Cerastium 2017

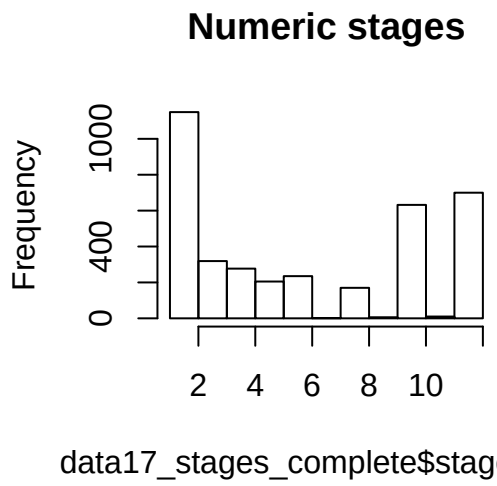
See number of cases per plot (all data)

```
with(data17_stages,aggregate(id~plot,FUN=length))
```

```
##    plot  id
## 1   H01 330
## 2   H02 330
## 3   H03 300
## 4   H04 294
## 5   H05 302
## 6   H08 330
## 7   H09 323
## 8   H10 326
## 9   H13 280
## 10  HC1 231
## 11 HC2a 179
## 12 HC2b  65
## 13  HC4 239
## 14  HC5 249
## 15  HC6 213
```

Stages as numeric

```
hist(data17_stages_complete$stage_num,main="Numeric stages")
```




```
subset(data17_stages_complete,stage_num==7) #Only 1, recode?
```

```
##      record   id plot  x  y peak comments       date temp stage stage_corr
## 1486      4 H801  H10 NA NA               2017-06-16   NA    B5         B5
##      stage_num
## 1486         7
```

```
subset(data17_stages_complete,stage_num==9) #Only 6, recode?
```

```
##      record    id plot  x  y peak comments       date temp stage
## 2013      5 H1113  HC4 NA NA               2017-07-11   NA FL100
## 2015      5 H1115  HC4 NA NA               2017-07-11   NA FL100
## 2025      5 H1125  HC5 NA NA               2017-07-11   NA FL100
## 2344      6  H835  HC1 NA NA               2017-07-19   NA FL100
## 2423      6 H1115  HC4 NA NA               2017-07-19   NA FL100
## 3481      9  H368  H09 NA NA               2017-07-21   NA FL100
##      stage_corr stage_num
## 2013      FL100         9
## 2015      FL100         9
## 2025      FL100         9
## 2344      FL100         9
## 2423      FL100         9
## 3481      FL100         9
```

```
subset(data17_stages_complete,stage_num==11) #Only 10, recode?
```

```
##      record    id plot  x  y peak comments       date temp stage
## 2054      5 H1154  HC6 NA NA               2017-07-11   NA   W50
## 2061      5 H1162  HC6 NA NA               2017-07-11   NA   W50
## 2064      5 H1168  HC6 NA NA               2017-07-11   NA   W50
## 2067      5 H1171  HC6 NA NA               2017-07-11   NA   W50
## 2068      5 H1172  HC6 NA NA               2017-07-11   NA   W50
## 2069      5 H1173  HC6 NA NA               2017-07-11   NA   W50
## 2071      5 H1177  HC6 NA NA               2017-07-11   NA   W50
## 2072      5 H1178  HC6 NA NA               2017-07-11   NA   W50
## 2075      5 H1182  HC6 NA NA               2017-07-11   NA   W50
## 2076      5 H1183  HC6 NA NA               2017-07-11   NA   W50
##      stage_corr stage_num
## 2054        W50        11
## 2061        W50        11
## 2064        W50        11
## 2067        W50        11
## 2068        W50        11
## 2069        W50        11
## 2071        W50        11
## 2072        W50        11
## 2075        W50        11
## 2076        W50        11
```

Number of cases per plot (data with meaningful stages)

```
##    plot  id
## 1   H01 300
## 2   H02 280
## 3   H03 274
## 4   H04 282
## 5   H05 297
## 6   H08 321
## 7   H09 311
## 8   H10 283
## 9   H13 260
## 10  HC1 215
## 11 HC2a 179
## 12 HC2b  57
## 13  HC4 216
```

```
## 14  HC5 238
## 15  HC6 191
```

Number of cases per plot(ids that flowered - reached FL)

```
##    plot  id
## 1   H01 134
## 2   H02  87
## 3   H03 118
## 4   H04  90
## 5   H05 125
## 6   H08  98
## 7   H09 114
## 8   H10  96
## 9   H13 120
## 10  HC1 110
## 11 HC2a  96
## 12 HC2b  19
## 13  HC4 118
## 14  HC5 107
## 15  HC6  86
```

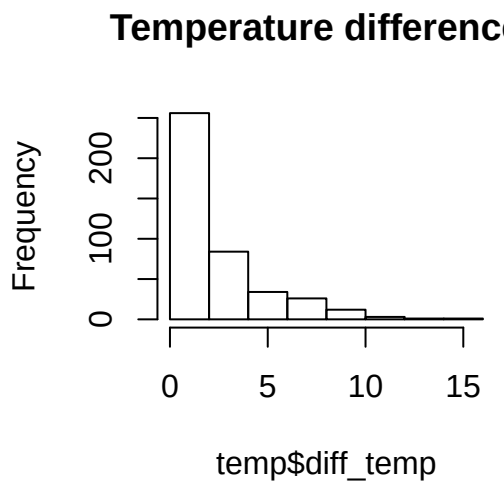
FFD mid-interval for each plant

```
head(FFD)
```

```
##      id   max_date   min_date        FFD
## 1    H1 2017-06-16 2017-06-26 2017-06-21
## 2   H10 2017-08-03       <NA>       <NA>
## 3   H11 2017-08-03       <NA>       <NA>
## 4 H1100 2017-07-04 2017-07-11 2017-07-07
## 5 H1101 2017-06-22 2017-06-28 2017-06-25
## 6 H1102 2017-06-22 2017-06-28 2017-06-25
```

Differences in temperature measurements for the same plant at different dates

```
hist(temp$diff_temp,main="Temperature differences")
```



```
nrow(temp) #417 pls w temp
```

```
## [1] 417
```

```
nrow(subset(temp,diff_temp>5)) #54 pls w temp diff > 5 - 13%
```

```
## [1] 54
```

```
nrow(subset(temp,diff_temp>10)) #5 pls w temp diff >10 - 1%
```

```
## [1] 5
```

Dataset

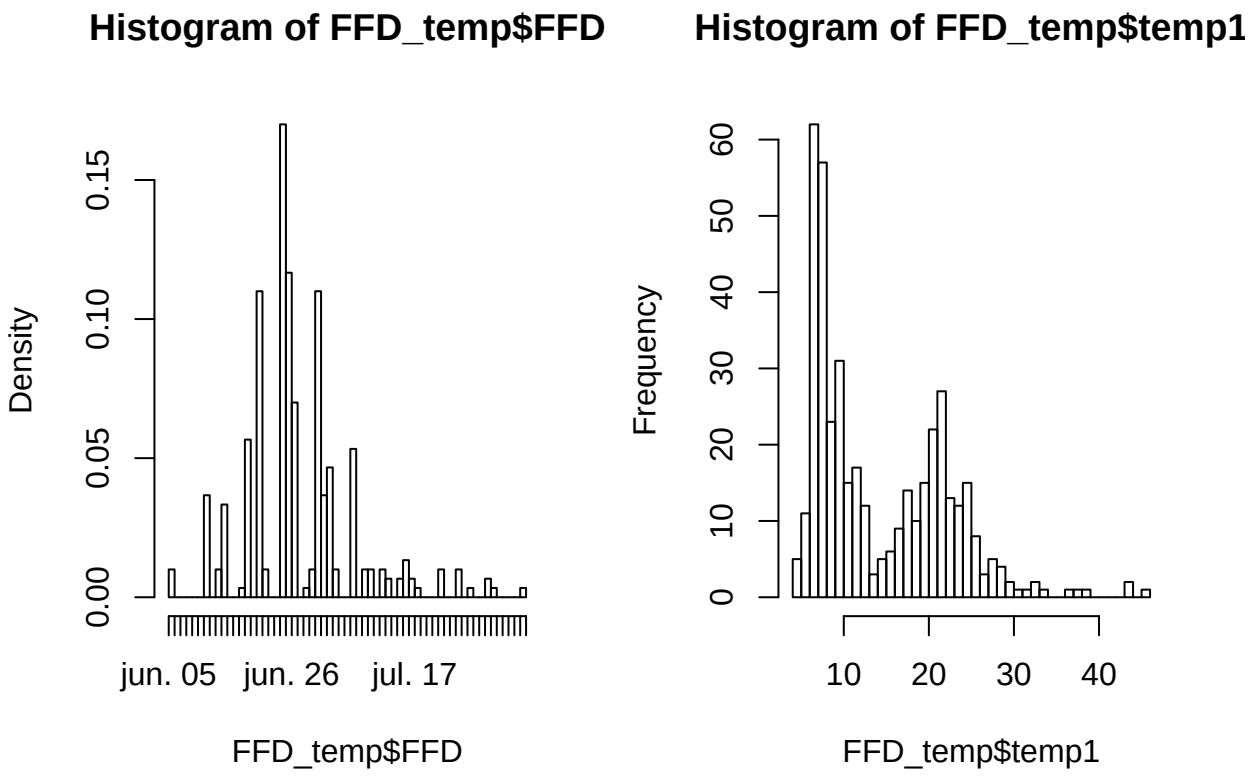
```
head(FFD_temp)
```

```
##      id        FFD mean_temp temp1 plot
## 1    H1 2017-06-21  19.60000  19.4  H01
## 2   H10       <NA>  21.23333  22.0  H01
## 3   H11       <NA>  21.96667  22.2  H01
## 4 H1100 2017-07-07   5.00000   5.0  HC4
## 5 H1101 2017-06-25   4.60000   4.6  HC4
## 6 H1102 2017-06-25   5.90000   5.9  HC4
```

Number of cases (i.e. plants) per plot with FFD available

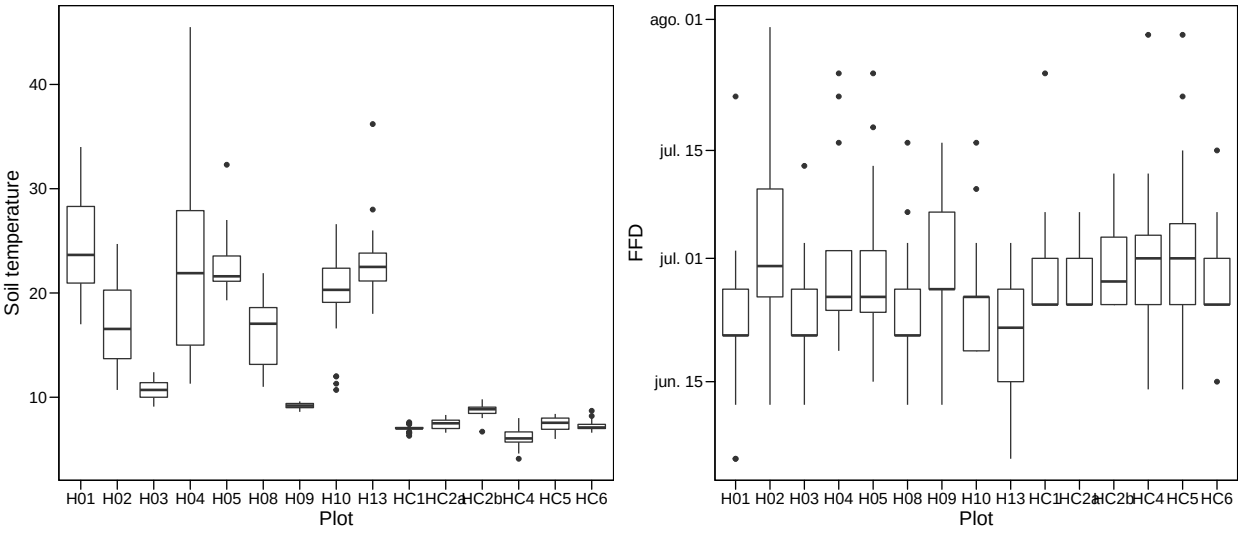
```
##    plot id
## 1   H01 21
## 2   H02 21
## 3   H03 24
## 4   H04 20
## 5   H05 27
## 6   H08 16
## 7   H09 21
## 8   H10 18
## 9   H13 24
## 10  HC1 24
## 11 HC2a 17
## 12 HC2b  4
## 13  HC4 26
## 14  HC5 22
## 15  HC6 15
```

Histograms



Differences among plots

```
## Warning: Removed 117 rows containing non-finite values (stat_boxplot).
```




```
with(FFD_temp,Anova(lm(temp1~plot)))
```

```
## Anova Table (Type II tests)
##
## Response: temp1
##            Sum Sq  Df F value    Pr(>F)
```

```
## plot      20151.4  14  105.92 < 2.2e-16 ***
## Residuals  5462.7 402
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
with(FFD_temp,Anova(lm(yday(FFD)~plot)))
```

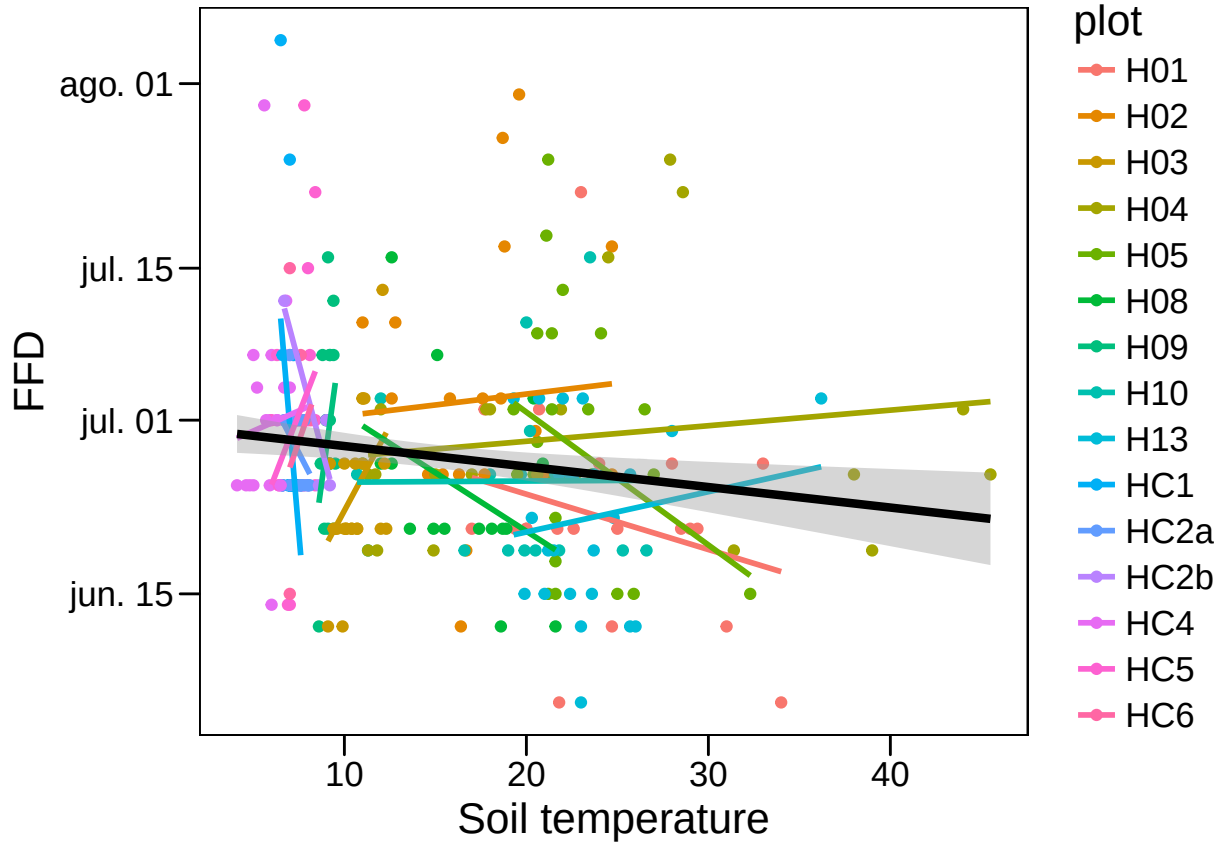
```
## Anova Table (Type II tests)
##
## Response: yday(FFD)
##            Sum Sq  Df F value    Pr(>F)
## plot       3502.2  14   3.048 0.0002065 ***
## Residuals 23390.9 285
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

FFD against soil t (overall + for each plot)

```
## Warning: Removed 117 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 117 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 117 rows containing missing values (geom_point).
```




```
summary(lm(yday(FFD) ~ temp1, data = FFD_temp)) #Linear regr pooled data, * R2=0.03
```

```
##
## Call:
## lm(formula = yday(FFD) ~ temp1, data = FFD_temp)
```

```
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -21.387  -4.685  -1.465   4.186  36.723
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 181.50461    1.11775 162.384   <2e-16 ***
## temp1        -0.18888    0.06754  -2.796   0.0055 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.378 on 298 degrees of freedom
##   (117 observations deleted due to missingness)
## Multiple R-squared:  0.02557,    Adjusted R-squared:  0.0223
## F-statistic:  7.82 on 1 and 298 DF,  p-value: 0.005502
```

```
model_17 <- lm(yday(FFD) ~ temp1*plot,FFD_temp) #Different slopes and intercepts for each plot
Anova(model_17) #Plot and interaction significant
```

```
## Anova Table (Type II tests)
##
## Response: yday(FFD)
##             Sum Sq  Df F value   Pr(>F)
## temp1          1.9   1  0.0244 0.875879
## plot        2816.4  14  2.5432 0.001943 **
## temp1:plot  2031.5  14  1.8344 0.033869 *
## Residuals  21357.5 270
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
model2_17 <- lm(yday(FFD) ~ temp1+plot,FFD_temp) #Common slope, different intercepts
Anova(model2_17) #Only plot significant
```

```
## Anova Table (Type II tests)
##
## Response: yday(FFD)
##            Sum Sq  Df F value   Pr(>F)
## temp1         1.9   1  0.0235 0.878330
## plot       2816.4  14  2.4427 0.002916 **
## Residuals 23389.0 284
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#Likelihood ratio test comparing the full and reduced models
anova(model_17,model2_17, test="Chisq")
```

```
## Analysis of Variance Table
##
## Model 1: yday(FFD) ~ temp1 * plot
## Model 2: yday(FFD) ~ temp1 + plot
##   Res.Df   RSS  Df Sum of Sq Pr(>Chi)
## 1    270 21358
## 2    284 23389 -14   -2031.5   0.0284 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
#Support for significant differences between slopes-->keep model_17

anova(lm(yday(FFD) ~ temp1+plot+temp1:plot,FFD_temp)) #Type I, one var after the other
```

```
## Analysis of Variance Table
##
## Response: yday(FFD)
##             Df  Sum Sq Mean Sq F value   Pr(>F)
## temp1        1   687.7  687.70  8.6938 0.003472 **
## plot        14  2816.4  201.17  2.5432 0.001943 **
## temp1:plot  14  2031.5  145.11  1.8344 0.033869 *
## Residuals  270 21357.5   79.10
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
anova(lm(yday(FFD) ~ plot+temp1+temp1:plot,FFD_temp)) #Different results!
```

```
## Analysis of Variance Table
##
## Response: yday(FFD)
##             Df  Sum Sq Mean Sq F value    Pr(>F)
## plot        14  3502.2 250.157  3.1625 0.0001285 ***
## temp1        1     1.9   1.934  0.0244 0.8758789
## plot:temp1  14  2031.5 145.108  1.8344 0.0338685 *
## Residuals  270 21357.5  79.102
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
model3_17<-lm(yday(FFD) ~ temp1, data = FFD_temp)
summary(model3_17) #Temp significant
```

```
##
## Call:
## lm(formula = yday(FFD) ~ temp1, data = FFD_temp)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -21.387  -4.685  -1.465   4.186  36.723
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 181.50461    1.11775 162.384   <2e-16 ***
## temp1        -0.18888    0.06754  -2.796   0.0055 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.378 on 298 degrees of freedom
##   (117 observations deleted due to missingness)
## Multiple R-squared:  0.02557,    Adjusted R-squared:  0.0223
## F-statistic:  7.82 on 1 and 298 DF,  p-value: 0.005502
```

```r
anova(model2_17,model3_17, test="Chisq")
```

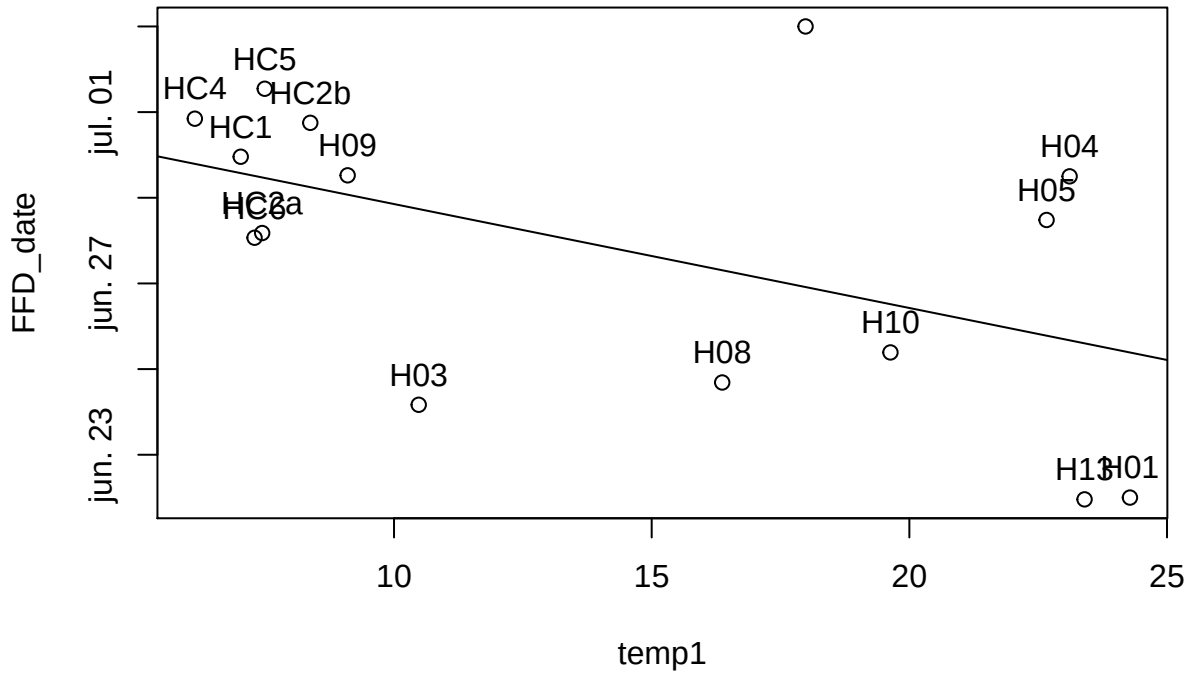
```
## Analysis of Variance Table
##
## Model 1: yday(FFD) ~ temp1 + plot
```

```
## Model 2: yday(FFD) ~ temp1
##   Res.Df   RSS  Df Sum of Sq Pr(>Chi)
## 1    284 23389
## 2    298 26205 -14   -2816.4 0.001929 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#Highly significant differences in intercepts between streams-->keep model2
```

Model for effects of plot mean temperatures on mean FFD

```
##    plot      FFD     temp1
## 1   H01 17339.00 24.280952
## 2   H02 17350.00 17.985714
## 3   H03 17341.17 10.479167
## 4   H04 17346.50 23.110000
## 5   H05 17345.48 22.662963
## 6   H08 17341.69 16.368750
## 7   H09 17346.52  9.100000
## 8   H10 17342.39 19.633333
## 9   H13 17338.96 23.400000
## 10  HC1 17346.96  7.025000
## 11 HC2a 17345.18  7.441176
## 12 HC2b 17347.75  8.375000
## 13  HC4 17347.85  6.134615
## 14  HC5 17348.55  7.490909
## 15  HC6 17345.07  7.293333
```



```r
with(FFD_temp_means,summary(lm(FFD~temp1)))
```

```
##
## Call:
## lm(formula = FFD ~ temp1)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.5704 -2.0319  0.3829  1.7927  6.0847
##
## Coefficients:
##               Estimate Std. Error  t value Pr(>|t|)
## (Intercept) 17348.2803     1.8133 9567.066   <2e-16 ***
## temp1          -0.2427     0.1158   -2.095   0.0563 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.096 on 13 degrees of freedom
## Multiple R-squared:  0.2524, Adjusted R-squared:  0.1949
## F-statistic:  4.39 on 1 and 13 DF,  p-value: 0.0563
```

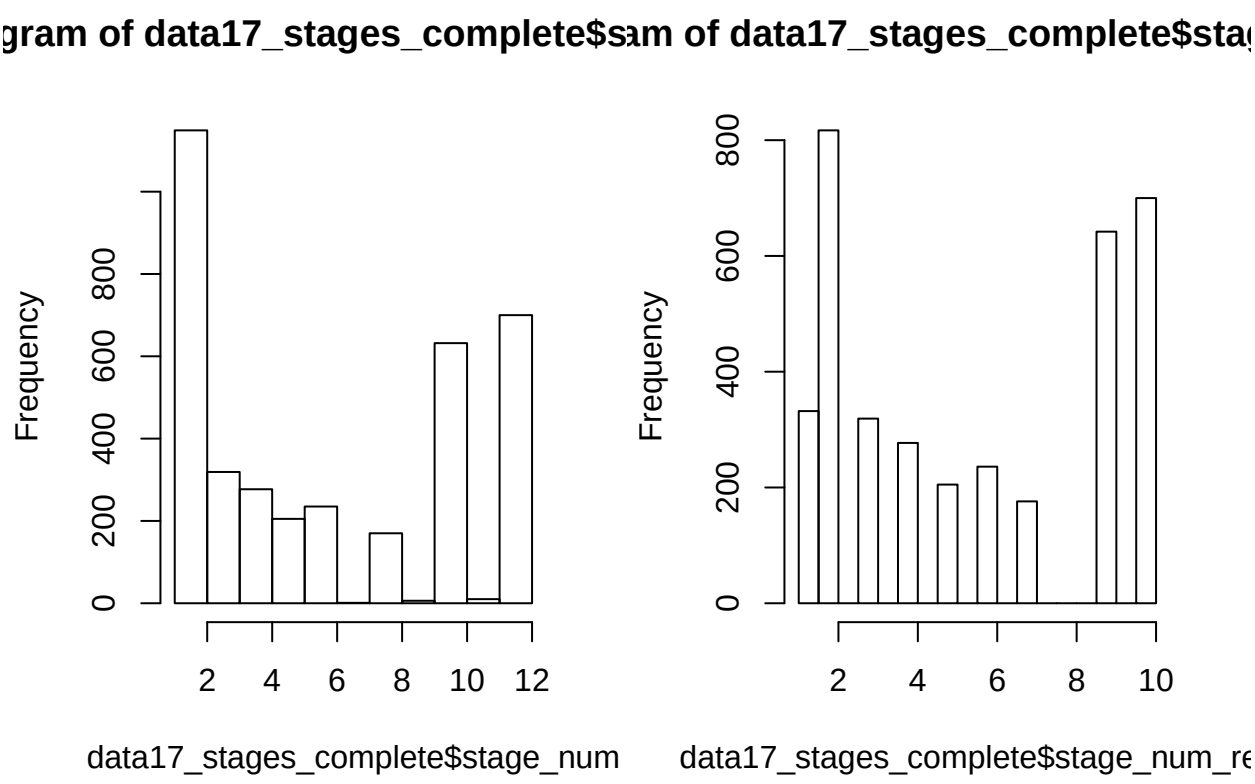
Flowering stages Recoding stages with few counts

```r
# B5-->B4
# FL100-->FL
# W50-->W

data17_stages_complete <- within(data17_stages_complete, {
  stage_corr_rec <- Recode(stage_corr, '"B5"="B4"; "FL100"="FL"; "W50"="W"', as.factor.result=TRUE)
}) #

data17_stages_complete <- within(data17_stages_complete, {
  stage_num_rec <- Recode(stage_corr_rec, '"VS"=1; "VL"=2; "B1"=3; "B2"=4; "B3"=5; "B4"=6; "FL"=7; "W"=
}) #Convert to numeric

par(mfrow=c(1,2))
hist(data17_stages_complete$stage_num)
hist(data17_stages_complete$stage_num_rec)
```




```
table(data17_stages_complete$stage_num_rec)
```

```
##
##   1   2   3   4   5   6   7   9  10
## 332 817 319 277 205 236 176 642 700
```

Some preliminary models

```
summary(lm(stage_num_rec~date*temp,data17_stages_complete))
```

```
##
## Call:
## lm(formula = stage_num_rec ~ date * temp, data = data17_stages_complete)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.3276 -0.9467 -0.0100  0.7914  3.9601
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -8.080e+02  2.713e+02  -2.979  0.00297 **
## date         4.678e-02  1.566e-02   2.987  0.00289 **
## temp        -3.305e+01  1.400e+01  -2.361  0.01842 *
## date:temp    1.911e-03  8.082e-04   2.364  0.01826 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.244 on 945 degrees of freedom
```

```
##   (2755 observations deleted due to missingness)
## Multiple R-squared:  0.1873, Adjusted R-squared:  0.1847
## F-statistic:  72.6 on 3 and 945 DF,  p-value: < 2.2e-16
```

```
summary(lm(stage_num_rec~date,data17_stages_complete))
```

```
##
## Call:
## lm(formula = stage_num_rec ~ date, data = data17_stages_complete)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.6739 -1.5532  0.6356  2.0154  4.7153
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.581e+03  3.694e+01  -42.80   <2e-16 ***
## date         9.144e-02  2.129e-03   42.95   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.748 on 3702 degrees of freedom
## Multiple R-squared:  0.3325, Adjusted R-squared:  0.3323
## F-statistic:  1844 on 1 and 3702 DF,  p-value: < 2.2e-16
```

```
summary(lm(stage_num_rec~temp,data17_stages_complete))
```

```
##
## Call:
## lm(formula = stage_num_rec ~ temp, data = data17_stages_complete)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.7148 -0.9718 -0.1850  0.9582  4.0465
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 2.374994   0.109705  21.649  < 2e-16 ***
## temp        0.030450   0.006082   5.007  6.6e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.361 on 947 degrees of freedom
##   (2755 observations deleted due to missingness)
## Multiple R-squared:  0.02579,    Adjusted R-squared:  0.02476
## F-statistic: 25.07 on 1 and 947 DF,  p-value: 6.602e-07
```