

More BCI plots with modeled light values

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I. Estimate total light received

We need to estimate the total light received by each tree to make the energy equivalence plot for light received to juxtapose with biomass produced. To do this, I used the allometric equation from Bohlman and O'Brien to get an estimate of the area of each crown as a horizontal disk, given diameter: $r_{crown} = e^{-0.438+0.658 \ln d}$, so $A_{crown} = \pi r_{crown}^2$. I multiplied this by the percent relative irradiance p_{light} . This quantity, $A_{crown}p_{light}$, gives a measure of the effective area in square meters of the crown receiving full light. In other words if the crown area is 10 square meters and the relative irradiance is 30%, that tree is getting an equivalent of 3 square meters of PAR. Then, I multiplied that by the average insolation of BCI (just a rough approximation to put the answer into correct units of W). The source of the approximation is "Analytical solution to a simple climate model with diffusive heat transport" (North 1975, J. Atmos. Sci.) It comes out to 418 W/m^2 , a very rough value. The crude estimate of light energy received by each tree is thus $418 A_{crown}p_{light}$, in units of W.

I grouped the trees into three groups, low, intermediate, and high light received, by the percentage of full light they received. So depending on the tree's crown area, two trees in the same group could have very different amounts of total energy received. Some of the figures below are based on these light groups.

```
# Function to get a rough approximation of insolation by latitude.

insolation <- function(lat) {
  lat <- lat * pi/180 # to radians
  y <- sin(lat)
  0.25 * 1367 * (1 - 0.482 * (3*y^2 - 1)/2)
}

# Insolation at BCI, 9.2 degrees N
(insol_bci <- insolation(9.2))

## [1] 417.7958

# Function to get tree height and crown dimensions from dbh
# Use same parameters for all trees, taken from Bohlman and O'Brien

tp <- function(dbh) {
  h <- exp(.438 + .595 * log(dbh)) # Height
  cd <- exp(-.157 + .702 * log(dbh)) # Crown depth
  cr <- exp(-.438 + .658 * log(dbh)) # Crown radius
  cV <- exp(-.681 + 2.02 * log(dbh)) # Crown volume
  data.frame(h=h, cd=cd, cr=cr, cV=cV)
}

crowndim <- tp(bcicensusdat$dbh)
bcicensusdat$crownarea <- pi * crowndim$cr^2
bcicensusdat <- transform(bcicensusdat, light_received = light * crownarea * insol_bci)

# Classification of light into 3 groups.
# This is percent of full irradiance, not the total light received.
```

```

light_groups <- cut(bcicensusdat$light, breaks = 3)
table(light_groups)

## light_groups
## (0.00152,0.331] (0.331,0.659] (0.659,0.988]
##          143289          5673          1578

light_groupcodes <- factor(light_groups,
                           labels = c('Low light', 'Intermediate light', 'High light'))

bcicensusdat$light_group <- light_groupcodes

alltreedat <- subset(bcicensusdat,
                    !is.na(dbh) & production34 > 0 & !is.na(light))
shadedat <- subset(bcicensusdat,
                  !is.na(dbh) & production34 > 0 & !is.na(light) & tol_wright == 'S')
intdat <- subset(bcicensusdat,
                !is.na(dbh) & production34 > 0 & !is.na(light) & tol_wright == 'I')
gapdat <- subset(bcicensusdat,
                !is.na(dbh) & production34 > 0 & !is.na(light) & tol_wright == 'G')

```

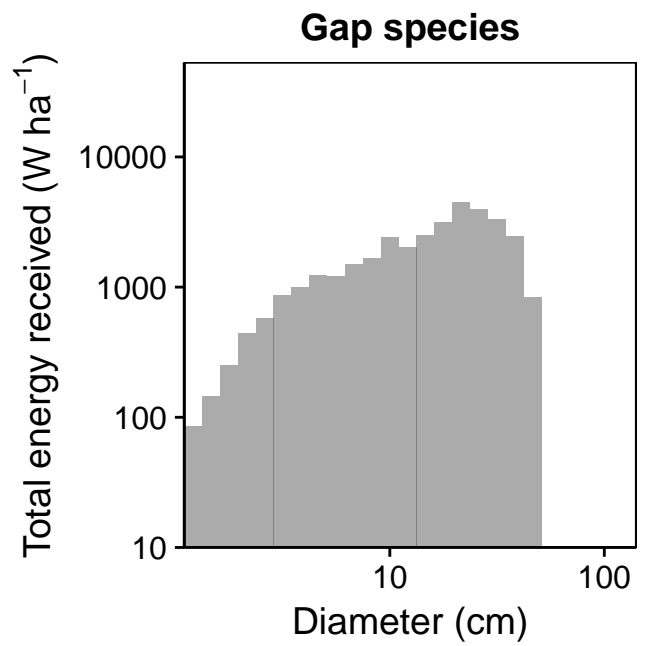
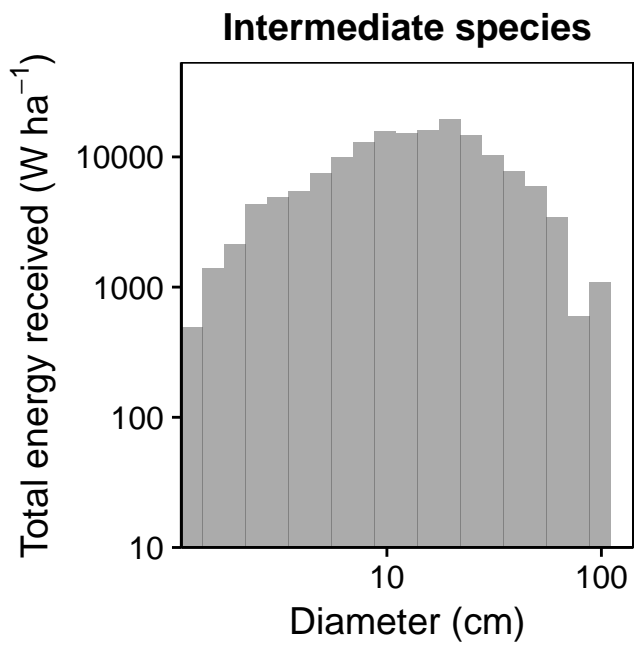
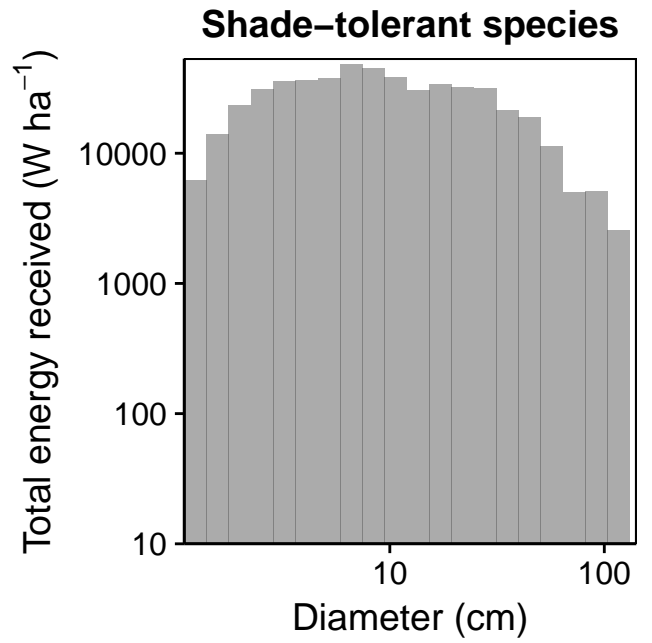
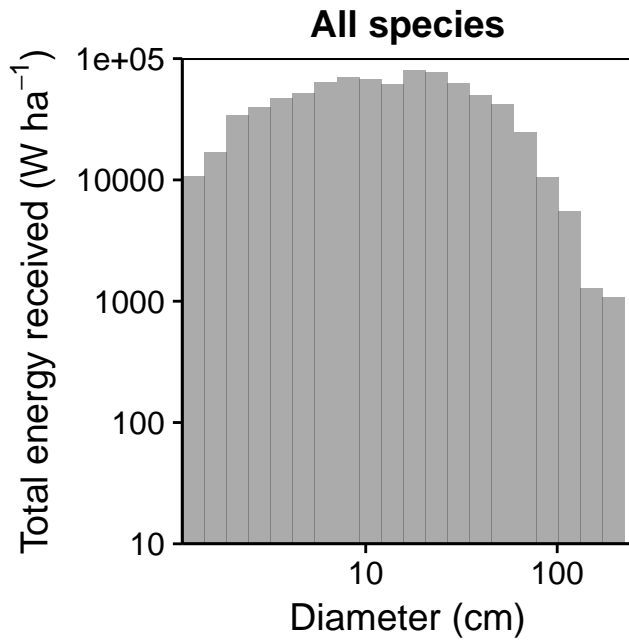
II. Plots of total energy received by shade-tolerance group

Compare these with the energy-equivalence plots (total production by shade-tolerance group). These should represent the inputs of energy per hectare to each size class within each shade-tolerance group. I also plotted it for the entire BCI plot. The three groups are on the same x- and y-axis limits but the plot of all trees is on a different set of axes.

```
# Run binning algorithm.

numbins <- 20 # Can be edited if desired. ***NOT JUST FOR LOOKS***

# Log bins
bci_par_logbin_all <- with(alltreedat,
                           logbin(x=dbh, y=light_received, n=numbins))
bci_par_logbin_shade <- with(shadedat,
                             logbin(x=dbh, y=light_received, n=numbins))
bci_par_logbin_inter <- with(intdat,
                             logbin(x=dbh, y=light_received, n=numbins))
bci_par_logbin_gap <- with(gapdat,
                           logbin(x=dbh, y=light_received, n=numbins))
```



III. 3x3 density scaling by light group vs. shade tolerance group

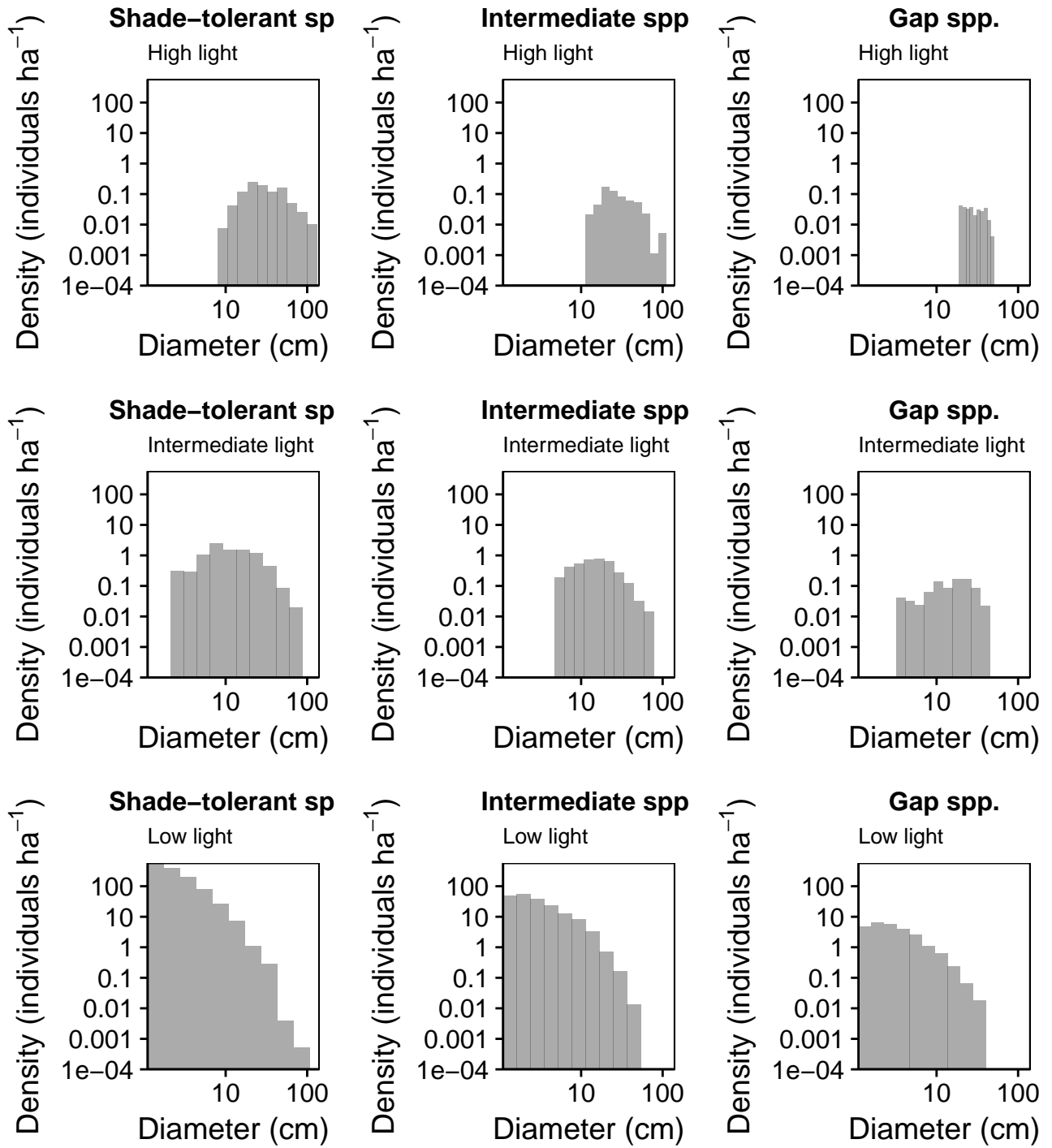
Here, I only did 10 bins per plot because of the low numbers of individuals especially in the gap specialist/high light group. However, for this plot, the binning is only for visualization purposes and does not enter into the analysis as it does for the energy equivalence plots. This plot was envisioned as a stacked bar plot but since we need to plot the y-axis on a logarithmic scale, this was not possible. It could also be done as a grouped bar plot.

```
# Run binning algorithm for density scaling in the 9 groups.
numbins <- 10 # only for visualizing

shade_lowlight_bin <- with(subset(shadedat, light_group == 'Low light'),
                           logbin(x=dbh, y=NULL, n = numbins))
shade_intlight_bin <- with(subset(shadedat, light_group == 'Intermediate light'),
                           logbin(x=dbh, y=NULL, n = numbins))
shade_highlight_bin <- with(subset(shadedat, light_group == 'High light'),
                           logbin(x=dbh, y=NULL, n = numbins))

int_lowlight_bin <- with(subset(intdat, light_group == 'Low light'),
                        logbin(x=dbh, y=NULL, n = numbins))
int_intlight_bin <- with(subset(intdat, light_group == 'Intermediate light'),
                        logbin(x=dbh, y=NULL, n = numbins))
int_highlight_bin <- with(subset(intdat, light_group == 'High light'),
                        logbin(x=dbh, y=NULL, n = numbins))

gap_lowlight_bin <- with(subset(gapdat, light_group == 'Low light'),
                        logbin(x=dbh, y=NULL, n = numbins))
gap_intlight_bin <- with(subset(gapdat, light_group == 'Intermediate light'),
                        logbin(x=dbh, y=NULL, n = numbins))
gap_highlight_bin <- with(subset(gapdat, light_group == 'High light'),
                        logbin(x=dbh, y=NULL, n = numbins))
```



IV. Best-fit lines of proportion abundance as a function of light received for each shade tolerance group

Here the scales are log-log as usual.

log-log plot as usual

```
abund_prop_dat <- rbind(transform(bci_par_logbin_shade,
                                proportion = bin_count/sum(bin_count), tolerance = 'shade'),
                        transform(bci_par_logbin_inter,
                                proportion = bin_count/sum(bin_count), tolerance = 'intermediate'),
                        transform(bci_par_logbin_gap,
                                proportion = bin_count/sum(bin_count), tolerance = 'gap'))

ggplot(abund_prop_dat, aes(x = bin_midpoint, y = proportion, group = tolerance, color = tolerance)) +
  geom_point() +
  scale_x_log10(name = 'Diameter (cm)') + scale_y_log10(name = 'Proportion abundance') +
  geom_smooth(method = lm, se = FALSE)
```

