Using 3PG to support thesis progress in climate change

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Overview

Background

Experimenting with the model

Interpreting the results

Background Summary

- Crux of my thesis project:
  - **Estimating future tree coverage and adaptations at species and individual levels requires more knowledge.**
  - **Important for understanding and Predicting effects of climate change**
- Main tree of focus for 3PG: Douglas-fir
- Location of project: HJ Andrews LTER

Importance & Issues

PNW to experience more anomalous weather (1)

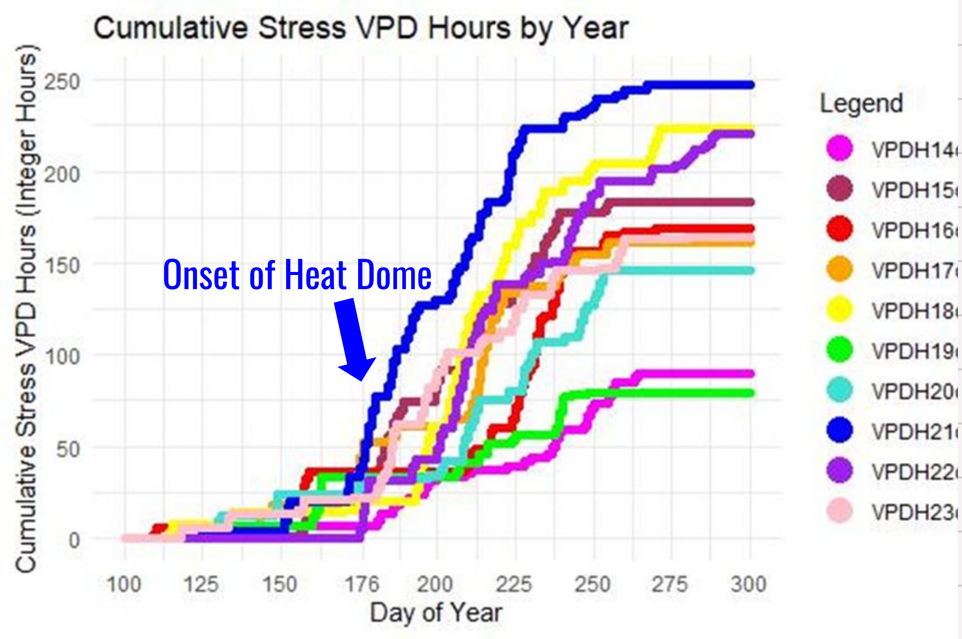
Research tends to focus on drought more than heat (4,5)

Heat wave issues can vary by species & age (6,7)

Effects of heat and drought are hard to disentangle since they often overlap (2)

Trees are important for every life form (3)

2021 Heat Dome was a big deal (4)



Stand information

- HJ Andrews LTER
  - 44.1734° N, 122.1968° W
  - near Willamette National Forest
- Discovery Trail (3)
  - Moist valley
  - Some old growth, most secondary from 1960s clearcut
  - Douglas-fir and western hemlock

Why use 3PG?

- Easy yet thorough estimation of biomass allocation based on stand and environmental data (8)
- Many ways to quantify outputs
    - Value for scientists and timber producers
- Low-effort compared to physical measurements
- Great for validating other methods of research
- Great for low-stakes experimenting with other variables/inputs
    - Scientific creativity

What did I do with 3PG?

- Want to supplement other work on disentangling heat and drought effects
- Only changed one variable
    - rainfall or Tmax in June

How does growth change when a stand is only affect by heat wave *or* drought?

Experimenting with the model

Manipulating Precipitation

June only
Original: 53.41 mm
Manipulated: 0 mm

Manipulating Temperature

June only
Original: 25.07°C
Manipulated: 35°C

Selecting outputs

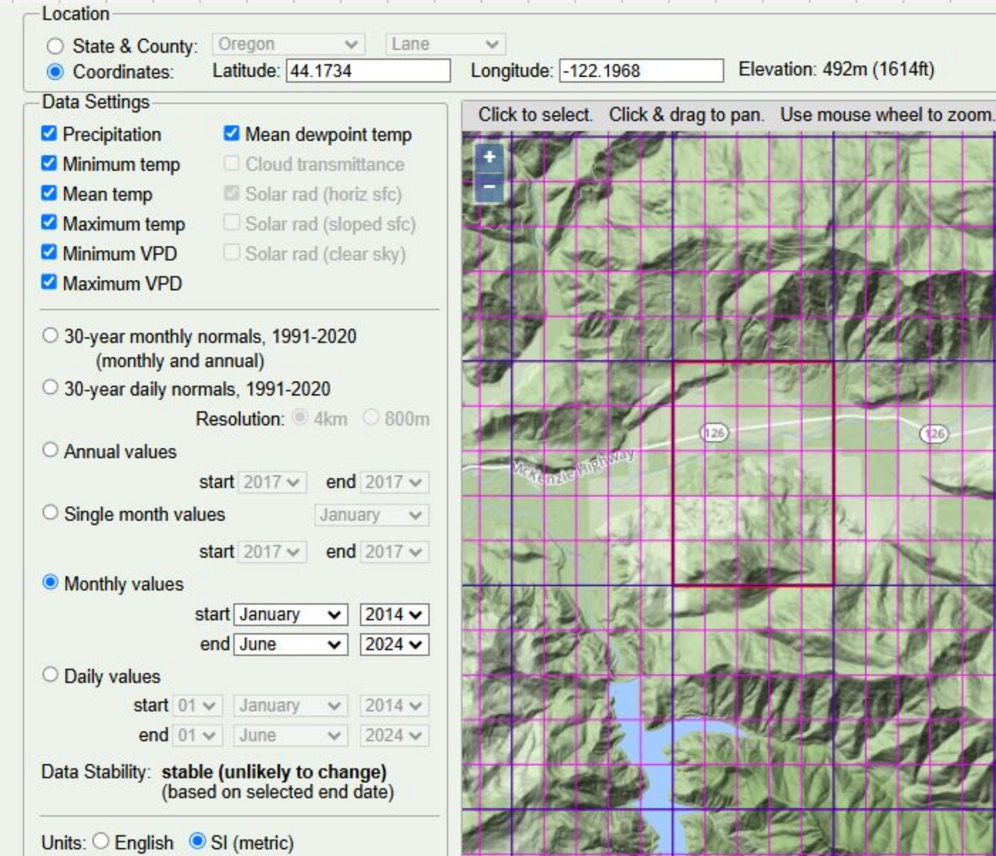
All getting at comparing photosynthetic productivity:
LAI, stand volume, DBH, NPP

Experimenting with the model

Step 1:

Gathering inputs

- Data from
  - PRISM
  - HJA expert
    - Mark Schulze
  - HJA Data portal
  - 3PG estimates



Andrews Forest
Long Term Ecological Research

Data harvest and management powered by GCE Toolbox

Home > HJA Data Portal (powered by GCE) > DSCMET > Data > Dataset Details | Plots

Dataset Details

Data Set ID:	**dscmet_422_a_5min_2023**
Originator:	Chris Still
Title:	Canopy Processes at HJA. Variables include: dendrometer from 01-Oct-2022 to 01-Oct-2023

Initial Biomass Estimation

Enter Age (years)	54.0
Enter DBH (cm)	
Enter Height (m)	30.00
Enter stocking (ha-1)	1,250

Note: Height is optional for age>2 year

```
```{r}
P230long_filled_select<-P230long_filled|>select(c(Date,SOLAR_TOT_100_0_02,Flag_SOLAR_TOT_100_0_02,RAD_TOT_100_0_01.1,Flag_RAD_TOT_100_0_01.1))

P230long_filled_select$SOLAR_TOT_100_0_02[P230long_filled_select$Flag_SOLAR_TOT_100_0_02=="Q"] <- NA
P230long_filled_select$RAD_TOT_100_0_01.1[P230long_filled_select$Flag_RAD_TOT_100_0_01.1=="Q"] <- NA


P230longer_filled_select<-P230long_filled_select|>pivot_longer(
    cols = c(SOLAR_TOT_100_0_02,RAD_TOT_100_0_01.1),
    names_to = "Rad",
    values_to = "Rad_mj_per_m2")

P230longer_filled_select$Date<-as.POSIXct(P230longer_filled_select$Date,format="%Y-%m-%d %H:%M:%S")
```


#Daily sum
```{r}
P230longer_filled_select$day<-format(P230longer_filled_select$Date,"%Y-%m-%d")
DailySum_P230longer_filled_select<- P230longer_filled_select |> group_by(day) |> summarise(Rad_mj_per_m2 = sum(Rad_mj_per_m2, na.rm = TRUE))
```
#monthly av
```{r}
DailySum_P230longer_filled_select$day<-as.POSIXct(DailySum_P230longer_filled_select$day,format="%Y-%m-%d")
DailySum_P230longer_filled_select$month<-format(DailySum_P230longer_filled_select$day,"%m")
mAvg_P230longer_filled_select<-DailySum_P230longer_filled_select |> group_by(month) |> summarise(Rad_mj_per_m2 = mean(Rad_mj_per_m2, na.rm = TRUE))
write.csv(file = "mAvg_P230longer_filled_select.csv",mAvg_P230longer_filled_select)
```
```

Experimenting with the model

Step 2:

Running it

Month	tmax	tmin	rain	SolarRad
Jan	6.69091	0.72727	240.958	1.559199
Feb	7.98182	0.83636	225.216	3.43192
Mar	11.1091	1.62727	206.935	6.583065
Apr	15.2909	3.53636	177.185	10.318467
May	20.8818	7.08182	100.322	14.002196
Jun	25.0727	9.88182	53.4127	17.315915
Jul	30.32	12.22	8.141	21.688751
Aug	30.37	12.36	6.96	18.31727
Sep	24.28	9.7	69.082	11.203797
Oct	16.69	6.55	164.158	4.760377
Nov	9.88	3.06	235.406	1.967997
Dec	5.84	1.15	315.996	1.22512

Stand initialisation and site factor data

Date planted =	1960/1	Latitude =	44.1734
Initial year =	54	Fertility rating =	0.5
Initial month =	January	Soil class =	SL
End age =	74	Maximum ASW =	200
Initial WF =	216.0783	Minimum ASW =	0
Initial WR =	150.1866	Atmospheric CO2 =	410
Initial WS =	427.6705		
Initial stocking =	1250		
Initial ASW =	250		

Output details

Output frequency : A

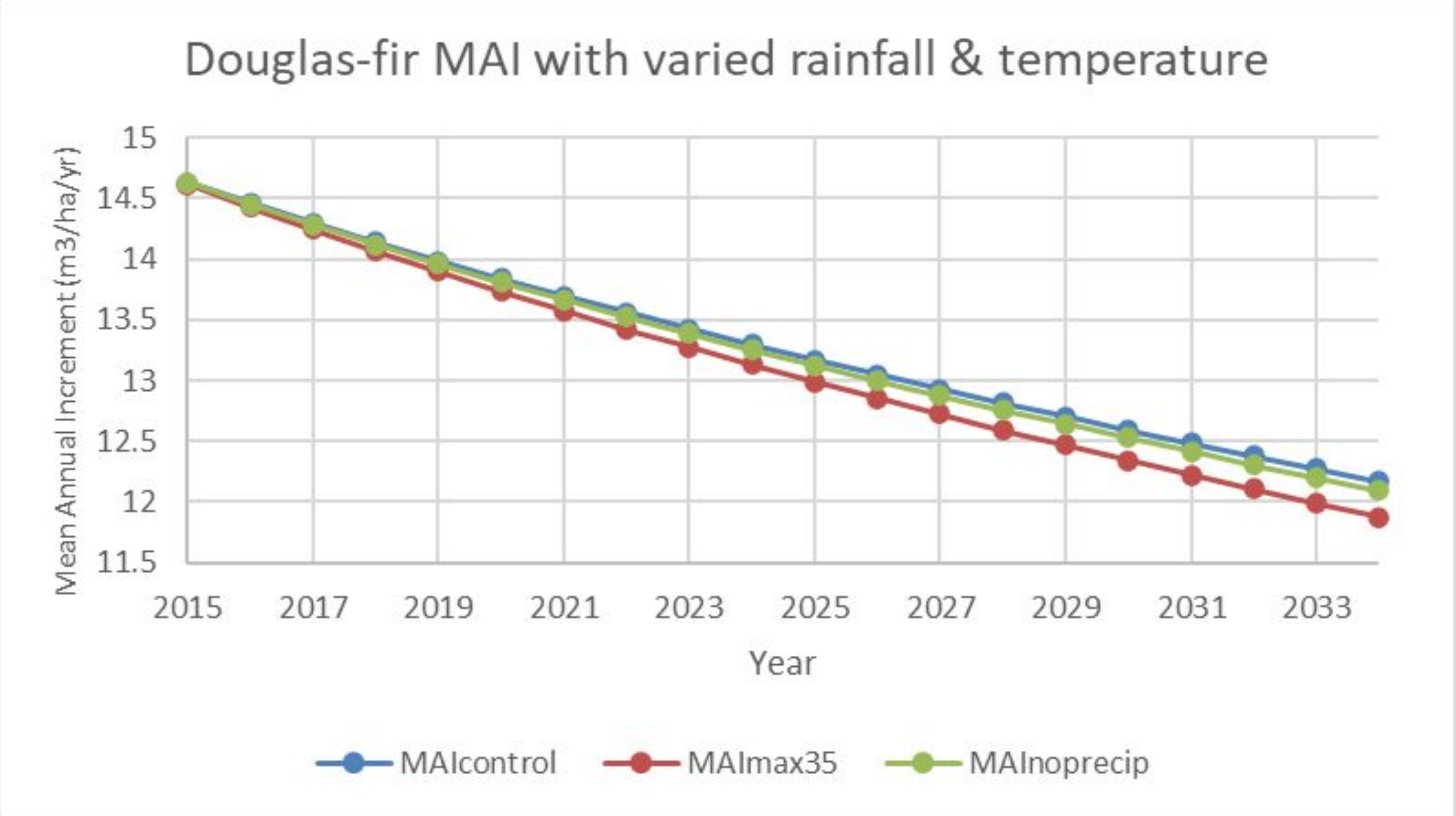
Output data : MAI, StandVol, avDBH,NPP

Experimenting with the model

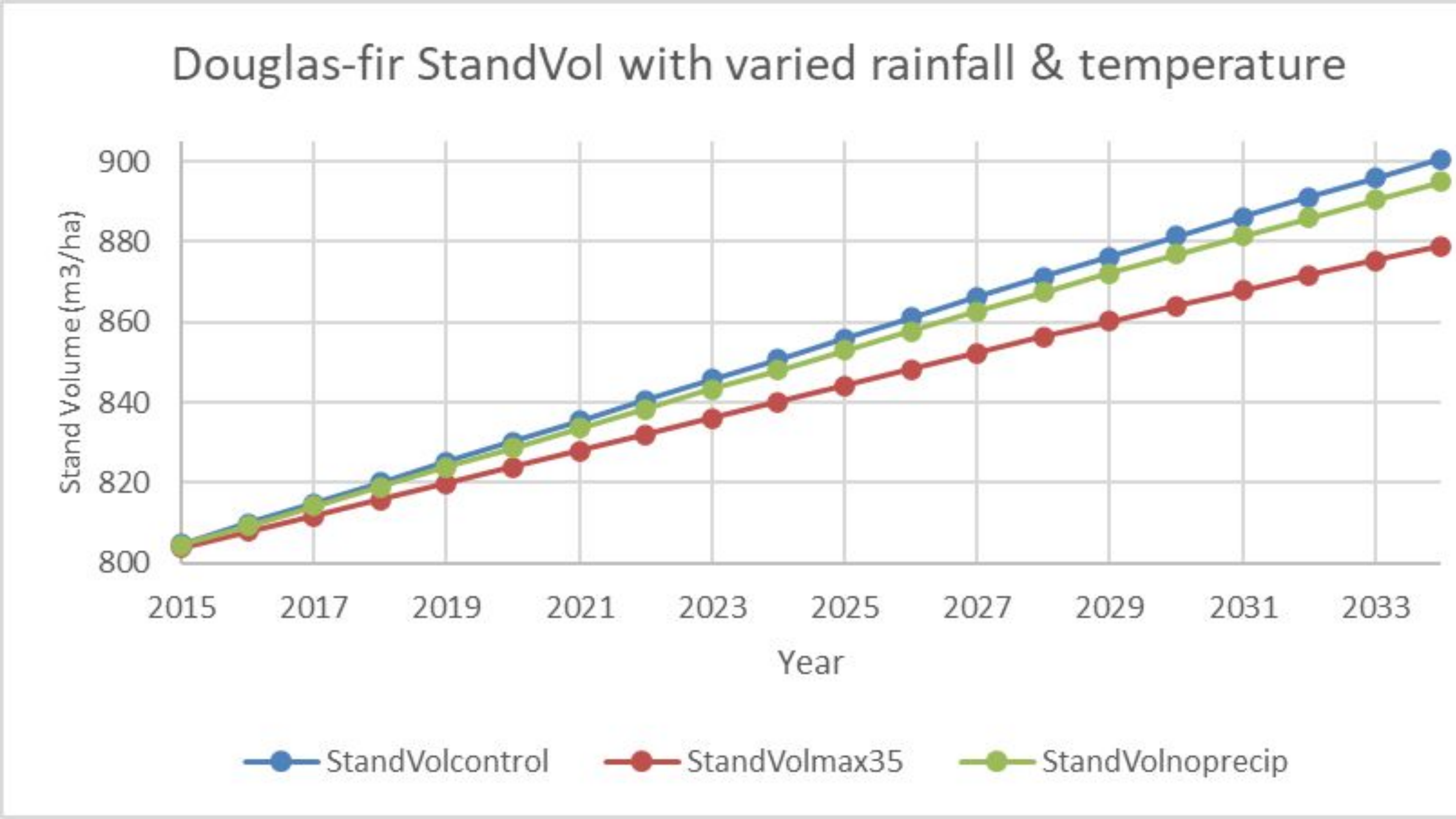
Step 3:

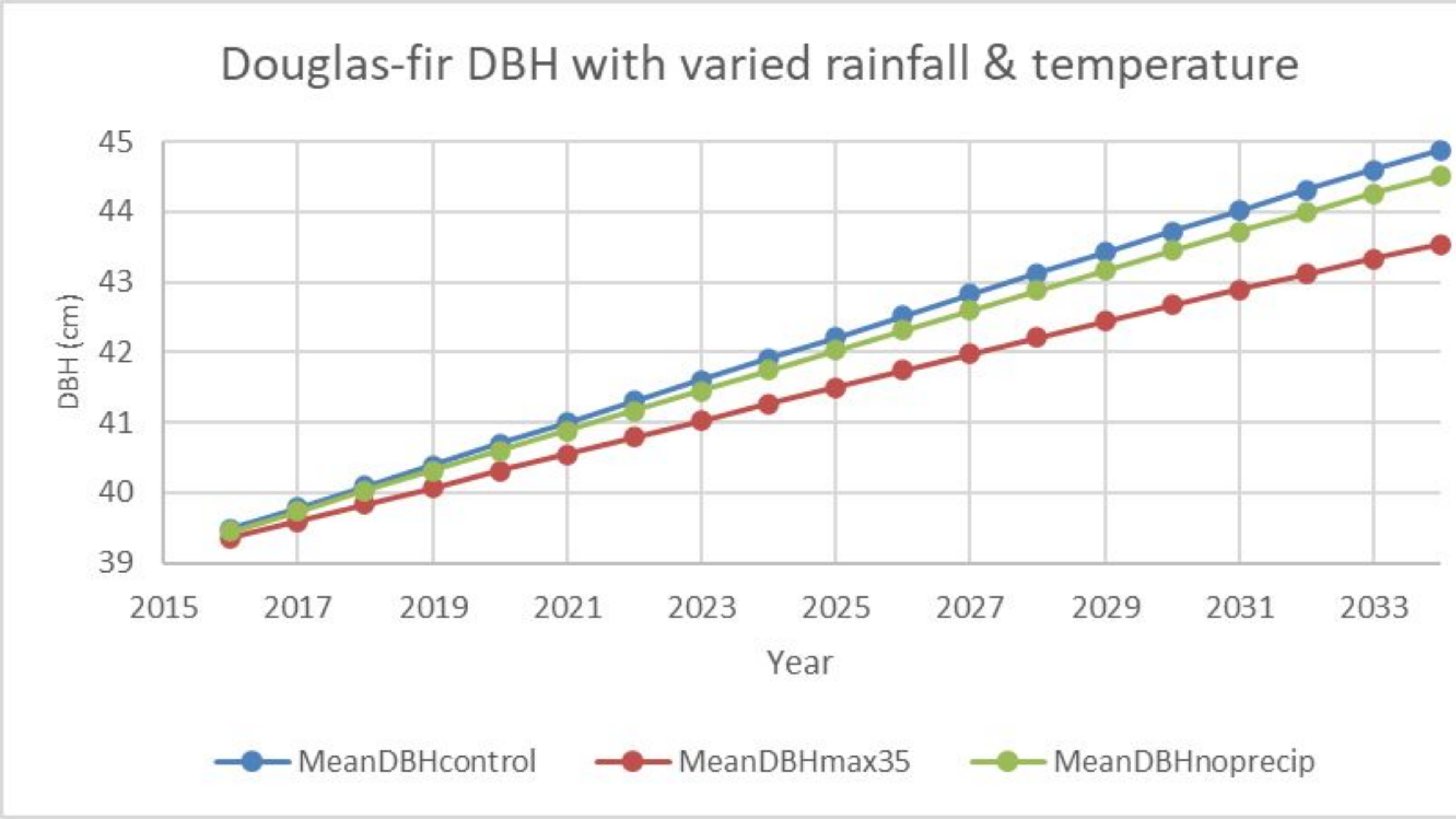
Graphing and interpreting results!

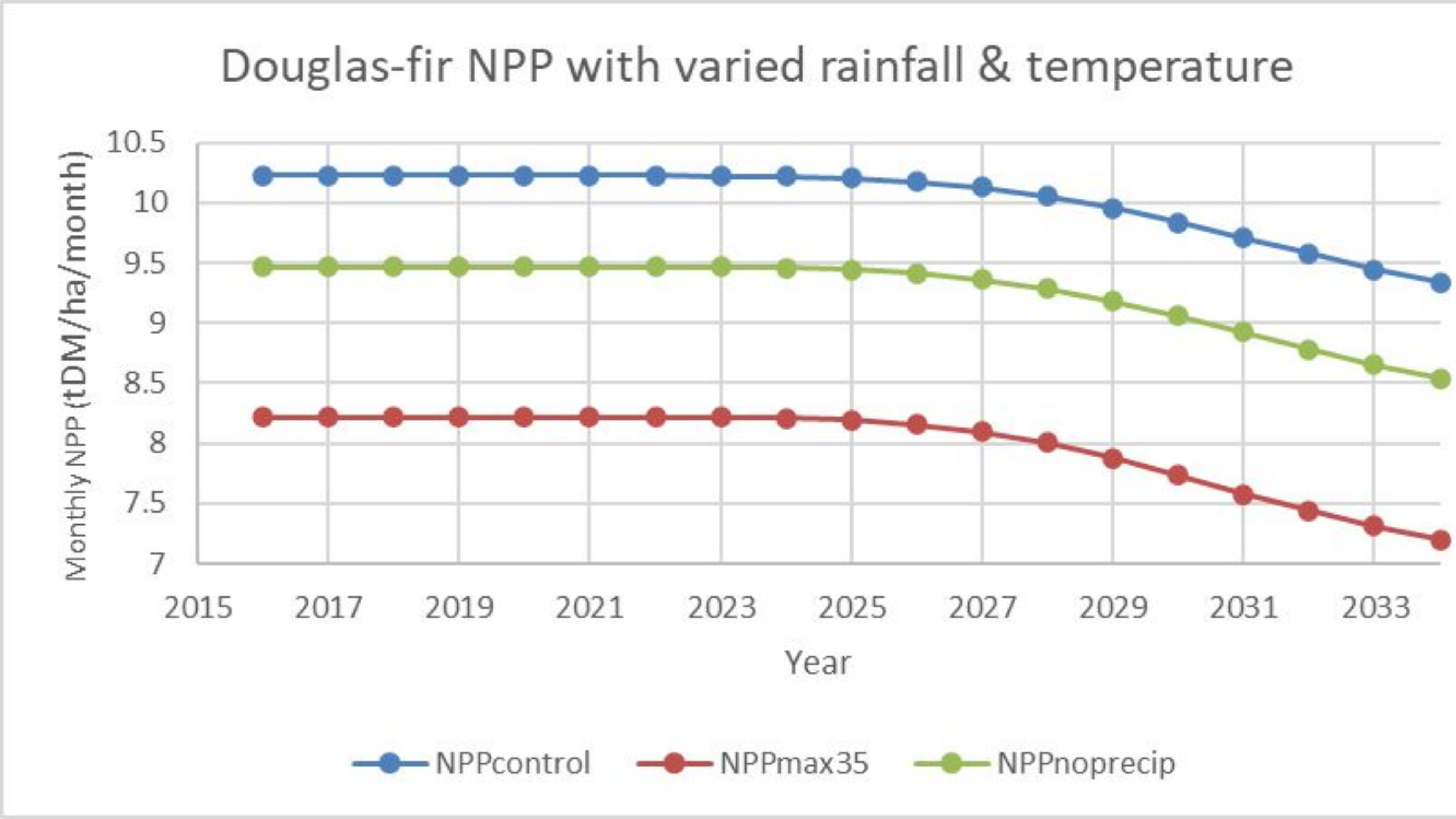
- Similarities in all figures
  - X = year
  - Y = output variable
  - Trends
    - Manipulated temperature reduced productivity more than manipulated precipitation
    - No manipulations have highest productivity



Douglas-fir MAI with varied rainfall & temperature
Mean Annual Increment (m3/ha/yr)
15
14.5
14
13.5
13
12.5
12
11.5
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
Year
MAIcontrol
MAImax35
MAInoprecip

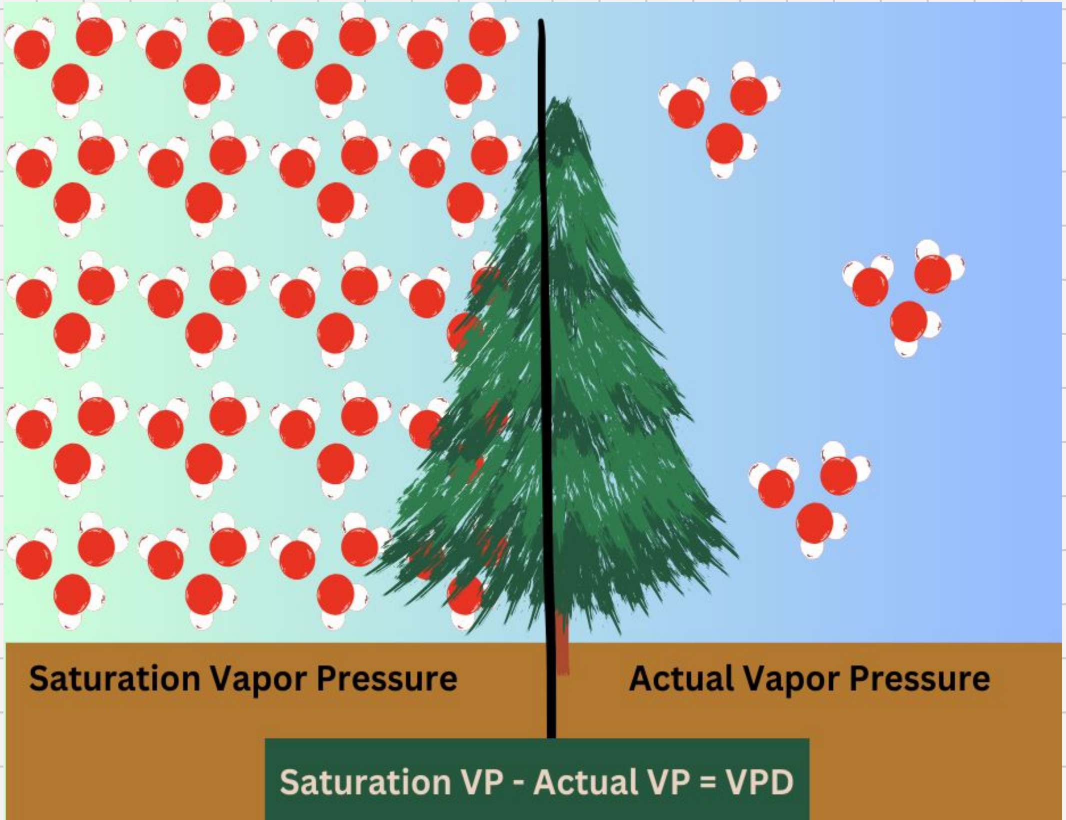

Douglas-fir StandVol with varied rainfall & temperature
Stand Volume (m3/ha)
900
880
860
840
820
800
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
Year
StandVolcontrol
StandVolmax35
StandVolnoprecip


Douglas-fir DBH with varied rainfall & temperature
DBH (cm)
45
44
43
42
41
40
39
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
Year
MeanDBHcontrol
MeanDBHmax35
MeanDBHnoprecip


Douglas-fir NPP with varied rainfall & temperature
Monthly NPP (tDM/ha/month)
10.5
10
9.5
9
8.5
8
7.5
7
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
Year
NPPcontrol
NPPmax35
NPPnoprecip

What did I learn?

- Supports my work: these things *do* have an effect
- Hypothesis that temperature is main driver of VPD
  - **↑ VPD → ↓ GPP (9)**
  - **Chemistry of warm air**
- Class exercise of VPD and canopy conductance



References - THANK YOU!

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