

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

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OVERVIEW

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

Directions

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.

first part processed,

na_omit takes out any any data from the entire data frame that has an NA na_exclude takes out any NAs from a specific column that you specify

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/amandabraun/Documents/Classes Spring 2020/Data Analytics/Environmental_Data_Analytics_2020"
```

```
library(tidyverse)
```

```
## -- Attaching packages ----- tidyverse 1.3.0 --
```

```
## 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_conflicts() --
```

```
## x dplyr::filter() masks stats::filter()
```

```
## x dplyr::lag()    masks stats::lag()
```

```
library(corrplot)
```

```
## corrplot 0.84 loaded
```

```
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>.

#2
NTER.chem.phys <- read.csv("./Data/Raw/NTL-LTER_Lake_ChemistryPhysics_Raw.csv")
NEON_NIWO_Litter <- read.csv("./Data/Processed/NEON_NIWO_Litter_mass_trap_Processed.csv")
```

NTL-LTER test processed

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
NTR.July.Complete.Cases <- NTER.chem.phys %>%
  filter(daynum > 181 & daynum < 213) %>%
  select(lakename, year4, daynum, depth, temperature_C) %>%
  na.omit()

NTR.July.AIC <- lm(data = NTR.July.Complete.Cases, temperature_C ~ year4 + daynum + depth)
step(NTR.July.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 = NTR.July.Complete.Cases)
##
## Coefficients:
## (Intercept)      year4      daynum      depth
##    -6.45556      0.01013      0.04134     -1.94726

#4
July.Temp.Model <-lm(data = NTR.July.Complete.Cases, temperature_C ~ year4 + daynum + depth)
summary(July.Temp.Model)

##
## Call:
## lm(formula = temperature_C ~ year4 + daynum + depth, data = NTR.July.Complete.Cases)
##
## 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: Year, day in July, and depth are all significant explanatory variables, 74% of the observed variance is explained by this model.

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

```
#6
July.Temp.ancova.main <- lm(data = NTR.July.Complete.Cases, temperature_C ~ lakenname * depth)
summary(July.Temp.ancova.main)

##
## Call:
## lm(formula = temperature_C ~ lakenname * depth, data = NTR.July.Complete.Cases)
##
## 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 ***
## lakenamCrampton Lake       2.2173      0.6804   3.259 0.00112 **
## lakenamEast Long Lake     -4.3884      0.6191  -7.089 1.45e-12 ***
## lakenamHummingbird Lake   -2.4126      0.8379  -2.879 0.00399 **
## lakenamPaul Lake           0.6105      0.5983   1.020 0.30754
## lakenamPeter Lake          0.2998      0.5970   0.502 0.61552
## lakenamTuesday Lake      -2.8932      0.6060  -4.774 1.83e-06 ***
## lakenamWard Lake           2.4180      0.8434   2.867 0.00415 **
## lakenamWest Long Lake     -2.4663      0.6168  -3.999 6.42e-05 ***
## depth                     -2.5820      0.2411 -10.711 < 2e-16 ***
## lakenamCrampton Lake:depth  0.8058      0.2465   3.268 0.00109 **
## lakenamEast Long Lake:depth 0.9465      0.2433   3.891 0.00010 ***
## lakenamHummingbird Lake:depth -0.6026      0.2919  -2.064 0.03903 *
## lakenamPaul Lake:depth      0.4022      0.2421   1.662 0.09664 .
## lakenamPeter Lake:depth      0.5799      0.2418   2.398 0.01649 *
## lakenamTuesday Lake:depth    0.6605      0.2426   2.723 0.00648 **
## lakenamWard Lake:depth      -0.6930      0.2862  -2.421 0.01548 *
## lakenamWest Long Lake:depth  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 lakenam? How much variance in the temperature observations does this explain?

Answer: Yes there is a significant interaction between depth and lakenam, the model explains 78.5% of the variance.

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
JulyTemps.Graph <- ggplot(NTR.July.Complete.Cases, aes(x = depth, y = temperature_C,
  color = lakenam)) +
  geom_point(alpha= .50) +
  scale_color_brewer(palette = "Set1", direction = 1) +
  geom_smooth(method = "lm", se = FALSE, line = .3) +
  labs(x = "Depth (m)", y = expression("Temperature(^o*C)"), color = "") +
  ylim(0, 35) +
  xlim(0,15)
```

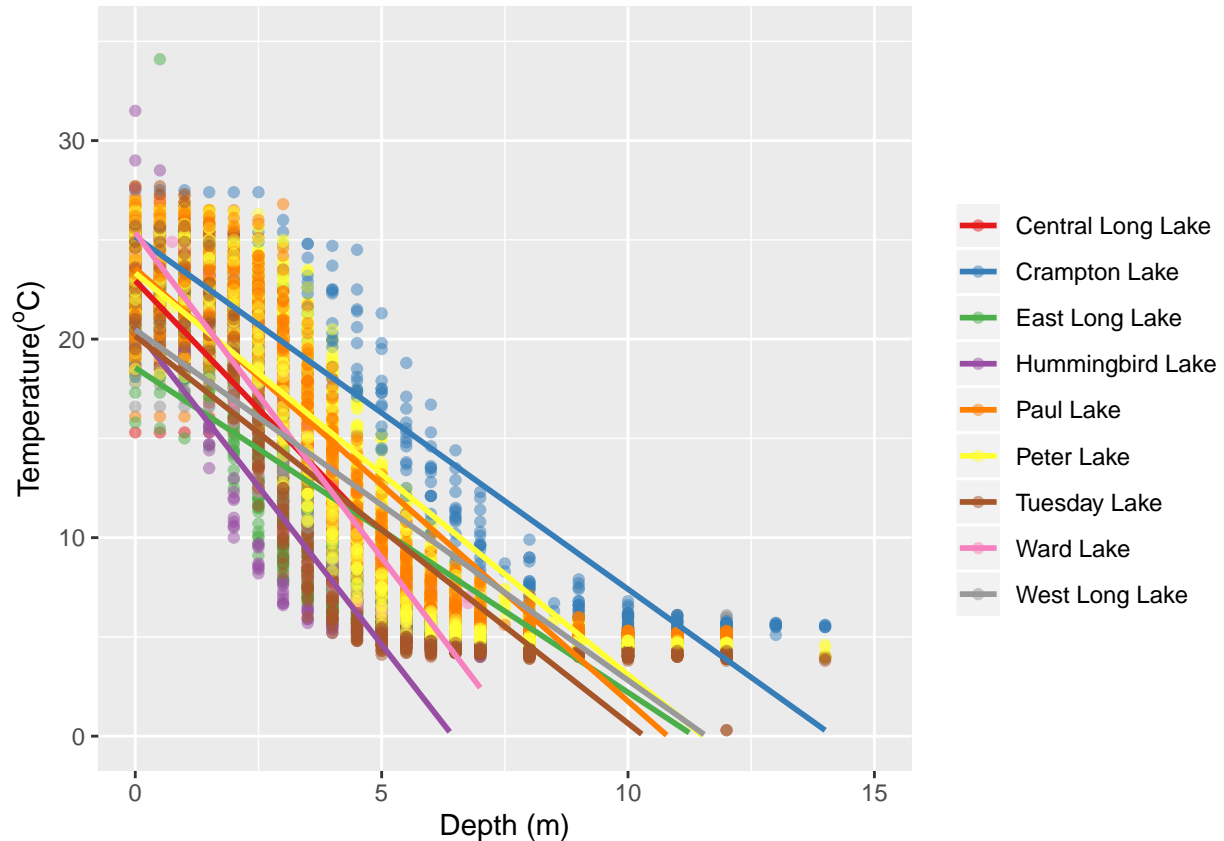
```
## Warning: Ignoring unknown parameters: line
```

```
print(JulyTemps.Graph)
```

```
## Warning: Removed 8 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 8 rows containing missing values (geom_point).
```

```
## Warning: Removed 58 rows containing missing values (geom_smooth).
```



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.

- Build and run a mixed effects model.
- Check the difference between the marginal and conditional R² of the model.

```
Litter.Mixed.Effects <- lme(data= NEON_NIWO_Litter, dryMass ~ nlcdClass*
                             functionalGroup, random = ~1|plotID)
summary(Litter.Mixed.Effects)
```

```
## Linear mixed-effects model fit by REML
## Data: NEON_NIWO_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
##
##      (Intercept)                                Value Std.Error
## nlcdClassgrasslandHerbaceous                -0.156004 0.7789816
```

| | | |
|---|-----------|-----------|
| ## nlcdClasssshrubScrub | -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 |
| ## nlcdClasssshrubScrub:functionalGroupLeaves | 0.173857 | 0.7510320 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupMixed | -0.467648 | 1.1201304 |
| ## nlcdClasssshrubScrub:functionalGroupMixed | 0.633876 | 0.9217911 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupNeedles | -2.118299 | 0.8705440 |
| ## nlcdClasssshrubScrub:functionalGroupNeedles | -2.909142 | 0.7347172 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupOther | 0.143603 | 0.8976715 |
| ## nlcdClasssshrubScrub:functionalGroupOther | 0.104935 | 0.7528434 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupSeeds | 0.049290 | 0.8976827 |
| ## nlcdClasssshrubScrub:functionalGroupSeeds | 0.076708 | 0.7547591 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches | -0.986627 | 0.8850639 |
| ## nlcdClasssshrubScrub:functionalGroupTwigs/branches | -1.503446 | 0.7409024 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupWoody material | -1.017803 | 0.8802289 |
| ## nlcdClasssshrubScrub:functionalGroupWoody material | -0.979078 | 0.7317033 |
| ## | DF | t-value |
| ## (Intercept) | 1659 | 0.319706 |
| ## nlcdClassgrasslandHerbaceous | 9 | -0.200266 |
| ## nlcdClasssshrubScrub | 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 |
| ## nlcdClasssshrubScrub:functionalGroupLeaves | 1659 | 0.231490 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupMixed | 1659 | -0.417495 |
| ## nlcdClasssshrubScrub:functionalGroupMixed | 1659 | 0.687657 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupNeedles | 1659 | -2.433305 |
| ## nlcdClasssshrubScrub:functionalGroupNeedles | 1659 | -3.959540 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupOther | 1659 | 0.159972 |
| ## nlcdClasssshrubScrub:functionalGroupOther | 1659 | 0.139385 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupSeeds | 1659 | 0.054908 |
| ## nlcdClasssshrubScrub:functionalGroupSeeds | 1659 | 0.101632 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches | 1659 | -1.114752 |
| ## nlcdClasssshrubScrub:functionalGroupTwigs/branches | 1659 | -2.029209 |
| ## nlcdClassgrasslandHerbaceous:functionalGroupWoody material | 1659 | -1.156293 |
| ## nlcdClasssshrubScrub:functionalGroupWoody material | 1659 | -1.338081 |
| ## | p-value | |
| ## (Intercept) | 0.7492 | |
| ## nlcdClassgrasslandHerbaceous | 0.8457 | |
| ## nlcdClasssshrubScrub | 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 |
| ## | fncTG0 | 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 |

```

## nlcdClasssshrubScrub:functionalGroupWoody material      0.528  0.227  0.515
## nCH:GS nCS:GS nCH:GT
## 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
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds
## nlcdClasssshrubScrub:functionalGroupSeeds      0.447
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches 0.508  0.224
## nlcdClasssshrubScrub:functionalGroupTwigs/branches      0.225  0.507  0.442
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.511  0.225  0.518
## nlcdClasssshrubScrub:functionalGroupWoody material      0.228  0.514  0.231
## nCS:GT nCH:Gm
## 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
## nlcdClassgrasslandHerbaceous:functionalGroupSeeds
## nlcdClasssshrubScrub:functionalGroupSeeds
## nlcdClassgrasslandHerbaceous:functionalGroupTwigs/branches
## nlcdClasssshrubScrub:functionalGroupTwigs/branches
## nlcdClassgrasslandHerbaceous:functionalGroupWoody material 0.229
## nlcdClasssshrubScrub: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
```

```
rsquared(Litter.Mixed.Effects)
```

```
## 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: $.02 = 2\%$

c. Run the same model without the random effect.

d. Run an anova on the two tests.

```
Litter.Fixed.Effects <- lm(data = NEON_NIWO_Litter, dryMass ~ nlcdClass*
                           functionalGroup)
summary(Litter.Fixed.Effects)
```

```
##
## Call:
## lm(formula = dryMass ~ nlcdClass * functionalGroup, data = NEON_NIWO_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
```

```
rsquared(Litter.Fixed.Effects)
```

```
## Response family link method R.squared
## 1 dryMass gaussian identity none 0.2515836
```

```
#F, R2 and P
```

```
anova(Litter.Mixed.Effects, Litter.Fixed.Effects)
```

```
## Model df AIC BIC logLik Test L.Ratio
## Litter.Mixed.Effects 1 26 9038.575 9179.479 -4493.287
## Litter.Fixed.Effects 2 25 9058.088 9193.573 -4504.044 1 vs 2 21.51338
## p-value
## Litter.Mixed.Effects
## Litter.Fixed.Effects <.0001
```

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

Answer: The mixed effect model is better, because the AIC value is lower, the AIC for the mixed effects model is 9038.575, and the mixed effects for fixed effects model is 9058.088.