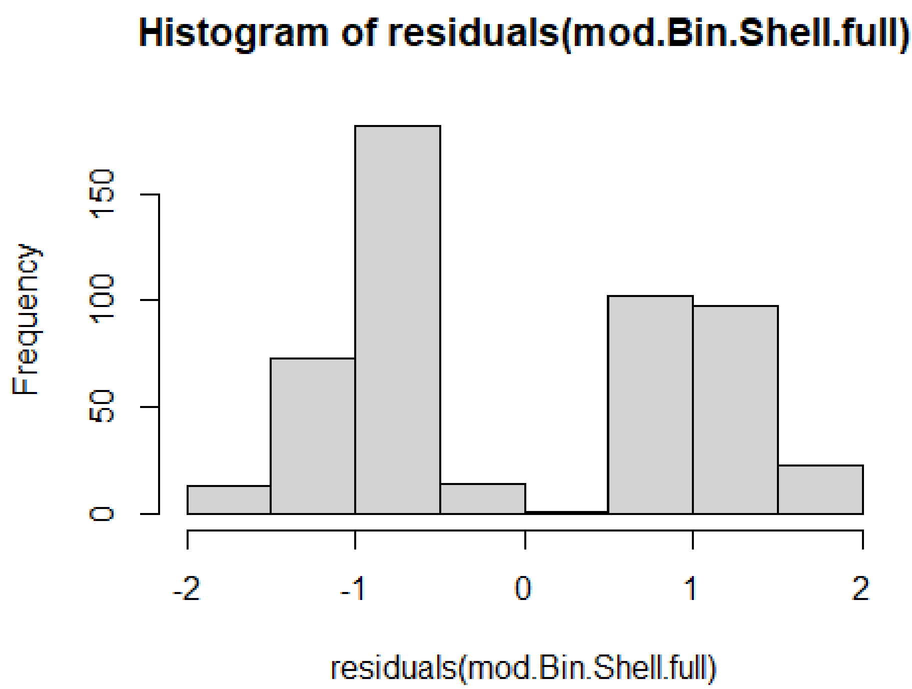
```
mod.Bin.Shell.full <- glmer(Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled + T
ime.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.1000
.Scaled + water.900.Scaled + (1|Site) + (1|Code), data = MixedData, family =
binomial, na.action=na.exclude)

summary(mod.Bin.Shell.full)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula: Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.1000.Scale
d +
##     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
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.300. a.1000 u.1000
## JulnDt.Scld -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)
```

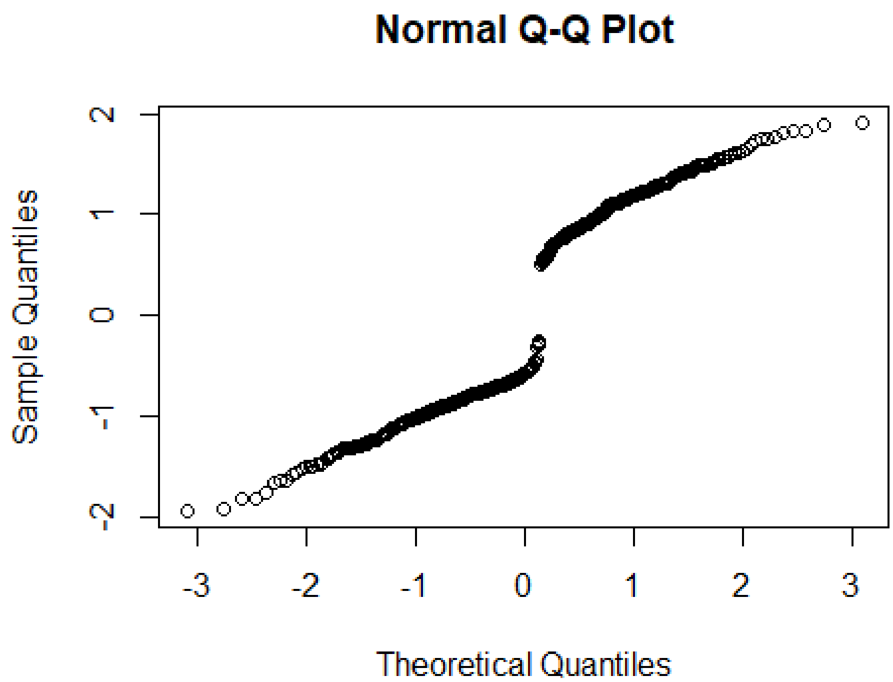
```
plot(mod.Bin.Shell.full)
```




```
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 ~ JulianDate.Scaled + A.Temp.Scaled + W.Temp.Scaled +
Time.Scaled + Mass.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Sc
aled + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled, data = MixedD
ata, na.action=na.exclude)
gvif(mod.Move.vif)
```

```
##                       GVIF df GVIF^(1/(2*df))
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + W.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.10
0.Scaled + urban.1000.Scaled + water.1000.Scaled, data = MixedData, na.action
=na.exclude)
gvif(mod.Move.vif)
```

```
##                      GVIF df GVIF^(1/(2*df))
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + P
L.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled + urba
n.1000.Scaled + water.1000.Scaled, data = MixedData, na.action=na.exclude)
gvif(mod.Move.vif)
```

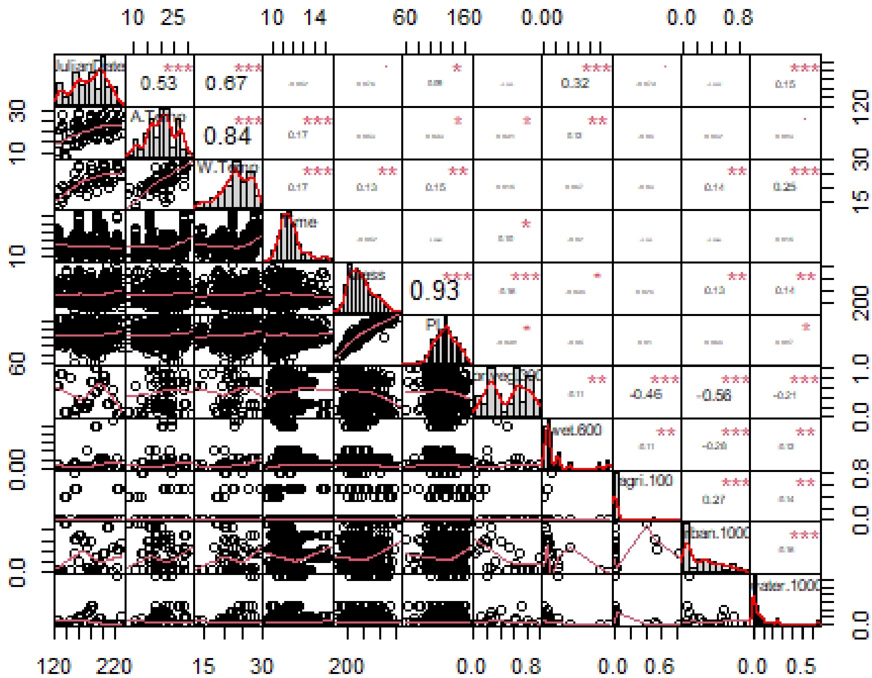
```
##                      GVIF df GVIF^(1/(2*df))
## JulianDate.Scaled  1.6927  1          1.3010
## A.Temp.Scaled      1.5492  1          1.2447
## Time.Scaled        1.1070  1          1.0521
## PL.Scaled          1.3734  1          1.1719
## Sex                1.3747  1          1.1725
## for.veg.300.Scaled 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)
```




```r
# 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$r # Pearson correlation c
oefficients
table.cor.pearson.Move.p <- table.corr.pearson.Move$P # P values of the corre
lations
table.cor.pearson.Move.r
```

```
##               JulianDate      A.Temp      W.Temp         Time        Mass
## JulianDate   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
## JulianDate   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
## JulianDate   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
```

```
##               JulianDate       A.Temp       W.Temp         Time          Ma
ss
## JulianDate            NA 0.000000e+00 0.000000e+00 2.322103e-01 0.08033738
37
## A.Temp      0.000000e+00           NA 0.000000e+00 6.283828e-05 0.22469108
77
## W.Temp      0.000000e+00 0.000000e+00           NA 2.346306e-04 0.00349965
95
## Time        2.322103e-01 6.283828e-05 2.346306e-04           NA 0.22538053
35
## 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 0.00000000
00
## for.veg.300 7.552233e-01 3.501640e-02 7.345696e-01 1.983870e-02 0.00027413
92
## wet.600     5.284662e-14 4.643928e-03 1.376963e-01 6.398062e-01 0.02969254
49
## agri.100    6.861526e-02 3.559077e-01 5.061950e-01 7.626040e-01 0.57822999
89
## urban.1000  9.362578e-01 3.311946e-01 1.464223e-03 8.879110e-01 0.00313231
18
## water.1000  5.088140e-04 5.446734e-02 4.280305e-08 7.266910e-01 0.00163080
42
##                      PL  for.veg.300      wet.600     agri.100   urban.100
0
## JulianDate  0.038468345 7.552233e-01 5.284662e-14 6.861526e-02 9.362578e-0
1
## A.Temp      0.032421052 3.501640e-02 4.643928e-03 3.559077e-01 3.311946e-0
```

```
1
## W.Temp      0.001256393 7.345696e-01 1.376963e-01 5.061950e-01 1.464223e-0
3
## Time        0.827165890 1.983870e-02 6.398062e-01 7.626040e-01 8.879110e-0
1
## Mass        0.000000000 2.741392e-04 2.969254e-02 5.782300e-01 3.132312e-0
3
## PL                   NA 2.301169e-02 2.502745e-01 8.108043e-01 1.396467e-0
1
## for.veg.300 0.023011686           NA 7.758640e-03 0.000000e+00 0.000000e+0
0
## wet.600     0.250274454 7.758640e-03           NA 8.776242e-03 6.305312e-1
1
## agri.100    0.810804345 0.000000e+00 8.776242e-03           NA 1.518086e-1
0
## urban.1000  0.139646656 0.000000e+00 6.305312e-11 1.518086e-10           N
A
## water.1000  0.044750150 1.287993e-06 7.561412e-03 1.508389e-03 1.495518e-0
4
##               water.1000
## JulianDate  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 cor
relations
table.cor.spearman.Move.r
```

```
##               JulianDate     A.Temp     W.Temp        Time        Mass
## JulianDate   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
## JulianDate   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
## JulianDate  -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
```

```
##               JulianDate       A.Temp       W.Temp         Time         Mas
s
## JulianDate            NA 0.000000e+00 0.000000e+00 0.0219948308 0.06291206
1
## A.Temp      0.000000e+00           NA 0.000000e+00 0.0013067179 0.12758048
3
## W.Temp      0.000000e+00 0.000000e+00           NA 0.0001191832 0.00337907
1
## Time        2.199483e-02 1.306718e-03 1.191832e-04           NA 0.35222846
3
## Mass        6.291206e-02 1.275805e-01 3.379071e-03 0.3522284632           N
A
## PL          3.964107e-02 1.567793e-02 7.879312e-04 0.7528559899 0.00000000
0
## for.veg.300 8.195721e-01 2.011107e-02 6.928619e-02 0.0452390586 0.00578463
5
## wet.600     0.000000e+00 2.564232e-05 4.913921e-08 0.0001034490 0.00420271
2
## agri.100    3.866754e-02 5.744009e-01 1.362161e-01 0.1448442211 0.24939811
```

```
4
## urban.1000  1.854229e-01 2.366128e-03 1.246624e-06 0.0984350178 0.01181043
0
## water.1000  8.749580e-08 1.656624e-02 6.917336e-01 0.4348325411 0.24137815
2
##                       PL  for.veg.300      wet.600     agri.100   urban.10
00
## JulianDate  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
## JulianDate  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)).

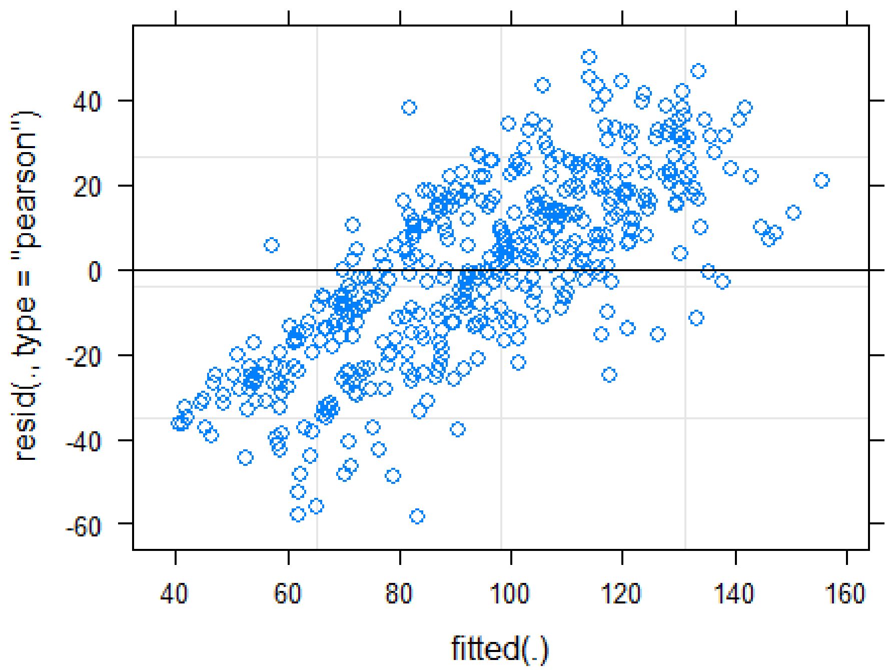
Verification of the assumptions with the initial model

```
mod.Move.full <- lmer(Move ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled + u
rban.1000.Scaled + water.1000.Scaled + (1|Code) + (1|Site), data = MixedData,
```

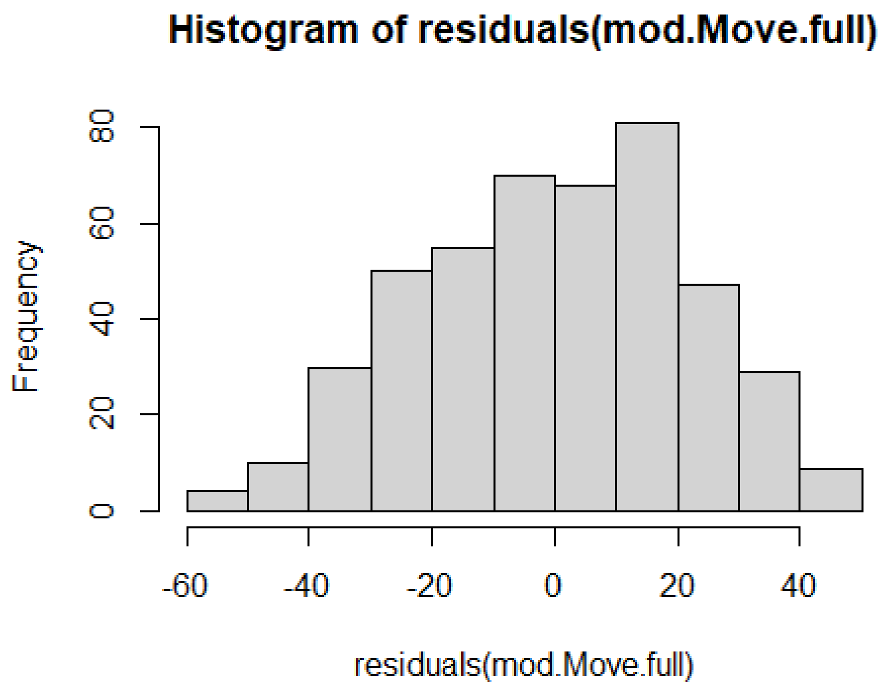
```
REML = TRUE, na.action=na.exclude)

summary(mod.Move.full)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Move ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scale
d +
##     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 ***
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   f..300 w.600. a.100.
## JulnDt.Scld -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
## JulnDt.Scld
## 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
```

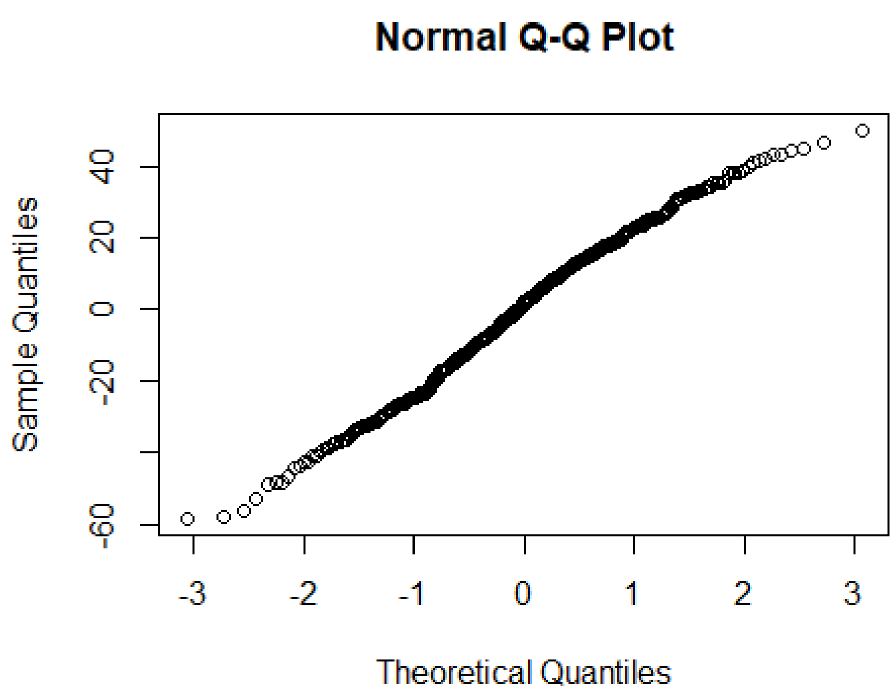
```
plot(mod.Move.full)
```




```
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 ~ JulianDate.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.exclud
e, control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

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

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

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 ~ JulianDate.Scaled + A.Temp.Scaled + Time
.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled + urban.1000.Sca
led + water.400.Scaled + (1 | Dummy)
## mod.Aggression.dummy.site: Aggression ~ JulianDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled + urban.10
00.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time
.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled + urban.1000.Sca
led + water.400.Scaled + (1 | Dummy)
## mod.Aggression.dummy.code: Aggression ~ JulianDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled + urban.10
00.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 ~ JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scal
ed + Time.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled + urban
.1000.Scaled + water.400.Scaled + (1|Code) + (1|Site), data = MixedData, na.a
ction=na.exclude, control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALS
E)

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

```
## Data: MixedData
## Models:
## mod.Aggression.code: Aggression ~ JulianDate.Scaled + A.Temp.Scaled + Time
.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled + urban.1000.Sca
led + water.400.Scaled + (1 | Code)
## mod.Aggression.code.site: Aggression ~ JulianDate.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 ~ JulianDate.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 ~ JulianDate.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 ***
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.200. a.100. u.1000
## JulnDt.Scld -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 ~ JulianDate.Scaled + A.Temp.Scaled + Tim
e.Scaled + PL.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled +
water.400.Scaled + (1|Code), data = MixedData, na.action=na.exclude, REML = F
ALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Aggression, MixedData$
JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time
.Scaled + PL.Scaled + Sex + wet.200.Scaled + agri.100.Scaled + urban.1000.Sca
led + water.400.Scaled + (1|Code), data = MixedData.adjust, na.action=na.excl
ude, REML = FALSE)

mod.Aggression.1.adjust <- lmer(Aggression ~ JulianDate.Scaled + A.Temp.Scale
d + Time.Scaled + PL.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.S
caled + water.400.Scaled + (1|Code), data = MixedData.adjust, na.action=na.ex
clude, REML = FALSE)

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

```
## Data: MixedData.adjust
## Models:
## mod.Aggression.1.adjust: Aggression ~ JulianDate.Scaled + A.Temp.Scaled +
```

```
Time.Scaled + PL.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scale
d + water.400.Scaled + (1 | Code)
## mod.full.adjust: Aggression ~ JulianDate.Scaled + A.Temp.Scaled + Time.Sca
led + 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 ~ JulianDate.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 ***
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl PL.Scl w.200. a.100. u.1000
```

```
## JulnDt.Scld -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 ~ JulianDate.Scaled + A.Temp.Scaled + PL.
Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled + water.400.Sca
led + (1|Code), data = MixedData, na.action=na.exclude, REML = FALSE)

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

mod.full.adjust <- lmer(Aggression ~ JulianDate.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, R
EML = FALSE)

mod.Aggression.2.adjust <- lmer(Aggression ~ JulianDate.Scaled + A.Temp.Scale
d + 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 ~ JulianDate.Scaled + A.Temp.Scaled +
PL.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled + water.400.
Scaled + (1 | Code)
## mod.full.adjust: Aggression ~ JulianDate.Scaled + A.Temp.Scaled + Time.Sca
led + PL.Scaled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled + wate
r.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 ~ JulianDate.Scaled + A.Temp.Scaled + PL.Scaled +
##     wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled + water.400.Scale
d +
##     (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 ***
## JulianDate.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) JlnD.S A.Tm.S PL.Scl w.200. a.100. u.1000
## JulnDt.Scld -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 Julian date of testing (JulianDate).

```
mod.Aggression.3 <- lmer(Aggression ~ A.Temp.Scaled + PL.Scaled + wet.200.Sca
led + 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$Aggression, MixedData$
JulianDate.Scaled, MixedData$A.Temp.Scaled, MixedData$PL.Scaled, MixedData$we
```

```
t.200.Scaled, MixedData$agri.100.Scaled, MixedData$urban.1000.Scaled, MixedDa
ta$water.400.Scaled),]

mod.full.adjust <- lmer(Aggression ~ JulianDate.Scaled + A.Temp.Scaled + PL.S
caled + wet.200.Scaled + agri.100.Scaled + urban.1000.Scaled + water.400.Scal
ed + (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 ~ JulianDate.Scaled + A.Temp.Scaled + PL.Scale
d + 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.Sca
led + urban.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData, na.a
ction=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.Scal
ed + 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 = MixedDat
a.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(>C
hisq)
## 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.Scale
d +
##     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.Scal
ed + 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 + urba
n.1000.Scaled + water.400.Scaled + (1|Code), data = MixedData.adjust, na.acti
on=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.10
00.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 + wat
er.400.Scaled + (1|Code), data = MixedData, na.action=na.exclude, REML = FALS
E)

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

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

mod.Aggression.6.adjust <- lmer(Aggression ~ A.Temp.Scaled + urban.1000.Scale
d + water.400.Scaled + (1|Code), data = MixedData.adjust, na.action=na.exclud
e, 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.Scale
d + water.400.Scaled + (1 | Code)
##                         npar    AIC    BIC logLik deviance Chisq Df Pr(>Ch
isq)
## 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.

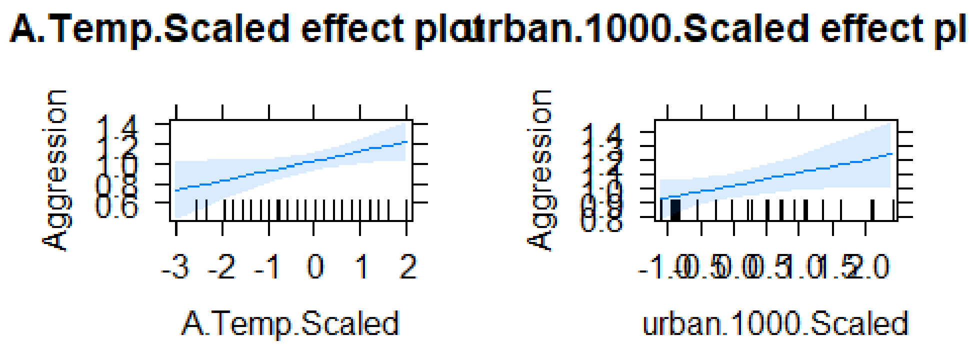
```
mod.Aggression.final <- lmer(Aggression ~ A.Temp.Scaled + urban.1000.Scaled +
water.400.Scaled + (1|Code), data = MixedData, na.action=na.exclude, REML = T
RUE)
summary(mod.Aggression.final)
```

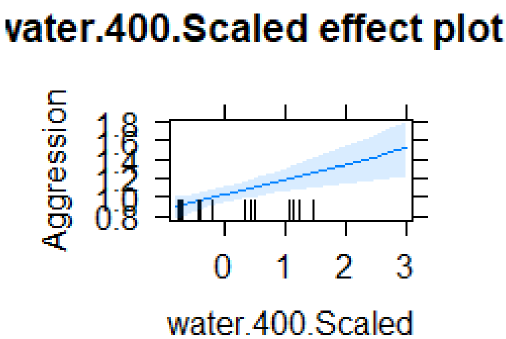
```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
```

```
## 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
```

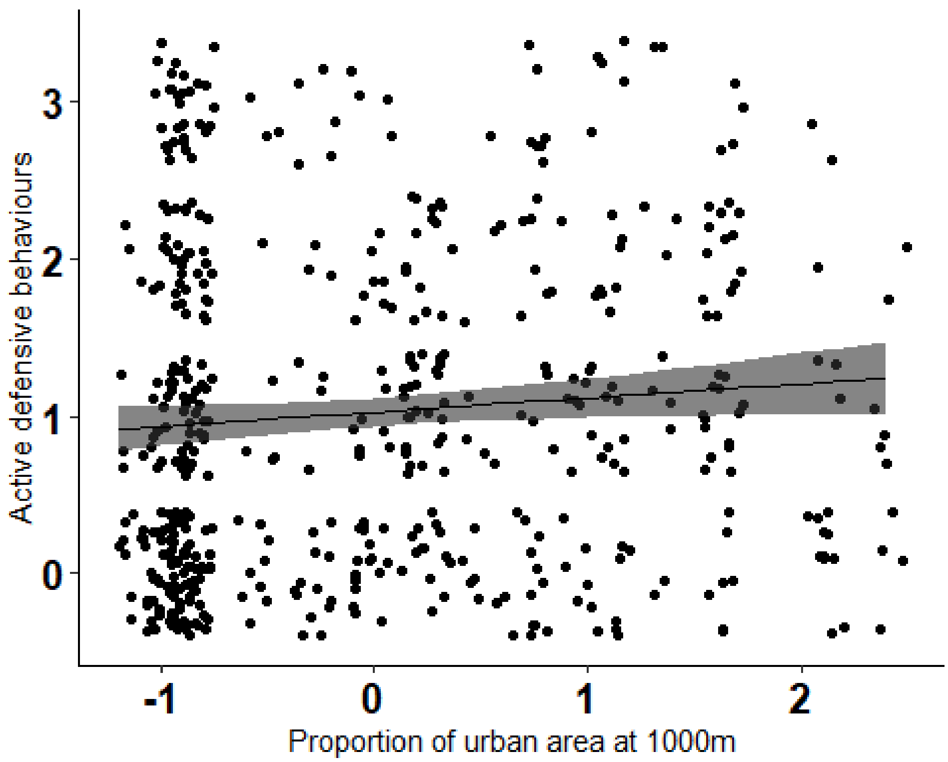
```
## # Predicted values of Aggression
##
## urban.1000.Scaled | Predicted |       95% CI
## ------------------------------------------
##             -1.20 |      0.92 | [0.78, 1.06]
##             -0.80 |      0.95 | [0.84, 1.07]
##             -0.20 |      1.01 | [0.91, 1.10]
##              0.20 |      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.urba
n.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, y
max= 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 ~ JulianDate.Scaled + A.Temp.Scaled + T
ime.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 ~ JulianDate.Scaled + A.Temp.Scal
ed + Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urba
n.1000.Scaled + water.900.Scaled + (1|Dummy) + (1|Site), data = MixedData, fa
mily = binomial, control=glmerControl(check.nlev.gtr.1="ignore"), na.action=n
a.exclude)
```

```
## only turtle ID as random variable
mod.Bin.Shell.dummy.code <- glmer(Bin.Shell ~ JulianDate.Scaled + A.Temp.Scal
ed + Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urba
n.1000.Scaled + water.900.Scaled + (1|Dummy) + (1|Code), data = MixedData, fa
mily = binomial, control=glmerControl(check.nlev.gtr.1="ignore"), na.action=n
a.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.1000.Scal
ed + water.900.Scaled + (1 | Dummy)
## mod.Bin.Shell.dummy.site: Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.100
0.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.1000.Scal
ed + water.900.Scaled + (1 | Dummy)
## mod.Bin.Shell.dummy.code: Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.100
0.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.

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

## Site identity without the dummy variable
mod.Bin.Shell.site <- glmer(Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled + T
ime.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.1000
.Scaled + water.900.Scaled + (1|Site), data = MixedData, family = binomial, c
ontrol=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 ~ JulianDate.Scaled + A.Temp.Scale
d + Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban
.1000.Scaled + water.900.Scaled + (1|Code) + (1|Site), data = MixedData, fami
ly = 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.1000.Scal
ed + water.900.Scaled + (1 | Code)
## mod.Bin.Shell.code.site: Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled + T
ime.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(>C
hisq)
## 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.1000.Scal
ed + water.900.Scaled + (1 | Site)
## mod.Bin.Shell.code.site: Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled + T
ime.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 ~ JulianDate.Scaled + A.Temp.Scaled + Tim
e.Scaled + PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.1000.S
caled + water.900.Scaled, data = MixedData, family = binomial, na.action=na.e
xclude)

summary(mod.Bin.Shell.full)

##
## Call:
## glm(formula = Bin.Shell ~ JulianDate.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
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled + water.900.Scal
ed, data = MixedData, family = binomial, na.action=na.exclude)

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

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

mod.Bin.Shell.1.adjust <- glm(Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled + water.90
0.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled + water.900.Scale
d
## Model 2: Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + agri.1000.Scaled + urban.1000.Scale
d +
##     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 ~ JulianDate.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
## JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled, data = MixedDat
a, family = binomial, na.action=na.exclude)

MixedData.adjust <- MixedData[complete.cases(MixedData$Bin.Shell, MixedData$J
ulianDate.Scaled, MixedData$A.Temp.Scaled, MixedData$Time.Scaled, MixedData$P
L.Scaled, MixedData$Sex, MixedData$wet.300.Scaled, MixedData$urban.1000.Scale
d, MixedData$water.900.Scaled),]

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

mod.Bin.Shell.2.adjust <- glm(Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled, data = Mi
xedData.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled
## Model 2: Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.300.Scaled + urban.1000.Scaled + water.900.Scale
d
##   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 ~ JulianDate.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
## JulianDate.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).

```
mod.Bin.Shell.3 <- glm(Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + wet.300.Scaled + urban.1000.Scaled, data = MixedData, fam
ily = binomial, na.action=na.exclude)

MixedData.adjust <- MixedData[complete.cases(MixedData$Bin.Shell, MixedData$J
ulianDate.Scaled, MixedData$A.Temp.Scaled, MixedData$Time.Scaled, MixedData$P
```

```
L.Scaled, MixedData$Sex, MixedData$wet.300.Scaled, MixedData$urban.1000.Scale
d),]

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

mod.Bin.Shell.3.adjust <- glm(Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + wet.300.Scaled + urban.1000.Scaled, data = MixedDat
a.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + wet.300.Scaled + urban.1000.Scaled
## Model 2: Bin.Shell ~ JulianDate.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

summary(mod.Bin.Shell.3)

##
## Call:
## glm(formula = Bin.Shell ~ JulianDate.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 **
## JulianDate.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

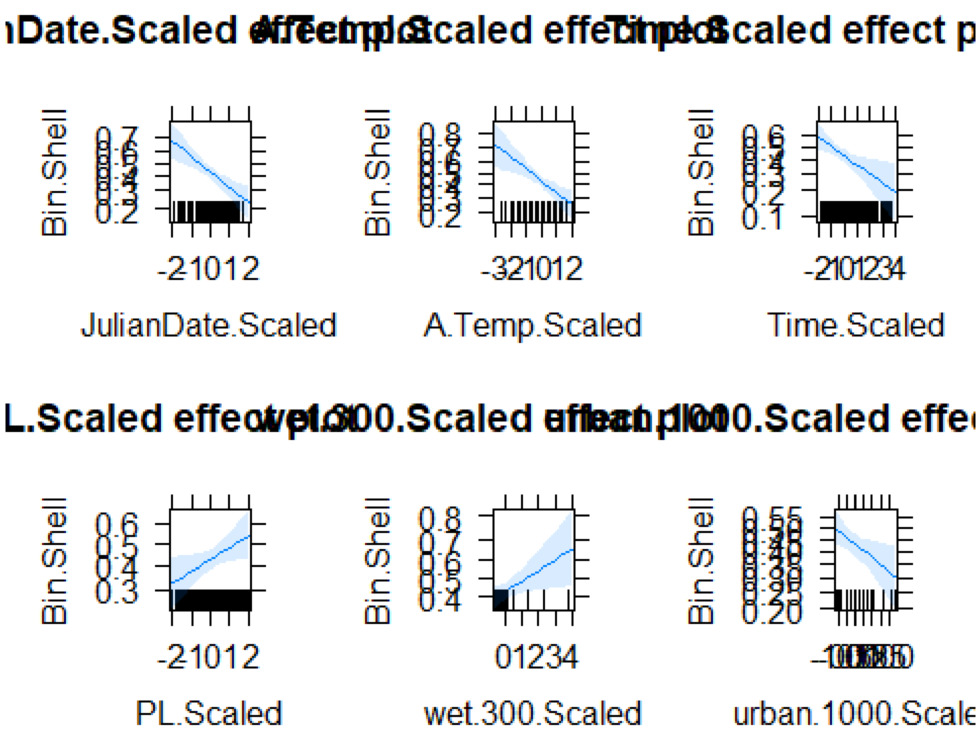
Summary statistics

Data was jittered.

```
mod.Bin.Shell.final <- glm(Bin.Shell ~ JulianDate.Scaled + A.Temp.Scaled + Ti
me.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 ~ JulianDate.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 **
## JulianDate.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
## JulianDate.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

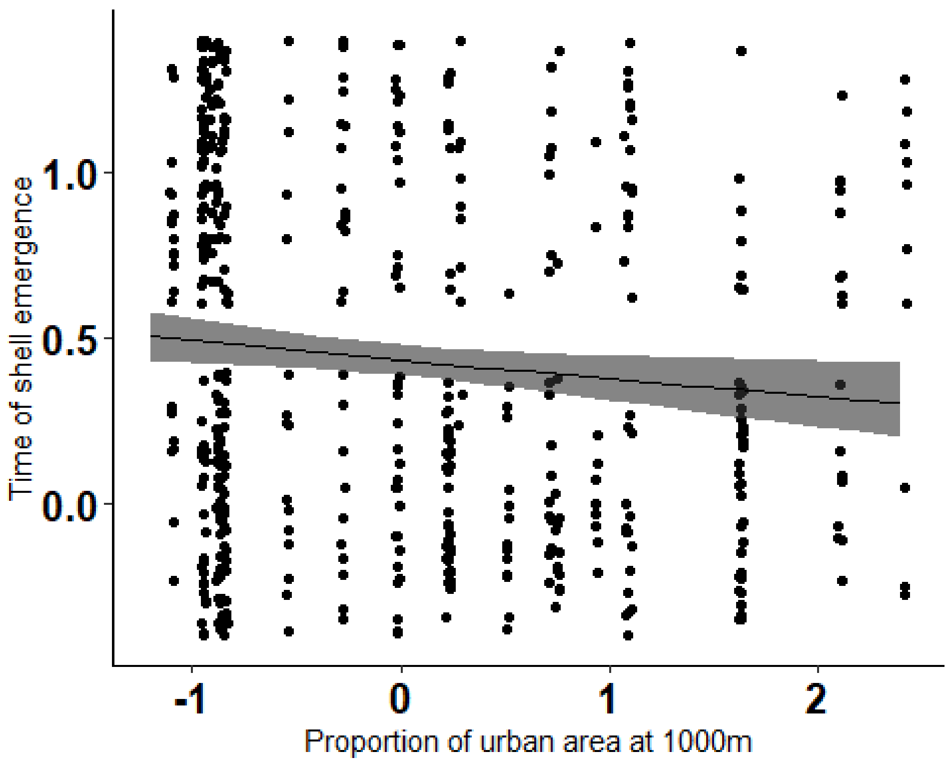
```
pred.con.model.Bin.Shell.final <- ggpredict(mod.Bin.Shell.final, terms = "urb
an.1000.Scaled")
pred.con.model.Bin.Shell.final
```

```
## # 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:
## * JulianDate.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.Sh
ell), position = position_jitter(width = 0.01)) +
  geom_ribbon(data=pred.con.model.Bin.Shell.final, aes(ymin=conf.low, ymax= c
onf.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")

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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time
.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Sc
aled + urban.1000.Scaled + water.500.Scaled + (1|Dummy) + (1|Site), data = Mi
xedData, 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time
.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Sc
aled + urban.1000.Scaled + water.500.Scaled + (1|Dummy) + (1|Code), data = Mi
xedData, 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled + urb
an.1000.Scaled + water.500.Scaled + (1 | Dummy)
## mod.Start.dummy.site: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Sca
led + 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(>Chi
sq)
## 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  0.0003
985
##
## 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled + urb
an.1000.Scaled + water.500.Scaled + (1 | Dummy)
## mod.Start.dummy.code: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Sca
led + 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(>Chi
sq)
## 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     0.1
781
```

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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.
Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Sca
led + urban.1000.Scaled + water.500.Scaled + (1|Code) + (1|Site), data = Mixe
dData, 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled + urb
an.1000.Scaled + water.500.Scaled + (1 | Site)
## mod.Start.code.site: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scal
ed + 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(>Chis
q)
## 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     0.33
87
```

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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scal
ed +
##     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 ***
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   f..200 w.400. a.600.
## JulnDt.Scld -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
## JulnDt.Scld
## 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + w
ater.500.Scaled + (1|Site), data = MixedData, na.action=na.exclude, REML = FA
LSE)

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

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

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

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

## Data: MixedData.adjust
## Models:
## mod.Start.1.adjust: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled
+ water.500.Scaled + (1 | Site)
## mod.full.adjust: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + agri.600.Scaled + urb
an.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     0.891
4
```

```
summary(mod.Start.1)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scal
ed +
##     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 ***
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   f..200 w.400. u.1000
## JulnDt.Scld -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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.5
00.Scaled + (1|Site), data = MixedData, na.action=na.exclude, REML = FALSE)

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

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

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

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

## Data: MixedData.adjust
## Models:
## mod.Start.2.adjust: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + PL.Scaled + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + wat
er.500.Scaled + (1 | Site)
## mod.full.adjust: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + w
ater.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     0.788
5

summary(mod.Start.2)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scal
ed +
##     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 ***
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl PL.Scl f..200 w.400. u.1000
## JulnDt.Scld -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).

```
mod.Start.3 <- lmer(Start ~ JulianDate.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$Start, MixedData$Julia
nDate.Scaled, MixedData$A.Temp.Scaled, MixedData$Time.Scaled, MixedData$PL.Sc
aled, MixedData$for.veg.200.Scaled, MixedData$wet.400.Scaled, MixedData$urban
.1000.Scaled, MixedData$water.500.Scaled),]

mod.full.adjust <- lmer(Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scal
ed + PL.Scaled + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + wa
```

```
ter.500.Scaled + (1|Site), data = MixedData.adjust, na.action=na.exclude, REM
L = FALSE)

mod.Start.3.adjust <- lmer(Start ~ JulianDate.Scaled + Time.Scaled + PL.Scale
d + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scale
d + (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 ~ JulianDate.Scaled + Time.Scaled + PL.Scaled +
for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled +
(1 | Site)
## mod.full.adjust: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + for.veg.200.Scaled + wet.400.Scaled + urban.1000.Scaled + water.5
00.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     0.671
6

summary(mod.Start.3)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## Start ~ JulianDate.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 ***
## JulianDate.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) JlnD.S Tm.Scl PL.Scl f..200 w.400. u.1000
## JulnDt.Scld -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 ~ JulianDate.Scaled + PL.Scaled + for.veg.200.Scale
d + 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$Start, MixedData$Julia
nDate.Scaled, MixedData$Time.Scaled, MixedData$PL.Scaled, MixedData$for.veg.2
00.Scaled, MixedData$wet.400.Scaled, MixedData$urban.1000.Scaled, MixedData$w
ater.500.Scaled),]

mod.full.adjust <- lmer(Start ~ JulianDate.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 ~ JulianDate.Scaled + PL.Scaled + for.veg.20
0.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 ~ JulianDate.Scaled + PL.Scaled + for.veg.200.Sc
aled + wet.400.Scaled + urban.1000.Scaled + water.500.Scaled + (1 | Site)
## mod.full.adjust: Start ~ JulianDate.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     0.289
6
```

```
summary(mod.Start.4)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ JulianDate.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 ***
## JulianDate.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) JlnD.S PL.Scl f..200 w.400. u.1000
## JulnDt.Scld -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 ~ JulianDate.Scaled + PL.Scaled + for.veg.200.Scale
d + urban.1000.Scaled + water.500.Scaled + (1|Site), data = MixedData, na.act
ion=na.exclude, REML = FALSE)
```

```
MixedData.adjust <- MixedData[complete.cases(MixedData$Start, MixedData$Julia
nDate.Scaled, MixedData$PL.Scaled, MixedData$for.veg.200.Scaled, MixedData$we
t.400.Scaled, MixedData$urban.1000.Scaled, MixedData$water.500.Scaled),]

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

mod.Start.5.adjust <- lmer(Start ~ JulianDate.Scaled + PL.Scaled + for.veg.20
0.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 ~ JulianDate.Scaled + PL.Scaled + for.veg.200.Sc
aled + urban.1000.Scaled + water.500.Scaled + (1 | Site)
## mod.full.adjust: Start ~ JulianDate.Scaled + PL.Scaled + for.veg.200.Scale
d + 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      0.23
8

summary(mod.Start.5)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ JulianDate.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 ***
## JulianDate.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) JlnD.S PL.Scl f..200 u.1000
## JulnDt.Scld -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 Julian date of testing (JulianDate).

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

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

mod.full.adjust <- lmer(Start ~ JulianDate.Scaled + PL.Scaled + for.veg.200.S
caled +    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.100
0.Scaled + water.500.Scaled + (1|Site), data = MixedData.adjust,  na.action=n
a.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.Sc
aled + water.500.Scaled + (1 | Site)
## mod.full.adjust: Start ~ JulianDate.Scaled + PL.Scaled + for.veg.200.Scale
d + 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     0.108
5

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.Scale
d + (1|Site), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start, MixedData$PL.Sc
aled, MixedData$for.veg.200.Scaled, MixedData$urban.1000.Scaled, MixedData$wa
ter.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.e
xclude, REML = FALSE)

mod.Start.7.adjust <- lmer(Start ~ PL.Scaled + for.veg.200.Scaled + urban.100
```

```
0.Scaled + (1|Site), data = MixedData.adjust,  na.action=na.exclude, REML = F
ALSE)

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.Sc
aled + (1 | Site)
## mod.full.adjust: Start ~ PL.Scaled + for.veg.200.Scaled + urban.1000.Scale
d + 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    0.0510
2 .
## ---
## 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
```

Since the LRT P-value is almost significant (0.051) and the removal of water.500 changed urban.1000 from non-significant to significant, I decided to calculate the AICc values for mod.Start.6 and mod.Start.7 in order to compare their parsimony.

AIC test

I had to recreate the initial model for initial time of movement for the AIC test.

```
mod.Start.0 <- lmer(Start ~ agri.600.Scaled + JulianDate.Scaled + A.Temp.Scal
ed + Time.Scaled + PL.Scaled + Sex + for.veg.200.Scaled + wet.400.Scaled + ur
ban.1000.Scaled + water.500.Scaled + (1|Site), data = MixedData, na.action=na
.exclude, REML = FALSE)

#define list of models
Start.models <- list(mod.Start.0, mod.Start.1, mod.Start.2, mod.Start.3, mod.
Start.4, mod.Start.5, mod.Start.6, mod.Start.7)

#specify model names
Start.mod.names <- c('mod.Start.0', 'mod.Start.1', 'mod.Start.2', 'mod.Start.
3', 'mod.Start.4', 'mod.Start.5', 'mod.Start.6', 'mod.Start.7')

#calculate AICc of each model
aictab(cand.set = Start.models, modnames = Start.mod.names)

##
## Model selection based on AICc:
##
##              K    AICc Delta_AICc AICcWt Cum.Wt       LL
## mod.Start.1 12 5619.23       0.00   0.74   0.74 -2797.26
## mod.Start.0 13 5621.33       2.10   0.26   1.00 -2797.25
## mod.Start.5  8 5670.80      51.57   0.00   1.00 -2827.24
## mod.Start.6  7 5671.31      52.08   0.00   1.00 -2828.53
## mod.Start.4  9 5671.49      52.26   0.00   1.00 -2826.55
## mod.Start.3 10 5672.46      53.23   0.00   1.00 -2825.99
## mod.Start.7  6 5673.05      53.82   0.00   1.00 -2830.43
## mod.Start.2 11 5674.38      55.15   0.00   1.00 -2825.90
```

mod.Start.6 and mod.Start.7 had an AICc value within 2 of each other which suggests that they are equally parsimonious, so I decided to average them.

Averaging mod.Start.6 and mod.Start.7

```
# Average the two models using model.avg
averaged.model.Start <- model.avg(mod.Start.6, mod.Start.7)
```

```
summary(averaged.model.Start)

## 
## Call:
## model.avg(object = mod.Start.6, mod.Start.7)
## 
## Component model call: 
## lmer(formula = <2 unique values>, data = MixedData, REML = FALSE, 
##      na.action = na.exclude)
## 
## Component models: 
##      df   logLik    AICc delta weight
## 1234  7 -2828.53 5671.31  0.00   0.71
## 123   6 -2830.43 5673.05  1.74   0.29
## 
## Term codes: 
## for.veg.200.Scaled          PL.Scaled  urban.1000.Scaled   water.500.Scale
d 
##                  1                  2                  3                  
4 
## 
## Model-averaged coefficients:  
## (full average) 
##                    Estimate Std. Error Adjusted SE z value Pr(>|z|)    
## (Intercept)         124.249     11.003      11.032  11.262  < 2e-16 ***
## PL.Scaled            16.554      5.905       5.920   2.796  0.00517 ** 
## for.veg.200.Scaled  -24.815     12.690      12.723   1.951  0.05112 .  
## urban.1000.Scaled   -25.830     12.524      12.555   2.057  0.03965 *  
## water.500.Scaled    -15.453     13.400      13.416   1.152  0.24938    
##  
## (conditional average) 
##                    Estimate Std. Error Adjusted SE z value Pr(>|z|)    
## (Intercept)         124.249     11.003      11.032  11.262  < 2e-16 ***
## PL.Scaled            16.554      5.905       5.920   2.796  0.00517 ** 
## for.veg.200.Scaled  -24.815     12.690      12.723   1.951  0.05112 .  
## urban.1000.Scaled   -25.830     12.524      12.555   2.057  0.03965 *  
## water.500.Scaled    -21.911     10.635      10.663   2.055  0.03989 *  
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

To create the final model I will extract the conditional average coefficients, as they are only averaged over the models where the fixed effects appear.

```
#Extracting the conditional average coefficients from the averaged model
con.avg.coefs.Start <- averaged.model.Start$coefs[,1]
```

Final model

Summary statistics

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

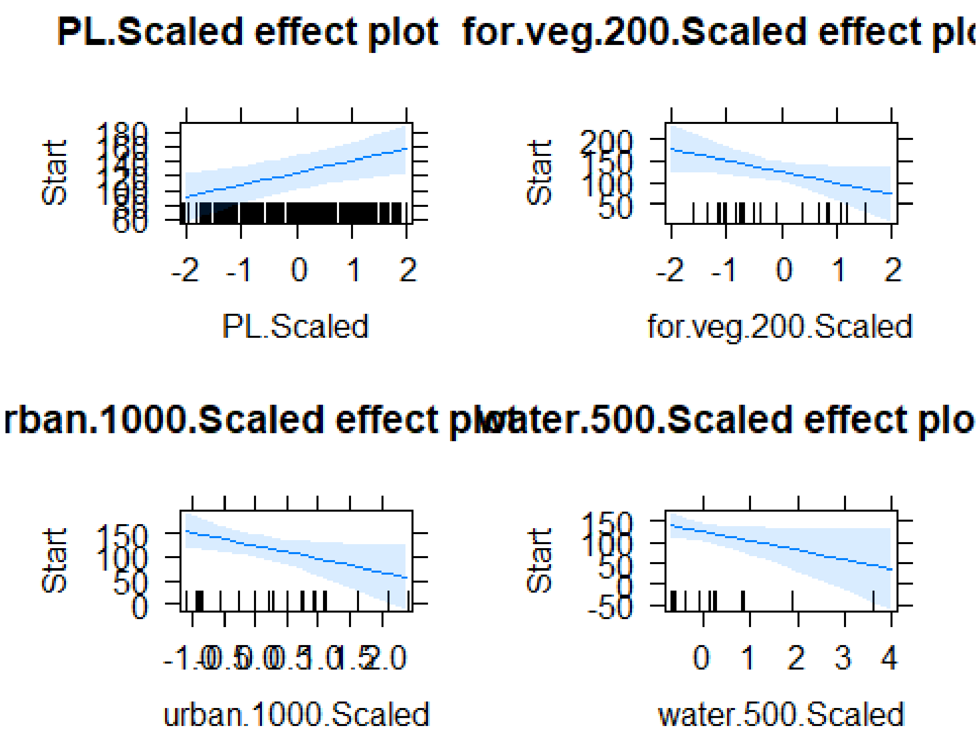
```
#Creating model with just the conditional average coefficients
con.averaged.model.Start <- lmer(Start ~ PL.Scaled + for.veg.200.Scaled + urb
an.1000.Scaled + water.500.Scaled + (1|Site),
                           data = MixedData,
                           REML = TRUE,
                           na.action = na.exclude,
                           weights = con.avg.coefs.Start)
summary(con.averaged.model.Start)
```

```
## Linear mixed model fit by REML. 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
## Weights: con.avg.coefs.Start
##
## REML criterion at convergence: 5624.9
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.8024 -0.6303 -0.2929  0.4734  4.2838
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  2380     48.79
##  Residual             12393    111.32
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                    Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)         124.820     11.956  15.948  10.440 1.55e-08 ***
## PL.Scaled            16.389      5.909 453.319   2.774  0.00577 **
## for.veg.200.Scaled  -26.082     13.534  16.464  -1.927  0.07139 .
## urban.1000.Scaled   -28.002     13.211  17.100  -2.120  0.04896 *
## water.500.Scaled    -21.845     11.946  15.733  -1.829  0.08648 .
## ---
## 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   -0.028
## fr.vg.200.S  0.160 -0.022
## urbn.1000.S -0.005 -0.045  0.469
## wtr.500.Scl -0.008 -0.059  0.234  0.326
```

Proportion of urban area at 1000m (urban.1000) has a statistically significant effect on time of initial movement.

Visualization of the predictor effects

```
plot(allEffects(con.averaged.model.Start))
```



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

```
r.squaredGLMM(con.averaged.model.Start)

##            R2m      R2c
## [1,] 0.0650692 0.215701
```

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

Calculation of the 95% confidence intervals

```
confint(con.averaged.model.Start, level = 0.95, method = "Wald")

##                         2.5 %      97.5 %
## .sig01                     NA          NA
## .sigma                     NA          NA
## (Intercept)        101.387414 148.2528846
## PL.Scaled            4.807912  27.9706575
## for.veg.200.Scaled -52.607602   0.4437976
```

```
## urban.1000.Scaled  -53.894410  -2.1098848
## water.500.Scaled   -45.259851   1.5689630
```

Creation of the prediction figure for urban area at 1000m

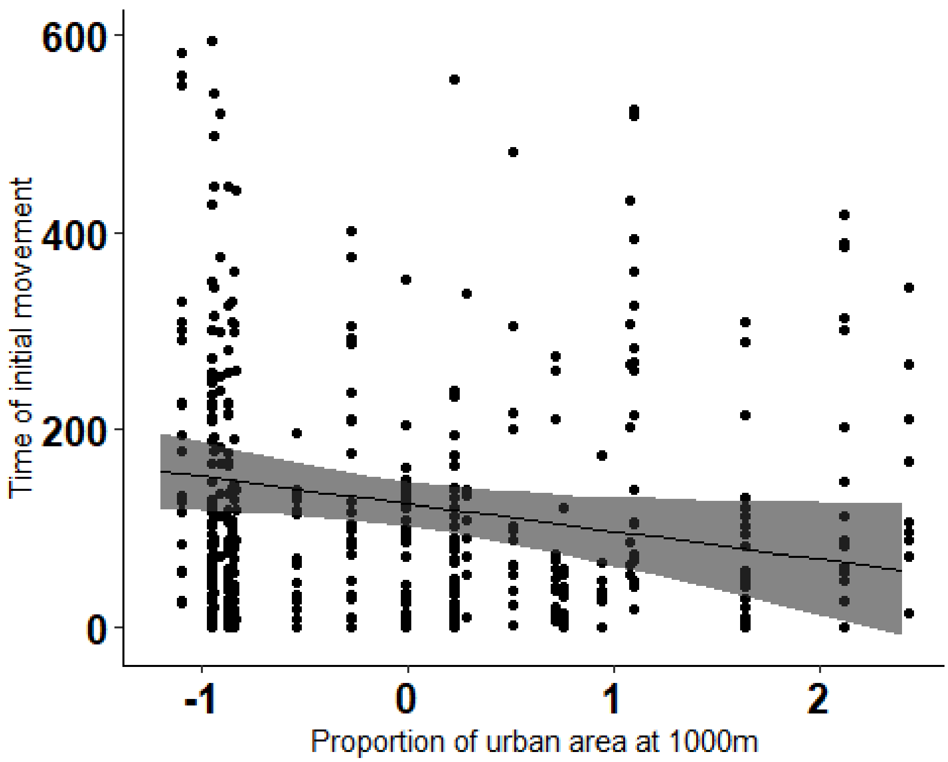
```
pred.con.averaged.model.Start.urban.1000 <- ggpredict(con.averaged.model.Star
t, terms = "urban.1000.Scaled")
pred.con.averaged.model.Start.urban.1000
```

```
## # Predicted values of Start
##
## urban.1000.Scaled | Predicted |           95% CI
## ---------------------------------------------------
##             -1.20 |    158.07 | [119.26, 196.88]
##             -0.80 |    146.87 | [115.67, 178.07]
##             -0.20 |    130.07 | [106.05, 154.09]
##              0.20 |    118.87 | [ 94.78, 142.96]
##              0.60 |    107.67 | [ 79.41, 135.93]
##              1.00 |     96.47 | [ 61.38, 131.56]
##              1.40 |     85.27 | [ 41.93, 128.61]
##              2.40 |     57.26 | [ -9.33, 123.86]
##
## Adjusted for:
## *          PL.Scaled = 0.02
## * for.veg.200.Scaled = 0.01
## *   water.500.Scaled = 0.02
## *               Site = 0 (population-level)
```

```
# New dataset to only have complete observations for all the variables
MixedData.adjust.final.model.Start <- MixedData[complete.cases(MixedData$PL.S
caled, MixedData$for.veg.200.Scaled, MixedData$urban.1000.Scaled, MixedData$w
ater.500.Scaled),]
```

Figure for proportion of urban area at 1000m

```
graph.con.Start.urban.1000 <- ggplot(data=pred.con.averaged.model.Start.urban
.1000, aes(x, predicted)) + geom_point(data=MixedData, aes(urban.1000.Scaled,
Start)) +
  geom_ribbon(data=pred.con.averaged.model.Start.urban.1000, aes(ymin=conf.lo
w, ymax= conf.high), alpha=0.6) +
  geom_line(data=pred.con.averaged.model.Start.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("Time of initial movement") +
  xlab("Proportion of urban area at 1000m")

graph.con.Start.urban.1000
```



Model selection

Log(x+1) transformed version of 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.log.Start.null <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Ti
me.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.S
caled + water.100.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.log.Start.dummy.site <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scale
d + Time.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.
1000.Scaled + water.100.Scaled + (1|Dummy) + (1|Site), data = MixedData, na.a
ction=na.exclude, control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALS
E)
```

```r
## only turtle ID as random variable
mod.log.Start.dummy.code <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scale
d + Time.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.
1000.Scaled + water.100.Scaled + (1|Dummy) + (1|Code), data = MixedData, na.a
ction=na.exclude, control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALS
E)
```

Likelihood ratio tests between the mixed models

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

## Data: MixedData
## Models:
## mod.log.Start.null: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.Scale
d + water.100.Scaled + (1 | Dummy)
## mod.log.Start.dummy.site: log.Start ~ JulianDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000
.Scaled + water.100.Scaled + (1 | Dummy) + (1 | Site)
##                          npar    AIC    BIC  logLik deviance  Chisq Df
## mod.log.Start.null         12 1692.3 1741.7 -834.16   1668.3
## mod.log.Start.dummy.site   13 1686.3 1739.8 -830.15   1660.3 8.0127  1
##                          Pr(>Chisq)
## mod.log.Start.null
## mod.log.Start.dummy.site   0.004645 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

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

## Data: MixedData
## Models:
## mod.log.Start.null: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.Scale
d + water.100.Scaled + (1 | Dummy)
## mod.log.Start.dummy.code: log.Start ~ JulianDate.Scaled + A.Temp.Scaled +
Time.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000
.Scaled + water.100.Scaled + (1 | Dummy) + (1 | Code)
##                          npar    AIC    BIC  logLik deviance Chisq Df
## mod.log.Start.null         12 1692.3 1741.7 -834.16   1668.3
## mod.log.Start.dummy.code   13 1693.4 1746.9 -833.69   1667.4 0.936  1
##                          Pr(>Chisq)
## mod.log.Start.null
## mod.log.Start.dummy.code     0.3333
```

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.

```r
## Site identity without the dummy variable
mod.log.Start.site <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Ti
me.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.S
caled + water.100.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.log.Start.code.site <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.10
00.Scaled + water.100.Scaled + (1|Code) + (1|Site), data = MixedData, na.acti
on=na.exclude, control=lmerControl(check.nlev.gtr.1="ignore"), REML = FALSE)

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

## Data: MixedData
## Models:
## mod.log.Start.site: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.Scale
d + water.100.Scaled + (1 | Site)
## mod.log.Start.code.site: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + T
ime.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.
Scaled + water.100.Scaled + (1 | Code) + (1 | Site)
##                         npar    AIC    BIC  logLik deviance  Chisq Df
## mod.log.Start.site        12 1684.3 1733.7 -830.15   1660.3
## mod.log.Start.code.site   13 1685.5 1739.0 -829.73   1659.5 0.8478  1
##                         Pr(>Chisq)
## mod.log.Start.site
## mod.log.Start.code.site     0.3572
```

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.

```r
mod.log.Start.full <- lmer(Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.Scale
d + water.100.Scaled + (1|Site), data = MixedData, na.action=na.exclude, REML
= FALSE)

summary(mod.log.Start.full)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scal
ed +
##     Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.Scaled +
##     water.100.Scaled + (1 | Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   5619.1   5668.6  -2797.6   5595.1      442
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.7757 -0.6533 -0.3065  0.4705  4.1817
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept)  1352     36.77
##  Residual             12481    111.72
## Number of obs: 454, groups:  Site, 23
##
## Fixed effects:
##                    Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)         121.087     12.282  41.750   9.859 1.83e-12 ***
## JulianDate.Scaled   -22.644     11.241  27.449  -2.014  0.05385 .
## A.Temp.Scaled        -7.177      9.167  97.611  -0.783  0.43557
## Time.Scaled          -4.954      5.852 451.163  -0.847  0.39772
## PL.Scaled            18.912      6.828 451.897   2.770  0.00584 **
## SexM                  4.566     12.721 448.796   0.359  0.71980
## wet.400.Scaled       26.169     10.552  18.449   2.480  0.02299 *
## agri.400.Scaled       5.182      8.308  25.656   0.624  0.53828
## urban.1000.Scaled    -3.624      9.976  19.570  -0.363  0.72028
## water.100.Scaled    -10.805     11.088  18.579  -0.974  0.34233
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.400. a.400. u.1000
## JulnDt.Scld -0.069
## A.Temp.Scld  0.113 -0.412
## Time.Scaled  0.050  0.085 -0.237
## PL.Scaled   -0.312 -0.044 -0.054 -0.030
## SexM        -0.602  0.041 -0.107 -0.058  0.474
## wt.400.Scld -0.051 -0.256  0.130 -0.015  0.048  0.005
## agr.400.Scl -0.092  0.065 -0.007  0.046 -0.050 -0.038  0.161
## urbn.1000.S -0.084 -0.170  0.122  0.030  0.022  0.050  0.327 -0.019
## wtr.100.Scl  0.035  0.173  0.132 -0.083 -0.059 -0.052  0.234  0.081  0.003
```

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

```r
mod.log.Start.1 <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.
Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + water.100.Scale
d + (1|Site), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start, MixedData$Julia
nDate.Scaled, MixedData$A.Temp.Scaled, MixedData$Time.Scaled, MixedData$PL.Sc
aled, MixedData$Sex, MixedData$wet.400.Scaled, MixedData$agri.400.Scaled, Mix
edData$urban.1000.Scaled, MixedData$water.100.Scaled),]

mod.full.adjust <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.
Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.Scal
ed + water.100.Scaled + (1|Site), data = MixedData.adjust, na.action=na.exclu
de, REML = FALSE)

mod.log.Start.1.adjust <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled
+ Time.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + water.10
0.Scaled + (1|Site), data = MixedData.adjust, na.action=na.exclude, REML = FA
LSE)

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

## Data: MixedData.adjust
## Models:
## mod.log.Start.1.adjust: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Ti
me.Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + water.100.Sc
aled + (1 | Site)
## mod.full.adjust: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scal
ed + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + urban.1000.Scaled +
water.100.Scaled + (1 | Site)
##                        npar    AIC    BIC  logLik deviance  Chisq Df Pr(>C
hisq)
## mod.log.Start.1.adjust   11 1683.3 1728.7 -830.68   1661.3
## mod.full.adjust          12 1684.3 1733.7 -830.15   1660.3 1.0476  1     0
.3061

summary(mod.log.Start.1)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
##     PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + water.100.Scaled
+
##     (1 | Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1683.4   1728.7   -830.7   1661.4      443
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
```

```
## -3.2853 -0.4431  0.1587  0.6841  2.3076
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept) 0.1972   0.444
##  Residual             2.1656   1.472
## Number of obs: 454, groups:  Site, 23
##
## Fixed effects:
##                    Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         4.17950    0.15545  46.17081  26.887   <2e-16 ***
## JulianDate.Scaled  -0.20921    0.13942  29.10646  -1.501   0.1442
## A.Temp.Scaled      -0.21045    0.11700  90.93424  -1.799   0.0754 .
## Time.Scaled         0.06512    0.07675 447.58010   0.848   0.3966
## PL.Scaled           0.21406    0.08973 453.01909   2.386   0.0175 *
## SexM               -0.25630    0.16706 451.59760  -1.534   0.1257
## wet.400.Scaled      0.26264    0.12429  19.58936   2.113   0.0476 *
## agri.400.Scaled     0.15050    0.10438  27.45810   1.442   0.1607
## water.100.Scaled   -0.27459    0.13814  19.21437  -1.988   0.0613 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.400. a.400.
## JulnDt.Scld -0.087
## A.Temp.Scld  0.125 -0.410
## Time.Scaled  0.054  0.093 -0.242
## PL.Scaled   -0.322 -0.042 -0.061 -0.030
## SexM        -0.622  0.051 -0.113 -0.062  0.475
## wt.400.Scld -0.023 -0.216  0.099 -0.026  0.044 -0.011
## agr.400.Scl -0.084  0.060 -0.007  0.050 -0.053 -0.038  0.177
## wtr.100.Scl  0.037  0.184  0.134 -0.087 -0.063 -0.054  0.242  0.080
```

I deleted time of testing (Time).

```
mod.log.Start.2 <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Sc
aled + Sex + wet.400.Scaled + agri.400.Scaled + water.100.Scaled + (1|Site),
data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start, MixedData$Julia
nDate.Scaled, MixedData$A.Temp.Scaled, MixedData$Time.Scaled, MixedData$PL.Sc
aled, MixedData$Sex, MixedData$wet.400.Scaled, MixedData$agri.400.Scaled, Mix
edData$water.100.Scaled),]

mod.full.adjust <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.
Scaled + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + water.100.Scale
d + (1|Site), data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.log.Start.2.adjust <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled
+ PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + water.100.Scaled + (1|
```

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

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

## Data: MixedData.adjust
## Models:
## mod.log.Start.2.adjust: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL
.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + water.100.Scaled + (1 | Si
te)
## mod.full.adjust: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scal
ed + PL.Scaled + Sex + wet.400.Scaled + agri.400.Scaled + water.100.Scaled +
(1 | Site)
##                        npar    AIC    BIC  logLik deviance  Chisq Df Pr(>C
hisq)
## mod.log.Start.2.adjust   10 1682.1 1723.2 -831.03   1662.1
## mod.full.adjust          11 1683.3 1728.7 -830.68   1661.3 0.7111  1     0
.3991

summary(mod.log.Start.2)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Scaled + Sex +
##     wet.400.Scaled + agri.400.Scaled + water.100.Scaled + (1 |      Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1682.1   1723.2   -831.0   1662.1      444
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.2866 -0.4403  0.1559  0.7085  2.2337
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept) 0.1884   0.434
##  Residual             2.1721   1.474
## Number of obs: 454, groups:  Site, 23
##
## Fixed effects:
##                    Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         4.16989    0.15395  46.48752  27.085   <2e-16 ***
## JulianDate.Scaled  -0.21898    0.13733  28.94543  -1.594   0.1217
## A.Temp.Scaled      -0.18946    0.11291  87.59331  -1.678   0.0969 .
## PL.Scaled           0.21769    0.08978 453.13083   2.425   0.0157 *
## SexM               -0.24670    0.16689 452.86811  -1.478   0.1400
## wet.400.Scaled      0.26570    0.12260  19.56986   2.167   0.0427 *
## agri.400.Scaled     0.14678    0.10310  27.38158   1.424   0.1658
## water.100.Scaled   -0.26598    0.13575  18.91447  -1.959   0.0650 .
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) JlnD.S A.Tm.S PL.Scl SexM   w.400. a.400.
## JulnDt.Scld -0.093
## A.Temp.Scld  0.143 -0.404
## PL.Scaled   -0.324 -0.039 -0.072
## SexM        -0.626  0.058 -0.132  0.475
## wt.400.Scld -0.022 -0.215  0.096  0.044 -0.013
## agr.400.Scl -0.084  0.055  0.006 -0.052 -0.036  0.178
## wtr.100.Scl  0.042  0.196  0.118 -0.067 -0.061  0.239  0.085
```

I deleted proportion of agricultural area at 400m (agri.400).

```
mod.log.Start.3 <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Sc
aled + Sex + wet.400.Scaled + water.100.Scaled + (1|Site), data = MixedData,
na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start, MixedData$Julia
nDate.Scaled, MixedData$A.Temp.Scaled, MixedData$PL.Scaled, MixedData$Sex, Mi
xedData$wet.400.Scaled, MixedData$agri.400.Scaled, MixedData$water.100.Scaled
),]

mod.full.adjust <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Sc
aled + Sex + wet.400.Scaled + agri.400.Scaled + water.100.Scaled + (1|Site),
data = MixedData.adjust, na.action=na.exclude, REML = FALSE)

mod.log.Start.3.adjust <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled
+ PL.Scaled + Sex + wet.400.Scaled + water.100.Scaled + (1|Site), data = Mixe
dData.adjust, na.action=na.exclude, REML = FALSE)

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

## Data: MixedData.adjust
## Models:
## mod.log.Start.3.adjust: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL
.Scaled + Sex + wet.400.Scaled + water.100.Scaled + (1 | Site)
## mod.full.adjust: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Scaled
+ Sex + wet.400.Scaled + agri.400.Scaled + water.100.Scaled + (1 | Site)
##                        npar    AIC    BIC  logLik deviance  Chisq Df Pr(>C
hisq)
## mod.log.Start.3.adjust    9 1682.0 1719.0 -831.98   1664.0
## mod.full.adjust          10 1682.1 1723.2 -831.03   1662.1 1.8953  1     0
.1686

summary(mod.log.Start.3)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Scaled + Sex +
##     wet.400.Scaled + water.100.Scaled + (1 | Site)
```

```
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##     1682     1719     -832     1664      445
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.2463 -0.4611  0.1448  0.7046  2.2515
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept) 0.225    0.4744
##  Residual             2.169    1.4728
## Number of obs: 454, groups:  Site, 23
##
## Fixed effects:
##                   Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)         4.1988     0.1589  48.8803  26.424   <2e-16 ***
## JulianDate.Scaled  -0.2345     0.1435  30.5100  -1.634   0.1124
## A.Temp.Scaled      -0.1793     0.1157 105.6708  -1.550   0.1242
## PL.Scaled           0.2187     0.0898 452.9378   2.436   0.0152 *
## SexM               -0.2419     0.1670 451.9804  -1.448   0.1482
## wet.400.Scaled      0.2337     0.1275  20.8536   1.833   0.0811 .
## water.100.Scaled   -0.2766     0.1431  20.3342  -1.933   0.0673 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) JlnD.S A.Tm.S PL.Scl SexM   w.400.
## JulnDt.Scld -0.086
## A.Temp.Scld  0.143 -0.395
## PL.Scaled   -0.320 -0.036 -0.067
## SexM        -0.611  0.058 -0.133  0.473
## wt.400.Scld -0.006 -0.228  0.094  0.052 -0.007
## wtr.100.Scl  0.049  0.183  0.116 -0.059 -0.055  0.233
```

I deleted turtle sex (Sex).

```
mod.log.Start.4 <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Sc
aled + wet.400.Scaled + water.100.Scaled + (1|Site), data = MixedData, na.act
ion=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start, MixedData$Julia
nDate.Scaled, MixedData$A.Temp.Scaled, MixedData$PL.Scaled, MixedData$Sex, Mi
xedData$wet.400.Scaled, MixedData$water.100.Scaled),]

mod.full.adjust <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Sc
aled + Sex + wet.400.Scaled + water.100.Scaled + (1|Site), data = MixedData.a
djust, na.action=na.exclude, REML = FALSE)
```

```
mod.log.Start.4.adjust <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled
+ PL.Scaled + wet.400.Scaled + water.100.Scaled + (1|Site), data = MixedData.
adjust, na.action=na.exclude, REML = FALSE)

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

## Data: MixedData.adjust
## Models:
## mod.log.Start.4.adjust: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL
.Scaled + wet.400.Scaled + water.100.Scaled + (1 | Site)
## mod.full.adjust: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Scaled
+ Sex + wet.400.Scaled + water.100.Scaled + (1 | Site)
##                        npar  AIC  BIC  logLik deviance  Chisq Df Pr(>Chisq
)
## mod.log.Start.4.adjust    8 1682 1715 -833.02     1666
## mod.full.adjust           9 1682 1719 -831.98     1664 2.0844  1     0.148
8

summary(mod.log.Start.4)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Scaled + wet.400.Scaled
+
##     water.100.Scaled + (1 | Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1698.4   1731.4   -841.2   1682.4      451
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.2243 -0.4728  0.1780  0.7005  2.2212
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept) 0.2194   0.4684
##  Residual             2.1721   1.4738
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                    Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         4.05638    0.12454  20.75064  32.571  < 2e-16 ***
## JulianDate.Scaled  -0.21411    0.14210  30.81161  -1.507 0.142046
## A.Temp.Scaled      -0.22010    0.11385 106.82315  -1.933 0.055859 .
## PL.Scaled           0.27503    0.07759 458.99096   3.544 0.000434 ***
## wet.400.Scaled      0.22597    0.12636  21.16093   1.788 0.088055 .
## water.100.Scaled   -0.30304    0.14128  20.29591  -2.145 0.044235 *
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) JlnD.S A.Tm.S PL.Scl w.400.
## JulnDt.Scld -0.066
## A.Temp.Scld  0.079 -0.393
## PL.Scaled   -0.034 -0.067 -0.010
## wt.400.Scld -0.012 -0.228  0.092  0.058
## wtr.100.Scl  0.017  0.190  0.106 -0.038  0.231
```

I deleted Julian date of testing (JulianDate).

```
mod.log.Start.5 <- lmer(log.Start ~ A.Temp.Scaled + PL.Scaled + wet.400.Scale
d + water.100.Scaled + (1|Site), data = MixedData, na.action=na.exclude, REML
= FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start, MixedData$Julia
nDate.Scaled, MixedData$A.Temp.Scaled, MixedData$PL.Scaled, MixedData$wet.400
.Scaled, MixedData$water.100.Scaled),]

mod.full.adjust <- lmer(log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Sc
aled + wet.400.Scaled + water.100.Scaled + (1|Site), data = MixedData.adjust,
na.action=na.exclude, REML = FALSE)

mod.log.Start.5.adjust <- lmer(log.Start ~ A.Temp.Scaled + PL.Scaled + wet.40
0.Scaled + water.100.Scaled + (1|Site), data = MixedData.adjust, na.action=na
.exclude, REML = FALSE)

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

## Data: MixedData.adjust
## Models:
## mod.log.Start.5.adjust: log.Start ~ A.Temp.Scaled + PL.Scaled + wet.400.Sc
aled + water.100.Scaled + (1 | Site)
## mod.full.adjust: log.Start ~ JulianDate.Scaled + A.Temp.Scaled + PL.Scaled
+ wet.400.Scaled + water.100.Scaled + (1 | Site)
##                        npar    AIC    BIC  logLik deviance  Chisq Df Pr(>C
hisq)
## mod.log.Start.5.adjust    7 1698.6 1727.5 -842.31   1684.6
## mod.full.adjust           8 1698.4 1731.4 -841.19   1682.4 2.2357  1     0
.1349

summary(mod.log.Start.5)

## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula:
## log.Start ~ A.Temp.Scaled + PL.Scaled + wet.400.Scaled + water.100.Scaled
+
##     (1 | Site)
##    Data: MixedData
```

```
##
##      AIC      BIC   logLik deviance df.resid
##   1698.6   1727.5   -842.3   1684.6      452
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.2385 -0.4510  0.1859  0.6909  2.1771
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept) 0.2395   0.4894
##  Residual             2.1768   1.4754
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                   Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)        4.04785    0.12794  19.43850  31.639  < 2e-16 ***
## A.Temp.Scaled     -0.28209    0.10626  77.82417  -2.655 0.009623 **
## PL.Scaled          0.26514    0.07761 458.99814   3.416 0.000692 ***
## wet.400.Scaled     0.18150    0.12664  19.69936   1.433 0.167499
## water.100.Scaled  -0.26040    0.14297  17.99773  -1.821 0.085224 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) A.Tm.S PL.Scl w.400.
## A.Temp.Scld  0.059
## PL.Scaled   -0.038 -0.036
## wt.400.Scld -0.028  0.002  0.043
## wtr.100.Scl  0.031  0.196 -0.025  0.288
```

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

```
mod.log.Start.6 <- lmer(log.Start ~ A.Temp.Scaled + PL.Scaled + water.100.Sca
led + (1|Site), data = MixedData, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Start, MixedData$A.Tem
p.Scaled, MixedData$PL.Scaled, MixedData$wet.400.Scaled, MixedData$water.100.
Scaled),]

mod.full.adjust <- lmer(log.Start ~ A.Temp.Scaled + PL.Scaled + wet.400.Scale
d + water.100.Scaled + (1|Site), data = MixedData.adjust, na.action=na.exclud
e, REML = FALSE)

mod.log.Start.6.adjust <- lmer(log.Start ~ A.Temp.Scaled + PL.Scaled + water.
100.Scaled + (1|Site), data = MixedData.adjust, na.action=na.exclude, REML =
FALSE)

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

```
## Data: MixedData.adjust
## Models:
## mod.log.Start.6.adjust: log.Start ~ A.Temp.Scaled + PL.Scaled + water.100.
Scaled + (1 | Site)
## mod.full.adjust: log.Start ~ A.Temp.Scaled + PL.Scaled + wet.400.Scaled +
water.100.Scaled + (1 | Site)
##                          npar    AIC    BIC  logLik deviance  Chisq Df Pr(>C
hisq)
## mod.log.Start.6.adjust    6 1698.5 1723.3 -843.26   1686.5
## mod.full.adjust           7 1698.6 1727.5 -842.31   1684.6 1.9138  1     0
.1665
```

```
summary(mod.log.Start.6)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: log.Start ~ A.Temp.Scaled + PL.Scaled + water.100.Scaled + (1 |
##     Site)
##    Data: MixedData
##
##      AIC      BIC   logLik deviance df.resid
##   1698.5   1723.3   -843.3   1686.5      453
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.2482 -0.4496  0.1993  0.7078  2.2029
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept) 0.2836   0.5325
##  Residual             2.1736   1.4743
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                    Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)         4.06011    0.13542  20.72958  29.981  < 2e-16 ***
## A.Temp.Scaled      -0.27120    0.10916  91.85078  -2.484  0.01479 *
## PL.Scaled           0.25683    0.07769 458.85146   3.306  0.00102 **
## water.100.Scaled  -0.31479    0.14519  19.78048  -2.168  0.04253 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) A.Tm.S PL.Scl
## A.Temp.Scld  0.060
## PL.Scaled   -0.035 -0.029
## wtr.100.Scl  0.042  0.195 -0.037
```

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

Final model

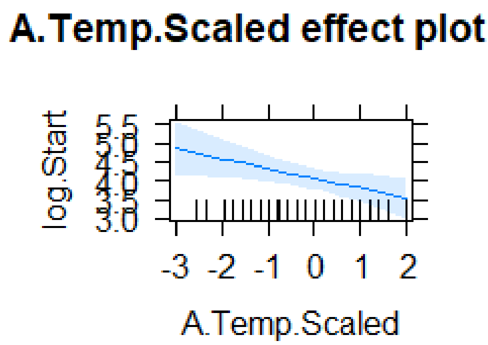
Summary statistics

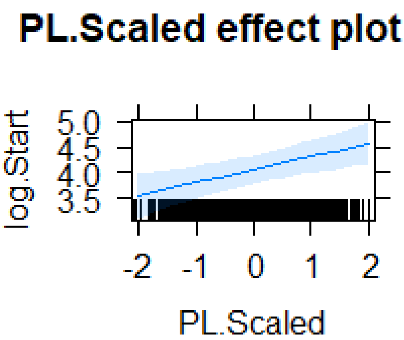
I changed the REML to TRUE to calculate the summary statistics of the final model.

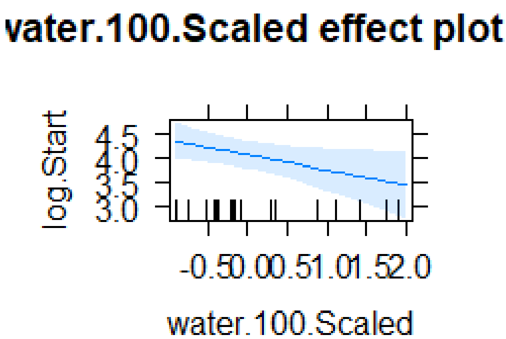
```
mod.log.Start.final <- lmer(log.Start ~ A.Temp.Scaled + PL.Scaled + water.100
.Scaled + (1|Site), data = MixedData, na.action=na.exclude, REML = TRUE)

summary(mod.log.Start.final)

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: log.Start ~ A.Temp.Scaled + PL.Scaled + water.100.Scaled + (1 |
##     Site)
##    Data: MixedData
##
## REML criterion at convergence: 1696.5
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.2455 -0.4547  0.2023  0.7024  2.2234
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Site     (Intercept) 0.3389   0.5822
##  Residual             2.1801   1.4765
## Number of obs: 459, groups:  Site, 23
##
## Fixed effects:
##                   Estimate Std. Error        df t value Pr(>|t|)
## (Intercept)        4.06719    0.14435  19.04324  28.176  < 2e-16 ***
## A.Temp.Scaled     -0.25963    0.11241  95.45498  -2.310  0.02306 *
## PL.Scaled          0.25354    0.07802 454.88303   3.250  0.00124 **
## water.100.Scaled  -0.31011    0.15498  18.31420  -2.001  0.06044 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) A.Tm.S PL.Scl
## A.Temp.Scld  0.061
## PL.Scaled   -0.034 -0.023
## wtr.100.Scl  0.043  0.186 -0.036
```

Visualization of the predictor effects

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







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

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

##             R2m       R2c
## [1,] 0.05926647 0.1858313
```

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

Calculation of the 95% confidence intervals

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

##                        2.5 %       97.5 %
## .sig01                    NA           NA
## .sigma                    NA           NA
## (Intercept)        3.7842661  4.350113266
## A.Temp.Scaled     -0.4799473 -0.039307505
## PL.Scaled          0.1006257  0.406453293
## water.100.Scaled  -0.6138571 -0.006360052
```

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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled + u
rban.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scal
ed + urban.1000.Scaled + water.1000.Scaled + (1|Dummy) + (1|Site), data = Mix
edData, 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.S
caled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scal
ed + urban.1000.Scaled + water.1000.Scaled + (1|Dummy) + (1|Code), data = Mix
edData, 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 ~ JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + 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(>Chis
q)
## 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  0.00063
```

```
68
##
## 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 ~ JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + 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(>Chis
q)
## 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    0.034
83 *
## ---
## 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled + u
rban.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled + u
rban.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Sc
aled + PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scale
d + urban.1000.Scaled + water.1000.Scaled + (1|Code) + (1|Site), data = Mixed
Data, na.action=na.exclude, control=lmerControl(check.nlev.gtr.1="ignore"), R
EML = FALSE)

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

```
## Data: MixedData
## Models:
## mod.Move.site: Move ~ JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled + u
rban.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    0.0479
2 *
## ---
## 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 ~ JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled + u
rban.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  0.000851
8 ***
## ---
## 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled + u
rban.1000.Scaled + water.1000.Scaled + (1|Site) + (1|Code), data = MixedData,
```

```r
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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scale
d +
##     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 ***
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   f..300 w.600. a.100.
## JulnDt.Scld -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
## JulnDt.Scld
## 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + P
L.Scaled + Sex + wet.600.Scaled + agri.100.Scaled + urban.1000.Scaled + water
.1000.Scaled + (1|Site) + (1|Code), data = MixedData, na.action=na.exclude, R
EML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move, MixedData$Julian
Date.Scaled, MixedData$A.Temp.Scaled, MixedData$Time.Scaled, MixedData$PL.Sca
led, MixedData$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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Sca
led + 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled
+ PL.Scaled + Sex + wet.600.Scaled + agri.100.Scaled + urban.1000.Scaled + wa
ter.1000.Scaled + (1 | Site) + (1 | Code)
## mod.full.adjust: Move ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + for.veg.300.Scaled + wet.600.Scaled + agri.100.Scaled + urb
an.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scale
d +
##     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 ***
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   w.600. a.100. u.1000
## JulnDt.Scld -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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + P
L.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$Move, MixedData$Julian
Date.Scaled, MixedData$A.Temp.Scaled, MixedData$Time.Scaled, MixedData$PL.Sca
led, MixedData$Sex,  MixedData$wet.600.Scaled, MixedData$agri.100.Scaled, Mix
edData$urban.1000.Scaled, MixedData$water.1000.Scaled),]

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

mod.Move.2.adjust <- lmer(Move ~ JulianDate.Scaled + A.Temp.Scaled + Time.Sca
led + PL.Scaled + Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scal
ed + (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 ~ JulianDate.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled +
PL.Scaled + Sex + wet.600.Scaled + agri.100.Scaled + urban.1000.Scaled + wate
r.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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + PL.Scale
d +
##     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 ***
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl PL.Scl SexM   a.100. u.1000
## JulnDt.Scld -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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + S
ex + 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$Move, MixedData$Julian
Date.Scaled, MixedData$A.Temp.Scaled, MixedData$Time.Scaled, MixedData$PL.Sca
led, MixedData$Sex, MixedData$agri.100.Scaled, MixedData$urban.1000.Scaled, M
ixedData$water.1000.Scaled),]

mod.full.adjust <- lmer(Move ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Sca
led + 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 ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled
+ Sex + agri.100.Scaled + urban.1000.Scaled + water.1000.Scaled + (1 | Site)
+ (1 | Code)
## mod.full.adjust: Move ~ JulianDate.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 ~ JulianDate.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 ***
## JulianDate.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) JlnD.S A.Tm.S Tm.Scl SexM   a.100. u.1000
## JulnDt.Scld -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 ~ JulianDate.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$Move, MixedData$Julian
Date.Scaled, MixedData$A.Temp.Scaled, MixedData$Time.Scaled, MixedData$Sex, M
ixedData$agri.100.Scaled, MixedData$urban.1000.Scaled, MixedData$water.1000.S
caled),]

mod.full.adjust <- lmer(Move ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scale
d + 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 ~ JulianDate.Scaled + A.Temp.Scaled + Sex + ag
ri.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 ~ JulianDate.Scaled + A.Temp.Scaled + Sex + agri.1
00.Scaled + urban.1000.Scaled + water.1000.Scaled + (1 | Site) + (1 | Code)
## mod.full.adjust: Move ~ JulianDate.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 ~ JulianDate.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 ***
## JulianDate.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) JlnD.S A.Tm.S SexM   a.100. u.1000
## JulnDt.Scld -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 ~ JulianDate.Scaled + Sex + agri.100.Scaled + urban.1
000.Scaled + water.1000.Scaled + (1|Site) + (1|Code), data = MixedData, na.ac
tion=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move, MixedData$Julian
Date.Scaled, MixedData$A.Temp.Scaled, MixedData$Sex, MixedData$agri.100.Scale
```

```
d, MixedData$urban.1000.Scaled, MixedData$water.1000.Scaled),]

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

mod.Move.5.adjust <- lmer(Move ~ JulianDate.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 ~ JulianDate.Scaled + Sex + agri.100.Scaled + urba
n.1000.Scaled + water.1000.Scaled + (1 | Site) + (1 | Code)
## mod.full.adjust: Move ~ JulianDate.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 ~ JulianDate.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 ***
## JulianDate.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) JlnD.S SexM   a.100. u.1000
## JulnDt.Scld -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 Julian date of testing (JulianDate).

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

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

mod.full.adjust <- lmer(Move ~ JulianDate.Scaled + Sex + agri.100.Scaled + ur
ban.1000.Scaled + water.1000.Scaled + (1|Site) + (1|Code), data = MixedData.a
djust, 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=n
a.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 + wate
r.1000.Scaled + (1 | Site) + (1 | Code)
## mod.full.adjust: Move ~ JulianDate.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, M
ixedData$agri.100.Scaled, MixedData$urban.1000.Scaled, MixedData$water.1000.S
caled),]

mod.full.adjust <- lmer(Move ~ Sex + agri.100.Scaled + urban.1000.Scaled + wa
ter.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 = FA
LSE)
```

```
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, M
ixedData$agri.100.Scaled, MixedData$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 = FALS
E)

mod.Move.8.adjust <- lmer(Move ~ agri.100.Scaled + urban.1000.Scaled + (1|Sit
e) + (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 | S
ite) + (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 = Mixed
Data, na.action=na.exclude, REML = FALSE)

MixedData.adjust <- MixedData[complete.cases(MixedData$Move, MixedData$agri.1
00.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
```

Since the LRT P-value is barely significant (0.0499) after the removal of urban.1000, I decided to calculate the AICc values for mod.Move.8 and mod.Move.9 in order to compare their parsimony.

AIC test

I had to recreate the initial model for total time spent moving (Move) for the AIC test

```
mod.Move.0 <- lmer(Move ~ JulianDate.Scaled + A.Temp.Scaled + Time.Scaled + P
L.Scaled + Sex + wet.600.Scaled + for.veg.300.Scaled + agri.100.Scaled + urba
n.1000.Scaled + water.1000.Scaled + (1|Site) + (1|Code), data = MixedData, na
.action=na.exclude, REML = FALSE)

#define list of models
Move.models <- list(mod.Move.0, mod.Move.1, mod.Move.2, mod.Move.3, mod.Move.
4, mod.Move.5, mod.Move.6, mod.Move.7, mod.Move.8, mod.Move.9)

#specify model names
Move.mod.names <- c('mod.Move.0', 'mod.Move.1', 'mod.Move.2', 'mod.Move.3', '
mod.Move.4', 'mod.Move.5', 'mod.Move.6', 'mod.Move.7', 'mod.Move.8', 'mod.Mov
e.9')

#calculate AICc of each model
aictab(cand.set = Move.models, modnames = Move.mod.names)

##
## Model selection based on AICc:
##
##             K    AICc Delta_AICc AICcWt Cum.Wt       LL
## mod.Move.2 12 4676.26       0.00   0.41   0.41 -2325.78
```

```
## mod.Move.7  7 4677.52       1.26   0.22   0.62 -2331.63
## mod.Move.1 13 4678.30       2.04   0.15   0.77 -2325.73
## mod.Move.6  8 4678.78       2.52   0.12   0.88 -2331.23
## mod.Move.0 14 4680.43       4.17   0.05   0.93 -2325.73
## mod.Move.5  9 4680.73       4.47   0.04   0.98 -2331.16
## mod.Move.4 10 4682.63       6.37   0.02   0.99 -2331.07
## mod.Move.3 11 4684.54       8.28   0.01   1.00 -2330.97
## mod.Move.8  6 4729.05      52.79   0.00   1.00 -2358.43
## mod.Move.9  5 4730.84      54.58   0.00   1.00 -2360.35
```

mod.Move.8 and mod.Move.9 had an AICc value within 2 of each other which suggests that they are equally parsimonious, so I decided to average them.

Averaging mod.Move.8 and mod.Move.9

```
# Average the two models using model.avg
averaged.model.move <- model.avg(mod.Move.8, mod.Move.9)

summary(averaged.model.move)
```

```
## 
## Call:
## model.avg(object = mod.Move.8, mod.Move.9)
## 
## Component model call: 
## lmer(formula = <2 unique values>, data = MixedData, REML = FALSE, 
##      na.action = na.exclude)
## 
## Component models: 
##    df   logLik    AICc delta weight
## 12  6 -2358.43 4729.05  0.00   0.71
## 1   5 -2360.35 4730.84  1.79   0.29
## 
## Term codes: 
##   agri.100.Scaled urban.1000.Scaled 
##                 1                 2 
## 
## Model-averaged coefficients:  
## (full average) 
##                   Estimate Std. Error Adjusted SE z value Pr(>|z|)    
## (Intercept)         92.601      3.374       3.383  27.374   <2e-16 ***
## agri.100.Scaled      7.940      3.093       3.101   2.560   0.0105 *  
## urban.1000.Scaled    4.756      4.098       4.103   1.159   0.2464    
##  
## (conditional average) 
##                   Estimate Std. Error Adjusted SE z value Pr(>|z|)    
## (Intercept)         92.601      3.374       3.383  27.374   <2e-16 ***
## agri.100.Scaled      7.940      3.093       3.101   2.560   0.0105 *  
## urban.1000.Scaled    6.698      3.263       3.272   2.047   0.0406 *
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

To create the final model I will extract the conditional average coefficients, as they are only averaged over the models where the fixed effects appear.

```
#Extracting the conditional average coefficients from the averaged model
con.average.coefs.move <- averaged.model.move$coefs[,1]
```

Final model

Summary statistics

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

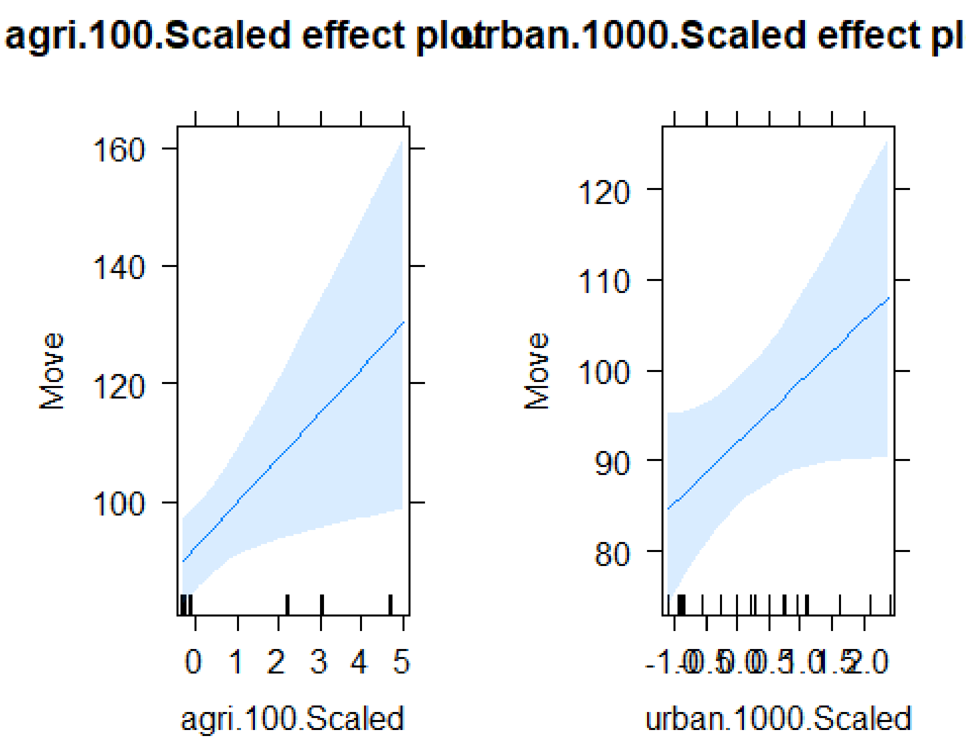
```
#Creating model with just the conditional average coefficients
con.average.model.move <- lmer(Move ~ agri.100.Scaled + urban.1000.Scaled + (
1|Site) + (1|Code),
                           data = MixedData,
                           REML = TRUE,
                           na.action = na.exclude,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

## 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
## Weights: con.average.coefs.move
##
## 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 land area at 1000m does not have a statistically significant effect on total time spent moving.

Visualization of the predictor effects

```
plot(allEffects(con.average.model.move))
```



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

```
r.squaredGLMM(con.average.model.move)

##             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

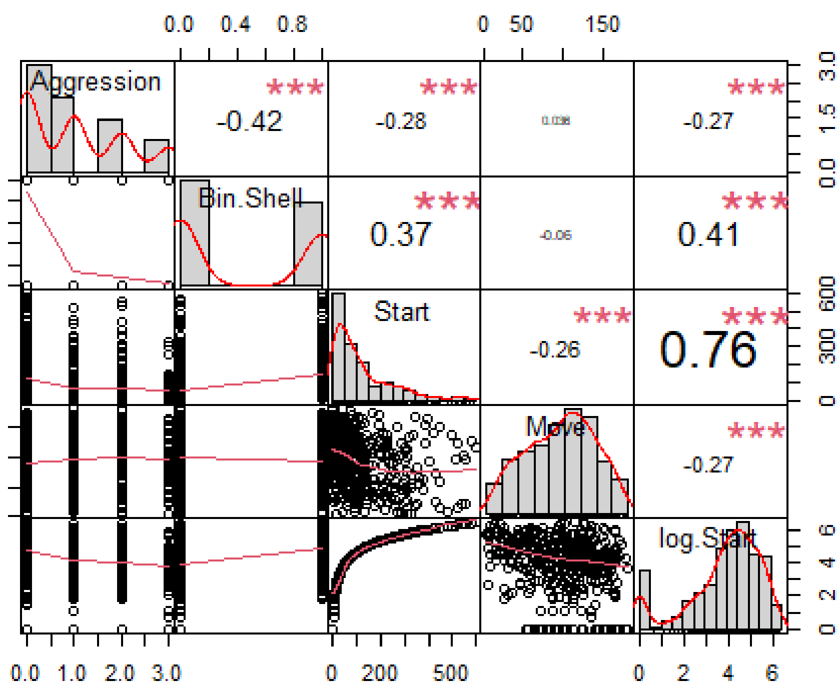
```
confint(con.average.model.move, level = 0.95, method = "Wald")
```

```
##                           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(11,13,14,15,68)]
chart.Correlation(cor.behaviour, histogram=TRUE, pch=19)
```




```
# Creation of the correlation table
table.corr.pearson.behaviour <- rcorr(as.matrix(MixedData[,c(11,13,14,15,68)]
), type="pearson")
table.cor.pearson.behaviour.r <- table.corr.pearson.behaviour$r # Pearson cor
relation coefficients
table.cor.pearson.behaviour.p <- table.corr.pearson.behaviour$P # P values of
the correlations
table.cor.pearson.behaviour.r
```

```
##              Aggression   Bin.Shell      Start        Move  log.Start
## Aggression  1.00000000 -0.42367744 -0.2759465  0.03613673 -0.2663096
## Bin.Shell  -0.42367744  1.00000000  0.3699742 -0.06016433  0.4081813
## Start      -0.27594651  0.36997418  1.0000000 -0.26028477  0.7558242
## Move        0.03613673 -0.06016433 -0.2602848  1.00000000 -0.2732679
## log.Start  -0.26630957  0.40818132  0.7558242 -0.27326794  1.0000000
```

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

```
##               Aggression    Bin.Shell        Start         Move    log.Star
t
## Aggression            NA 0.000000e+00 1.748938e-09 4.399102e-01 6.582143e-0
9
## Bin.Shell  0.000000e+00           NA 2.220446e-16 1.982237e-01 0.000000e+0
0
## Start      1.748938e-09 2.220446e-16           NA 1.522212e-08 0.000000e+0
0
## Move       4.399102e-01 1.982237e-01 1.522212e-08           NA 2.644465e-0
9
## log.Start  6.582143e-09 0.000000e+00 0.000000e+00 2.644465e-09           N
A
```

Spearman correlation coefficients

```
# Creation of the correlation table
table.corr.spearman.behaviour <- rcorr(as.matrix(MixedData[,c(11,13,14,15,68)
]), type="spearman")
table.cor.spearman.behaviour.r <- table.corr.spearman.behaviour$r # Pearson c
orrelation coefficients
table.cor.spearman.behaviour.p <- table.corr.spearman.behaviour$P # P values
of the correlations
table.cor.spearman.behaviour.r
```

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

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

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