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

Cristiana Falvo

## OVERVIEW

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

## Directions

1. Change “Student Name” on line 3 (above) with your name.
2. Work through the steps, **creating code and output** that fulfill each instruction.
3. Be sure to **answer the questions** in this assignment document.
4. When you have completed the assignment, **Knit** the text and code into a single PDF file.
5. 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

1. 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.
2. 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?

1. 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))

1. 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)

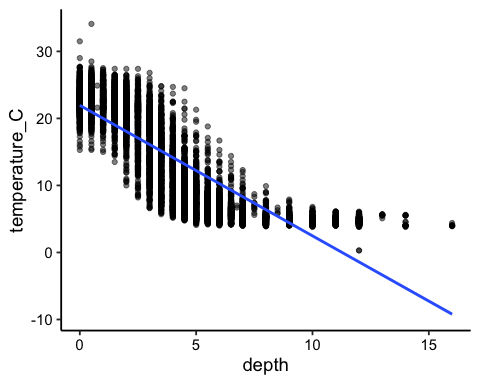
## Start: AIC=26016.31  
## temperature\_C ~ year4 + daynum + depth  
##   
## Df Sum of Sq RSS AIC  
## <none> 141118 26016  
## - year4 1 80 141198 26020  
## - daynum 1 1333 142450 26106  
## - depth 1 403925 545042 39151

##   
## 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)



1. 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.

1. 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 16.3606   
##   
## 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

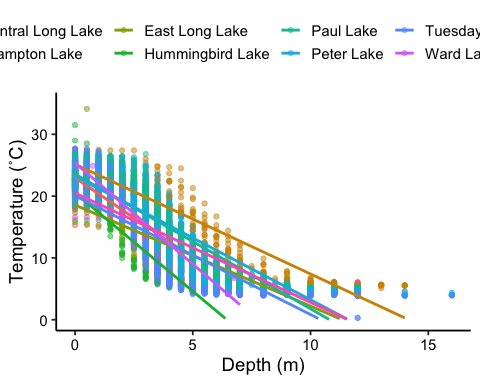
1. Is there a significant interaction between depth and lakename? How much variance in the temperature observations does this explain?

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.

1. 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).



1. 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
2. Build and run a mixed effects model.
3. 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   
## 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

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

Answer: ~2.13 %

1. Run the same model without the random effect.
2. 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   
## 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

1. 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.