# Growth_mort

*Carmen*

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

## Define parameters

```
fire <- "AMRC"
year <- "2016"
years <- 20
iterations <- 1000
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 function

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

**Simulation function**

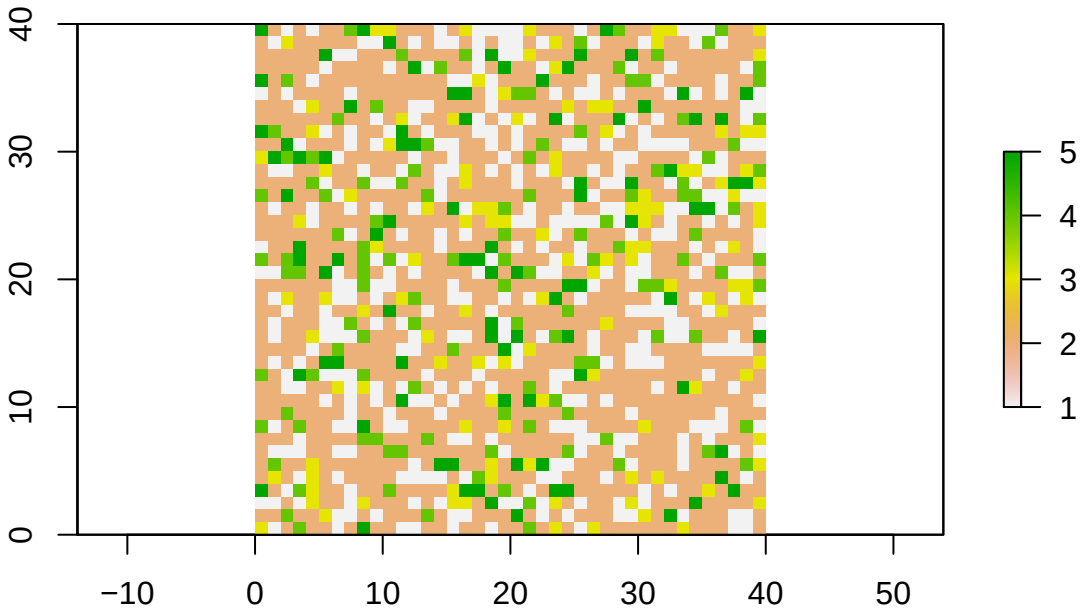
```
source("functions/sim.R")
```

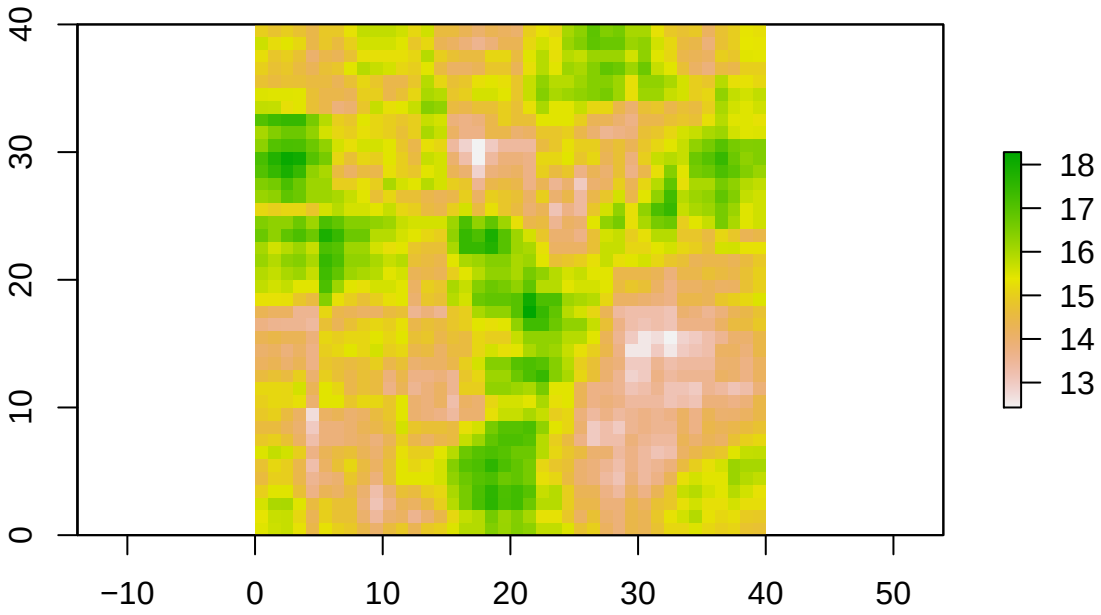
**Iteration function**

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

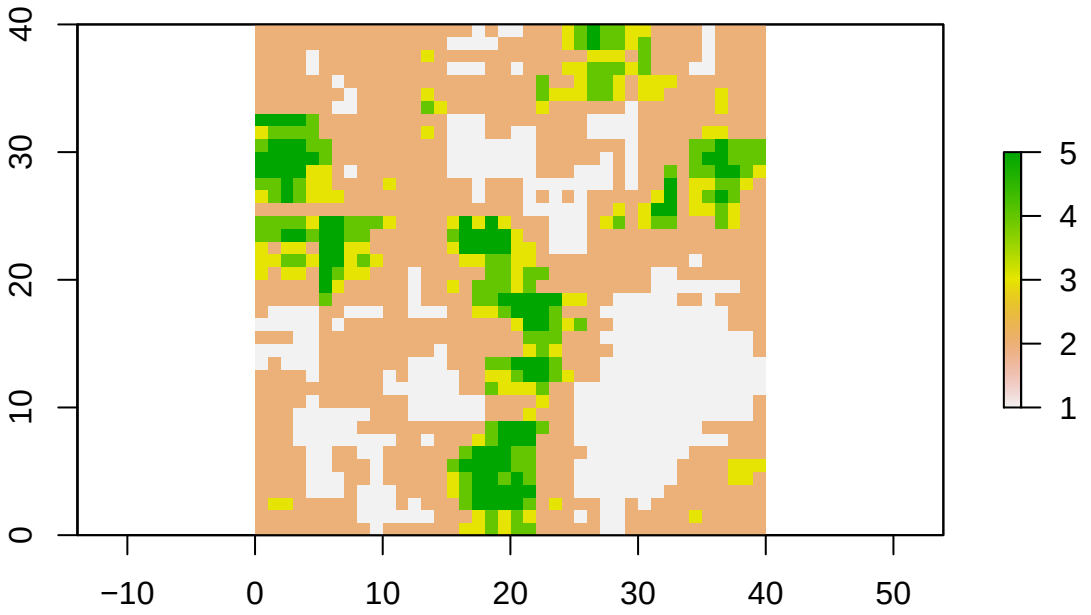
## Initialize

```
shrubclump()
```






```
plot(r)
```




```
initialize()
```

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

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

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

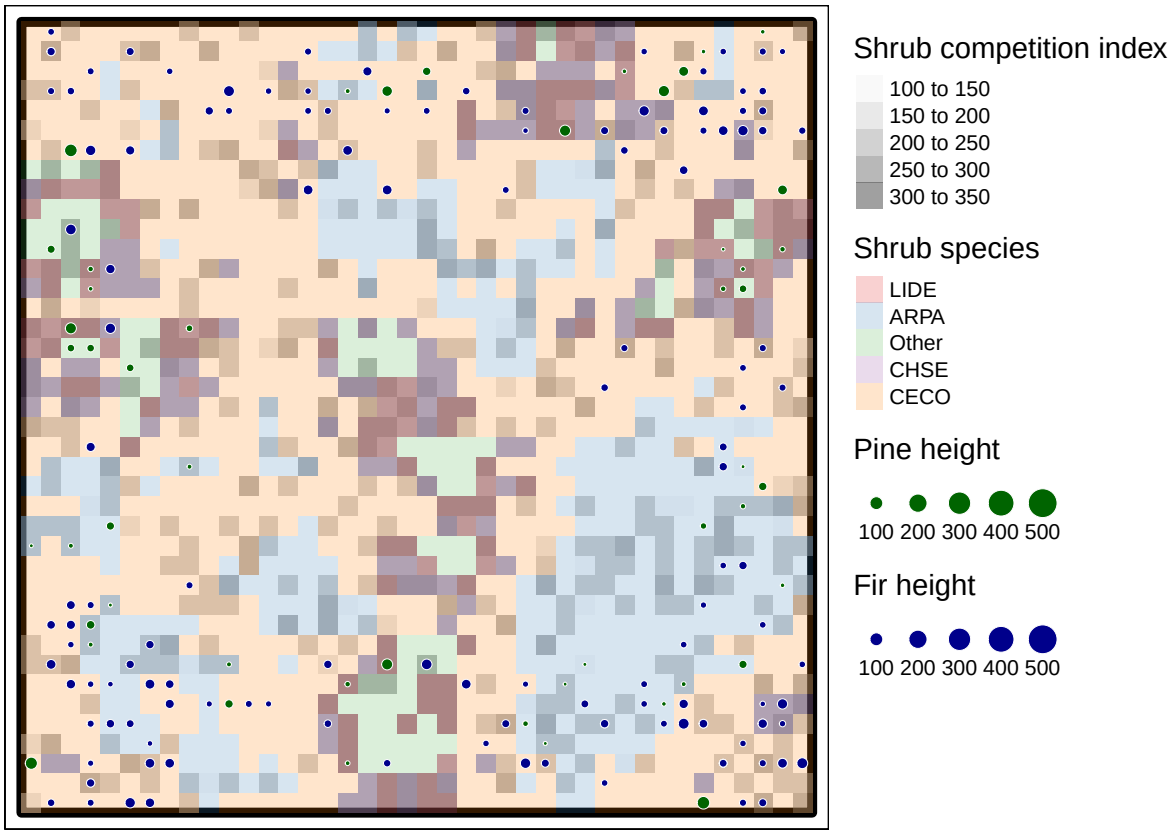
## Plot patch before simulation

```
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 =
```



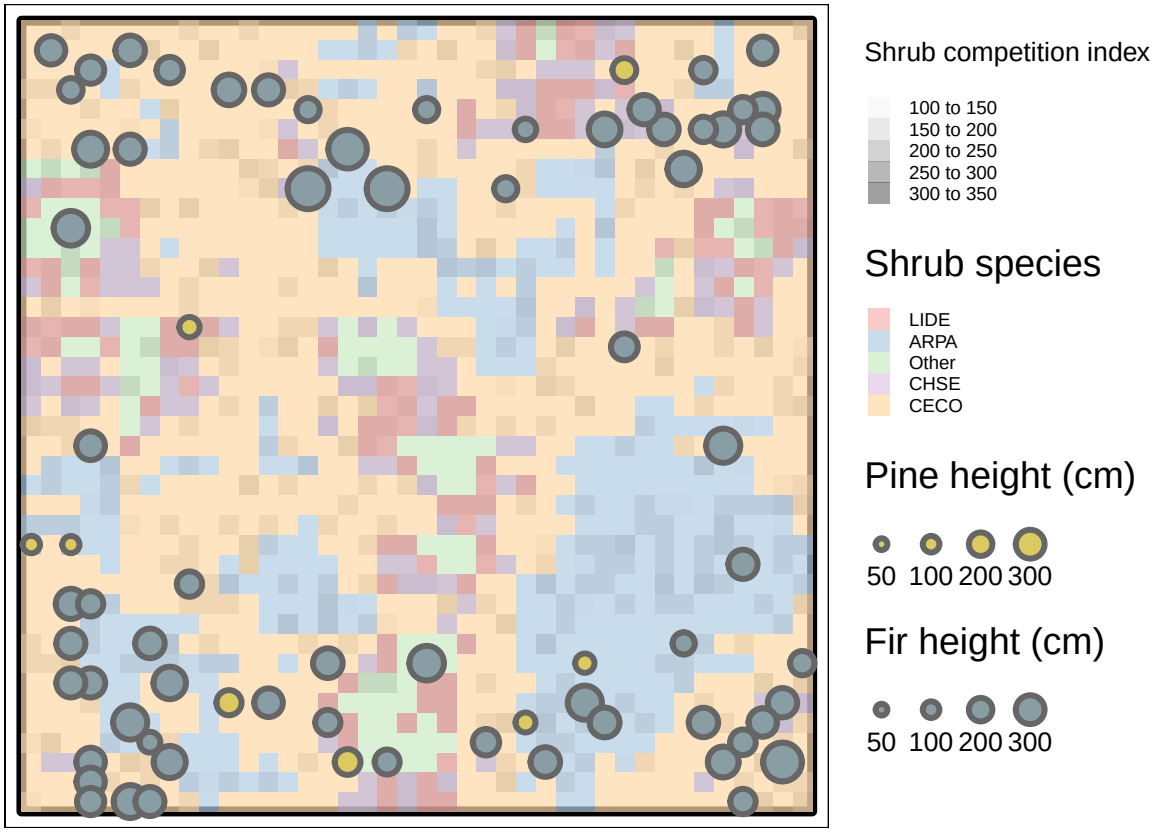

## Simulate across years

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

```
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 40 values of the variable "Fir height (cm)" (the highest being 604.870825878987) are large
```




## Iterate

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

```
## # A tibble: 1,000 x 2
##      rep `mean(Ht_cm1)`
##    <int>          <dbl>
##  1     1           134.
##  2     2           133.
##  3     3           127.
##  4     4           132.
##  5     5           125.
##  6     6           129.
##  7     7           131.
##  8     8           132.
##  9     9           135.
## 10    10           126.
## # ... with 990 more rows
```

## Summarize

### Height by year

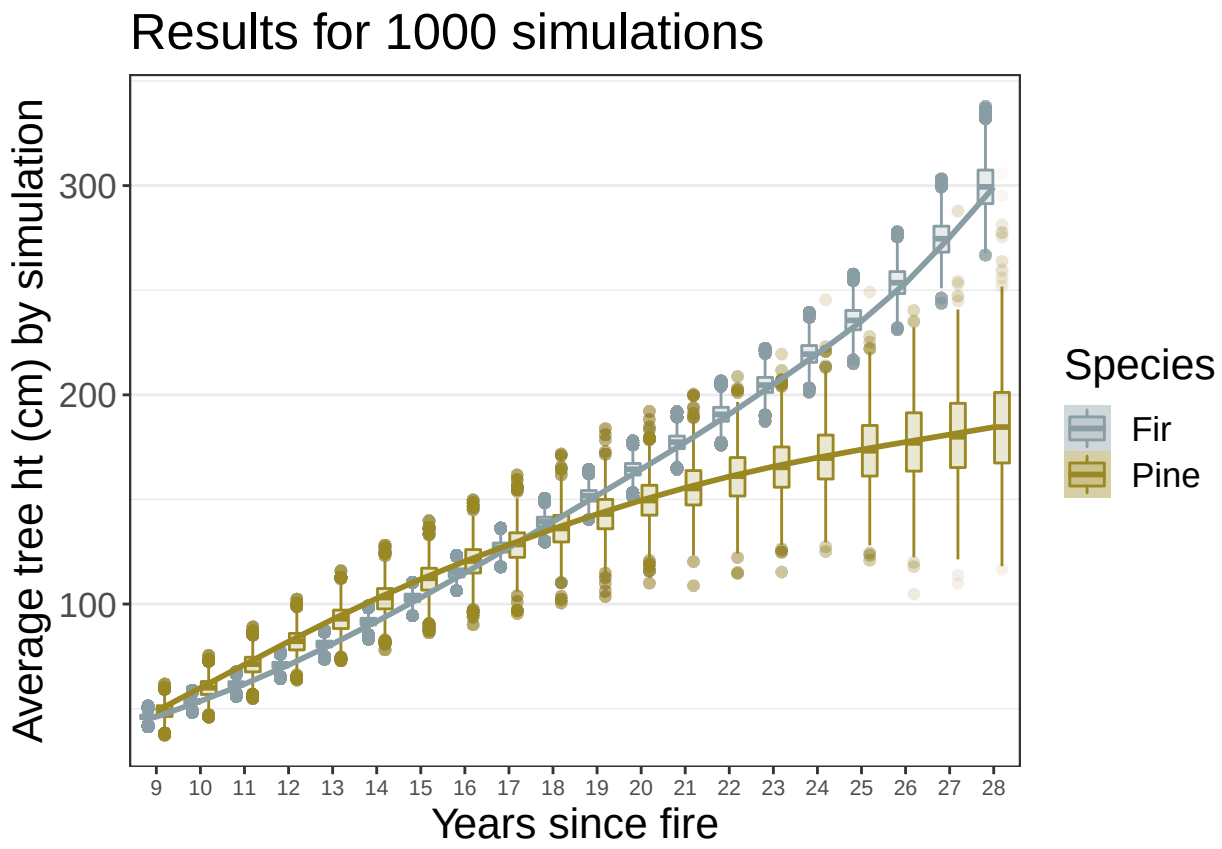
```
dfsimallreps_summary <- dfsimallreps %>%
  ungroup() %>%
  mutate(rep = as.factor(paste(rep))) %>%
  group_by(rep, Years, Species) %>%
  mutate(mean_ht_years = mean(Ht_cm1))
dfsimallreps_summary %>% dplyr::select(rep, Years, mean_ht_years) %>% summary()
```

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

```
##  Species             rep             Years      mean_ht_years
##  ABCO:2016418   208    :   3114   Min.   : 9.0   Min.   : 37.21
##  PIPO: 841389   312    :   3104   1st Qu.:12.0   1st Qu.: 77.14
##                 906    :   3091   Median :16.0   Median :119.01
##                 801    :   3081   Mean   :16.9   Mean   :130.11
##                 140    :   3067   3rd Qu.:21.0   3rd Qu.:168.19
##                 238    :   3061   Max.   :28.0   Max.   :337.95
##                 (Other):2839289
```

```
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)
```

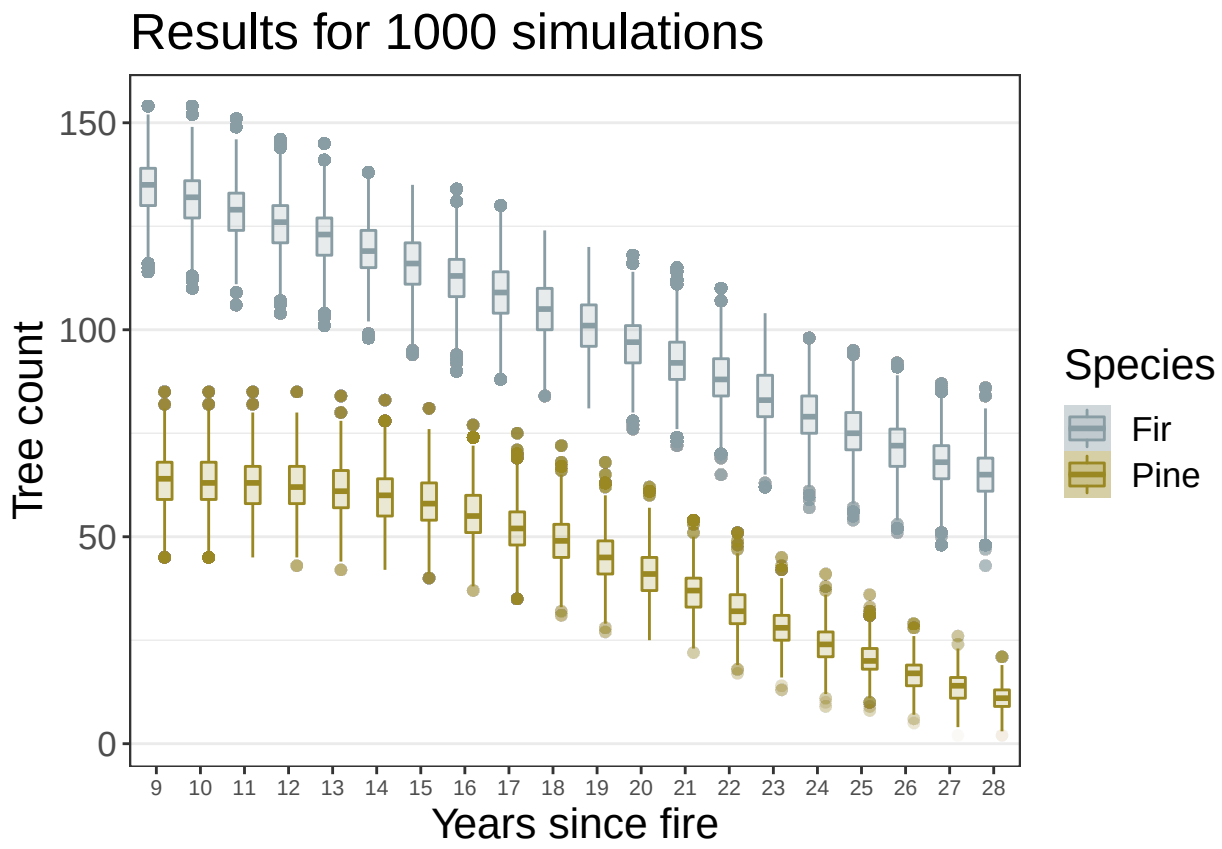
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```

### 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)
```

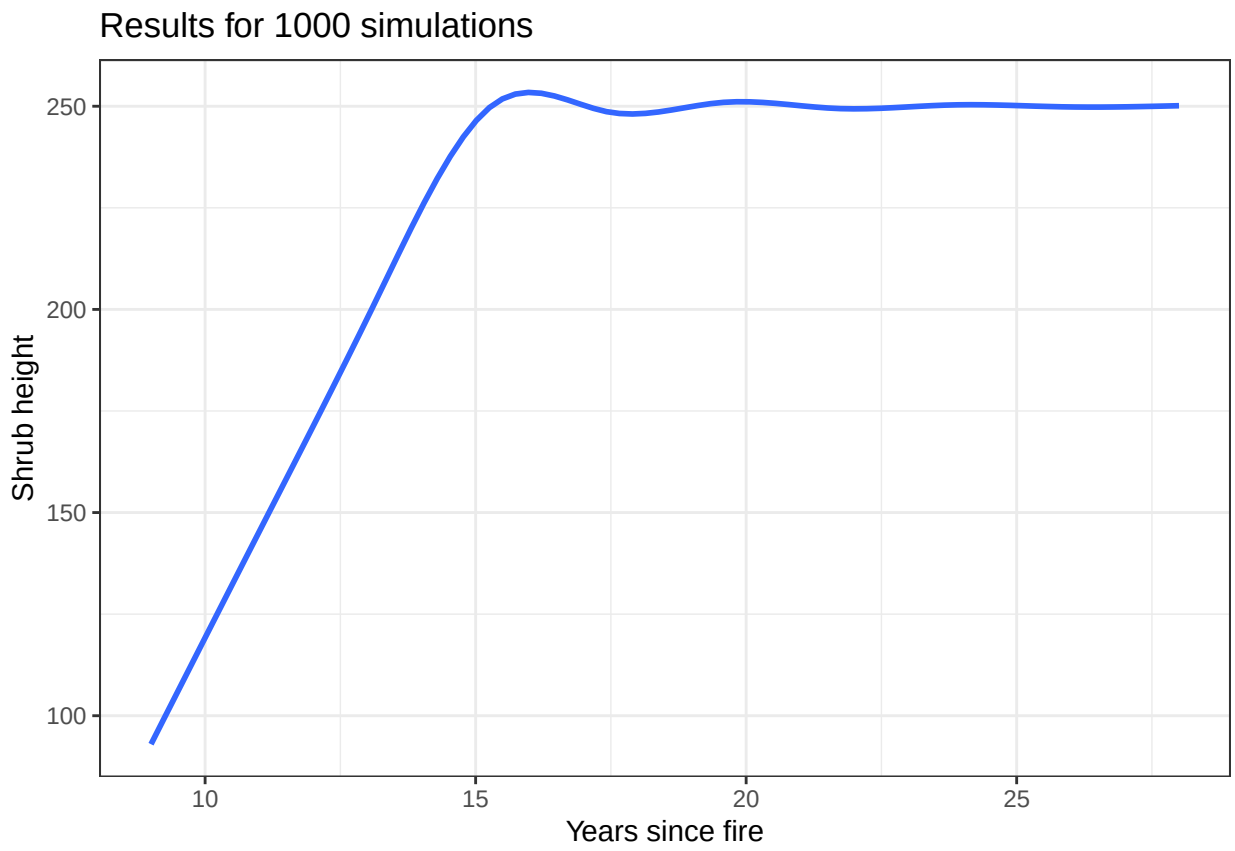
```
## `geom_smooth()` using method = 'gam' and formula 'y ~ s(x, bs = "cs")'
```

### Shrub height by year

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

```
ggplot(dfsimallreps_summary, aes(x = as.factor(Years), y = mean_shrub_ht))+
  geom_smooth(aes(x = Years, y = mean_shrub_ht))+
  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")'
```

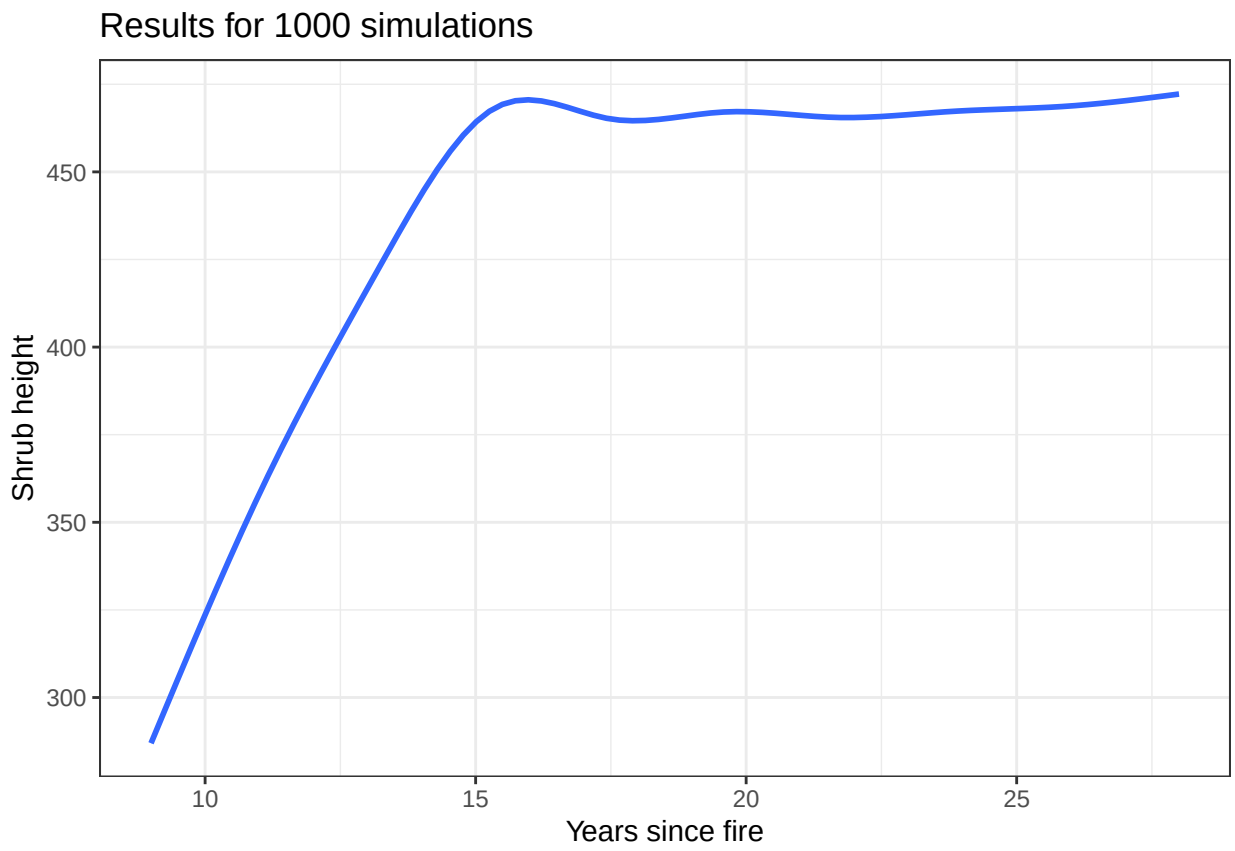



### Shrub competition by year

```
dfsimallreps_summary <- dfsimallreps %>%
  ungroup() %>%
  group_by(rep, Years, sqrt_shrubarea3) %>%
  mutate(mean_shrub_comp = mean(sqrt_shrubarea3))
```

```
ggplot(dfsimallreps_summary, aes(x = Years, y = mean_shrub_comp))+
  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")'
```




```
ggsave(file = "../../results/figures/sim_1000_shrub.png", width = 3, height = 3, dpi = 400)
```

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

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

```
## Time difference of 1.125492 hours
```

## 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
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 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