

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

Xueying Feng

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/ethel/Desktop/Environ 872/Environmental_Data_Analytics_2020"

library(tidyverse)

## -- Attaching packages ----- tidyverse 1
## v ggplot2 3.2.1      v purrr   0.3.3
## v tibble  2.1.3      v dplyr  0.8.3
## v tidyr   1.0.0      v stringr 1.4.0
## v readr   1.3.1      v forcats 0.4.0

## -- Conflicts ----- tidyverse_conflic
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()

library(lubridate)

##
## Attaching package: 'lubridate'
## The following object is masked from 'package:base':
##
##     date

#install.packages("nlme")
library(nlme)
```

```
##
## Attaching package: 'nlme'

## The following object is masked from 'package:dplyr':
##
## collapse

#install.packages("piecewiseSEM")
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>.

ChemPhy <- read.csv("./Data/Raw/NTL-LTER_Lake_ChemistryPhysics_Raw.csv")
Litter <- read.csv("./Data/Processed/NEON_NIWO_Litter_mass_trap_Processed.csv")

ChemPhy$sampldate <- as.Date(ChemPhy$sampldate, format = "%m/%d/%y")
Litter$collectDate <- as.Date(Litter$collectDate, format = "%Y-%m-%d")

#2
# Set theme
mytheme <- theme_minimal(base_size = 12, base_family = "Times") +
  theme(axis.text = element_text(color = "DarkGrey"),
        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?

3. 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.
 - Only the columns: lakename, year4, daynum, depth, temperature_C
 - Only complete cases (i.e., remove NAs)
4. 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.

```
#3
ChemPhy_Wrangle <- filter(ChemPhy, daynum %in% c(182:212)) %>%
  select(lakename, year4, daynum, depth, temperature_C) %>%
  na.omit()

#4
```

```
TempAIC <- lm(data = ChemPhy_Wrangle, temperature_C ~ year4 + daynum + depth)
step(TempAIC)
```

```
## 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 = ChemPhy_Wrangle)
##
## Coefficients:
## (Intercept)      year4      daynum      depth
##    -6.45556     0.01013     0.04134    -1.94726
summary(TempAIC)
```

```
##
## Call:
## lm(formula = temperature_C ~ year4 + daynum + depth, data = ChemPhy_Wrangle)
##
## 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
```

5. 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 is year4, daynum, depth from my multiple regression. Because according to AIC value of TempAIC, the smallest is 26781.56 (three variables). Each time an independent variable is removed, the value of AIC becomes larger, so the best set is year4, daynum, and depth. 74.17% variation of a dependent variable is explained by the independent variable(s) in a regression model.

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

```
#6
LakeAncova.interaction <- aov(data = ChemPhy_Wrangle, temperature_C ~ depth * lakenname)
```

```
summary(LakeAncova.interaction) # show if it is significant interaction
```

```
##              Df Sum Sq Mean Sq  F value Pr(>F)
## depth          1 403868  403868 33525.96 <2e-16 ***
## lakenname       8  20949    2619   217.37 <2e-16 ***
## depth:lakenname  8   4687     586    48.64 <2e-16 ***
## Residuals      9704 116899     12
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
LakeAncova.interaction1 <- lm(data = ChemPhy_Wrangle, temperature_C ~ depth * lakenname)
summary(LakeAncova.interaction1) # to get R-square
```

```
##
## Call:
## lm(formula = temperature_C ~ depth * lakenname, data = ChemPhy_Wrangle)
##
## 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 ***
## lakennameCrampton Lake      2.2173     0.6804    3.259  0.00112 **
## lakennameEast Long Lake    -4.3884     0.6191   -7.089 1.45e-12 ***
## lakennameHummingbird Lake  -2.4126     0.8379   -2.879  0.00399 **
## lakennamePaul Lake         0.6105     0.5983    1.020  0.30754
## lakennamePeter Lake        0.2998     0.5970    0.502  0.61552
## lakennameTuesday Lake     -2.8932     0.6060   -4.774 1.83e-06 ***
## lakennameWard Lake         2.4180     0.8434    2.867  0.00415 **
## lakennameWest Long Lake    -2.4663     0.6168   -3.999 6.42e-05 ***
## depth:lakennameCrampton Lake  0.8058     0.2465    3.268  0.00109 **
## depth:lakennameEast Long Lake  0.9465     0.2433    3.891  0.00010 ***
## depth:lakennameHummingbird Lake -0.6026     0.2919   -2.064  0.03903 *
## depth:lakennamePaul Lake     0.4022     0.2421    1.662  0.09664 .
## depth:lakennamePeter Lake     0.5799     0.2418    2.398  0.01649 *
## depth:lakennameTuesday Lake   0.6605     0.2426    2.723  0.00648 **
## depth:lakennameWard Lake     -0.6930     0.2862   -2.421  0.01548 *
## depth:lakennameWest 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
```

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

Answer: There is a significant interaction between depth and lakenname. 78.61% proportion of variance in temperature can be explained.

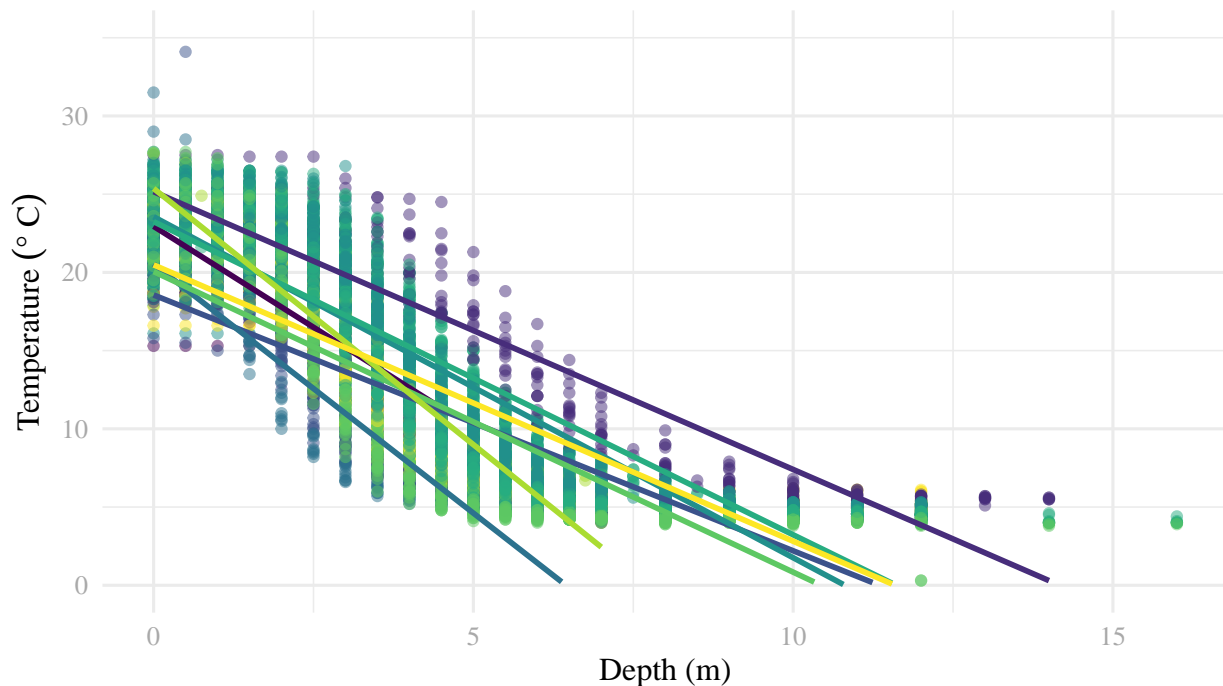
8. Create a graph that depicts temperature by depth, with a separate color for each lake. Add a `geom_smooth` (method = "lm", se = FALSE) for each lake. Make your points 50 % transparent. Adjust

your y axis limits to go from 0 to 35 degrees. Clean up your graph to make it pretty.

```
#8
Temp_model <-
ggplot(ChemPhy_Wrangle, aes(x = depth, y = temperature_C, color = lakename)) +
  geom_point(alpha = 0.5) +
  scale_color_viridis_d() +
  ylim(0,35) +
  geom_smooth(method = "lm", se = FALSE) +
  labs(x = "Depth (m)", y = expression("Temperature " ( degree~C)), color = "") +
  theme(legend.spacing.x = unit(1, "cm"))
print(Temp_model)
```

Warning: Removed 73 rows containing missing values (geom_smooth).

ral Long Lake		East Long Lake		Paul Lake		Tuesday Lake	
pton Lake		Hummingbird Lake		Peter Lake		Ward Lake	



9. 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.
 - a. Build and run a mixed effects model.
 - b. Check the difference between the marginal and conditional R² of the model. (Notes: The marginal R squared values are those associated with your fixed effects, the conditional ones are those of your fixed effects plus the random effects)

```
#mixed effects model (nlme)
litter.mixed.nlme = lme(dryMass ~ nlcdClass*functionalGroup,
```

```

random = ~ 1|plotID,
data = Litter)

summary(litter.mixed.nlme) # AIC = 9038.575

## 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
## (Intercept)                        0.155492
## nlcdClassgrasslandHerbaceous      -0.156004
## nlcdClassshrubScrub               -0.107080
## functionalGroupLeaves             -0.126008
## functionalGroupMixed               1.477797
## functionalGroupNeedles             7.284064
## functionalGroupOther              -0.048525
## functionalGroupSeeds              -0.058702
## functionalGroupTwigs/branches      1.929441
## functionalGroupWoody material      1.068772
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves 0.181416
## nlcdClassshrubScrub:functionalGroupLeaves 0.173857
## nlcdClassgrasslandHerbaceous:functionalGroupMixed -0.467648
## nlcdClassshrubScrub:functionalGroupMixed 0.633876
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles -2.118299
## nlcdClassshrubScrub:functionalGroupNeedles -2.909142
## nlcdClassgrasslandHerbaceous:functionalGroupOther 0.143603
## nlcdClassshrubScrub:functionalGroupOther 0.104935
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds 0.049290
## nlcdClassshrubScrub:functionalGroupSeeds 0.076708
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.986627
## nlcdClassshrubScrub:functionalGroupTwigs/branches -1.503446
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material -1.017803
## nlcdClassshrubScrub:functionalGroupWoody material -0.979078
##                                     Std. Error   DF
## (Intercept)                0.4863580 1659
## nlcdClassgrasslandHerbaceous 0.7789816    9
## nlcdClassshrubScrub         0.6636775    9
## functionalGroupLeaves       0.5501061 1659
## functionalGroupMixed        0.6323043 1659
## functionalGroupNeedles      0.5313161 1659
## functionalGroupOther        0.5500878 1659
## functionalGroupSeeds        0.5501061 1659
## functionalGroupTwigs/branches 0.5385556 1659
## functionalGroupWoody material 0.5259330 1659
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves 0.8847246 1659
## nlcdClassshrubScrub:functionalGroupLeaves 0.7510320 1659

```

## nlcdClassgrasslandHerbaceous:functionalGroupMixed	1.1201304	1659
## nlcdClassshrubScrub:functionalGroupMixed	0.9217911	1659
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	0.8705440	1659
## nlcdClassshrubScrub:functionalGroupNeedles	0.7347172	1659
## nlcdClassgrasslandHerbaceous:functionalGroupOther	0.8976715	1659
## nlcdClassshrubScrub:functionalGroupOther	0.7528434	1659
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	0.8976827	1659
## nlcdClassshrubScrub:functionalGroupSeeds	0.7547591	1659
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	0.8850639	1659
## nlcdClassshrubScrub:functionalGroupTwigs/branches	0.7409024	1659
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	0.8802289	1659
## nlcdClassshrubScrub:functionalGroupWoody material	0.7317033	1659
##	t-value	
## (Intercept)	0.319706	
## nlcdClassgrasslandHerbaceous	-0.200266	
## nlcdClassshrubScrub	-0.161343	
## functionalGroupLeaves	-0.229061	
## functionalGroupMixed	2.337160	
## functionalGroupNeedles	13.709474	
## functionalGroupOther	-0.088213	
## functionalGroupSeeds	-0.106711	
## functionalGroupTwigs/branches	3.582622	
## functionalGroupWoody material	2.032144	
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves	0.205053	
## nlcdClassshrubScrub:functionalGroupLeaves	0.231490	
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	-0.417495	
## nlcdClassshrubScrub:functionalGroupMixed	0.687657	
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	-2.433305	
## nlcdClassshrubScrub:functionalGroupNeedles	-3.959540	
## nlcdClassgrasslandHerbaceous:functionalGroupOther	0.159972	
## nlcdClassshrubScrub:functionalGroupOther	0.139385	
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	0.054908	
## nlcdClassshrubScrub:functionalGroupSeeds	0.101632	
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	-1.114752	
## nlcdClassshrubScrub:functionalGroupTwigs/branches	-2.029209	
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	-1.156293	
## nlcdClassshrubScrub:functionalGroupWoody material	-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
## nlcdClassgrasslandHerbaceous	-0.624
## nlcdClassshrubScrub	-0.733 0.458
## functionalGroupLeaves	-0.559 0.349
## functionalGroupMixed	-0.485 0.303
## functionalGroupNeedles	-0.579 0.361
## functionalGroupOther	-0.559 0.349
## functionalGroupSeeds	-0.559 0.349
## functionalGroupTwigs/branches	-0.571 0.356
## functionalGroupWoody material	-0.584 0.365
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves	0.347 -0.586
## nlcdClassshrubScrub:functionalGroupLeaves	0.409 -0.255
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	0.274 -0.462
## nlcdClassshrubScrub:functionalGroupMixed	0.333 -0.208
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	0.353 -0.595
## nlcdClassshrubScrub:functionalGroupNeedles	0.418 -0.261
## nlcdClassgrasslandHerbaceous:functionalGroupOther	0.342 -0.577
## nlcdClassshrubScrub:functionalGroupOther	0.408 -0.255
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	0.342 -0.577
## nlcdClassshrubScrub:functionalGroupSeeds	0.407 -0.254
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	0.347 -0.586
## nlcdClassshrubScrub:functionalGroupTwigs/branches	0.415 -0.259
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	0.349 -0.589
## nlcdClassshrubScrub:functionalGroupWoody material	0.420 -0.262
##	nlcdCS fnctGL
## nlcdClassgrasslandHerbaceous	
## nlcdClassshrubScrub	
## functionalGroupLeaves	0.409
## functionalGroupMixed	0.356 0.429
## functionalGroupNeedles	0.424 0.511
## functionalGroupOther	0.409 0.494
## functionalGroupSeeds	0.409 0.494
## functionalGroupTwigs/branches	0.418 0.504
## functionalGroupWoody material	0.428 0.516
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves	-0.255 -0.622
## nlcdClassshrubScrub:functionalGroupLeaves	-0.569 -0.732
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	-0.201 -0.242
## nlcdClassshrubScrub:functionalGroupMixed	-0.464 -0.295
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	-0.259 -0.312
## nlcdClassshrubScrub:functionalGroupNeedles	-0.582 -0.370
## nlcdClassgrasslandHerbaceous:functionalGroupOther	-0.251 -0.303
## nlcdClassshrubScrub:functionalGroupOther	-0.568 -0.361
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	-0.251 -0.303
## nlcdClassshrubScrub:functionalGroupSeeds	-0.566 -0.360
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	-0.254 -0.307


```

## nlcdClassshrubScrub:functionalGroupTwigs/branches -0.577 -0.367
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material -0.256 -0.309
## nlcdClassshrubScrub:functionalGroupWoody material -0.584 -0.371
## fncGM fncGN
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub
## functionalGroupLeaves
## functionalGroupMixed
## functionalGroupNeedles 0.445
## functionalGroupOther 0.430 0.511
## functionalGroupSeeds 0.429 0.511
## functionalGroupTwigs/branches 0.439 0.522
## functionalGroupWoody material 0.449 0.535
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves -0.267 -0.318
## nlcdClassshrubScrub:functionalGroupLeaves -0.314 -0.374
## nlcdClassgrasslandHerbaceous:functionalGroupMixed -0.564 -0.251
## nlcdClassshrubScrub:functionalGroupMixed -0.686 -0.305
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles -0.272 -0.610
## nlcdClassshrubScrub:functionalGroupNeedles -0.322 -0.723
## nlcdClassgrasslandHerbaceous:functionalGroupOther -0.263 -0.313
## nlcdClassshrubScrub:functionalGroupOther -0.314 -0.374
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds -0.263 -0.313
## nlcdClassshrubScrub:functionalGroupSeeds -0.313 -0.373
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.267 -0.318
## nlcdClassshrubScrub:functionalGroupTwigs/branches -0.319 -0.380
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material -0.268 -0.320
## nlcdClassshrubScrub:functionalGroupWoody material -0.322 -0.384
## fncG0 fncGS
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub
## functionalGroupLeaves
## functionalGroupMixed
## functionalGroupNeedles
## functionalGroupOther
## functionalGroupSeeds 0.494
## functionalGroupTwigs/branches 0.504 0.504
## functionalGroupWoody material 0.516 0.517
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves -0.307 -0.307
## nlcdClassshrubScrub:functionalGroupLeaves -0.362 -0.362
## nlcdClassgrasslandHerbaceous:functionalGroupMixed -0.243 -0.242
## nlcdClassshrubScrub:functionalGroupMixed -0.295 -0.294
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles -0.312 -0.312
## nlcdClassshrubScrub:functionalGroupNeedles -0.370 -0.370
## nlcdClassgrasslandHerbaceous:functionalGroupOther -0.613 -0.303
## nlcdClassshrubScrub:functionalGroupOther -0.731 -0.361
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds -0.303 -0.613
## nlcdClassshrubScrub:functionalGroupSeeds -0.360 -0.729
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.307 -0.307
## nlcdClassshrubScrub:functionalGroupTwigs/branches -0.367 -0.367
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material -0.309 -0.309
## nlcdClassshrubScrub:functionalGroupWoody material -0.371 -0.371
## fncGT/ fncGwm
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub

```

```

## functionalGroupLeaves
## functionalGroupMixed
## functionalGroupNeedles
## functionalGroupOther
## functionalGroupSeeds
## functionalGroupTwigs/branches
## functionalGroupWoody material          0.528
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves -0.314 -0.321
## nlcdClassshrubScrub:functionalGroupLeaves -0.369 -0.378
## nlcdClassgrasslandHerbaceous:functionalGroupMixed -0.248 -0.253
## nlcdClassshrubScrub:functionalGroupMixed -0.301 -0.308
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles -0.319 -0.326
## nlcdClassshrubScrub:functionalGroupNeedles -0.378 -0.387
## nlcdClassgrasslandHerbaceous:functionalGroupOther -0.309 -0.316
## nlcdClassshrubScrub:functionalGroupOther -0.369 -0.377
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds -0.309 -0.317
## nlcdClassshrubScrub:functionalGroupSeeds -0.368 -0.376
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -0.608 -0.321
## nlcdClassshrubScrub:functionalGroupTwigs/branches -0.727 -0.384
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material -0.315 -0.597
## nlcdClassshrubScrub:functionalGroupWoody material -0.379 -0.719
## nCH:GL nCS:GL
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub
## functionalGroupLeaves
## functionalGroupMixed
## functionalGroupNeedles
## functionalGroupOther
## functionalGroupSeeds
## functionalGroupTwigs/branches
## functionalGroupWoody material
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves
## nlcdClassshrubScrub:functionalGroupLeaves          0.455
## nlcdClassgrasslandHerbaceous:functionalGroupMixed 0.406 0.178
## nlcdClassshrubScrub:functionalGroupMixed 0.183 0.410
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles 0.524 0.229
## nlcdClassshrubScrub:functionalGroupNeedles 0.230 0.514
## nlcdClassgrasslandHerbaceous:functionalGroupOther 0.508 0.222
## nlcdClassshrubScrub:functionalGroupOther 0.224 0.502
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds 0.508 0.222
## nlcdClassshrubScrub:functionalGroupSeeds 0.224 0.500
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 0.515 0.225
## nlcdClassshrubScrub:functionalGroupTwigs/branches 0.228 0.510
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.518 0.226
## nlcdClassshrubScrub:functionalGroupWoody material 0.231 0.516
## nCH:GM nCS:GM
## 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
## nlcdClassgrasslandHerbaceous:functionalGroupOther    0.401 0.181
## nlcdClassshrubScrub:functionalGroupOther            0.177 0.409
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds    0.402 0.180
## nlcdClassshrubScrub:functionalGroupSeeds            0.177 0.408
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 0.407 0.183
## nlcdClassshrubScrub:functionalGroupTwigs/branches    0.180 0.416
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.409 0.184
## nlcdClassshrubScrub:functionalGroupWoody material    0.182 0.420
##                                                     nCH:GN nCS:GN
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub
## functionalGroupLeaves
## functionalGroupMixed
## functionalGroupNeedles
## functionalGroupOther
## functionalGroupSeeds
## functionalGroupTwigs/branches
## functionalGroupWoody material
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves
## nlcdClassshrubScrub:functionalGroupLeaves
## nlcdClassgrasslandHerbaceous:functionalGroupMixed
## nlcdClassshrubScrub:functionalGroupMixed
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles
## nlcdClassshrubScrub:functionalGroupNeedles          0.441
## nlcdClassgrasslandHerbaceous:functionalGroupOther    0.517 0.227
## nlcdClassshrubScrub:functionalGroupOther            0.228 0.513
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds    0.517 0.227
## nlcdClassshrubScrub:functionalGroupSeeds            0.227 0.512
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 0.524 0.230
## nlcdClassshrubScrub:functionalGroupTwigs/branches    0.232 0.521
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.527 0.231
## nlcdClassshrubScrub:functionalGroupWoody material    0.235 0.528
##                                                     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
## nlcdClassshrubScrub:functionalGroupOther          0.448
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds  0.501  0.221
## nlcdClassshrubScrub:functionalGroupSeeds          0.221  0.499
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 0.508  0.224
## nlcdClassshrubScrub:functionalGroupTwigs/branches 0.225  0.509
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.511  0.225
## nlcdClassshrubScrub:functionalGroupWoody material 0.227  0.515
##                                                    nCH:GS nCS:GS
## 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
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.511  0.225
## nlcdClassshrubScrub:functionalGroupWoody material 0.228  0.514
##                                                    nCH:GT nCS: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
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches

```

```
## nlcdClassshrubScrub:functionalGroupTwigs/branches          0.442
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.518 0.229
## nlcdClassshrubScrub:functionalGroupWoody material          0.231 0.523
##                                                            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
## nlcdClassshrubScrub:functionalGroupWoody material          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
```

```
rsquared(litter.mixed.nlme)
```

```
## Response family link method Marginal Conditional
## 1 dryMass gaussian identity none 0.2465822 0.2679023
```

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

Answer: 2.14% more variance is explained by adding the random effect to the model

c. Run the same model without the random effect.

d. Run an anova on the two tests.

```
#model without the random effect (Fixed model)
litter.fixed <- gls(data = Litter,dryMass ~ nlcdClass*functionalGroup)
summary(litter.fixed) # AIC = 9058.088
```

```
## Generalized least squares fit by REML
## Model: dryMass ~ nlcdClass * functionalGroup
## Data: Litter
##           AIC           BIC           logLik
## 9058.088 9193.573 -4504.044
##
```

```

## Coefficients:
##
## (Intercept) 0.119625
## nlcdClassgrasslandHerbaceous -0.114199
## nlcdClassshrubScrub -0.104119
## functionalGroupLeaves -0.103599
## functionalGroupMixed 1.504750
## functionalGroupNeedles 7.312264
## functionalGroupOther -0.034817
## functionalGroupSeeds -0.046163
## functionalGroupTwigs/branches 1.959669
## functionalGroupWoody material 1.084311
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves 0.128646
## nlcdClassshrubScrub:functionalGroupLeaves 0.147030
## nlcdClassgrasslandHerbaceous:functionalGroupMixed -0.381176
## nlcdClassshrubScrub:functionalGroupMixed 0.745929
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles -2.138801
## nlcdClassshrubScrub:functionalGroupNeedles -2.921481
## nlcdClassgrasslandHerbaceous:functionalGroupOther 0.126058
## nlcdClassshrubScrub:functionalGroupOther 0.085888
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds 0.046155
## nlcdClassshrubScrub:functionalGroupSeeds 0.059436
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches -1.015195
## nlcdClassshrubScrub:functionalGroupTwigs/branches -1.495591
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material -1.040859
## nlcdClassshrubScrub:functionalGroupWoody material -0.971848
## Std. Error
## (Intercept) 0.3906950
## nlcdClassgrasslandHerbaceous 0.6422303
## nlcdClassshrubScrub 0.5383767
## functionalGroupLeaves 0.5560568
## functionalGroupMixed 0.6380023
## functionalGroupNeedles 0.5369590
## functionalGroupOther 0.5560568
## functionalGroupSeeds 0.5560568
## functionalGroupTwigs/branches 0.5443402
## functionalGroupWoody material 0.5315555
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves 0.8941030
## nlcdClassshrubScrub:functionalGroupLeaves 0.7591538
## nlcdClassgrasslandHerbaceous:functionalGroupMixed 1.1302365
## nlcdClassshrubScrub:functionalGroupMixed 0.9303798
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles 0.8799314
## nlcdClassshrubScrub:functionalGroupNeedles 0.7425783
## nlcdClassgrasslandHerbaceous:functionalGroupOther 0.9074253
## nlcdClassshrubScrub:functionalGroupOther 0.7610116
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds 0.9074253
## nlcdClassshrubScrub:functionalGroupSeeds 0.7629471
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 0.8946237
## nlcdClassshrubScrub:functionalGroupTwigs/branches 0.7488092
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.8897083
## nlcdClassshrubScrub:functionalGroupWoody material 0.7395676
## t-value
## (Intercept) 0.306185
## nlcdClassgrasslandHerbaceous -0.177817

```

## nlcdClasssshrubScrub	-0.193395
## functionalGroupLeaves	-0.186311
## functionalGroupMixed	2.358534
## functionalGroupNeedles	13.617920
## functionalGroupOther	-0.062615
## functionalGroupSeeds	-0.083019
## functionalGroupTwigs/branches	3.600082
## functionalGroupWoody material	2.039883
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves	0.143882
## nlcdClasssshrubScrub:functionalGroupLeaves	0.193676
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	-0.337253
## nlcdClasssshrubScrub:functionalGroupMixed	0.801746
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	-2.430645
## nlcdClasssshrubScrub:functionalGroupNeedles	-3.934239
## nlcdClassgrasslandHerbaceous:functionalGroupOther	0.138919
## nlcdClasssshrubScrub:functionalGroupOther	0.112860
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	0.050863
## nlcdClasssshrubScrub:functionalGroupSeeds	0.077903
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	-1.134773
## nlcdClasssshrubScrub:functionalGroupTwigs/branches	-1.997293
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	-1.169888
## nlcdClasssshrubScrub:functionalGroupWoody material	-1.314076
##	p-value
## (Intercept)	0.7595
## nlcdClassgrasslandHerbaceous	0.8589
## nlcdClasssshrubScrub	0.8467
## functionalGroupLeaves	0.8522
## functionalGroupMixed	0.0185
## functionalGroupNeedles	0.0000
## functionalGroupOther	0.9501
## functionalGroupSeeds	0.9338
## functionalGroupTwigs/branches	0.0003
## functionalGroupWoody material	0.0415
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves	0.8856
## nlcdClasssshrubScrub:functionalGroupLeaves	0.8465
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	0.7360
## nlcdClasssshrubScrub:functionalGroupMixed	0.4228
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	0.0152
## nlcdClasssshrubScrub:functionalGroupNeedles	0.0001
## nlcdClassgrasslandHerbaceous:functionalGroupOther	0.8895
## nlcdClasssshrubScrub:functionalGroupOther	0.9102
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	0.9594
## nlcdClasssshrubScrub:functionalGroupSeeds	0.9379
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	0.2566
## nlcdClasssshrubScrub:functionalGroupTwigs/branches	0.0460
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	0.2422
## nlcdClasssshrubScrub:functionalGroupWoody material	0.1890
##	
## Correlation:	
##	(Intr) nlcdCH
## nlcdClassgrasslandHerbaceous	-0.608
## nlcdClasssshrubScrub	-0.726 0.441
## functionalGroupLeaves	-0.703 0.427
## functionalGroupMixed	-0.612 0.373

## functionalGroupNeedles	-0.728	0.443
## functionalGroupOther	-0.703	0.427
## functionalGroupSeeds	-0.703	0.427
## functionalGroupTwigs/branches	-0.718	0.437
## functionalGroupWoody material	-0.735	0.447
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves	0.437	-0.718
## nlcdClassshrubScrub:functionalGroupLeaves	0.515	-0.313
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	0.346	-0.568
## nlcdClassshrubScrub:functionalGroupMixed	0.420	-0.255
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	0.444	-0.730
## nlcdClassshrubScrub:functionalGroupNeedles	0.526	-0.320
## nlcdClassgrasslandHerbaceous:functionalGroupOther	0.431	-0.708
## nlcdClassshrubScrub:functionalGroupOther	0.513	-0.312
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	0.431	-0.708
## nlcdClassshrubScrub:functionalGroupSeeds	0.512	-0.312
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	0.437	-0.718
## nlcdClassshrubScrub:functionalGroupTwigs/branches	0.522	-0.317
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	0.439	-0.722
## nlcdClassshrubScrub:functionalGroupWoody material	0.528	-0.321
##	nlcdCS	fnctGL
## nlcdClassgrasslandHerbaceous		
## nlcdClassshrubScrub		
## functionalGroupLeaves	0.510	
## functionalGroupMixed	0.444	0.430
## functionalGroupNeedles	0.528	0.511
## functionalGroupOther	0.510	0.494
## functionalGroupSeeds	0.510	0.494
## functionalGroupTwigs/branches	0.521	0.504
## functionalGroupWoody material	0.533	0.516
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves	-0.317	-0.622
## nlcdClassshrubScrub:functionalGroupLeaves	-0.709	-0.732
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	-0.251	-0.243
## nlcdClassshrubScrub:functionalGroupMixed	-0.579	-0.295
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	-0.322	-0.312
## nlcdClassshrubScrub:functionalGroupNeedles	-0.725	-0.370
## nlcdClassgrasslandHerbaceous:functionalGroupOther	-0.312	-0.303
## nlcdClassshrubScrub:functionalGroupOther	-0.707	-0.361
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	-0.312	-0.303
## nlcdClassshrubScrub:functionalGroupSeeds	-0.706	-0.360
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	-0.317	-0.307
## nlcdClassshrubScrub:functionalGroupTwigs/branches	-0.719	-0.367
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	-0.319	-0.309
## nlcdClassshrubScrub:functionalGroupWoody material	-0.728	-0.371
##	fnctGM	fnctGN
## nlcdClassgrasslandHerbaceous		
## nlcdClassshrubScrub		
## functionalGroupLeaves		
## functionalGroupMixed		
## functionalGroupNeedles	0.446	
## functionalGroupOther	0.430	0.511
## functionalGroupSeeds	0.430	0.511
## functionalGroupTwigs/branches	0.440	0.522
## functionalGroupWoody material	0.450	0.535
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves	-0.268	-0.318

## nlcdClasssshrubScrub:functionalGroupLeaves	-0.315	-0.374
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	-0.564	-0.252
## nlcdClasssshrubScrub:functionalGroupMixed	-0.686	-0.306
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	-0.272	-0.610
## nlcdClasssshrubScrub:functionalGroupNeedles	-0.322	-0.723
## nlcdClassgrasslandHerbaceous:functionalGroupOther	-0.264	-0.313
## nlcdClasssshrubScrub:functionalGroupOther	-0.314	-0.374
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	-0.264	-0.313
## nlcdClasssshrubScrub:functionalGroupSeeds	-0.314	-0.373
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	-0.267	-0.318
## nlcdClasssshrubScrub:functionalGroupTwigs/branches	-0.320	-0.380
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	-0.269	-0.320
## nlcdClasssshrubScrub:functionalGroupWoody material	-0.324	-0.384
##	fnctG0	fnctGS
## nlcdClassgrasslandHerbaceous		
## nlcdClasssshrubScrub		
## functionalGroupLeaves		
## functionalGroupMixed		
## functionalGroupNeedles		
## functionalGroupOther		
## functionalGroupSeeds	0.494	
## functionalGroupTwigs/branches	0.504	0.504
## functionalGroupWoody material	0.516	0.516
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves	-0.307	-0.307
## nlcdClasssshrubScrub:functionalGroupLeaves	-0.362	-0.362
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	-0.243	-0.243
## nlcdClasssshrubScrub:functionalGroupMixed	-0.295	-0.295
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	-0.312	-0.312
## nlcdClasssshrubScrub:functionalGroupNeedles	-0.370	-0.370
## nlcdClassgrasslandHerbaceous:functionalGroupOther	-0.613	-0.303
## nlcdClasssshrubScrub:functionalGroupOther	-0.731	-0.361
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	-0.303	-0.613
## nlcdClasssshrubScrub:functionalGroupSeeds	-0.360	-0.729
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	-0.307	-0.307
## nlcdClasssshrubScrub:functionalGroupTwigs/branches	-0.367	-0.367
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	-0.309	-0.309
## nlcdClasssshrubScrub:functionalGroupWoody material	-0.371	-0.371
##	fncGT/	fncGWm
## nlcdClassgrasslandHerbaceous		
## nlcdClasssshrubScrub		
## functionalGroupLeaves		
## functionalGroupMixed		
## functionalGroupNeedles		
## functionalGroupOther		
## functionalGroupSeeds		
## functionalGroupTwigs/branches		
## functionalGroupWoody material	0.528	
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves	-0.314	-0.321
## nlcdClasssshrubScrub:functionalGroupLeaves	-0.369	-0.378
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	-0.248	-0.254
## nlcdClasssshrubScrub:functionalGroupMixed	-0.301	-0.309
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	-0.319	-0.326
## nlcdClasssshrubScrub:functionalGroupNeedles	-0.378	-0.387
## nlcdClassgrasslandHerbaceous:functionalGroupOther	-0.309	-0.316

## nlcdClassshrubScrub:functionalGroupOther	-0.368	-0.377
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	-0.309	-0.316
## nlcdClassshrubScrub:functionalGroupSeeds	-0.368	-0.376
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	-0.608	-0.321
## nlcdClassshrubScrub:functionalGroupTwigs/branches	-0.727	-0.383
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	-0.315	-0.597
## nlcdClassshrubScrub:functionalGroupWoody material	-0.379	-0.719
##	nCH:GL	nCS:GL
## nlcdClassgrasslandHerbaceous		
## nlcdClassshrubScrub		
## functionalGroupLeaves		
## functionalGroupMixed		
## functionalGroupNeedles		
## functionalGroupOther		
## functionalGroupSeeds		
## functionalGroupTwigs/branches		
## functionalGroupWoody material		
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves		
## nlcdClassshrubScrub:functionalGroupLeaves	0.456	
## nlcdClassgrasslandHerbaceous:functionalGroupMixed	0.408	0.178
## nlcdClassshrubScrub:functionalGroupMixed	0.183	0.410
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	0.524	0.229
## nlcdClassshrubScrub:functionalGroupNeedles	0.230	0.514
## nlcdClassgrasslandHerbaceous:functionalGroupOther	0.508	0.222
## nlcdClassshrubScrub:functionalGroupOther	0.224	0.502
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	0.508	0.222
## nlcdClassshrubScrub:functionalGroupSeeds	0.224	0.500
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	0.516	0.225
## nlcdClassshrubScrub:functionalGroupTwigs/branches	0.228	0.510
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	0.518	0.226
## nlcdClassshrubScrub:functionalGroupWoody material	0.231	0.516
##	nCH:GM	nCS:GM
## nlcdClassgrasslandHerbaceous		
## nlcdClassshrubScrub		
## functionalGroupLeaves		
## functionalGroupMixed		
## functionalGroupNeedles		
## functionalGroupOther		
## functionalGroupSeeds		
## functionalGroupTwigs/branches		
## functionalGroupWoody material		
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves		
## nlcdClassshrubScrub:functionalGroupLeaves		
## nlcdClassgrasslandHerbaceous:functionalGroupMixed		
## nlcdClassshrubScrub:functionalGroupMixed	0.387	
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles	0.415	0.186
## nlcdClassshrubScrub:functionalGroupNeedles	0.182	0.420
## nlcdClassgrasslandHerbaceous:functionalGroupOther	0.402	0.181
## nlcdClassshrubScrub:functionalGroupOther	0.177	0.409
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	0.402	0.181
## nlcdClassshrubScrub:functionalGroupSeeds	0.177	0.408
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	0.408	0.183
## nlcdClassshrubScrub:functionalGroupTwigs/branches	0.180	0.416
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	0.410	0.184

## nlcdClasssshrubScrub:functionalGroupWoody material	0.183	0.421
##	nCH:GN	nCS:GN
## nlcdClassgrasslandHerbaceous		
## nlcdClasssshrubScrub		
## functionalGroupLeaves		
## functionalGroupMixed		
## functionalGroupNeedles		
## functionalGroupOther		
## functionalGroupSeeds		
## functionalGroupTwigs/branches		
## functionalGroupWoody material		
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves		
## nlcdClasssshrubScrub:functionalGroupLeaves		
## nlcdClassgrasslandHerbaceous:functionalGroupMixed		
## nlcdClasssshrubScrub:functionalGroupMixed		
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles		
## nlcdClasssshrubScrub:functionalGroupNeedles	0.441	
## nlcdClassgrasslandHerbaceous:functionalGroupOther	0.517	0.227
## nlcdClasssshrubScrub:functionalGroupOther	0.228	0.513
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	0.517	0.227
## nlcdClasssshrubScrub:functionalGroupSeeds	0.227	0.512
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	0.524	0.230
## nlcdClasssshrubScrub:functionalGroupTwigs/branches	0.232	0.521
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	0.527	0.231
## nlcdClasssshrubScrub:functionalGroupWoody material	0.235	0.528
##	nCH:GO	nCS:GO
## nlcdClassgrasslandHerbaceous		
## nlcdClasssshrubScrub		
## functionalGroupLeaves		
## functionalGroupMixed		
## functionalGroupNeedles		
## functionalGroupOther		
## functionalGroupSeeds		
## functionalGroupTwigs/branches		
## functionalGroupWoody material		
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves		
## nlcdClasssshrubScrub:functionalGroupLeaves		
## nlcdClassgrasslandHerbaceous:functionalGroupMixed		
## nlcdClasssshrubScrub:functionalGroupMixed		
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles		
## nlcdClasssshrubScrub:functionalGroupNeedles		
## nlcdClassgrasslandHerbaceous:functionalGroupOther		
## nlcdClasssshrubScrub:functionalGroupOther	0.448	
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds	0.501	0.221
## nlcdClasssshrubScrub:functionalGroupSeeds	0.220	0.499
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches	0.508	0.224
## nlcdClasssshrubScrub:functionalGroupTwigs/branches	0.225	0.509
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material	0.511	0.225
## nlcdClasssshrubScrub:functionalGroupWoody material	0.227	0.515
##	nCH:GS	nCS:GS
## nlcdClassgrasslandHerbaceous		
## nlcdClasssshrubScrub		
## 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
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.511 0.225
## nlcdClassshrubScrub:functionalGroupWoody material 0.227 0.514
## nCH:GT nCS: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
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches
## nlcdClassshrubScrub:functionalGroupTwigs/branches 0.442
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.518 0.229
## nlcdClassshrubScrub:functionalGroupWoody material 0.231 0.523
## nCH:Gm
## nlcdClassgrasslandHerbaceous
## nlcdClassshrubScrub
## functionalGroupLeaves
## functionalGroupMixed
## functionalGroupNeedles
## functionalGroupOther
## functionalGroupSeeds
## functionalGroupTwigs/branches
## functionalGroupWoody material
## nlcdClassgrasslandHerbaceous:functionalGroupLeaves

```

```
## nlcdClasssshrubScrub:functionalGroupLeaves
## nlcdClassgrasslandHerbaceous:functionalGroupMixed
## nlcdClasssshrubScrub:functionalGroupMixed
## nlcdClassgrasslandHerbaceous:functionalGroupNeedles
## nlcdClasssshrubScrub:functionalGroupNeedles
## nlcdClassgrasslandHerbaceous:functionalGroupOther
## nlcdClasssshrubScrub:functionalGroupOther
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds
## nlcdClasssshrubScrub:functionalGroupSeeds
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches
## nlcdClasssshrubScrub:functionalGroupTwigs/branches
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material
## nlcdClasssshrubScrub:functionalGroupWoody material          0.429
##
## Standardized residuals:
##           Min           Q1           Med           Q3           Max
## -1.89209382 -0.13724016 -0.01672707 -0.00155260 14.03673076
##
## Residual standard error: 3.494483
## Degrees of freedom: 1692 total; 1668 residual
anova(litter.mixed.nlme, litter.fixed) # can compare AIC and P-value of two models

##           Model df          AIC          BIC    logLik    Test  L.Ratio
## litter.mixed.nlme      1 26 9038.575 9179.479 -4493.287
## litter.fixed           2 25 9058.088 9193.573 -4504.044 1 vs 2 21.51338
##           p-value
## litter.mixed.nlme
## litter.fixed          <.0001
```

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

Answer: I think the mixed effects model is a btter model, because AIC is smaller than fixed one.