Assignment 6

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1. Implement model

```
source("dCgrowth.R")

dCgrowth
```

```
## function (Time, C, parms)
## {
##     if (C >= parms$Ct) {
##         dC = parms$g * (1 - C/parms$K)
##     }
##     else {
##         dC = parms$r * C
##     }
##     return(list(dC))
## }
```

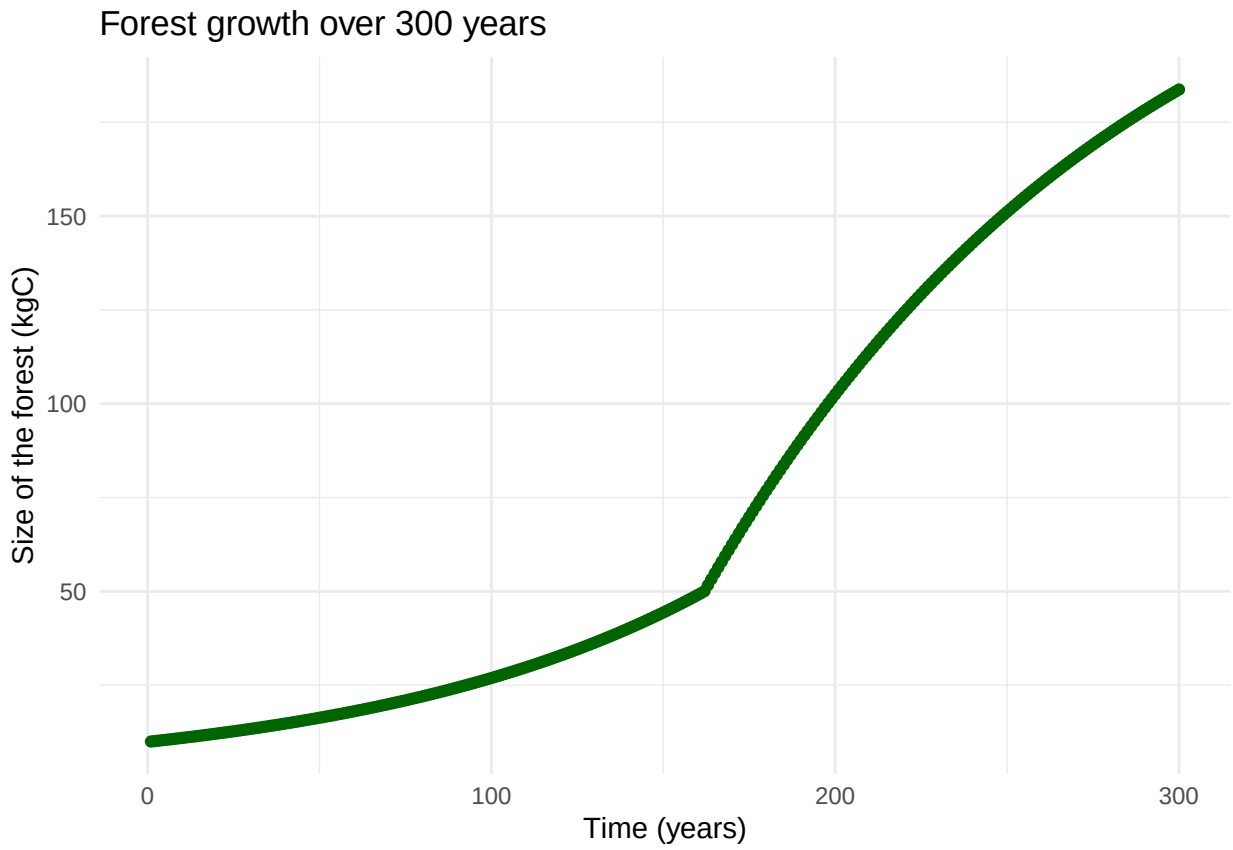
2. Run model for 300 years

```
simtimes = seq(from=1, to=300)
parms = list(Ct = 50, r=0.01, K=250, g = 2)
Cinitial = 10

result = ode(y=Cinitial, times=simtimes, func=dCgrowth, parms=parms)
colnames(result)=c("time","C")
```

3. Graph the results

```
# turn it into a data frame
result = as.data.frame(result)
ggplot(result, aes(time, C)) +
  geom_point(col = "darkgreen") +
  labs(x = "Time (years)",
       y = "Size of the forest (kgC)",
```

```
      title = "Forest growth over 300 years") +
  theme_minimal()
```



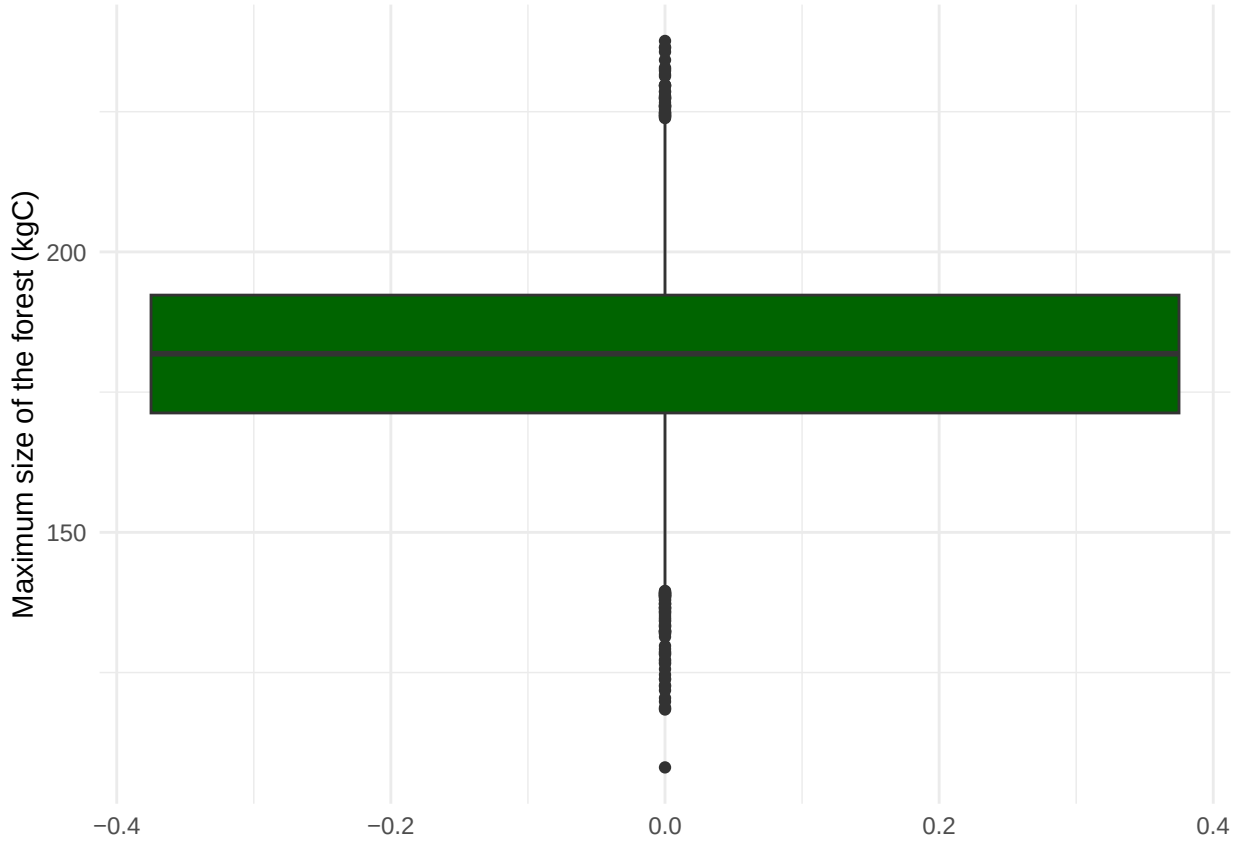
4. Run a sobol global (vary all parameters at the same time) sensitivity analysis that explores how the estimated maximum forest size (e.g maximum of 300 years), varies with these parameters

```
# want to learn about sensitivity pre-canopy closure growth rate (r), post-canopy closure growth rate (
# set the number of parameters
np=2000
# 10% standard deviation
pct_var = 0.1

K = rnorm(mean=250, sd=250*pct_var, n=np)
r = rnorm(mean=0.01, sd=0.01*pct_var, n=np)
g = rnorm(mean=2, sd=2*pct_var, n=np)
Ct = rnorm(mean=50, sd=50*pct_var, n=np)
X1 = cbind.data.frame(r=r, K=K, g=g, Ct=Ct)

# repeat to get our second set of samples
K = rnorm(mean=250, sd=250*pct_var, n=np)
```

```
r = rnorm(mean=0.01, sd=0.01*pct_var, n=np)
g = rnorm(mean=2, sd=2*pct_var, n=np)
Ct = rnorm(mean=50, sd=50*pct_var, n=np)
X2 = cbind.data.frame(r=r, K=K, g=g, Ct=Ct)

# fix any negative values and they are not meaningful
X1 = X1 %>% map_df(pmax, 0.0)
X2 = X2 %>% map_df(pmax, 0.0)

sens_C = sobolSalt(model = NULL,X1, X2, nboot = 300)

# lets add names
colnames(sens_C$X) = c("r","K","g", "Ct")

# turn computing max forest size into function
p_wrapper = function(r,K, g, Ct, Cinitial, simtimes, func) {
    parms = list(r=r, K=K, g=g, Ct=Ct)
    result = ode(y=Cinitial, times=simtimes, func=func, parms=parms)
    colnames(result)=c("time","C")
  # get metrics
  metrics=max(as.data.frame(result[,2]))
  return(metrics)
}

allresults = as.data.frame(sens_C$X) %>%
  pmap(p_wrapper, Cinitial=Cinitial, simtimes=simtimes, func=dCgrowth)

allres <- do.call(rbind, allresults) # "matrix" "array"
# convert to dataframe and change column name
allres <- as.data.frame(allres) %>%
  rename(maxC = V1)
```

5. Graph the results of the sensitivity analysis as a box plot of maximum forest size and record the two Sobol indices (S and T).

```
# create boxplot
ggplot(allres, aes(maxC))+
  geom_boxplot(fill = "darkgreen") +
  coord_flip() +
  theme(axis.text.x = element_blank(),
        axis.ticks.x = element_blank()) +
  labs(x = "Maximum size of the forest (kgC)") +
  theme_minimal()
```




```
sens_C_maxC = sensitivity::tell(sens_C,allres$maxC)

# first-order indices
rownames(sens_C_maxC$S) = c("r","K","g", "Ct")
print(sens_C_maxC$S)
```

```
##      original          bias std. error   min. c.i.  max. c.i.
## r  0.33868177 -0.0007557336 0.01950891 0.300739639 0.38127927
## K  0.32225541  0.0022073723 0.02109954 0.277953142 0.36049698
## g  0.22091537  0.0005597293 0.02088968 0.180490955 0.26314612
## Ct 0.04784596  0.0005505362 0.02115666 0.004681025 0.08503814
```

```
# total sensitivity
rownames(sens_C_maxC$T) = c("r","K","g", "Ct")
print(sens_C_maxC$T)
```

```
##      original          bias  std. error  min. c.i.  max. c.i.
## r  0.37008848 -1.379705e-03 0.015396863 0.33954258 0.40132154
## K  0.37127036  1.096110e-03 0.015353361 0.33760062 0.39881982
## g  0.22480794 -1.963114e-05 0.008925883 0.20572948 0.24276542
## Ct 0.06519351  5.339661e-05 0.003235851 0.05807935 0.07141021
```

6. In 2-3 sentences, discuss what the results of your simulation might mean. (For example think about how what parameters climate change might influence).

Pre-canopy closure growth rate (r) and carrying capacity (K) seem to be the most sensitive and canopy closure threshold (Ct) appears to be the least sensitive. Climate change could have an effect on the parameters. For example, increase in drought could lead to a decrease in growth rate or warming temperatures that increase the growing season could increase the growth rate. In addition, the threshold at which the canopy closes may change due to changes in growing conditions, which would effect the inflection point at which the growth rate changes.