Assignment 7: GLMs week 2 (Linear Regression and beyond)

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OVERVIEW

This exercise accompanies the lessons in Environmental Data Analytics on generalized linear models.

Directions

Change "Student Name" on line 3 (above) with your name.
Work through the steps, **creating code and output** that fulfill each instruction.
Be sure to **answer the questions** in this assignment document.
When you have completed the assignment, **Knit** the text and code into a single PDF file.
After Knitting, submit the completed exercise (PDF file) to the dropbox in Sakai. Add your last name into the file name (e.g., "Salk_A06_GLMs_Week1.Rmd") prior to submission.

The completed exercise is due on Tuesday, February 25 at 1:00 pm.

Set up your session

Set up your session. Check your working directory, load the tidyverse, nlme, and piecewiseSEM packages, import the *raw* NTL-LTER raw data file for chemistry/physics, and import the processed litter dataset. You will not work with dates, so no need to format your date columns this time.
Build a ggplot theme and set it as your default theme.

```
#1
getwd()
## [1] "/Users/cristiana/Documents/Duke/DataAnalytics/Environmental_Data_Analytics_2020"
library(tidyverse)
## ── Attaching packages ──────────────────────────────────────── tidyverse 1.3.0 ──
## ✓ ggplot2 3.2.1     ✓ purrr   0.3.3
## ✓ tibble  2.1.3     ✓ dplyr   0.8.3
## ✓ tidyr   1.0.0     ✓ stringr 1.4.0
## ✓ readr   1.3.1     ✓ forcats 0.4.0
## ── Conflicts ─────────────────────────────────────── tidyverse_conflicts() ──
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
library(nlme)
##
## Attaching package: 'nlme'
## The following object is masked from 'package:dplyr':
##
##     collapse
library(piecewiseSEM)
## Registered S3 methods overwritten by 'lme4':
##   method                         from
##   cooks.distance.influence.merMod car
##   influence.merMod               car
##   dfbeta.influence.merMod        car
##   dfbetas.influence.merMod       car
##
##   This is piecewiseSEM version 2.1.0.
##
##
##   Questions or bugs can be addressed to <LefcheckJ@si.edu>.
# to visualize linear reg
require(ggiraph)
## Loading required package: ggiraph
require(ggiraphExtra)
## Loading required package: ggiraphExtra
require(plyr)
## Loading required package: plyr
```

```
## ------------------------------------------------------------------------------
## You have loaded plyr after dplyr - this is likely to cause problems.
## If you need functions from both plyr and dplyr, please load plyr first, then dplyr:
## library(plyr); library(dplyr)
## ------------------------------------------------------------------------------
##
## Attaching package: 'plyr'
## The following objects are masked from 'package:dplyr':
##
##     arrange, count, desc, failwith, id, mutate, rename, summarise,
##     summarize
## The following object is masked from 'package:purrr':
##
##     compact
# data
chem_phys <-
read.csv("/Users/cristiana/Documents/Duke/DataAnalytics/Environmental_Data_Analytics_2020/
Data/Raw/NTL-LTER_Lake_ChemistryPhysics_Raw.csv")
litter <-
read.csv("/Users/cristiana/Documents/Duke/DataAnalytics/Environmental_Data_Analytics_2020/
Data/Processed/NEON_NIWO_Litter_mass_trap_Processed.csv")

#2
mytheme <- theme_classic(base_size = 14) +
 theme(axis.text = element_text(color = "black"),
       legend.position = "top")
theme_set(mytheme)
```

NTL-LTER test

Research question: What is the best set of predictors for lake temperatures in July across the monitoring period at the North Temperate Lakes LTER?

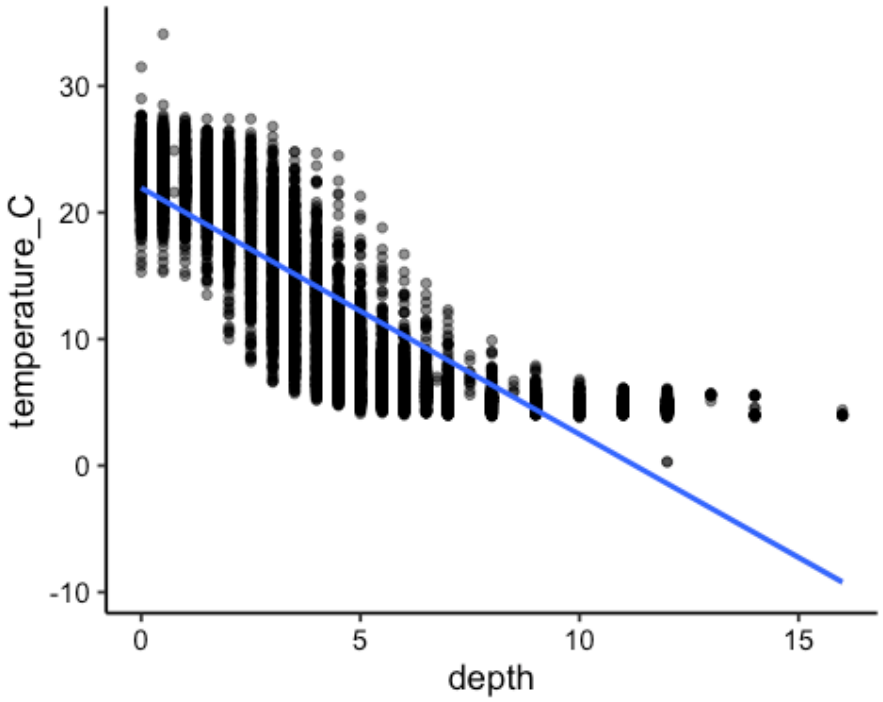
is this asking, what's the optimal combination of variables (aic..) to predict lake temps in july?

Wrangle your NTL-LTER dataset with a pipe function so that it contains only the following criteria:
Only dates in July (hint: use the daynum column). No need to consider leap years. (182-212)
Only the columns: lakename, year4, daynum, depth, temperature_C (select())
Only complete cases (i.e., remove NAs) (na.omit(data))
Run an AIC to determine what set of explanatory variables (year4, daynum, depth) is best suited to predict temperature. Run a multiple regression on the recommended set of variables. # run aic, this will give optimal combo of variables # with this optimal set of vars, run a 'multiple regression'

```
#3 get subset of data
chem_phys_subset <-
 chem_phys %>%
 filter(daynum >= 182 & daynum <= 212) %>%
 select(lakename, year4, daynum, depth, temperature_C) %>% # 10,836
 na.omit()

#4 run AIC to determine best combination of predictor variables
temp_AIC <- lm(data = chem_phys_subset, temperature_C ~ year4 + daynum + depth)
step(temp_AIC)
## Start:  AIC=26016.31
## temperature_C ~ year4 + daynum + depth
##
##          Df Sum of Sq    RSS   AIC
## <none>                 141118 26016
## - year4   1        80 141198 26020
## - daynum  1      1333 142450 26106
## - depth   1    403925 545042 39151
##
## Call:
## lm(formula = temperature_C ~ year4 + daynum + depth, data = chem_phys_subset)
##
## Coefficients:
## (Intercept)        year4       daynum        depth
##    -6.45556      0.01013      0.04134     -1.94726
temp_model <- lm(data = chem_phys_subset, temperature_C ~ year4 + daynum + depth)
summary(temp_model)
##
```

```
## Call:
## lm(formula = temperature_C ~ year4 + daynum + depth, data = chem_phys_subset)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.6517 -2.9937  0.0855  2.9692 13.6171
##
## Coefficients:
##              Estimate Std. Error  t value Pr(>|t|)
## (Intercept) -6.455560   8.638808   -0.747   0.4549
## year4        0.010131   0.004303    2.354   0.0186 *
## daynum       0.041336   0.004315    9.580   <2e-16 ***
## depth       -1.947264   0.011676 -166.782   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.811 on 9718 degrees of freedom
## Multiple R-squared:  0.7417, Adjusted R-squared:  0.7417
## F-statistic:  9303 on 3 and 9718 DF,  p-value: < 2.2e-16
# is this model the multiple regression?
# is there a way to visualize it?
 # can visualize individual relatinships (switch between year, daynum, depth - depth is only one
with noteable correlation)
linear_reg_rel <-
 ggplot(chem_phys_subset, aes(x = depth, y = temperature_C)) +
 geom_point(alpha = .5) +
 geom_smooth(method = lm)
print(linear_reg_rel)
```



What is the final set of explanatory variables that predict temperature from your multiple regression? How much of the observed variance does this model explain?

Answer: The final set of explanatory variables determined by our AIC analysis are year, day number and depth (the same variables we started with). The model explains 74.17% of variance.

Run an interaction effects ANCOVA to predict temperature based on depth and lakename from the same wrangled dataset.

```
#6
# want to see dif between main and interaction
# temp_ANCOVA_main <- lm(data = chem_phys_subset, temperature_C ~ depth + lakename)
temp_ANCOVA_interaction <- lm(data = chem_phys_subset, temperature_C ~ depth * lakename)

# summary(temp_ANCOVA_main) # 77.73% var explained
summary(temp_ANCOVA_interaction) # 78.57% var explained
##
## Call:
## lm(formula = temperature_C ~ depth * lakename, data = chem_phys_subset)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.6455 -2.9133 -0.2879  2.7567 16.3696
```

```
## -7.6455 -2.9153 -0.2879  2.7567 16.3606
##
## Coefficients:
##                                          Estimate Std. Error t value Pr(>|t|)
## (Intercept)                               22.9455     0.5861  39.147  < 2e-16 ***
## depth                                     -2.5820     0.2411 -10.711  < 2e-16 ***
## lakenameCrampton Lake                      2.2173     0.6804   3.259  0.00112 **
## lakenameEast Long Lake                    -4.3884     0.6191  -7.089 1.45e-12 ***
## lakenameHummingbird Lake                  -2.4126     0.8379  -2.879  0.00399 **
## lakenamePaul Lake                          0.6105     0.5983   1.020  0.30754
## lakenamePeter Lake                         0.2998     0.5970   0.502  0.61552
## lakenameTuesday Lake                      -2.8932     0.6060  -4.774 1.83e-06 ***
## lakenameWard Lake                          2.4180     0.8434   2.867  0.00415 **
## lakenameWest Long Lake                    -2.4663     0.6168  -3.999 6.42e-05 ***
## depth:lakenameCrampton Lake                0.8058     0.2465   3.268  0.00109 **
## depth:lakenameEast Long Lake               0.9465     0.2433   3.891  0.00010 ***
## depth:lakenameHummingbird Lake            -0.6026     0.2919  -2.064  0.03903 *
## depth:lakenamePaul Lake                    0.4022     0.2421   1.662  0.09664 .
## depth:lakenamePeter Lake                   0.5799     0.2418   2.398  0.01649 *
## depth:lakenameTuesday Lake                 0.6605     0.2426   2.723  0.00648 **
## depth:lakenameWard Lake                   -0.6930     0.2862  -2.421  0.01548 *
## depth:lakenameWest Long Lake               0.8154     0.2431   3.354  0.00080 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.471 on 9704 degrees of freedom
## Multiple R-squared:  0.7861, Adjusted R-squared:  0.7857
## F-statistic:  2097 on 17 and 9704 DF,  p-value: < 2.2e-16
```

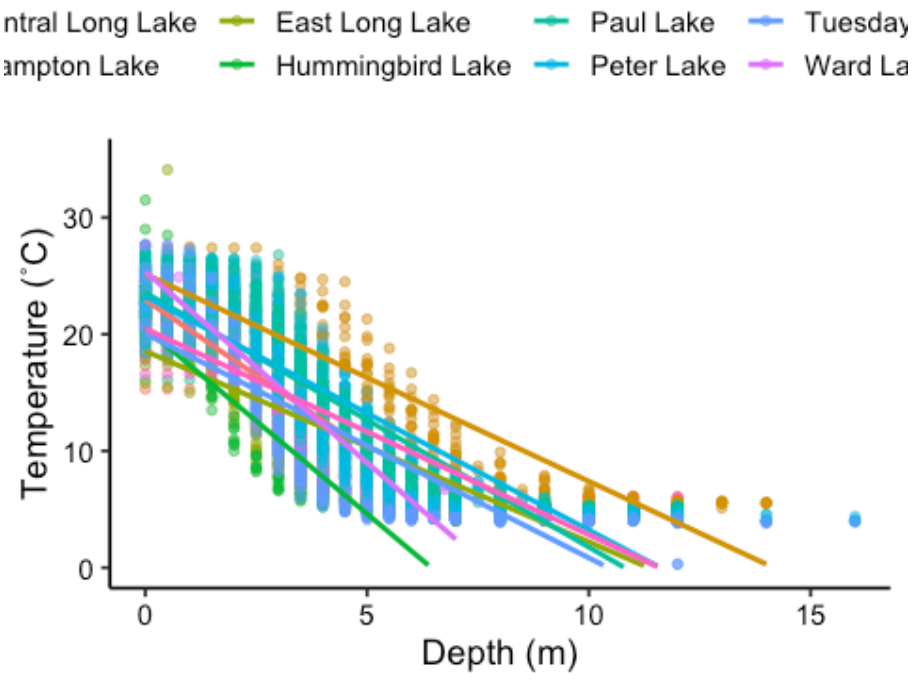
Is there a significant interaction between depth and lakename? How much variance in the temperature observations does this explain?

Answer: Our results show that there is a significant interaction between depth and lakename, meaning that depth varies significantly depending on which lake we're sampling. Our interaction effects model explains 78.57% of variance.

Create a graph that depicts temperature by depth, with a separate color for each lake. Add a geom_smooth (method = "lm", se = FALSE) for each lake. Make your points 50 % transparent. Adjust your y axis limits to go from 0 to 35 degrees. Clean up your graph to make it pretty.

```
#8
temp_depth <-
 ggplot(chem_phys_subset, aes(x = depth, y = temperature_C, color = lakename)) +
 geom_point(alpha = .5) +
 ylim(0, 35) +
 labs(x = "Depth (m)", y = "Temperature (°C)") +
 geom_smooth(method = 'lm', se = FALSE)

print(temp_depth)
## Warning: Removed 73 rows containing missing values (geom_smooth).
```



Run a mixed effects model to predict dry mass of litter. We already know that nlcdClass and functionalGroup have a significant interaction, so we will specify those two variables as fixed effects with an interaction. We also know that litter mass varies across plot ID, but we are less interested in the actual effect of the plot itself but rather in accounting for the variance among plots. Plot ID will be our random effect. # litter dataset - looking to predict drymass of litter # fixed effects = nlcdClass, functionalGroup (there is interaction between these) # random effects = plotID

Build and run a mixed effects model.

Check the difference between the marginal and conditional R2 of the model.

```
LitterDrymass_mixed <-
 lme(data = litter, dryMass ~ nlcdClass * functionalGroup, random = ~1|plotID)

summary(LitterDrymass_mixed) #
## Linear mixed-effects model fit by REML
##  Data: litter
##        AIC      BIC    logLik
##   9038.575 9179.479 -4493.287
##
## Random effects:
##  Formula: ~1 | plotID
##         (Intercept) Residual
## StdDev:   0.5899105 3.456817
##
## Fixed effects: dryMass ~ nlcdClass * functionalGroup
##                                                 Value Std.Error
## (Intercept)                                  0.155492 0.4863580
## nlcdClassgrasslandHerbaceous                -0.156004 0.7789816
## nlcdClassshrubScrub                         -0.107080 0.6636775
## functionalGroupLeaves                       -0.126008 0.5501061
## functionalGroupMixed                         1.477797 0.6323043
## functionalGroupNeedles                       7.284064 0.5313161
## functionalGroupOther                        -0.048525 0.5500878
## functionalGroupSeeds                        -0.058702 0.5501061
## functionalGroupTwigs/branches                1.929441 0.5385556
## functionalGroupWoody material                1.068772 0.5259330
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves  0.181416 0.8847246
## nlcdClassshrubScrub:functionalGroupLeaves    0.173857 0.7510320
## nlcdClassgrasslandHerbaceous:functionalGroupMixed  -0.467648 1.1201304
## nlcdClassshrubScrub:functionalGroupMixed     0.633876 0.9217911
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles -2.118299 0.8705440
## nlcdClassshrubScrub:functionalGroupNeedles  -2.909142 0.7347172
## nlcdClassgrasslandHerbaceous:functionalGroupOther  0.143603 0.8976715
## nlcdClassshrubScrub:functionalGroupOther     0.104935 0.7528434
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds  0.049290 0.8976827
## nlcdClassshrubScrub:functionalGroupSeeds     0.076708 0.7547591
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.986627 0.8850639
## nlcdClassshrubScrub:functionalGroupTwigs/branches  -1.503446 0.7409024
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material -1.017803 0.8802289
## nlcdClassshrubScrub:functionalGroupWoody material  -0.979078 0.7317033
##                                                   DF   t-value
## (Intercept)                                     1659  0.319706
## nlcdClassgrasslandHerbaceous                       9 -0.200266
## nlcdClassshrubScrub                                9 -0.161343
## functionalGroupLeaves                           1659 -0.229061
## functionalGroupMixed                            1659  2.337160
## functionalGroupNeedles                          1659 13.709474
## functionalGroupOther                            1659 -0.088213
## functionalGroupSeeds                            1659 -0.106711
## functionalGroupTwigs/branches                   1659  3.582622
## functionalGroupWoody material                   1659  2.032144
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves  1659  0.205053
## nlcdClassshrubScrub:functionalGroupLeaves       1659  0.231490
## nlcdClassgrasslandHerbaceous:functionalGroupMixed  1659 -0.417495
## nlcdClassshrubScrub:functionalGroupMixed        1659  0.687657
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles  1659 -2.433305
## nlcdClassshrubScrub:functionalGroupNeedles      1659 -3.959540
## nlcdClassgrasslandHerbaceous:functionalGroupOther  1659  0.159972
## nlcdClassshrubScrub:functionalGroupOther        1659  0.139385
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds  1659  0.054908
## nlcdClassshrubScrub:functionalGroupSeeds        1659  0.101632
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 1659 -1.114752
## nlcdClassshrubScrub:functionalGroupTwigs/branches  1659 -2.029209
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 1659 -1.156293
## nlcdClassshrubScrub:functionalGroupWoody material  1659 -1.338081
##                                                   p-value
```

```
## (Intercept)                                                    0.7492
## nlcdClassgrasslandHerbaceous                                   0.8457
## nlcdClassshrubScrub                                            0.8754
## functionalGroupLeaves                                          0.8188
## functionalGroupMixed                                           0.0195
## functionalGroupNeedles                                         0.0000
## functionalGroupOther                                           0.9297
## functionalGroupSeeds                                           0.9150
## functionalGroupTwigs/branches                                  0.0003
## functionalGroupWoody material                                  0.0423
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves             0.8376
## nlcdClassshrubScrub:functionalGroupLeaves                      0.8170
## nlcdClassgrasslandHerbaceous:functionalGroupMixed              0.6764
## nlcdClassshrubScrub:functionalGroupMixed                       0.4918
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles            0.0151
## nlcdClassshrubScrub:functionalGroupNeedles                     0.0001
## nlcdClassgrasslandHerbaceous:functionalGroupOther              0.8729
## nlcdClassshrubScrub:functionalGroupOther                       0.8892
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds              0.9562
## nlcdClassshrubScrub:functionalGroupSeeds                       0.9191
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches     0.2651
## nlcdClassshrubScrub:functionalGroupTwigs/branches              0.0426
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material     0.2477
## nlcdClassshrubScrub:functionalGroupWoody material              0.1811
##  Correlation:
##                                                               (Intr) nlcdCH nlcdCS
## nlcdClassgrasslandHerbaceous                                  -0.624
## nlcdClassshrubScrub                                           -0.733  0.458
## functionalGroupLeaves                                         -0.559  0.349  0.409
## functionalGroupMixed                                          -0.485  0.303  0.356
## functionalGroupNeedles                                        -0.579  0.361  0.424
## functionalGroupOther                                          -0.559  0.349  0.409
## functionalGroupSeeds                                          -0.559  0.349  0.409
## functionalGroupTwigs/branches                                 -0.571  0.356  0.418
## functionalGroupWoody material                                 -0.584  0.365  0.428
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves             0.347 -0.586 -0.255
## nlcdClassshrubScrub:functionalGroupLeaves                      0.409 -0.255 -0.569
## nlcdClassgrasslandHerbaceous:functionalGroupMixed              0.274 -0.462 -0.201
## nlcdClassshrubScrub:functionalGroupMixed                       0.333 -0.208 -0.464
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles            0.353 -0.595 -0.259
## nlcdClassshrubScrub:functionalGroupNeedles                     0.418 -0.261 -0.582
## nlcdClassgrasslandHerbaceous:functionalGroupOther              0.342 -0.577 -0.251
## nlcdClassshrubScrub:functionalGroupOther                       0.408 -0.255 -0.568
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds              0.342 -0.577 -0.251
## nlcdClassshrubScrub:functionalGroupSeeds                       0.407 -0.254 -0.566
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches     0.347 -0.586 -0.254
## nlcdClassshrubScrub:functionalGroupTwigs/branches              0.415 -0.259 -0.577
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material     0.349 -0.589 -0.256
## nlcdClassshrubScrub:functionalGroupWoody material              0.420 -0.262 -0.584
##                                                               fnctGL fnctGM fnctGN
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub
## functionalGroupLeaves
## functionalGroupMixed                                           0.429
## functionalGroupNeedles                                         0.511  0.445
## functionalGroupOther                                           0.494  0.430  0.511
## functionalGroupSeeds                                           0.494  0.429  0.511
## functionalGroupTwigs/branches                                  0.504  0.439  0.522
## functionalGroupWoody material                                  0.516  0.449  0.535
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves            -0.622 -0.267 -0.318
## nlcdClassshrubScrub:functionalGroupLeaves                     -0.732 -0.314 -0.374
## nlcdClassgrasslandHerbaceous:functionalGroupMixed             -0.242 -0.564 -0.251
## nlcdClassshrubScrub:functionalGroupMixed                      -0.295 -0.686 -0.305
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles           -0.312 -0.272 -0.610
## nlcdClassshrubScrub:functionalGroupNeedles                    -0.370 -0.322 -0.723
## nlcdClassgrasslandHerbaceous:functionalGroupOther             -0.303 -0.263 -0.313
## nlcdClassshrubScrub:functionalGroupOther                      -0.361 -0.314 -0.374
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds             -0.303 -0.263 -0.313
## nlcdClassshrubScrub:functionalGroupSeeds                      -0.360 -0.313 -0.373
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches    -0.307 -0.267 -0.318
## nlcdClassshrubScrub:functionalGroupTwigs/branches             -0.367 -0.319 -0.380
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material    -0.309 -0.268 -0.320
## nlcdClassshrubScrub:functionalGroupWoody material             -0.371 -0.322 -0.384
##                                                               fnctGO fnctGS fncGT/
## nlcdClassgrasslandHerbaceous
```

nlcdClassshrubScrub
functionalGroupLeaves
functionalGroupMixed
functionalGroupNeedles
functionalGroupOther
functionalGroupSeeds 0.494
functionalGroupTwigs/branches 0.504 0.504
functionalGroupWoody material 0.516 0.517 0.528
nlcdClassgrasslandHerbaceous:functionalGroupLeaves -0.307 -0.307 -0.314
nlcdClassshrubScrub:functionalGroupLeaves -0.362 -0.362 -0.369
nlcdClassgrasslandHerbaceous:functionalGroupMixed -0.243 -0.242 -0.248
nlcdClassshrubScrub:functionalGroupMixed -0.295 -0.294 -0.301
nlcdClassgrasslandHerbaceous:functionalGroupNeedles -0.312 -0.312 -0.319
nlcdClassshrubScrub:functionalGroupNeedles -0.370 -0.370 -0.378
nlcdClassgrasslandHerbaceous:functionalGroupOther -0.613 -0.303 -0.309
nlcdClassshrubScrub:functionalGroupOther -0.731 -0.361 -0.369
nlcdClassgrasslandHerbaceous:functionalGroupSeeds -0.303 -0.613 -0.309
nlcdClassshrubScrub:functionalGroupSeeds -0.360 -0.729 -0.368
nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.307 -0.307 -0.608
nlcdClassshrubScrub:functionalGroupTwigs/branches -0.367 -0.367 -0.727
nlcdClassgrasslandHerbaceous:functionalGroupWoody material -0.309 -0.309 -0.315
nlcdClassshrubScrub:functionalGroupWoody material -0.371 -0.371 -0.379
fncGWm nCH:GL nCS:GL
nlcdClassgrasslandHerbaceous
nlcdClassshrubScrub
functionalGroupLeaves
functionalGroupMixed
functionalGroupNeedles
functionalGroupOther
functionalGroupSeeds
functionalGroupTwigs/branches
functionalGroupWoody material
nlcdClassgrasslandHerbaceous:functionalGroupLeaves -0.321
nlcdClassshrubScrub:functionalGroupLeaves -0.378 0.455
nlcdClassgrasslandHerbaceous:functionalGroupMixed -0.253 0.406 0.178
nlcdClassshrubScrub:functionalGroupMixed -0.308 0.183 0.410
nlcdClassgrasslandHerbaceous:functionalGroupNeedles -0.326 0.524 0.229
nlcdClassshrubScrub:functionalGroupNeedles -0.387 0.230 0.514
nlcdClassgrasslandHerbaceous:functionalGroupOther -0.316 0.508 0.222
nlcdClassshrubScrub:functionalGroupOther -0.377 0.224 0.502
nlcdClassgrasslandHerbaceous:functionalGroupSeeds -0.317 0.508 0.222
nlcdClassshrubScrub:functionalGroupSeeds -0.376 0.224 0.500
nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.321 0.515 0.225
nlcdClassshrubScrub:functionalGroupTwigs/branches -0.384 0.228 0.510
nlcdClassgrasslandHerbaceous:functionalGroupWoody material -0.597 0.518 0.226
nlcdClassshrubScrub:functionalGroupWoody material -0.719 0.231 0.516
nCH:GM nCS:GM nCH:GN
nlcdClassgrasslandHerbaceous
nlcdClassshrubScrub
functionalGroupLeaves
functionalGroupMixed
functionalGroupNeedles
functionalGroupOther
functionalGroupSeeds
functionalGroupTwigs/branches
functionalGroupWoody material
nlcdClassgrasslandHerbaceous:functionalGroupLeaves
nlcdClassshrubScrub:functionalGroupLeaves
nlcdClassgrasslandHerbaceous:functionalGroupMixed
nlcdClassshrubScrub:functionalGroupMixed 0.387
nlcdClassgrasslandHerbaceous:functionalGroupNeedles 0.414 0.186
nlcdClassshrubScrub:functionalGroupNeedles 0.182 0.419 0.441
nlcdClassgrasslandHerbaceous:functionalGroupOther 0.401 0.181 0.517
nlcdClassshrubScrub:functionalGroupOther 0.177 0.409 0.228
nlcdClassgrasslandHerbaceous:functionalGroupSeeds 0.402 0.180 0.517
nlcdClassshrubScrub:functionalGroupSeeds 0.177 0.408 0.227
nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 0.407 0.183 0.524
nlcdClassshrubScrub:functionalGroupTwigs/branches 0.180 0.416 0.232
nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.409 0.184 0.527
nlcdClassshrubScrub:functionalGroupWoody material 0.182 0.420 0.235
nCS:GN nCH:GO nCS:GO
nlcdClassgrasslandHerbaceous
nlcdClassshrubScrub
functionalGroupLeaves
functionalGroupMixed
functionalGroupNeedles

functionalGroupNeedles
functionalGroupOther
functionalGroupSeeds
functionalGroupTwigs/branches
functionalGroupWoody material
nlcdClassgrasslandHerbaceous:functionalGroupLeaves
nlcdClassshrubScrub:functionalGroupLeaves
nlcdClassgrasslandHerbaceous:functionalGroupMixed
nlcdClassshrubScrub:functionalGroupMixed
nlcdClassgrasslandHerbaceous:functionalGroupNeedles
nlcdClassshrubScrub:functionalGroupNeedles
nlcdClassgrasslandHerbaceous:functionalGroupOther 0.227
nlcdClassshrubScrub:functionalGroupOther 0.513 0.448
nlcdClassgrasslandHerbaceous:functionalGroupSeeds 0.227 0.501 0.221
nlcdClassshrubScrub:functionalGroupSeeds 0.512 0.221 0.499
nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 0.230 0.508 0.224
nlcdClassshrubScrub:functionalGroupTwigs/branches 0.521 0.225 0.509
nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.231 0.511 0.225
nlcdClassshrubScrub:functionalGroupWoody material 0.528 0.227 0.515
nCH:GS nCS:GS nCH:GT
nlcdClassgrasslandHerbaceous
nlcdClassshrubScrub
functionalGroupLeaves
functionalGroupMixed
functionalGroupNeedles
functionalGroupOther
functionalGroupSeeds
functionalGroupTwigs/branches
functionalGroupWoody material
nlcdClassgrasslandHerbaceous:functionalGroupLeaves
nlcdClassshrubScrub:functionalGroupLeaves
nlcdClassgrasslandHerbaceous:functionalGroupMixed
nlcdClassshrubScrub:functionalGroupMixed
nlcdClassgrasslandHerbaceous:functionalGroupNeedles
nlcdClassshrubScrub:functionalGroupNeedles
nlcdClassgrasslandHerbaceous:functionalGroupOther
nlcdClassshrubScrub:functionalGroupOther
nlcdClassgrasslandHerbaceous:functionalGroupSeeds
nlcdClassshrubScrub:functionalGroupSeeds 0.447
nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 0.508 0.224
nlcdClassshrubScrub:functionalGroupTwigs/branches 0.225 0.507 0.442
nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.511 0.225 0.518
nlcdClassshrubScrub:functionalGroupWoody material 0.228 0.514 0.231
nCS:GT nCH:Gm
nlcdClassgrasslandHerbaceous
nlcdClassshrubScrub
functionalGroupLeaves
functionalGroupMixed
functionalGroupNeedles
functionalGroupOther
functionalGroupSeeds
functionalGroupTwigs/branches
functionalGroupWoody material
nlcdClassgrasslandHerbaceous:functionalGroupLeaves
nlcdClassshrubScrub:functionalGroupLeaves
nlcdClassgrasslandHerbaceous:functionalGroupMixed
nlcdClassshrubScrub:functionalGroupMixed
nlcdClassgrasslandHerbaceous:functionalGroupNeedles
nlcdClassshrubScrub:functionalGroupNeedles
nlcdClassgrasslandHerbaceous:functionalGroupOther
nlcdClassshrubScrub:functionalGroupOther
nlcdClassgrasslandHerbaceous:functionalGroupSeeds
nlcdClassshrubScrub:functionalGroupSeeds
nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches
nlcdClassshrubScrub:functionalGroupTwigs/branches
nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.229
nlcdClassshrubScrub:functionalGroupWoody material 0.523 0.429
##
Standardized Within-Group Residuals:
Min Q1 Med Q3 Max
-1.96496855 -0.23842984 -0.01535880 0.09027291 14.27434811
##
Number of Observations: 1692
Number of Groups: 12
```
rsq <- rsquared(LitterDrymass_mixed)
rsq
```

```
##   Response   family     link method  Marginal Conditional
## 1  dryMass gaussian identity   none 0.2465822   0.2679023
R2_diff <- as.numeric(rsq$Marginal - rsq$Conditional)
R2_diff
## [1] -0.02132006
```

continued… How much more variance is explained by adding the random effect to the model?

Answer: ~2.13 %

Run the same model without the random effect.
Run an anova on the two tests.

```
LitterDrymass_fixed <-
 lm(data = litter, dryMass ~ nlcdClass * functionalGroup)
# we were told that the two variables have interaction, thus we multiply


summary(LitterDrymass_fixed)
##
## Call:
## lm(formula = dryMass ~ nlcdClass * functionalGroup, data = litter)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -6.612 -0.480 -0.058 -0.005 49.051
##
## Coefficients:
##                                                  Estimate Std. Error
## (Intercept)                                       0.11963    0.39070
## nlcdClassgrasslandHerbaceous                     -0.11420    0.64223
## nlcdClassshrubScrub                              -0.10412    0.53838
## functionalGroupLeaves                            -0.10360    0.55606
## functionalGroupMixed                              1.50475    0.63800
## functionalGroupNeedles                            7.31226    0.53696
## functionalGroupOther                             -0.03482    0.55606
## functionalGroupSeeds                             -0.04616    0.55606
## functionalGroupTwigs/branches                     1.95967    0.54434
## functionalGroupWoody material                     1.08431    0.53156
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves  0.12865    0.89410
## nlcdClassshrubScrub:functionalGroupLeaves         0.14703    0.75915
## nlcdClassgrasslandHerbaceous:functionalGroupMixed  -0.38118    1.13024
## nlcdClassshrubScrub:functionalGroupMixed          0.74593    0.93038
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles  -2.13880    0.87993
## nlcdClassshrubScrub:functionalGroupNeedles        -2.92148    0.74258
## nlcdClassgrasslandHerbaceous:functionalGroupOther  0.12606    0.90743
## nlcdClassshrubScrub:functionalGroupOther          0.08589    0.76101
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds  0.04615    0.90743
## nlcdClassshrubScrub:functionalGroupSeeds          0.05944    0.76295
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -1.01519    0.89462
## nlcdClassshrubScrub:functionalGroupTwigs/branches  -1.49559    0.74881
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material -1.04086    0.88971
## nlcdClassshrubScrub:functionalGroupWoody material  -0.97185    0.73957
##                                                  t value Pr(>|t|)
## (Intercept)                                        0.306 0.759502
## nlcdClassgrasslandHerbaceous                      -0.178 0.858888
## nlcdClassshrubScrub                               -0.193 0.846673
## functionalGroupLeaves                             -0.186 0.852224
## functionalGroupMixed                               2.359 0.018462 *
## functionalGroupNeedles                            13.618  < 2e-16 ***
## functionalGroupOther                              -0.063 0.950081
## functionalGroupSeeds                              -0.083 0.933846
## functionalGroupTwigs/branches                      3.600 0.000327 ***
## functionalGroupWoody material                      2.040 0.041519 *
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves  0.144 0.885611
## nlcdClassshrubScrub:functionalGroupLeaves          0.194 0.846453
## nlcdClassgrasslandHerbaceous:functionalGroupMixed  -0.337 0.735969
## nlcdClassshrubScrub:functionalGroupMixed           0.802 0.422814
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles  -2.431 0.015177 *
## nlcdClassshrubScrub:functionalGroupNeedles         -3.934 8.69e-05 ***
## nlcdClassgrasslandHerbaceous:functionalGroupOther  0.139 0.889531
## nlcdClassshrubScrub:functionalGroupOther           0.113 0.910155
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds  0.051 0.959441
## nlcdClassshrubScrub:functionalGroupSeeds           0.078 0.937915
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches  -1.135 0.256634
## nlcdClassshrubScrub:functionalGroupTwigs/branches  -1.997 0.045956 *
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material  -1.170 0.242213
```

```
## nlcdClassshrubScrub:functionalGroupWoody material          -1.314 0.189001
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.494 on 1668 degrees of freedom
## Multiple R-squared:  0.2516, Adjusted R-squared:  0.2413
## F-statistic: 24.38 on 23 and 1668 DF,  p-value: < 2.2e-16
summary(LitterDrymass_mixed)
## Linear mixed-effects model fit by REML
##  Data: litter
##        AIC      BIC    logLik
##   9038.575 9179.479 -4493.287
##
## Random effects:
##  Formula: ~1 | plotID
##         (Intercept) Residual
## StdDev:   0.5899105 3.456817
##
## Fixed effects: dryMass ~ nlcdClass * functionalGroup
##                                                        Value Std.Error
## (Intercept)                                         0.155492 0.4863580
## nlcdClassgrasslandHerbaceous                       -0.156004 0.7789816
## nlcdClassshrubScrub                                -0.107080 0.6636775
## functionalGroupLeaves                              -0.126008 0.5501061
## functionalGroupMixed                                1.477797 0.6323043
## functionalGroupNeedles                              7.284064 0.5313161
## functionalGroupOther                               -0.048525 0.5500878
## functionalGroupSeeds                               -0.058702 0.5501061
## functionalGroupTwigs/branches                       1.929441 0.5385556
## functionalGroupWoody material                       1.068772 0.5259330
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves  0.181416 0.8847246
## nlcdClassshrubScrub:functionalGroupLeaves           0.173857 0.7510320
## nlcdClassgrasslandHerbaceous:functionalGroupMixed  -0.467648 1.1201304
## nlcdClassshrubScrub:functionalGroupMixed            0.633876 0.9217911
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles -2.118299 0.8705440
## nlcdClassshrubScrub:functionalGroupNeedles          -2.909142 0.7347172
## nlcdClassgrasslandHerbaceous:functionalGroupOther   0.143603 0.8976715
## nlcdClassshrubScrub:functionalGroupOther            0.104935 0.7528434
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds   0.049290 0.8976827
## nlcdClassshrubScrub:functionalGroupSeeds            0.076708 0.7547591
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.986627 0.8850639
## nlcdClassshrubScrub:functionalGroupTwigs/branches   -1.503446 0.7409024
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material -1.017803 0.8802289
## nlcdClassshrubScrub:functionalGroupWoody material   -0.979078 0.7317033
##                                                       DF   t-value
## (Intercept)                                         1659  0.319706
## nlcdClassgrasslandHerbaceous                           9 -0.200266
## nlcdClassshrubScrub                                    9 -0.161343
## functionalGroupLeaves                               1659 -0.229061
## functionalGroupMixed                                1659  2.337160
## functionalGroupNeedles                              1659 13.709474
## functionalGroupOther                                1659 -0.088213
## functionalGroupSeeds                                1659 -0.106711
## functionalGroupTwigs/branches                       1659  3.582622
## functionalGroupWoody material                       1659  2.032144
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves  1659  0.205053
## nlcdClassshrubScrub:functionalGroupLeaves           1659  0.231490
## nlcdClassgrasslandHerbaceous:functionalGroupMixed   1659 -0.417495
## nlcdClassshrubScrub:functionalGroupMixed            1659  0.687657
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles 1659 -2.433305
## nlcdClassshrubScrub:functionalGroupNeedles          1659 -3.959540
## nlcdClassgrasslandHerbaceous:functionalGroupOther   1659  0.159972
## nlcdClassshrubScrub:functionalGroupOther            1659  0.139385
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds   1659  0.054908
## nlcdClassshrubScrub:functionalGroupSeeds            1659  0.101632
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 1659 -1.114752
## nlcdClassshrubScrub:functionalGroupTwigs/branches   1659 -2.029209
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 1659 -1.156293
## nlcdClassshrubScrub:functionalGroupWoody material   1659 -1.338081
##                                                       p-value
## (Intercept)                                            0.7492
## nlcdClassgrasslandHerbaceous                           0.8457
## nlcdClassshrubScrub                                    0.8754
## functionalGroupLeaves                                  0.8188
## functionalGroupMixed                                   0.0195
```

```
## functionalGroupNeedles                                0.0000
## functionalGroupOther                                  0.9297
## functionalGroupSeeds                                  0.9150
## functionalGroupTwigs/branches                         0.0003
## functionalGroupWoody material                         0.0423
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves    0.8376
## nlcdClassshrubScrub:functionalGroupLeaves             0.8170
## nlcdClassgrasslandHerbaceous:functionalGroupMixed     0.6764
## nlcdClassshrubScrub:functionalGroupMixed              0.4918
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles   0.0151
## nlcdClassshrubScrub:functionalGroupNeedles            0.0001
## nlcdClassgrasslandHerbaceous:functionalGroupOther     0.8729
## nlcdClassshrubScrub:functionalGroupOther              0.8892
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds     0.9562
## nlcdClassshrubScrub:functionalGroupSeeds              0.9191
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches  0.2651
## nlcdClassshrubScrub:functionalGroupTwigs/branches     0.0426
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material  0.2477
## nlcdClassshrubScrub:functionalGroupWoody material     0.1811
##  Correlation:
##                                                       (Intr) nlcdCH nlcdCS
## nlcdClassgrasslandHerbaceous                          -0.624
## nlcdClassshrubScrub                                   -0.733  0.458
## functionalGroupLeaves                                 -0.559  0.349  0.409
## functionalGroupMixed                                  -0.485  0.303  0.356
## functionalGroupNeedles                                -0.579  0.361  0.424
## functionalGroupOther                                  -0.559  0.349  0.409
## functionalGroupSeeds                                  -0.559  0.349  0.409
## functionalGroupTwigs/branches                         -0.571  0.356  0.418
## functionalGroupWoody material                         -0.584  0.365  0.428
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves     0.347 -0.586 -0.255
## nlcdClassshrubScrub:functionalGroupLeaves              0.409 -0.255 -0.569
## nlcdClassgrasslandHerbaceous:functionalGroupMixed      0.274 -0.462 -0.201
## nlcdClassshrubScrub:functionalGroupMixed               0.333 -0.208 -0.464
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles    0.353 -0.595 -0.259
## nlcdClassshrubScrub:functionalGroupNeedles             0.418 -0.261 -0.582
## nlcdClassgrasslandHerbaceous:functionalGroupOther      0.342 -0.577 -0.251
## nlcdClassshrubScrub:functionalGroupOther               0.408 -0.255 -0.568
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds      0.342 -0.577 -0.251
## nlcdClassshrubScrub:functionalGroupSeeds               0.407 -0.254 -0.566
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches  0.347 -0.586 -0.254
## nlcdClassshrubScrub:functionalGroupTwigs/branches      0.415 -0.259 -0.577
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material  0.349 -0.589 -0.256
## nlcdClassshrubScrub:functionalGroupWoody material      0.420 -0.262 -0.584
##                                                       fnctGL fnctGM fnctGN
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub
## functionalGroupLeaves
## functionalGroupMixed                                   0.429
## functionalGroupNeedles                                 0.511  0.445
## functionalGroupOther                                   0.494  0.430  0.511
## functionalGroupSeeds                                   0.494  0.429  0.511
## functionalGroupTwigs/branches                          0.504  0.439  0.522
## functionalGroupWoody material                          0.516  0.449  0.535
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves    -0.622 -0.267 -0.318
## nlcdClassshrubScrub:functionalGroupLeaves             -0.732 -0.314 -0.374
## nlcdClassgrasslandHerbaceous:functionalGroupMixed     -0.242 -0.564 -0.251
## nlcdClassshrubScrub:functionalGroupMixed              -0.295 -0.686 -0.305
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles   -0.312 -0.272 -0.610
## nlcdClassshrubScrub:functionalGroupNeedles            -0.370 -0.322 -0.723
## nlcdClassgrasslandHerbaceous:functionalGroupOther     -0.303 -0.263 -0.313
## nlcdClassshrubScrub:functionalGroupOther              -0.361 -0.314 -0.374
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds     -0.303 -0.263 -0.313
## nlcdClassshrubScrub:functionalGroupSeeds              -0.360 -0.313 -0.373
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.307 -0.267 -0.318
## nlcdClassshrubScrub:functionalGroupTwigs/branches     -0.367 -0.319 -0.380
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material -0.309 -0.268 -0.320
## nlcdClassshrubScrub:functionalGroupWoody material     -0.371 -0.322 -0.384
##                                                       fnctGO fnctGS fncGT/
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub
## functionalGroupLeaves
## functionalGroupMixed
## functionalGroupNeedles
## functionalGroupOther
## functionalGroupSeeds                                   0.494
```

functionalGroupSeeds 0.494
functionalGroupTwigs/branches 0.504 0.504
functionalGroupWoody material 0.516 0.517 0.528
nlcdClassgrasslandHerbaceous:functionalGroupLeaves -0.307 -0.307 -0.314
nlcdClassshrubScrub:functionalGroupLeaves -0.362 -0.362 -0.369
nlcdClassgrasslandHerbaceous:functionalGroupMixed -0.243 -0.242 -0.248
nlcdClassshrubScrub:functionalGroupMixed -0.295 -0.294 -0.301
nlcdClassgrasslandHerbaceous:functionalGroupNeedles -0.312 -0.312 -0.319
nlcdClassshrubScrub:functionalGroupNeedles -0.370 -0.370 -0.378
nlcdClassgrasslandHerbaceous:functionalGroupOther -0.613 -0.303 -0.309
nlcdClassshrubScrub:functionalGroupOther -0.731 -0.361 -0.369
nlcdClassgrasslandHerbaceous:functionalGroupSeeds -0.303 -0.613 -0.309
nlcdClassshrubScrub:functionalGroupSeeds -0.360 -0.729 -0.368
nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.307 -0.307 -0.608
nlcdClassshrubScrub:functionalGroupTwigs/branches -0.367 -0.367 -0.727
nlcdClassgrasslandHerbaceous:functionalGroupWoody material -0.309 -0.309 -0.315
nlcdClassshrubScrub:functionalGroupWoody material -0.371 -0.371 -0.379
fncGWm nCH:GL nCS:GL
nlcdClassgrasslandHerbaceous
nlcdClassshrubScrub
functionalGroupLeaves
functionalGroupMixed
functionalGroupNeedles
functionalGroupOther
functionalGroupSeeds
functionalGroupTwigs/branches
functionalGroupWoody material
nlcdClassgrasslandHerbaceous:functionalGroupLeaves -0.321
nlcdClassshrubScrub:functionalGroupLeaves -0.378 0.455
nlcdClassgrasslandHerbaceous:functionalGroupMixed -0.253 0.406 0.178
nlcdClassshrubScrub:functionalGroupMixed -0.308 0.183 0.410
nlcdClassgrasslandHerbaceous:functionalGroupNeedles -0.326 0.524 0.229
nlcdClassshrubScrub:functionalGroupNeedles -0.387 0.230 0.514
nlcdClassgrasslandHerbaceous:functionalGroupOther -0.316 0.508 0.222
nlcdClassshrubScrub:functionalGroupOther -0.377 0.224 0.502
nlcdClassgrasslandHerbaceous:functionalGroupSeeds -0.317 0.508 0.222
nlcdClassshrubScrub:functionalGroupSeeds -0.376 0.224 0.500
nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.321 0.515 0.225
nlcdClassshrubScrub:functionalGroupTwigs/branches -0.384 0.228 0.510
nlcdClassgrasslandHerbaceous:functionalGroupWoody material -0.597 0.518 0.226
nlcdClassshrubScrub:functionalGroupWoody material -0.719 0.231 0.516
nCH:GM nCS:GM nCH:GN
nlcdClassgrasslandHerbaceous
nlcdClassshrubScrub
functionalGroupLeaves
functionalGroupMixed
functionalGroupNeedles
functionalGroupOther
functionalGroupSeeds
functionalGroupTwigs/branches
functionalGroupWoody material
nlcdClassgrasslandHerbaceous:functionalGroupLeaves
nlcdClassshrubScrub:functionalGroupLeaves
nlcdClassgrasslandHerbaceous:functionalGroupMixed
nlcdClassshrubScrub:functionalGroupMixed 0.387
nlcdClassgrasslandHerbaceous:functionalGroupNeedles 0.414 0.186
nlcdClassshrubScrub:functionalGroupNeedles 0.182 0.419 0.441
nlcdClassgrasslandHerbaceous:functionalGroupOther 0.401 0.181 0.517
nlcdClassshrubScrub:functionalGroupOther 0.177 0.409 0.228
nlcdClassgrasslandHerbaceous:functionalGroupSeeds 0.402 0.180 0.517
nlcdClassshrubScrub:functionalGroupSeeds 0.177 0.408 0.227
nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 0.407 0.183 0.524
nlcdClassshrubScrub:functionalGroupTwigs/branches 0.180 0.416 0.232
nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.409 0.184 0.527
nlcdClassshrubScrub:functionalGroupWoody material 0.182 0.420 0.235
nCS:GN nCH:GO nCS:GO
nlcdClassgrasslandHerbaceous
nlcdClassshrubScrub
functionalGroupLeaves
functionalGroupMixed
functionalGroupNeedles
functionalGroupOther
functionalGroupSeeds
functionalGroupTwigs/branches
functionalGroupWoody material
nlcdClassgrasslandHerbaceous:functionalGroupLeaves

```
## nlcdClassshrubScrub:functionalGroupLeaves
## nlcdClassgrasslandHerbaceous:functionalGroupMixed
## nlcdClassshrubScrub:functionalGroupMixed
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles
## nlcdClassshrubScrub:functionalGroupNeedles
## nlcdClassgrasslandHerbaceous:functionalGroupOther          0.227
## nlcdClassshrubScrub:functionalGroupOther                  0.513  0.448
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds         0.227  0.501  0.221
## nlcdClassshrubScrub:functionalGroupSeeds                  0.512  0.221  0.499
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches  0.230  0.508  0.224
## nlcdClassshrubScrub:functionalGroupTwigs/branches         0.521  0.225  0.509
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material  0.231  0.511  0.225
## nlcdClassshrubScrub:functionalGroupWoody material         0.528  0.227  0.515
##                                                       nCH:GS nCS:GS nCH:GT
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub
## functionalGroupLeaves
## functionalGroupMixed
## functionalGroupNeedles
## functionalGroupOther
## functionalGroupSeeds
## functionalGroupTwigs/branches
## functionalGroupWoody material
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves
## nlcdClassshrubScrub:functionalGroupLeaves
## nlcdClassgrasslandHerbaceous:functionalGroupMixed
## nlcdClassshrubScrub:functionalGroupMixed
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles
## nlcdClassshrubScrub:functionalGroupNeedles
## nlcdClassgrasslandHerbaceous:functionalGroupOther
## nlcdClassshrubScrub:functionalGroupOther
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds
## nlcdClassshrubScrub:functionalGroupSeeds                  0.447
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches  0.508  0.224
## nlcdClassshrubScrub:functionalGroupTwigs/branches         0.225  0.507  0.442
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material  0.511  0.225  0.518
## nlcdClassshrubScrub:functionalGroupWoody material         0.228  0.514  0.231
##                                                       nCS:GT nCH:Gm
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub
## functionalGroupLeaves
## functionalGroupMixed
## functionalGroupNeedles
## functionalGroupOther
## functionalGroupSeeds
## functionalGroupTwigs/branches
## functionalGroupWoody material
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves
## nlcdClassshrubScrub:functionalGroupLeaves
## nlcdClassgrasslandHerbaceous:functionalGroupMixed
## nlcdClassshrubScrub:functionalGroupMixed
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles
## nlcdClassshrubScrub:functionalGroupNeedles
## nlcdClassgrasslandHerbaceous:functionalGroupOther
## nlcdClassshrubScrub:functionalGroupOther
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds
## nlcdClassshrubScrub:functionalGroupSeeds
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches
## nlcdClassshrubScrub:functionalGroupTwigs/branches
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material  0.229
## nlcdClassshrubScrub:functionalGroupWoody material         0.523  0.429
##
## Standardized Within-Group Residuals:
##         Min          Q1         Med          Q3         Max
## -1.96496855 -0.23842984 -0.01535880  0.09027291 14.27434811
##
## Number of Observations: 1692
## Number of Groups: 12
# lme for mixed effects model, lm for fixed effects model

comparison_FixedMixed <- anova(LitterDrymass_mixed, LitterDrymass_fixed)
comparison_FixedMixed
##                    Model df      AIC      BIC    logLik   Test  L.Ratio
## LitterDrymass_mixed     1 26 9038.575 9179.479 -4493.287
## LitterDrymass_fixed     2 25 9058.088 9193.573 -4504.044 1 vs 2 21.51338
```

```
##                   p-value
## LitterDrymass_mixed
## LitterDrymass_fixed  <.0001
```

continued… Is the mixed effects model a better model than the fixed effects model? How do you know?

Answer: Our anova results tell us that the mixed effects model has a lower AIC value, suggesting it is a simpler/more efficient model. We can also see that the mixed and fixed models are significantly different from one another, given our small p-value, so we can conclude that the mixed effects model does a better job at predicting drymass than the fixed effects model.