Growth_mort

Carmen

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Next step: Consider adding CEIN to the initialization even though there isn't any in the American River footprint

This script runs simulations with the most up-to-date functions

Define parameters

```
fire <- "AMRC"
year <- "2016"
years <- 20
iterations <- 100
max_shrub_ht_cm <- 250
max_shrub_ht_years <- 15
n_seedlings <- 100
length_m <- 40
height_m <- 40
lambda <- 4
shrub_clumpiness <- 7
```

Load functions

Create shrub patch

```
source("functions/shrubclump.R")
```

Initialization function

```
source("functions/initialize.R")
```

Height growth functions

```
source("functions/abcogrowth.R")
source("functions/pipogrowth.R")
```

Diameter growth functions

```
source("functions/abcodia.R")
source("functions/pipodia.R")
```

Mortality functions

```
source("functions/abcomort.R")
source("functions/pipomort.R")
```

Shrub growth functions

```
source("functions/abco_shrubgrowth.R")
source("functions/pipo_shrubgrowth.R")
```

Simulation function

```
source("functions/sim.R")
```

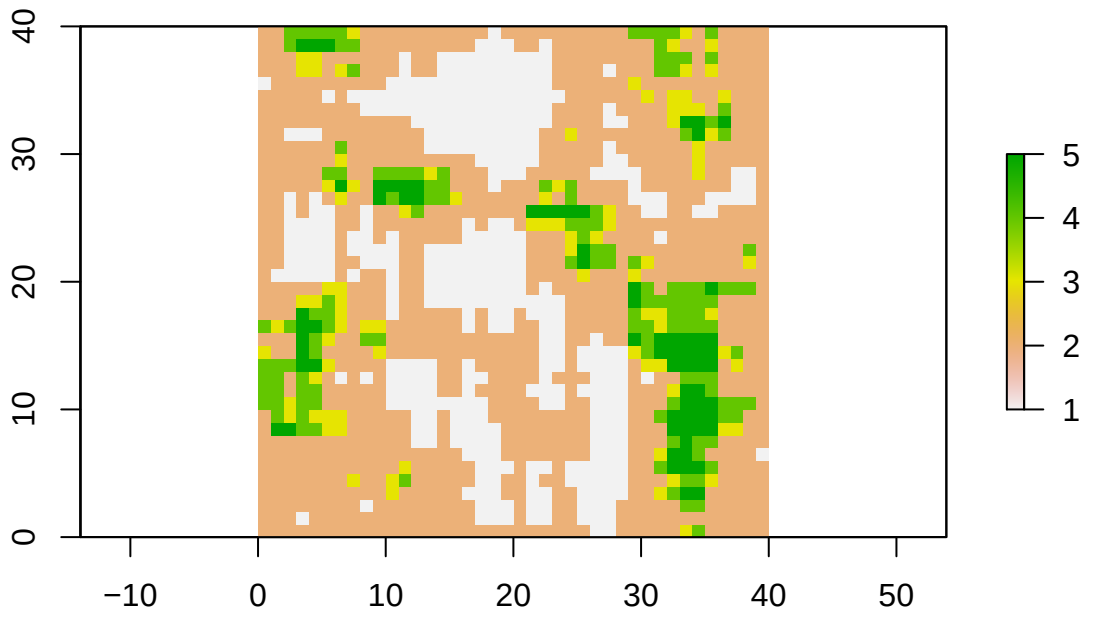
Iteration function

```
source("functions/iterate.R")
```

Initialize

Create clumped shrub pattern

```
shrubclump()
plot(r)
```



Randomly select seedlings from data and place them on the shrub patch

```
initialize()
```

```
## Joining, by = "ID"
```

```
## Joining, by = "Sdlg"
```

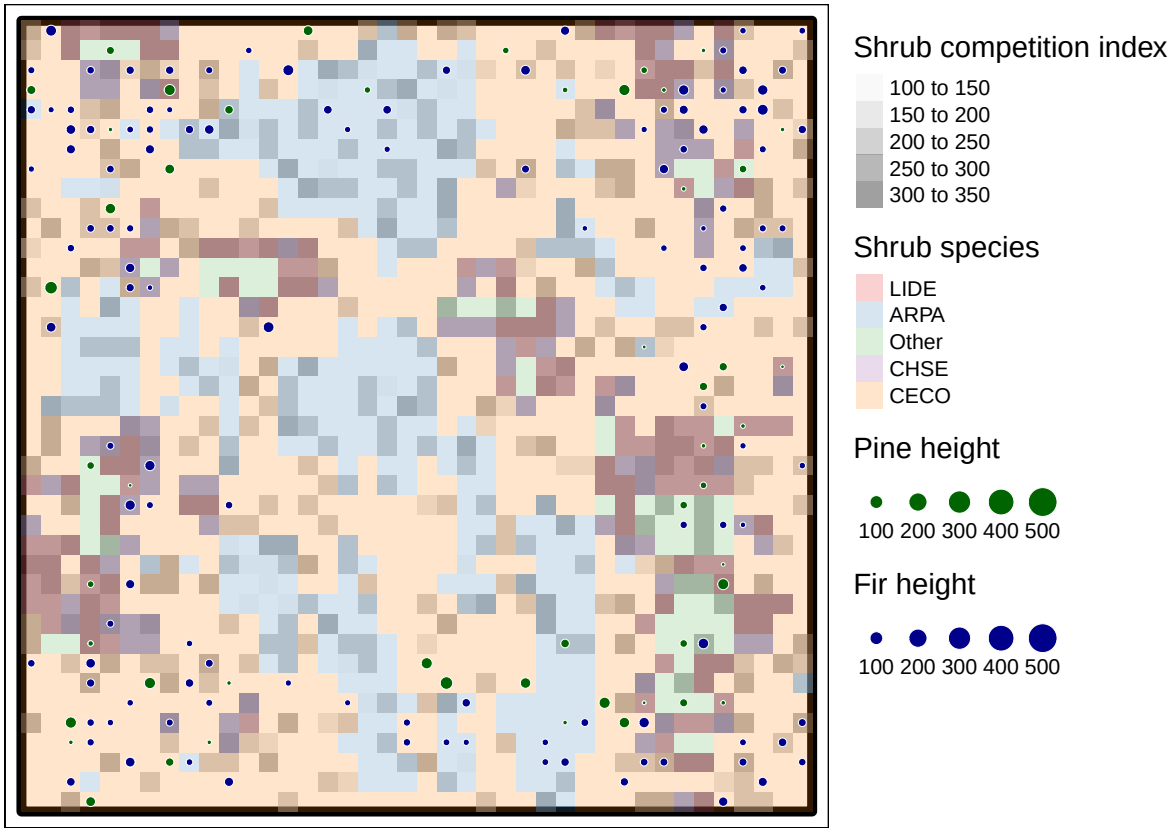
```
## Warning: Column `Sdlg` joining factors with different levels, coercing to
## character vector
```

Plot patch with seedlings

```
max_shrub <- max(r@data@attributes[[1]]$sqrt_shrubarea3)
r@data@attributes[[1]]$shrub_rel <- r@data@attributes[[1]]$sqrt_shrubarea3/max_shrub
```

```
pts.sf.pipo.graph <- pts.sf.pipo %>%
  rename("Pine height" = Ht_cm1)
pts.sf.abco.graph <- pts.sf.abco %>%
  rename("Fir height" = Ht_cm1)
```

```
tm_shape(p)+
  tm_borders(col = "black", lwd= 5)+
tm_shape(r)+
  tm_raster(col = "sqrt_shrubarea3", title = "Shrub competition index", palette = "Greys", alpha = .5)+
tm_shape(r)+
  tm_raster(col = "ShrubSpp03", alpha = .2, title = "Shrub species", palette = "Set1")+
  tm_layout(asp=1:1, legend.outside = T)+
tm_shape(pts.sf.pipo.graph)+
  tm_symbols(size = "Pine height", col = "darkgreen", size.max = 500, border.col = "white", border.lwd =
tm_shape(pts.sf.abco.graph)+
  tm_symbols(size = "Fir height", col = "darkblue", size.max = 500, border.col = "white", border.lwd =
```

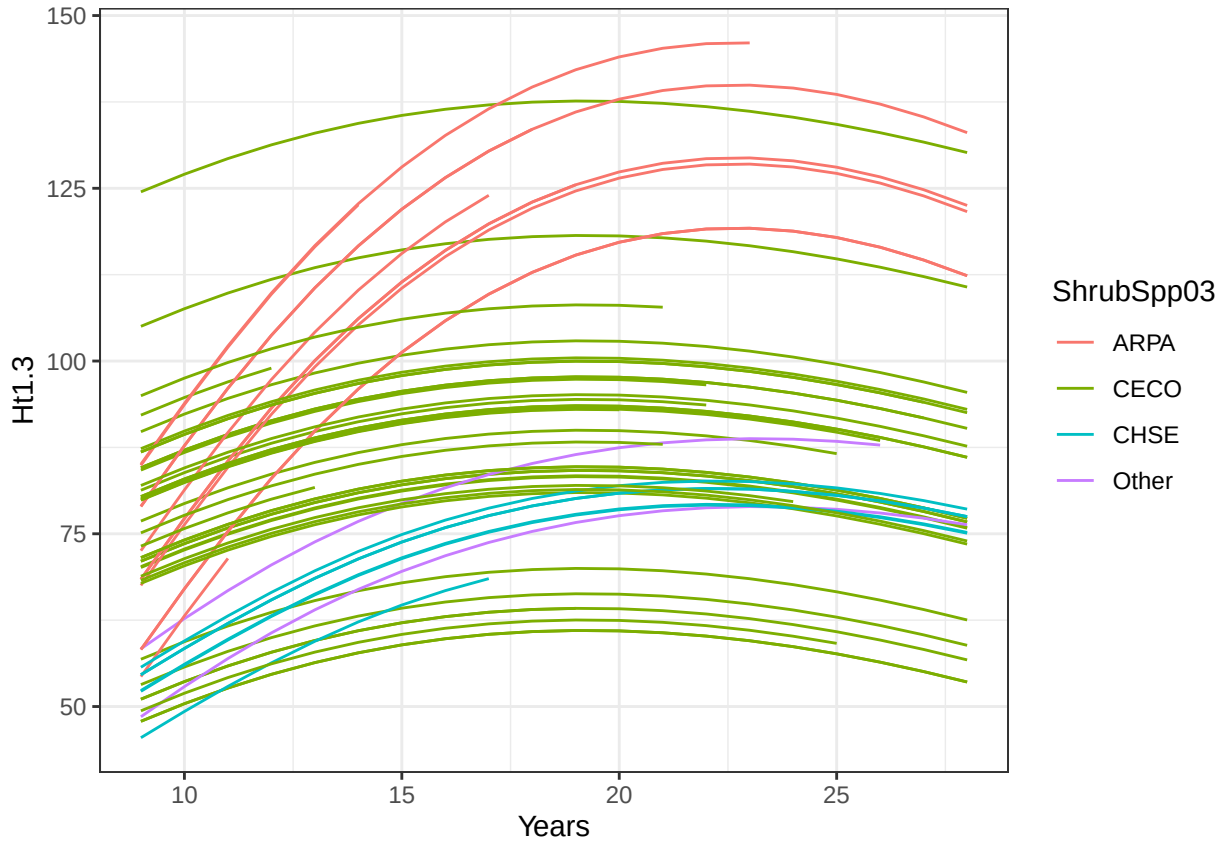


Simulate across years

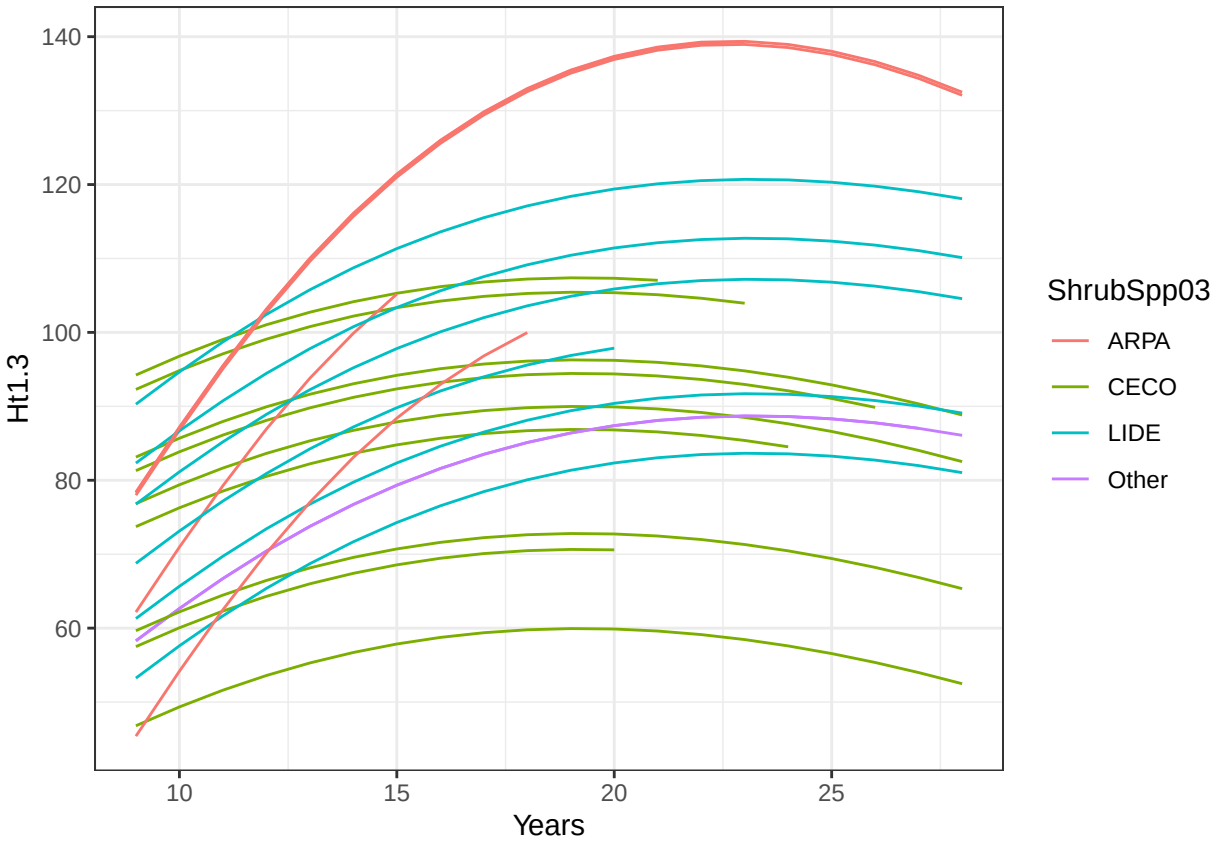
```
suppressMessages(sim(years))
```

Tests

```
ggplot(dfsimall %>% filter(Species == "ABCO"))+
  geom_line(aes(x = Years, y = Ht1.3, col = ShrubSpp03, group = Sdlg))+
  theme_bw()
```



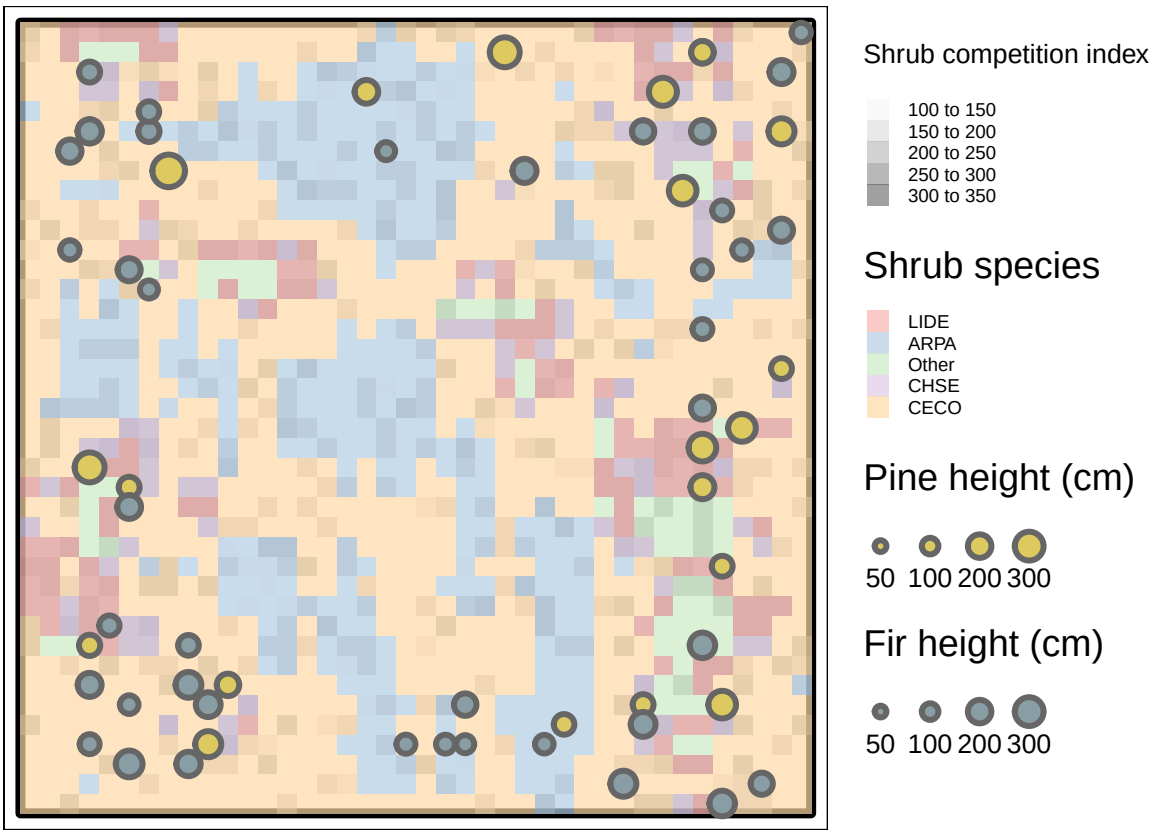

```
ggplot(dfsimall %>% filter(Species == "PIPO"))+
  geom_line(aes(x = Years, y = Ht1.3, col = ShrubSpp03, group = Sdlg))+
  theme_bw()
```




```
pts.sf.pipo.graph <- pts.sf.pipo %>%
  rename("Pine height (cm)" = Ht_cm1)
pts.sf.abco.graph <- pts.sf.abco %>%
  rename("Fir height (cm)" = Ht_cm1)
```

```
tm_shape(p)+
  tm_borders(col = "black", lwd= 5)+
tm_shape(r)+
  tm_raster(col = "sqrt_shrubarea3", title = "Shrub competition index", palette = "Greys", alpha = .5)+
tm_shape(r)+
  tm_raster(col = "ShrubSpp03", alpha = .7, title = "Shrub species", palette = "Pastel1")+
  tm_layout(asp=1:1, legend.outside = T, legend.title.size = 4, legend.text.size = 2)+
tm_shape(pts.sf.pipo.graph)+
  tm_symbols(size = "Pine height (cm)", col = "#DCC960", size.max = 300, border.lwd = 3)+
tm_shape(pts.sf.abco.graph)+
  tm_symbols(size = "Fir height (cm)", col = "#899DA4", size.max = 300, border.lwd = 3)
```

```
## Note that 3 values of the variable "Pine height (cm)" (the highest being 384.738575673223) are large
```



Iterate

```
iterate(iterations)
dfsimallreps %>%
  group_by(rep) %>%
  summarize(mean(Ht_cm1))
```

```
## # A tibble: 100 x 2
##      rep `mean(Ht_cm1)`
##    <int>          <dbl>
##  1     1           113.
##  2     2           116.
##  3     3           119.
##  4     4           111.
##  5     5           121.
##  6     6           115.
##  7     7           117.
##  8     8           114.
##  9     9           117.
## 10    10           109.
## # ... with 90 more rows
```

Summarize

Height by year

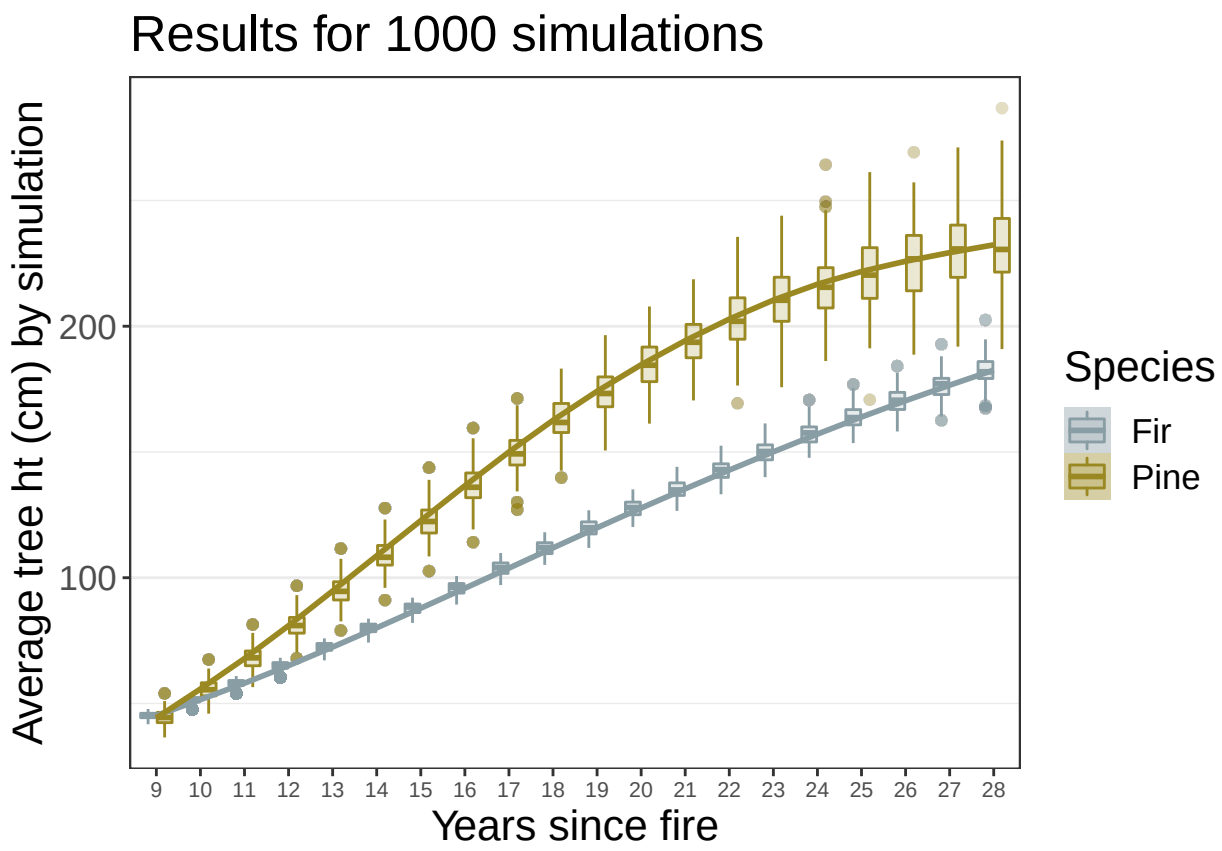
```
dfsimallreps_summary <- dfsimallreps %>%
  ungroup() %>%
  mutate(rep = as.factor(paste(rep))) %>%
  group_by(rep, Years, Species) %>%
  mutate(mean_ht_years = mean(Ht_cm1))
dfsimallreps_summary %>% dplyr::select(rep, Years, mean_ht_years) %>% summary()
```

```
## Adding missing grouping variables: `Species`
```

```
##  Species            rep            Years       mean_ht_years
##  ABCO:180969   75     :  3020   Min.   : 9.00   Min.   : 36.49
##  PIPO:100775   45     :  2975   1st Qu.:12.00   1st Qu.: 70.74
##                48     :  2972   Median :16.00   Median :107.91
##                96     :  2969   Mean   :16.78   Mean   :115.13
##                94     :  2957   3rd Qu.:21.00   3rd Qu.:153.91
##                52     :  2954   Max.   :28.00   Max.   :286.70
##                (Other):263897
```

```
ggplot(dfsimallreps_summary, aes(x = as.factor(Years), y = mean_ht_years, fill = Species, col = Species)
  geom_boxplot(alpha = .2, outlier.alpha = .02)+
  geom_smooth(aes(x = as.factor(Years), y = mean_ht_years, group = Species, col = Species), size = 1)+
  ggtitle("Results for 1000 simulations")+
  xlab("Years since fire")+
  ylab("Average tree ht (cm) by simulation")+
  theme_bw()+
  scale_color_manual(values = c("#899DA4", "#9A8822"), labels = c("Fir", "Pine"))+
  scale_fill_manual(values = c("#899DA4", "#9A8822"), labels = c("Fir", "Pine"))+
  theme(text = element_text(size = 16),
        panel.grid.minor.x = element_blank(),
        panel.grid.major.x = element_blank(),
        axis.text.x = element_text(size = 8))
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```




```
ggsave(file = "../../results/figures/sim_1000_hts.png", width = 6, height =4, dpi = 400)
```

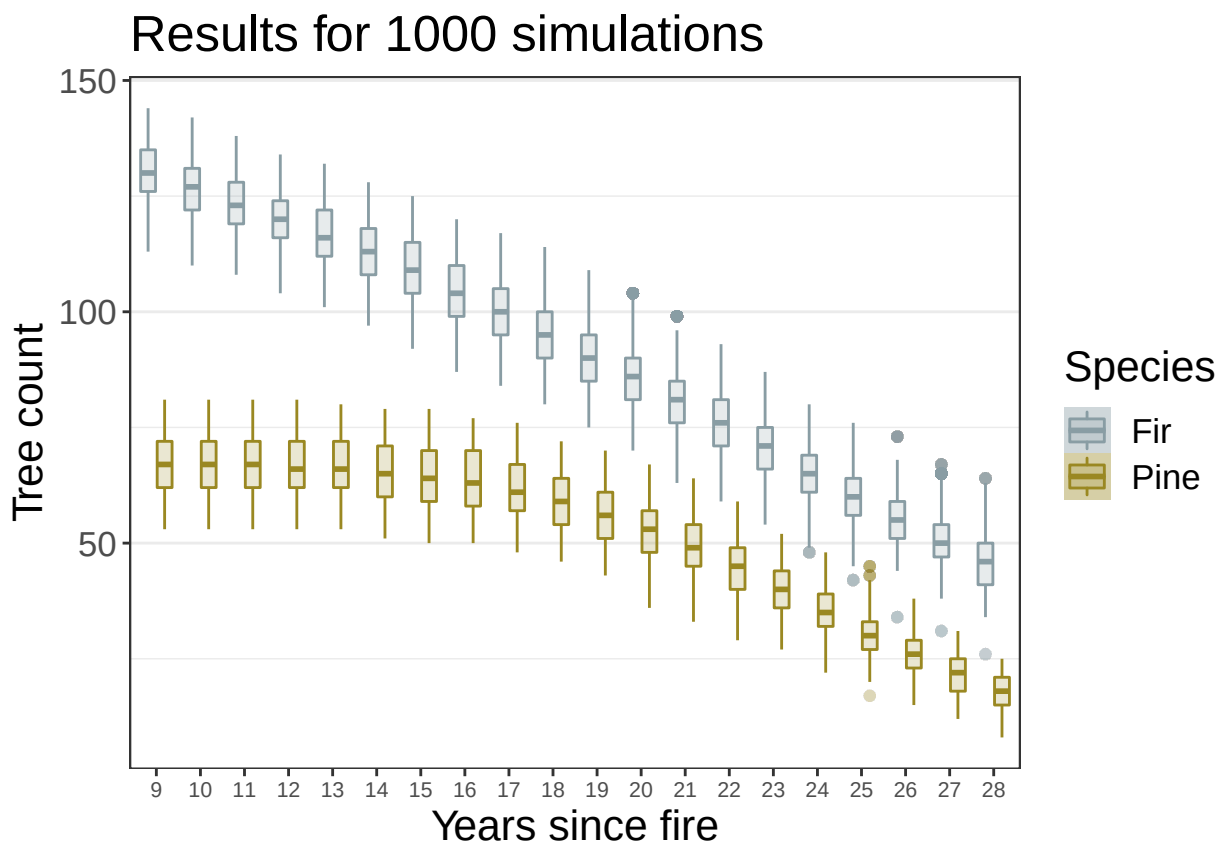
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```

Counts by year

```
dfsimallreps_summary <- dfsimallreps %>%
  ungroup() %>%
  group_by(rep, Years, Species) %>%
  mutate(count = n()) %>%
  mutate(count = as.numeric(count))
```

```
ggplot(dfsimallreps_summary, aes(x = as.factor(Years), y = count, fill = Species, col = Species))+
  geom_boxplot(alpha = .2, outlier.alpha = .02)+
  geom_smooth(aes(x = as.factor(Years), y = count, fill = Species, col = Species), size = 1)+
  ggtitle("Results for 1000 simulations")+
  xlab("Years since fire")+
  ylab("Tree count")+
  theme_bw()+
  scale_color_manual(values = c("#899DA4", "#9A8822"), labels = c("Fir", "Pine"))+
  scale_fill_manual(values = c("#899DA4", "#9A8822"), labels = c("Fir", "Pine"))+
  theme(text = element_text(size = 16),
        panel.grid.minor.x = element_blank(),
        panel.grid.major.x = element_blank(),
        axis.text.x = element_text(size = 8))
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```




```
ggsave(file = "../../results/figures/sim_1000_count.png", width = 6, height = 4, dpi = 400)
```

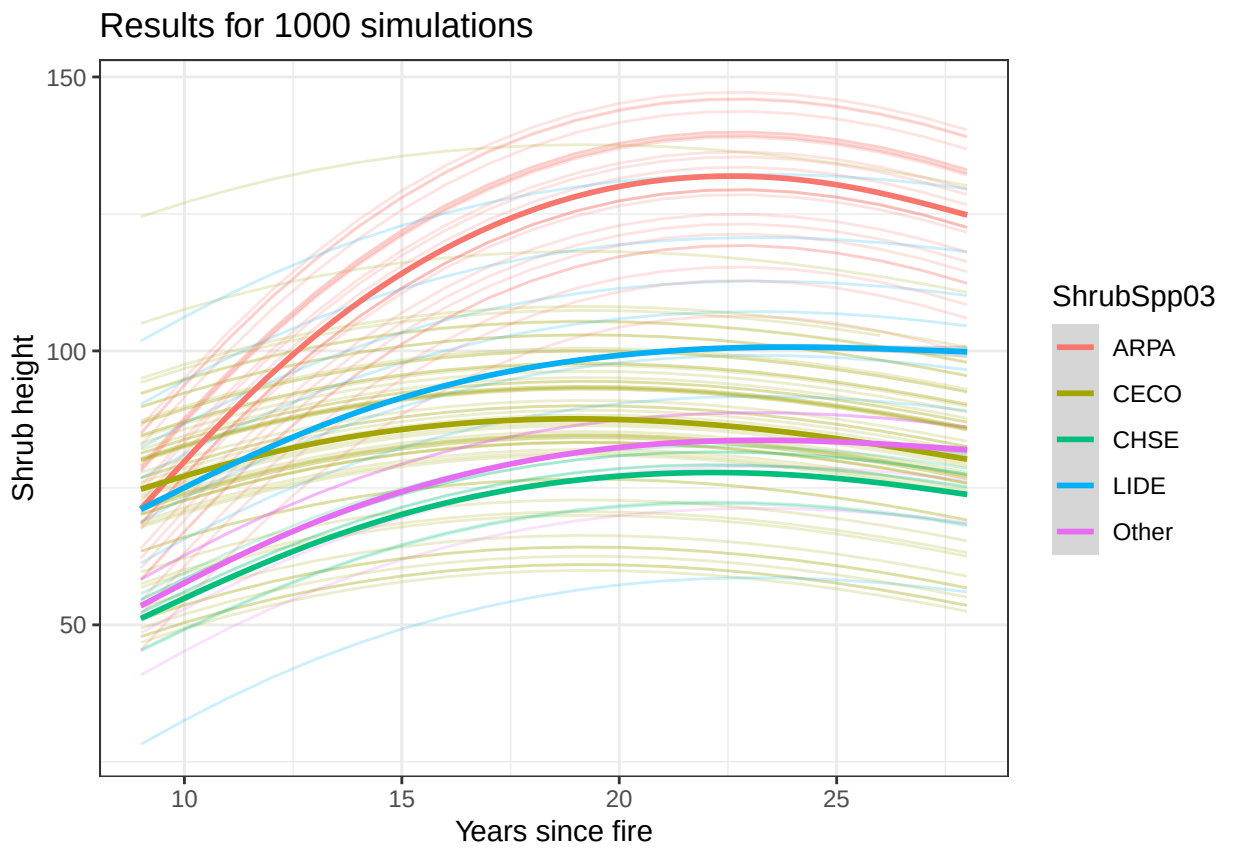
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```

Shrub height by year

```
dfsimallreps_summary <- dfsimallreps %>%
  ungroup() %>%
  group_by(rep, Years, Ht1.3, ShrubSpp03) %>%
  mutate(mean_shrub_ht = mean(Ht1.3))
```

```
ggplot(dfsimallreps_summary, aes(x = Years, y = mean_shrub_ht, group = ShrubSpp03, col = ShrubSpp03))+
  geom_line(aes(group = Sdlg), alpha = .2)+
  geom_smooth()+
  ggtitle("Results for 1000 simulations")+
  xlab("Years since fire")+
  ylab("Shrub height")+
  theme_bw()
```

```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```




```
print(Sys.time() - strt)
```

```
## Time difference of 12.94841 mins
```

Next steps to improve the model

1. Use Kristen's data or Hugh's data for initial conditions
2. Improve dispersal kernel based on Kristen/Hugh's data
3. Improve shrub growth based on data - DONE
4. Include residual surviving trees and their seed dispersal
5. Include seed dispersal of post-fire regen once it reaches reproductive age
6. Add customization of patch size and shape
7. Add customization of whether the weather conditions reflect those of 2015, 2016, or 2017
8. Change sapling growth equations once they emerge from the shrub canopy

For next week: - Improve shrub growth based on data - display dominant shrub species - make the shrub grid dependent upon surrounding cells so it's not so checkerboard - Update display of shrub competition after simulation years - what does shrub competition mean for new recruitment? - "emergent year" = when 50% of trees are above shrub canopy - maybe submit to American Naturalist - Global Change Biology - mixing up the years - no overstory reproduction for now - apply to King, American River Complex, rest of the fires I measured - switch diameter equation to be from dendro work