eDiValo Seedlings Natural Regeneration

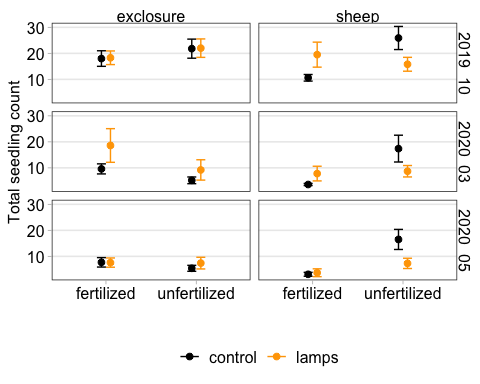
## Setup and data structuring

Loads libraries, sets up custom theme for ggplot, and reads in data (code not printed)

For summary richness and cout analyses, need to make sure block and plotid are being treated as factors ## Total seedlings count Summary for plotting total and richness (code not printed)

Summary for analyzing total and richness (code not printed)

### Total seedling count plot



### Total seedling analysis

#### With time

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| grazing | -5.8 | -12, 0.48 | 0.073 |
| nutrient | 2.1 | -4.2, 8.4 | 0.5 |
| light | 3.3 | -2.5, 9.1 | 0.3 |
| month |  |  |  |
| 2019\_10 |  |  |  |
| 2020\_03 | -8.2 | -12, -4.2 | <0.001 |
| 2020\_05 | -12 | -16, -7.7 | <0.001 |
| 2020\_06 | -17 | -21, -13 | <0.001 |
| grazing \* nutrient | 12 | 3.5, 20 | 0.007 |
| grazing \* light | 0.23 | -7.8, 8.2 | >0.9 |
| grazing \* month |  |  |  |
| sheep \* 2020\_03 | 0.80 | -3.1, 4.7 | 0.7 |
| sheep \* 2020\_05 | 2.7 | -1.2, 6.6 | 0.2 |
| sheep \* 2020\_06 | 3.6 | -0.33, 7.5 | 0.074 |
| nutrient \* light | -1.9 | -9.9, 6.1 | 0.6 |
| nutrient \* month |  |  |  |
| unfertilized \* 2020\_03 | -4.5 | -8.5, -0.62 | 0.024 |
| unfertilized \* 2020\_05 | -1.1 | -5.1, 2.8 | 0.6 |
| unfertilized \* 2020\_06 | -2.3 | -6.2, 1.6 | 0.3 |
| light \* month |  |  |  |
| lamps \* 2020\_03 | 2.2 | -1.8, 6.1 | 0.3 |
| lamps \* 2020\_05 | -1.6 | -5.6, 2.3 | 0.4 |
| lamps \* 2020\_06 | 0.46 | -3.5, 4.4 | 0.8 |
| grazing \* nutrient \* light | -9.1 | -21, 2.6 | 0.13 |

Looking at October and March time points as 1. separate models or 2. a combined sum. I think we can make the argument that if we do it this way we won’t need time series analyses since we expect Oct seedlings to have died or grown by March, mostly not resampling the same individuals. But there are other approaches to this that use the time series angle.

#### Fall only

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| grazing | -7.4 | -16, 1.6 | 0.11 |
| nutrient | 3.8 | -5.2, 13 | 0.4 |
| light | 0.30 | -8.7, 9.3 | >0.9 |
| grazing \* nutrient | 11 | -1.3, 24 | 0.082 |
| grazing \* light | 8.6 | -4.2, 21 | 0.2 |
| nutrient \* light | -0.10 | -13, 13 | >0.9 |
| grazing \* nutrient \* light | -19 | -37, -0.87 | 0.044 |

#### Spring only

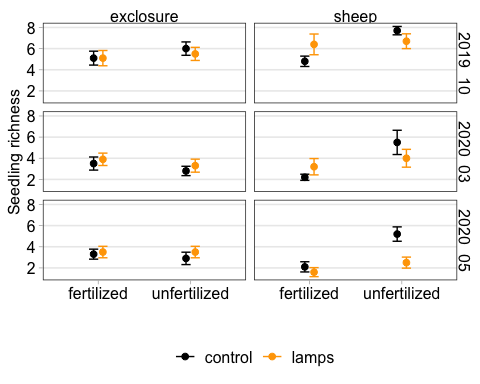
|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| grazing | -6.0 | -15, 3.4 | 0.2 |
| nutrient | -4.4 | -14, 5.0 | 0.4 |
| light | 9.0 | -0.38, 18 | 0.065 |
| grazing \* nutrient | 18 | 4.9, 31 | 0.009 |
| grazing \* light | -4.8 | -18, 8.5 | 0.5 |
| nutrient \* light | -5.0 | -18, 8.3 | 0.5 |
| grazing \* nutrient \* light | -7.9 | -27, 11 | 0.4 |

#### Both combined

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| grazing | -11 | -26, 3.6 | 0.14 |
| nutrient | 2.4 | -13, 18 | 0.8 |
| light | 8.5 | -6.5, 23 | 0.3 |
| grazing \* nutrient | 28 | 6.0, 49 | 0.015 |
| grazing \* light | 3.5 | -18, 25 | 0.7 |
| nutrient \* light | -4.3 | -26, 17 | 0.7 |
| grazing \* nutrient \* light | -26 | -57, 4.2 | 0.095 |

## Seedling richness

### Seedling richness plot



### Seedling richness analysis

#### With time

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| grazing | -0.10 | -1.3, 1.1 | 0.9 |
| nutrient | 0.30 | -0.91, 1.5 | 0.6 |
| light | 0.31 | -0.87, 1.5 | 0.6 |
| month |  |  |  |
| 2019\_10 |  |  |  |
| 2020\_03 | -1.9 | -2.9, -0.89 | <0.001 |
| 2020\_05 | -1.7 | -2.7, -0.72 | <0.001 |
| 2020\_06 | -4.3 | -5.3, -3.3 | <0.001 |
| grazing \* nutrient | 2.7 | 1.2, 4.2 | <0.001 |
| grazing \* light | 0.38 | -1.1, 1.8 | 0.6 |
| grazing \* month |  |  |  |
| sheep \* 2020\_03 | -0.62 | -1.6, 0.38 | 0.2 |
| sheep \* 2020\_05 | -1.4 | -2.4, -0.42 | 0.006 |
| sheep \* 2020\_06 | -0.57 | -1.6, 0.43 | 0.3 |
| nutrient \* light | -0.12 | -1.6, 1.3 | 0.9 |
| nutrient \* month |  |  |  |
| unfertilized \* 2020\_03 | -0.42 | -1.4, 0.58 | 0.4 |
| unfertilized \* 2020\_05 | -0.22 | -1.2, 0.78 | 0.7 |
| unfertilized \* 2020\_06 | -0.37 | -1.4, 0.63 | 0.5 |
| light \* month |  |  |  |
| lamps \* 2020\_03 | 0.12 | -0.89, 1.1 | 0.8 |
| lamps \* 2020\_05 | -0.58 | -1.6, 0.43 | 0.3 |
| lamps \* 2020\_06 | 0.12 | -0.89, 1.1 | 0.8 |
| grazing \* nutrient \* light | -1.8 | -3.9, 0.27 | 0.092 |

#### Fall only

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic** | **log(IRR)** | **95% CI** | **p-value** |
| grazing | -0.06 | -0.45, 0.33 | 0.8 |
| nutrient | 0.16 | -0.21, 0.54 | 0.4 |
| light | 0.00 | -0.39, 0.39 | >0.9 |
| grazing \* nutrient | 0.31 | -0.21, 0.83 | 0.2 |
| grazing \* light | 0.29 | -0.25, 0.83 | 0.3 |
| nutrient \* light | -0.09 | -0.62, 0.45 | 0.7 |
| grazing \* nutrient \* light | -0.34 | -1.1, 0.39 | 0.4 |

#### Spring only

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic** | **log(IRR)** | **95% CI** | **p-value** |
| grazing | -0.46 | -1.00, 0.07 | 0.087 |
| nutrient | -0.22 | -0.72, 0.27 | 0.4 |
| light | 0.11 | -0.35, 0.56 | 0.6 |
| grazing \* nutrient | 1.1 | 0.44, 1.8 | 0.001 |
| grazing \* light | 0.27 | -0.44, 0.97 | 0.5 |
| nutrient \* light | 0.06 | -0.62, 0.73 | 0.9 |
| grazing \* nutrient \* light | -0.75 | -1.7, 0.21 | 0.12 |

#### Both combined

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic** | **log(IRR)** | **95% CI** | **p-value** |
| grazing | -0.19 | -0.51, 0.12 | 0.2 |
| nutrient | 0.12 | -0.17, 0.42 | 0.4 |
| light | 0.05 | -0.25, 0.34 | 0.8 |
| grazing \* nutrient | 0.60 | 0.18, 1.0 | 0.005 |
| grazing \* light | 0.27 | -0.16, 0.70 | 0.2 |
| nutrient \* light | -0.05 | -0.46, 0.37 | 0.8 |
| grazing \* nutrient \* light | -0.48 | -1.1, 0.10 | 0.10 |

#### April/May

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic** | **log(IRR)** | **95% CI** | **p-value** |
| grazing | -0.45 | -1.00, 0.09 | 0.10 |
| nutrient | -0.13 | -0.63, 0.37 | 0.6 |
| light | 0.06 | -0.42, 0.53 | 0.8 |
| grazing \* nutrient | 1.0 | 0.33, 1.7 | 0.004 |
| grazing \* light | -0.33 | -1.1, 0.47 | 0.4 |
| nutrient \* light | 0.13 | -0.55, 0.81 | 0.7 |
| grazing \* nutrient \* light | -0.59 | -1.6, 0.47 | 0.3 |

## Seedling Traits

For the trait analyses we will look at the data sliced a slightly different way–the max number of seedlings per species across the time points (peak emergence for each species)

### Species traits abundance models

The data is overdispersed and/or zero-inflated. We want to try to put together a model format that seems reasonable before adding in the trait data. Using the ‘glmmTMB’ package, which is detailed in “glmmTMB Balances Speed and Flexibility Among Packages for Zero-inflated Generalized Linear Mixed Modeling” by Brooks et al 2017, and the AICtab() function in the ‘bblme’ package for convenient AIC comparisons of different models.

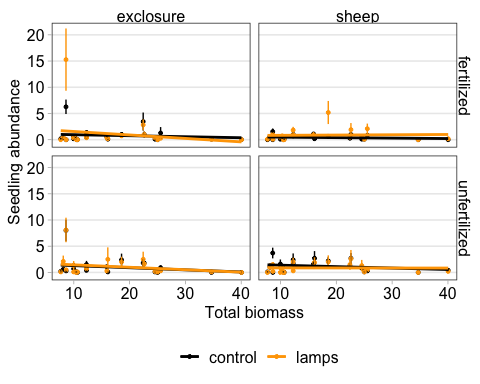
Options for model distrubtions are: Poisson, and negative binomial, as well as zero-inflated or hurdle models. Negative binomial is better than Poisson or the zero-inflated options (code included but not run)

Moving forward to the trait analyses. Running preliminary analyses for now with each trait separately. Could also consider models that include multiple traits, especially since most of the traits aren’t strongly correlated with each other.

For each trait, we are comparing five models: 0 – null model without the traits, with a random variable for species 1 – just the trait, no random variable for species 2 – trait and random variable for species full – all 2-way, 3-way, and 4-way interactions specific – 3-way interactions for grazing x light x trait and grazing x light x nutrients, which are the ones that are significant in some of the models.

Results below each model show the summary for the specific model, an AIC table comparing these options, and the under- or over-dispersion coefficient.

### Total biomass

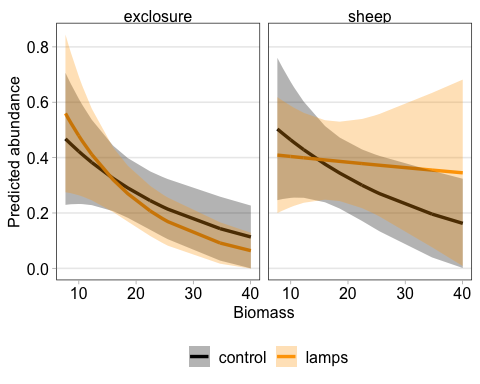
Preliminary plot of raw data 

Preliminary analysis of total biomass trait using a negative binomial distribution.

## Family: nbinom2 ( log )  
## Formula:   
## count.max ~ grazing \* nutrient + light + bm.tot + light \* grazing \*   
## bm.tot + light \* grazing \* nutrient + (1 | species) + (1 |   
## block:plotid)  
## Data: nat.seedlings.traits  
##   
## AIC BIC logLik deviance df.resid   
## 3618.9 3701.1 -1794.5 3588.9 1749   
##   
## Random effects:  
##   
## Conditional model:  
## Groups Name Variance Std.Dev.  
## species (Intercept) 2.1960 1.4819   
## block:plotid (Intercept) 0.2126 0.4611   
## Number of obs: 1764, groups: species, 21; block:plotid, 80  
##   
## Overdispersion parameter for nbinom2 family (): 0.547   
##   
## Conditional model:  
## Estimate Std. Error z value  
## (Intercept) -0.570288 0.766771 -0.744  
## grazingsheep -0.462032 0.445450 -1.037  
## nutrientunfertilized 0.314901 0.281631 1.118  
## lightlamps 0.371599 0.413202 0.899  
## bm.tot -0.043618 0.039841 -1.095  
## grazingsheep:nutrientunfertilized 0.819363 0.406056 2.018  
## grazingsheep:lightlamps -0.163276 0.606388 -0.269  
## lightlamps:bm.tot -0.022975 0.021173 -1.085  
## grazingsheep:bm.tot 0.009146 0.021211 0.431  
## nutrientunfertilized:lightlamps -0.036093 0.388629 -0.093  
## grazingsheep:lightlamps:bm.tot 0.052388 0.029274 1.790  
## grazingsheep:nutrientunfertilized:lightlamps -1.120730 0.565313 -1.982  
## Pr(>|z|)   
## (Intercept) 0.4570   
## grazingsheep 0.2996   
## nutrientunfertilized 0.2635   
## lightlamps 0.3685   
## bm.tot 0.2736   
## grazingsheep:nutrientunfertilized 0.0436 \*  
## grazingsheep:lightlamps 0.7877   
## lightlamps:bm.tot 0.2779   
## grazingsheep:bm.tot 0.6663   
## nutrientunfertilized:lightlamps 0.9260   
## grazingsheep:lightlamps:bm.tot 0.0735 .  
## grazingsheep:nutrientunfertilized:lightlamps 0.0474 \*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

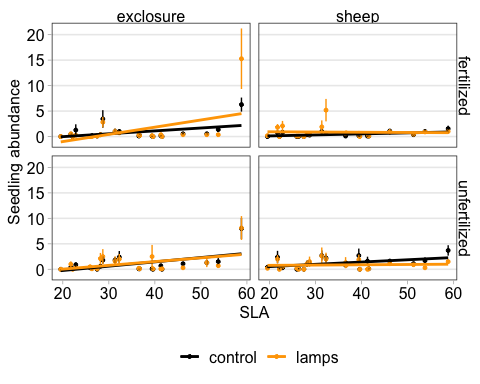
## dAIC df  
## m.biomass.specific 0.0 15  
## m.biomass.0 3.3 8   
## m.biomass.2 4.5 9   
## m.biomass.full 4.7 19  
## m.biomass.1 433.1 8

## [1] 0.8960955

Counterfactual plots (not including nutrients, since they don’t interact with the traits). Using re.form = NA to specific population-level predictions (setting all random effects to zero) 

### SLA

Preliminary plot of raw data

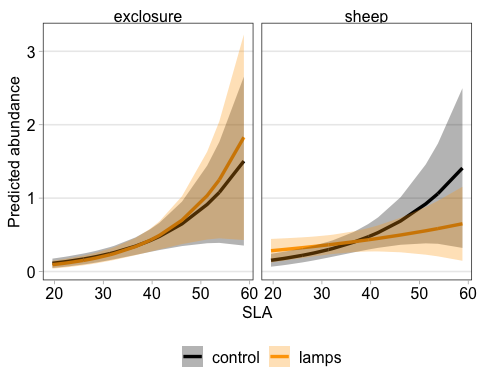


Preliminary analysis of SLA

## dAIC df  
## m.sla.specific 0.0 15  
## m.sla.full 5.1 19  
## m.sla.2 15.5 9   
## m.sla.0 17.1 8   
## m.sla.1 386.4 8

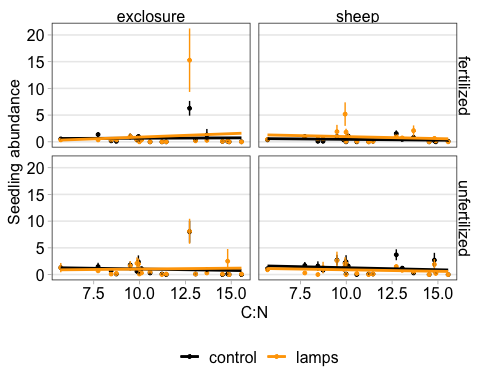
## [1] 0.9028797

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristic** | **Beta** | **95% CI** | **p-value** |
| grazing | 0.03 | -1.0, 1.1 | >0.9 |
| nutrient | 0.31 | -0.25, 0.87 | 0.3 |
| light | -0.36 | -1.4, 0.67 | 0.5 |
| sla.2 | 0.07 | 0.01, 0.12 | 0.023 |
| grazing \* nutrient | 0.82 | 0.01, 1.6 | 0.046 |
| grazing \* light | 2.3 | 0.80, 3.8 | 0.003 |
| light \* sla.2 | 0.01 | -0.01, 0.03 | 0.4 |
| grazing \* sla.2 | -0.01 | -0.03, 0.01 | 0.4 |
| nutrient \* light | 0.01 | -0.77, 0.78 | >0.9 |
| grazing \* light \* sla.2 | -0.04 | -0.08, -0.01 | 0.009 |
| grazing \* nutrient \* light | -1.2 | -2.3, -0.03 | 0.044 |
| sd\_\_(Intercept) | 1.4 | 0.36, 0.64 |  |
| sd\_\_(Intercept) | 0.48 | 0.48, 0.67 |  |

Counterfactual plots (not including nutrients, since they don’t interact with the traits). Using re.form = NA to specific population-level predictions (setting all random effects to zero) 

### C:N

Preliminary plot of raw data

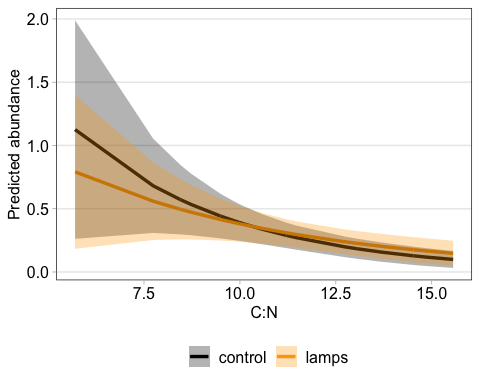
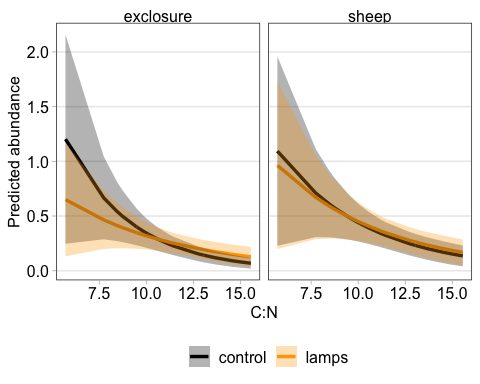


Preliminary analysis of C:N. Here there are two specific models, a includes the 3-way interaction between light, grazing, and C:N (which is not significant, but is consistent with the other models above. Also the light x C:N interaction is significant) and b which drops this interaction but then also loses the significance of the light x C:N interaction (but has a better AIC value). Really it’s a question of how we want to present/evaluate models–one option is to keep the same “specific” format for all traits, the other is to select it individually for each trait. Also if we are evaluating models based on their predicted significant interactions or on the AIC comparisons.

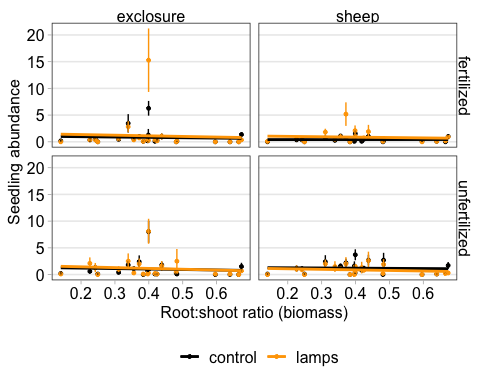
## Family: nbinom2 ( log )  
## Formula: count.max ~ grazing \* nutrient + light + c.n.ratio + light \*   
## grazing \* c.n.ratio + grazing \* nutrient \* light + (1 | species) +   
## (1 | block:plotid)  
## Data: nat.seedlings.traits  
##   
## AIC BIC logLik deviance df.resid   
## 3313.5 3394.9 -1641.7 3283.5 1665   
##   
## Random effects:  
##   
## Conditional model:  
## Groups Name Variance Std.Dev.  
## species (Intercept) 2.0498 1.4317   
## block:plotid (Intercept) 0.2771 0.5264   
## Number of obs: 1680, groups: species, 20; block:plotid, 80  
##   
## Overdispersion parameter for nbinom2 family (): 0.575   
##   
## Conditional model:  
## Estimate Std. Error z value  
## (Intercept) 1.63139 1.51901 1.074  
## grazingsheep -0.91280 0.71879 -1.270  
## nutrientunfertilized 0.40667 0.30825 1.319  
## lightlamps -1.31714 0.73069 -1.803  
## c.n.ratio -0.28862 0.13353 -2.161  
## grazingsheep:nutrientunfertilized 0.71482 0.44219 1.616  
## grazingsheep:lightlamps 1.65312 1.00994 1.637  
## lightlamps:c.n.ratio 0.12507 0.06202 2.017  
## grazingsheep:c.n.ratio 0.07549 0.06162 1.225  
## nutrientunfertilized:lightlamps -0.01409 0.42316 -0.033  
## grazingsheep:lightlamps:c.n.ratio -0.08985 0.08558 -1.050  
## grazingsheep:nutrientunfertilized:lightlamps -1.21406 0.61467 -1.975  
## Pr(>|z|)   
## (Intercept) 0.2828   
## grazingsheep 0.2041   
## nutrientunfertilized 0.1871   
## lightlamps 0.0715 .  
## c.n.ratio 0.0307 \*  
## grazingsheep:nutrientunfertilized 0.1060   
## grazingsheep:lightlamps 0.1017   
## lightlamps:c.n.ratio 0.0437 \*  
## grazingsheep:c.n.ratio 0.2205   
## nutrientunfertilized:lightlamps 0.9734   
## grazingsheep:lightlamps:c.n.ratio 0.2938   
## grazingsheep:nutrientunfertilized:lightlamps 0.0483 \*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

## dAIC df  
## m.cn.specific.b 0.0 13  
## m.cn.specific.a 2.4 15  
## m.cn.2 2.7 9   
## m.cn.full 7.6 19  
## m.cn.0 311.2 8   
## m.cn.1 459.8 8

## [1] 0.8488508

Counterfactual plots 

### Root-shoot ratio

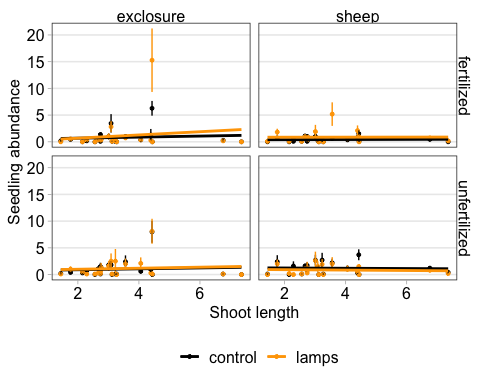
Preliminary plot of raw data 

## Family: nbinom2 ( log )  
## Formula:   
## count.max ~ grazing \* nutrient + light + rt.sh.bm + light \* grazing \*   
## rt.sh.bm + grazing \* nutrient \* light + (1 | species) + (1 |   
## block:plotid)  
## Data: nat.seedlings.traits  
##   
## AIC BIC logLik deviance df.resid   
## 3623.6 3705.7 -1796.8 3593.6 1749   
##   
## Random effects:  
##   
## Conditional model:  
## Groups Name Variance Std.Dev.  
## species (Intercept) 2.2329 1.4943   
## block:plotid (Intercept) 0.2155 0.4643   
## Number of obs: 1764, groups: species, 21; block:plotid, 80  
##   
## Overdispersion parameter for nbinom2 family (): 0.538   
##   
## Conditional model:  
## Estimate Std. Error z value  
## (Intercept) -0.35270 1.09730 -0.321  
## grazingsheep -1.04020 0.56717 -1.834  
## nutrientunfertilized 0.32163 0.28354 1.134  
## lightlamps 0.28396 0.56096 0.506  
## rt.sh.bm -2.33316 2.51423 -0.928  
## grazingsheep:nutrientunfertilized 0.81477 0.40854 1.994  
## grazingsheep:lightlamps 0.87828 0.80317 1.093  
## lightlamps:rt.sh.bm -0.65264 1.26070 -0.518  
## grazingsheep:rt.sh.bm 1.81416 1.20034 1.511  
## nutrientunfertilized:lightlamps -0.03474 0.39094 -0.089  
## grazingsheep:lightlamps:rt.sh.bm -0.47120 1.75116 -0.269  
## grazingsheep:nutrientunfertilized:lightlamps -1.13411 0.56871 -1.994  
## Pr(>|z|)   
## (Intercept) 0.7479   
## grazingsheep 0.0667 .  
## nutrientunfertilized 0.2566   
## lightlamps 0.6127   
## rt.sh.bm 0.3534   
## grazingsheep:nutrientunfertilized 0.0461 \*  
## grazingsheep:lightlamps 0.2742   
## lightlamps:rt.sh.bm 0.6047   
## grazingsheep:rt.sh.bm 0.1307   
## nutrientunfertilized:lightlamps 0.9292   
## grazingsheep:lightlamps:rt.sh.bm 0.7879   
## grazingsheep:nutrientunfertilized:lightlamps 0.0461 \*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

## dAIC df  
## m.rt.sh.bm.0 0.0 8   
## m.rt.sh.bm.specific 1.3 15  
## m.rt.sh.bm.2 1.4 9   
## m.rt.sh.bm.full 8.7 19  
## m.rt.sh.bm.1 451.5 8

## [1] 0.8786404

### Shoot length

Preliminary plot of raw data 

## Family: nbinom2 ( log )  
## Formula:   
## count.max ~ grazing \* nutrient + light + len.sh + light \* grazing \*   
## len.sh + grazing \* nutrient \* light + (1 | species) + (1 |   
## block:plotid)  
## Data: nat.seedlings.traits  
##   
## AIC BIC logLik deviance df.resid   
## 3626.7 3708.8 -1798.3 3596.7 1749   
##   
## Random effects:  
##   
## Conditional model:  
## Groups Name Variance Std.Dev.  
## species (Intercept) 2.3041 1.518   
## block:plotid (Intercept) 0.2181 0.467   
## Number of obs: 1764, groups: species, 21; block:plotid, 80  
##   
## Overdispersion parameter for nbinom2 family (): 0.534   
##   
## Conditional model:  
## Estimate Std. Error z value  
## (Intercept) -0.87069 0.94562 -0.921  
## grazingsheep -0.73703 0.51013 -1.445  
## nutrientunfertilized 0.31407 0.28444 1.104  
## lightlamps -0.40446 0.52609 -0.769  
## len.sh -0.12723 0.25249 -0.504  
## grazingsheep:nutrientunfertilized 0.82357 0.41023 2.008  
## grazingsheep:lightlamps 1.00606 0.70715 1.423  
## lightlamps:len.sh 0.12500 0.12995 0.962  
## grazingsheep:len.sh 0.12638 0.12303 1.027  
## nutrientunfertilized:lightlamps -0.01540 0.39246 -0.039  
## grazingsheep:lightlamps:len.sh -0.09482 0.16923 -0.560  
## grazingsheep:nutrientunfertilized:lightlamps -1.15585 0.57108 -2.024  
## Pr(>|z|)   
## (Intercept) 0.3572   
## grazingsheep 0.1485   
## nutrientunfertilized 0.2695   
## lightlamps 0.4420   
## len.sh 0.6143   
## grazingsheep:nutrientunfertilized 0.0447 \*  
## grazingsheep:lightlamps 0.1548   
## lightlamps:len.sh 0.3361   
## grazingsheep:len.sh 0.3043   
## nutrientunfertilized:lightlamps 0.9687   
## grazingsheep:lightlamps:len.sh 0.5753   
## grazingsheep:nutrientunfertilized:lightlamps 0.0430 \*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

## dAIC df  
## m.len.sh.0 0.0 8   
## m.len.sh.2 2.0 9   
## m.len.sh.specific 4.4 15  
## m.len.sh.full 9.9 19  
## m.len.sh.1 452.9 8

## [1] 0.8821429

### Trying combining trait models

I tried combining traits into a single model. The models do fine and the results are basically the same, so I think it’s fine to stick with separate models for now (because they’re simpler and more convenient to present results from) and keep this in case reviewers ask for it.

## dAIC df  
## m.sla.cn 0.0 19  
## m.all.traits 0.3 23  
## m.cn 22.2 15  
## m.sla 314.0 15  
## m.biomass 327.7 15

## Family: nbinom2 ( log )  
## Formula:   
## count.max ~ grazing \* nutrient + light + light \* grazing \* nutrient +   
## light \* grazing \* bm.tot + light \* grazing \* sla.2 + light \*   
## grazing \* c.n.ratio + (1 | species) + (1 | block:plotid)  
## Data: nat.seedlings.traits  
##   
## AIC BIC logLik deviance df.resid   
## 3291.6 3416.4 -1622.8 3245.6 1657   
##   
## Random effects:  
##   
## Conditional model:  
## Groups Name Variance Std.Dev.  
## species (Intercept) 1.6764 1.2947   
## block:plotid (Intercept) 0.2891 0.5377   
## Number of obs: 1680, groups: species, 20; block:plotid, 80  
##   
## Overdispersion parameter for nbinom2 family (): 0.653   
##   
## Conditional model:  
## Estimate Std. Error z value  
## (Intercept) -1.617545 2.083577 -0.776  
## grazingsheep -0.122675 1.064143 -0.115  
## nutrientunfertilized 0.395262 0.308117 1.283  
## lightlamps -0.890238 1.065359 -0.836  
## bm.tot -0.009031 0.041665 -0.217  
## sla.2 0.063844 0.030387 2.101  
## c.n.ratio -0.186235 0.134417 -1.386  
## grazingsheep:nutrientunfertilized 0.715222 0.440908 1.622  
## grazingsheep:lightlamps 2.774375 1.460992 1.899  
## nutrientunfertilized:lightlamps 0.034700 0.426168 0.081  
## lightlamps:bm.tot -0.040625 0.026998 -1.505  
## grazingsheep:bm.tot 0.013387 0.025024 0.535  
## lightlamps:sla.2 0.003429 0.013431 0.255  
## grazingsheep:sla.2 -0.015387 0.013730 -1.121  
## lightlamps:c.n.ratio 0.121400 0.062123 1.954  
## grazingsheep:c.n.ratio 0.035122 0.061917 0.567  
## grazingsheep:nutrientunfertilized:lightlamps -1.196593 0.615063 -1.946  
## grazingsheep:lightlamps:bm.tot 0.052065 0.034744 1.498  
## grazingsheep:lightlamps:sla.2 -0.036018 0.019083 -1.888  
## grazingsheep:lightlamps:c.n.ratio -0.143347 0.086244 -1.662  
## Pr(>|z|)   
## (Intercept) 0.4376   
## grazingsheep 0.9082   
## nutrientunfertilized 0.1996   
## lightlamps 0.4034   
## bm.tot 0.8284   
## sla.2 0.0356 \*  
## c.n.ratio 0.1659   
## grazingsheep:nutrientunfertilized 0.1048   
## grazingsheep:lightlamps 0.0576 .  
## nutrientunfertilized:lightlamps 0.9351   
## lightlamps:bm.tot 0.1324   
## grazingsheep:bm.tot 0.5927   
## lightlamps:sla.2 0.7985   
## grazingsheep:sla.2 0.2624   
## lightlamps:c.n.ratio 0.0507 .  
## grazingsheep:c.n.ratio 0.5706   
## grazingsheep:nutrientunfertilized:lightlamps 0.0517 .  
## grazingsheep:lightlamps:bm.tot 0.1340   
## grazingsheep:lightlamps:sla.2 0.0591 .  
## grazingsheep:lightlamps:c.n.ratio 0.0965 .  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1