CLIMATE ADAPTED TREE SPECIES TRIALS: IN THE SBSmc2BL, SBSmc2FIRE, AND THE IDFdk3

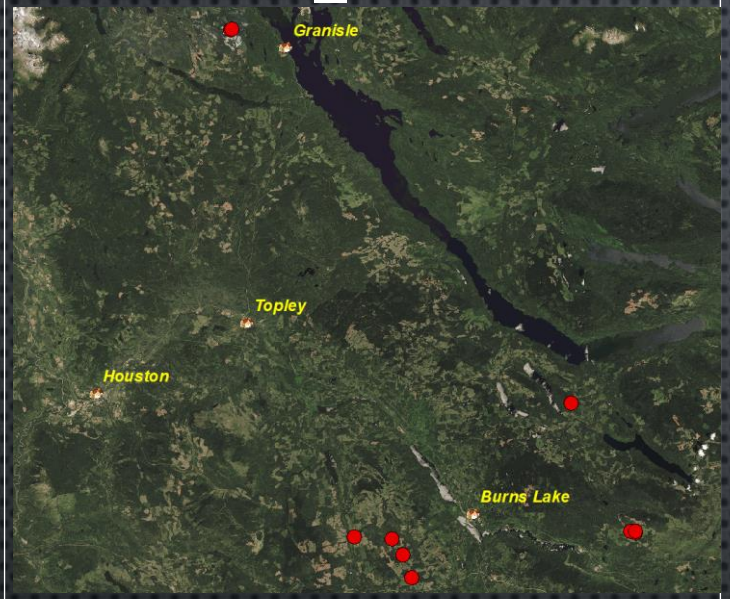
Pamela Dykstra, Research Leader Forest Ecology Interpretations

Larry McCulloch, Project Manager, LM Forest Resource Solutions

Jan, 2024

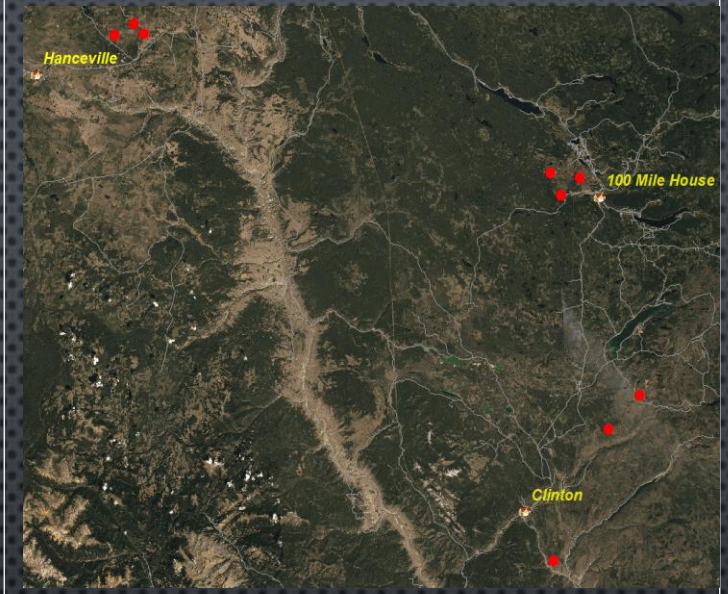
Preliminary Findings Regarding Weather Impacts And Survival

SBSmc2_BurnsLake



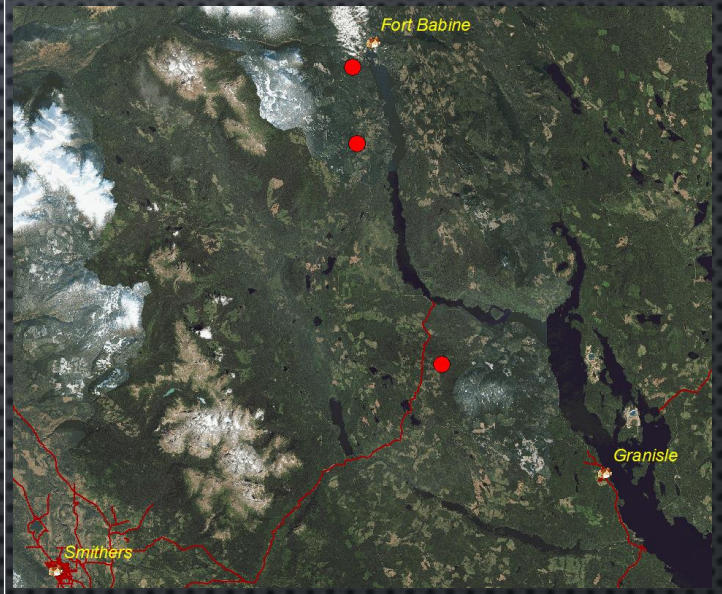
- Established 2019
- 7 sites and10 trial blocks
- Local, near, far seedlots for each of Pl, Sx, Fd, Lw, Cw
- 117,639 trees planted
- 7 weather stations

IDFdk3



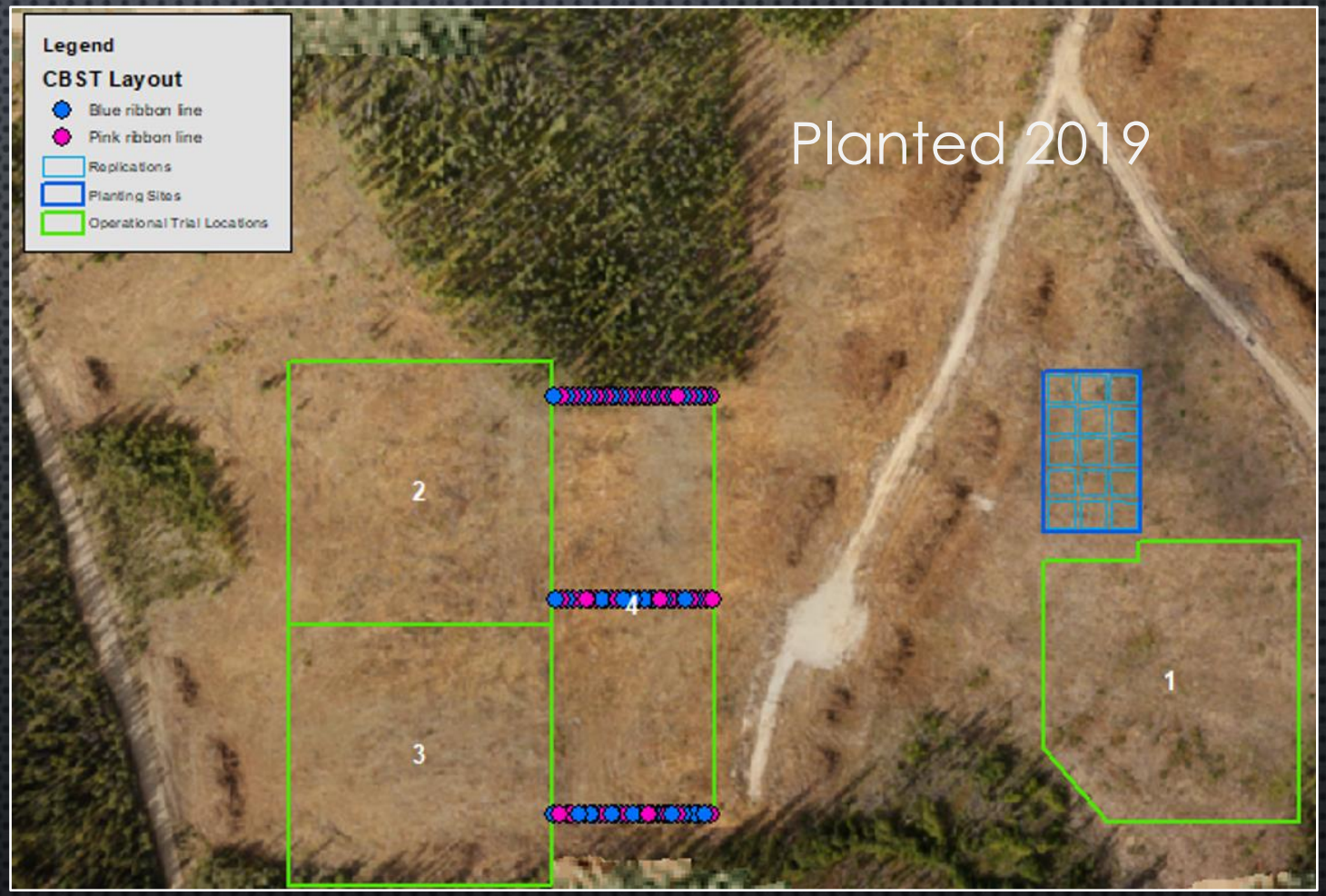
- Established 2021
- 9 sites and 90 trial blocks
- Local, near, far seedlots for each of Pl, Sx, Fd, Lw, Py
- Other variables: fire severity, season, shade, ripping
- 133,815 trees planted
- 18 weather stations

SBSmc2_Fire



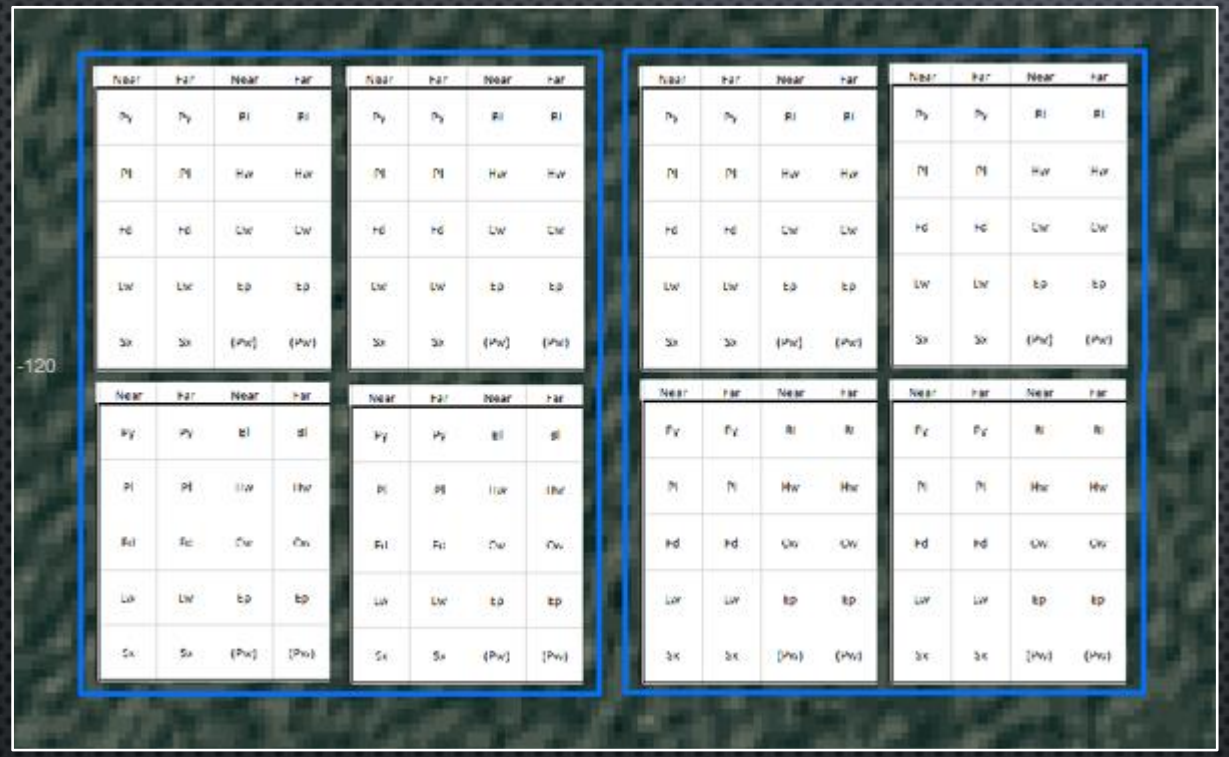
- Established 2022
- 3 sites and 24 trial blocks
- Near and far seedlots for each of Pl, Py, Pw, Fd, Lw, Sx, Bl, Hw, Cw, Ep
- Prescribed fire
- ~ 24K trees planted
- 3 weather stations

Trial Design in the SBSmc2 Burns Lake



- 7 sites, 10 trial blocks, 15 plots per block, 5 species, 3 seedlots (local, near, far), 36 trees/plot
- 3 operational mixed bag plants of local, near, far seedlots, and 1 CBST block
- Circum mesic sites

Trial Design in the SBSmc2Fire



- 3 cutblocks, winter logging, relatively wet sites
- Prescribed fire
- 4 trial blocks in a Burned area and 4 in an Unburned area

Planting Configuration

Near	Far	Near	Far
Py	Py	Bl	Bl
Pl	Pl	Hw	Hw
Fd	Fd	Cw	Cw
Lw	Lw	Ep	Ep
Sx	Sx	(Pw)	(Pw)

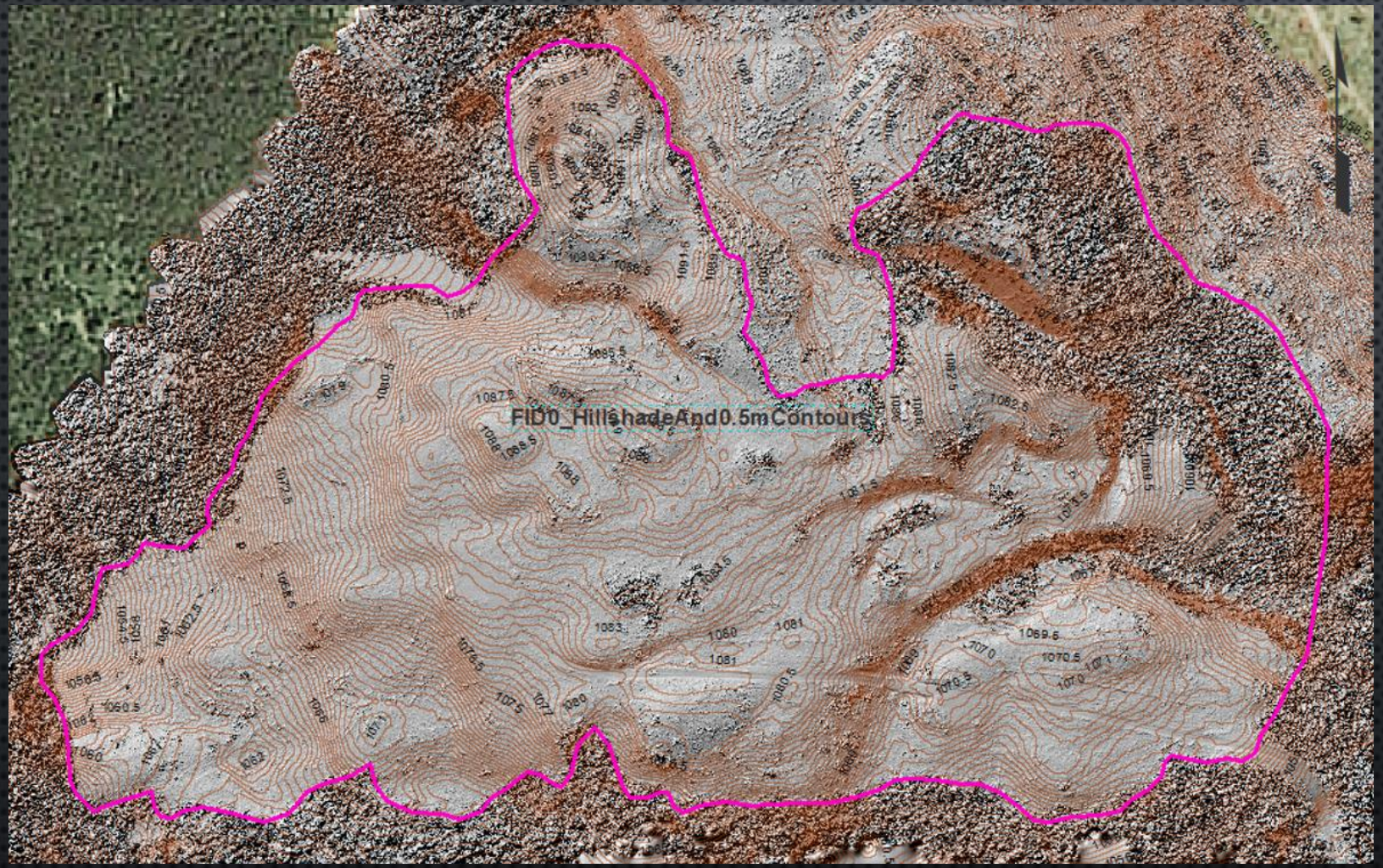
Species and seedlot in each trial block. 20 plots, each with 36 trees.

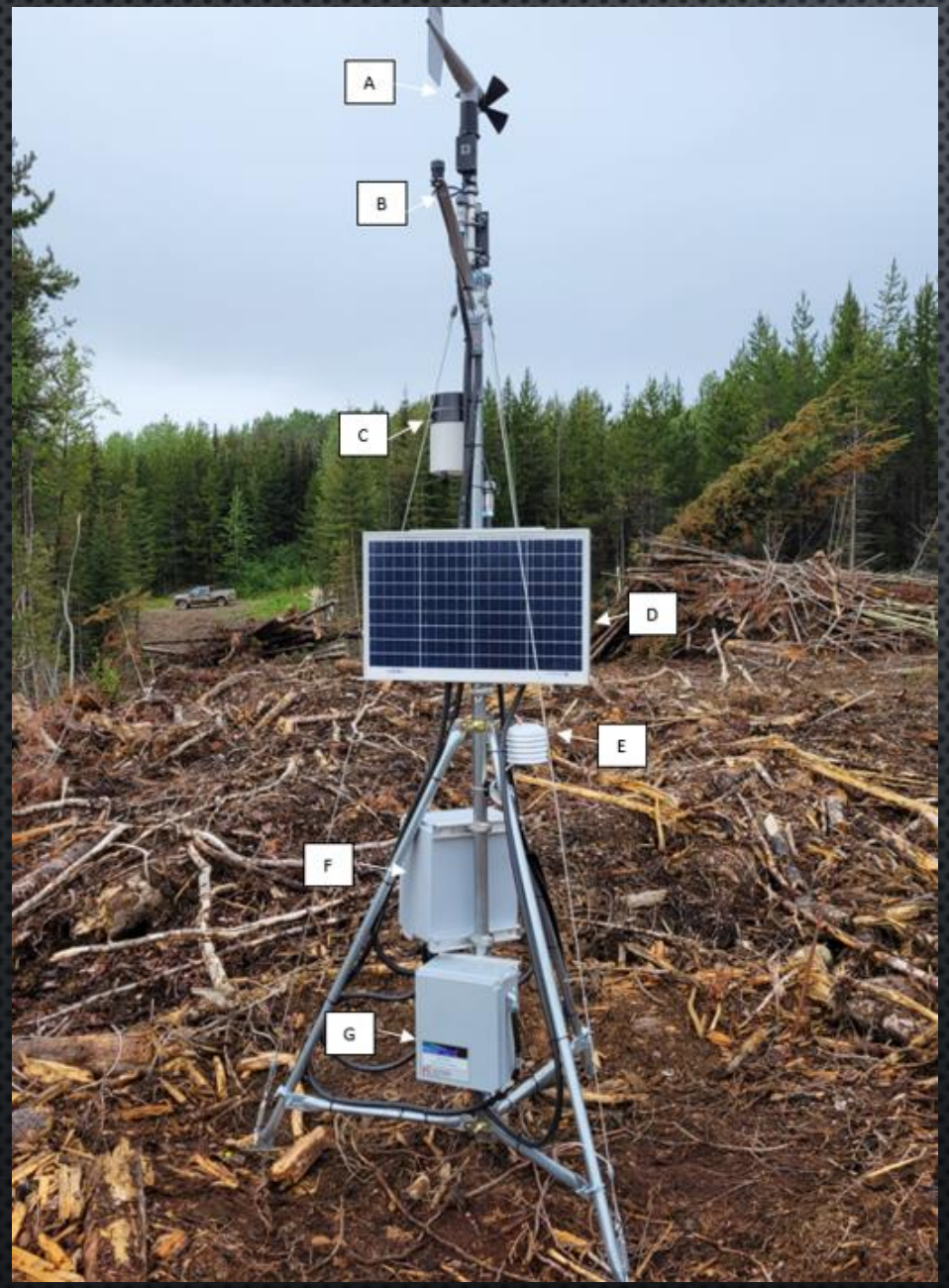
Trial Design IDFdk3 (3 wildfires, 3 sites at each)

Trial Design At One Site:

- 5 tree species x 3 seedlots
  - **Pl, Sx, Fd, Lw, & Py** for local, near, far for the Trial Blocks
  - **Fdi** local, near, and far for the Shade and Fall Plant Blocks
- 4 trial blocks (blue)
- 4 fall plant blocks (yellow), 2 planting dates for each
- 2 shade blocks (green)
- An operational plant (red)
- 2 levels of fire intensity
- 2 levels of site prep (pink dots)
- 2 levels of shade
- 18 weather stations
  - temp, precip, RH, solar
- 136 soil moisture probes
- 1 CBST plant

Other Features of the Trials: **Drone Imagery**





Other Features: **Weather Stations**

An Iridium weather station in the SBSmc2Fire project equipped with:

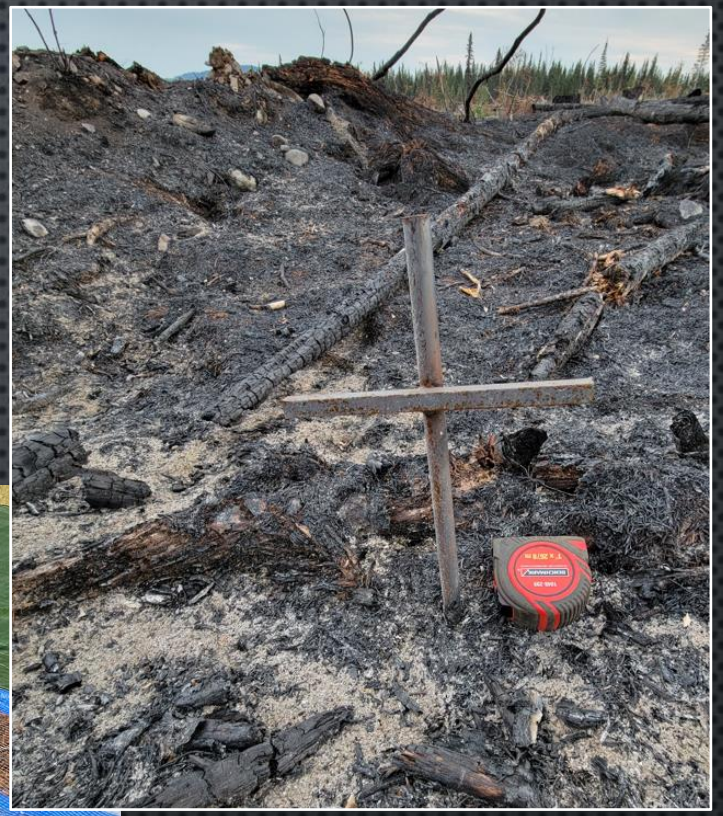
- A) a wind gauge,
- B) a pyranometer and attachment bracket, C) a rain gauge
- D) a solar panel,
- E) a temp/RH sensor with solar shield,
- F) a H22 cable box (see figure 6),
- G) a 12V battery box

Soil moisture station: H21 data logger, 2 – 4 EC5 sensors, cables buried

Other Features:
Fuel Measurements
(SBSmc2Fire only)

Fine fuel moisture content

Fuel transects and LFH weights and volumes



Burn depth pins

Other Features: **Burn Severity**

(SBSmc2Fire only)

Burn Severity	574_001	573_004	400_404
Unburned (m2)	313	0	0
%	**2**	**0**	**0**
Low (m2)	6871	2092	0
%	**49**	**14**	**0**
Mod (m2)	4087	5775	6608
%	**29**	**40**	**40**
High (m2)	2689	6670	9894
%	**19**	**46**	**60**
Total (m2)*	13960	14537	16502

Burn severity class where green cross hatch is Unburned, yellow vertical hatch is Low, orange cross hatch is Moderate, red cross hatch is High severity, and light blue crosses are burn pin locations

Other Features: **Prescribed Fire**

(SBSmc2Fire only)

- Site Selection and Layout - LMFRS
- Burn Plans – LMFRS
- Fire Weather Indices - LMFRS
- Guarding and Sumps – West Fraser PIR
- Authorizations – MoF
- Pre-Burn Mobilization – BC Wildfire Service
- Ignition and Control - BC Wildfire Service
- Mopup and Monitoring– BC Wildfire Service

Analysis - Weather Impacts And Survival

Key Concepts Underpinning The Assisted Migration Research

- When a novel seedlot or species is introduced to an area, **normal environmental conditions for a given biogeoclimatic unit may be suitable** in terms of survival and early growth, however, **this may not be the case when there are environmental extremes** for which they are mal adapted.

- Events such as extreme cold (2020), low rainfall (2021), and extreme heat events (2021) are extremely valuable because they provide insights into **how to best mitigate against fluctuations in environmental conditions outside the normal range**.

- By taking a careful look at the species and seedlots that did relatively well despite these extremes. **we may be able to choose the best seedlots and sites**, change planting timing, undertake specific site preparation, or undertake nursery cultural practices, **that will allow us to introduce novel species and seedlots well before the arrival of future favourable climate conditions**."

Some Important Definitions

Vapour Pressure Deficit (VPD)

- VPD is the difference between the amount of moisture in the air and how much moisture the air can hold when it is saturated. If VPD is high, meaning the air is relatively dry, transpiration rates will increase. When VPD gets beyond a certain threshold, seedling may close their stomata and stop transpiring, leading to hydrologic dysfunction and carbon starvation which could lead to mortality.

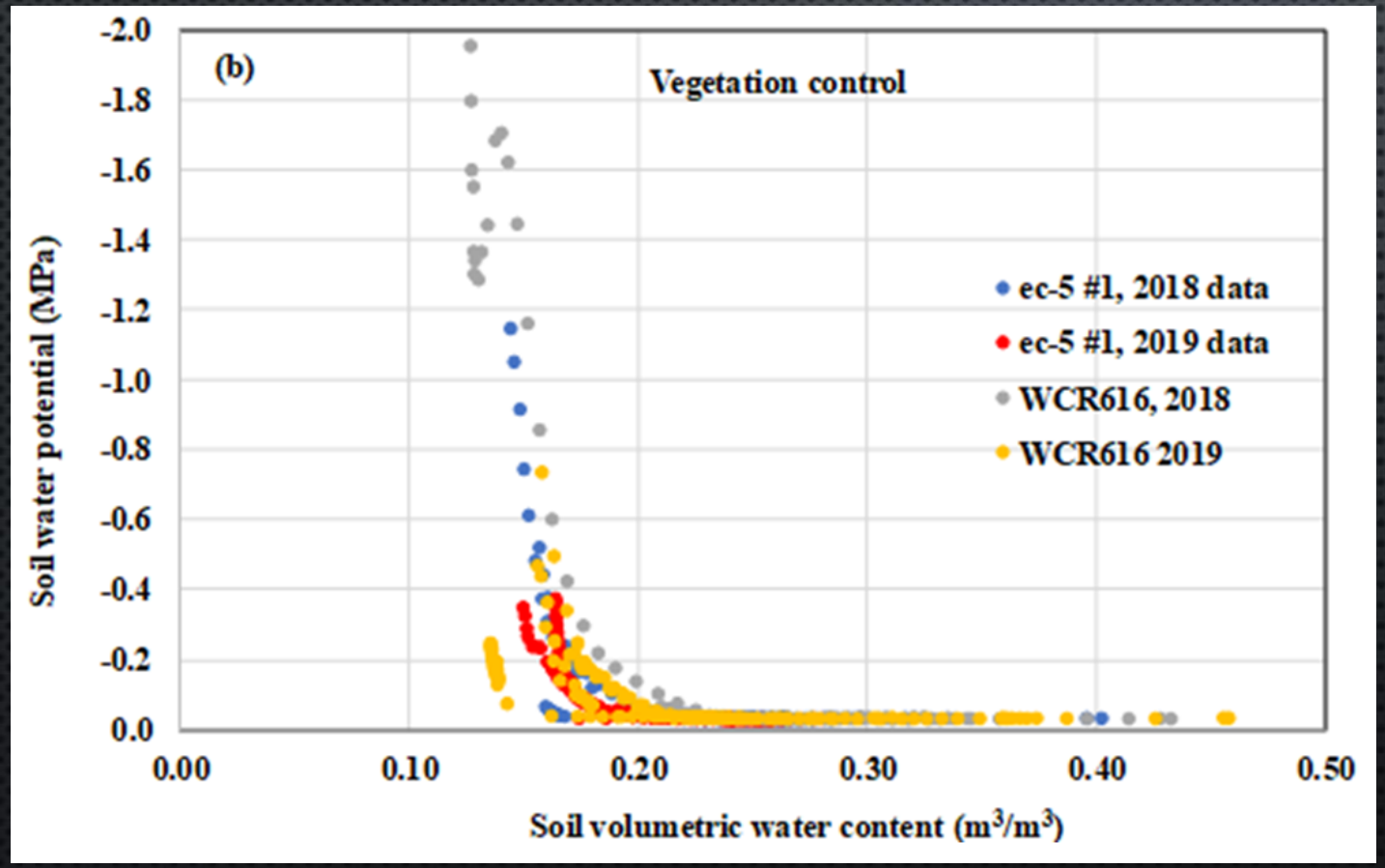
Air Temperature	Relative Humidity								
°C	90%	80%	70%	60%	50%	40%	30%	20%	10%
0									
5	0.1	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.8
10	0.1	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.1
15	0.2	0.3	0.5	0.7	0.9	1.0	1.2	1.4	1.5
20	0.2	0.5	0.7	0.9	1.2	1.4	1.6	1.9	2.1
25	0.3	0.6	1.0	1.3	1.6	1.9	2.2	2.5	2.9
30	0.4	0.9	1.3	1.7	2.1	2.5	3.0	3.4	3.8
35	0.6	1.1	1.7	2.2	2.8	3.4	3.9	4.5	5.1
40	0.7	1.5	2.2	3.0	3.7	4.4	5.2	5.9	6.6

VPD

VPD is a function of air temperature and relative humidity (shown in the chart above). The area in the table that is blue green is optimum, yellow denotes marginal conditions, and red indicates stressful conditions for planted seedlings – Courtesy of Steve Grossnickle, Seedling physiologist.

Soil Water Potential

- It is not only VPD that one must be concerned about, but the combination of soil water availability and VPD. One way to measure soil water availability is a soil water retention curve. The soil water retention curves provide an indication of where soil water starts becoming tightly bound and thus not very available for plant use. The more negative the soil water potential, the greater the hydrologic draw. Courtesy of Bob Sagar, BioMeteorologist.



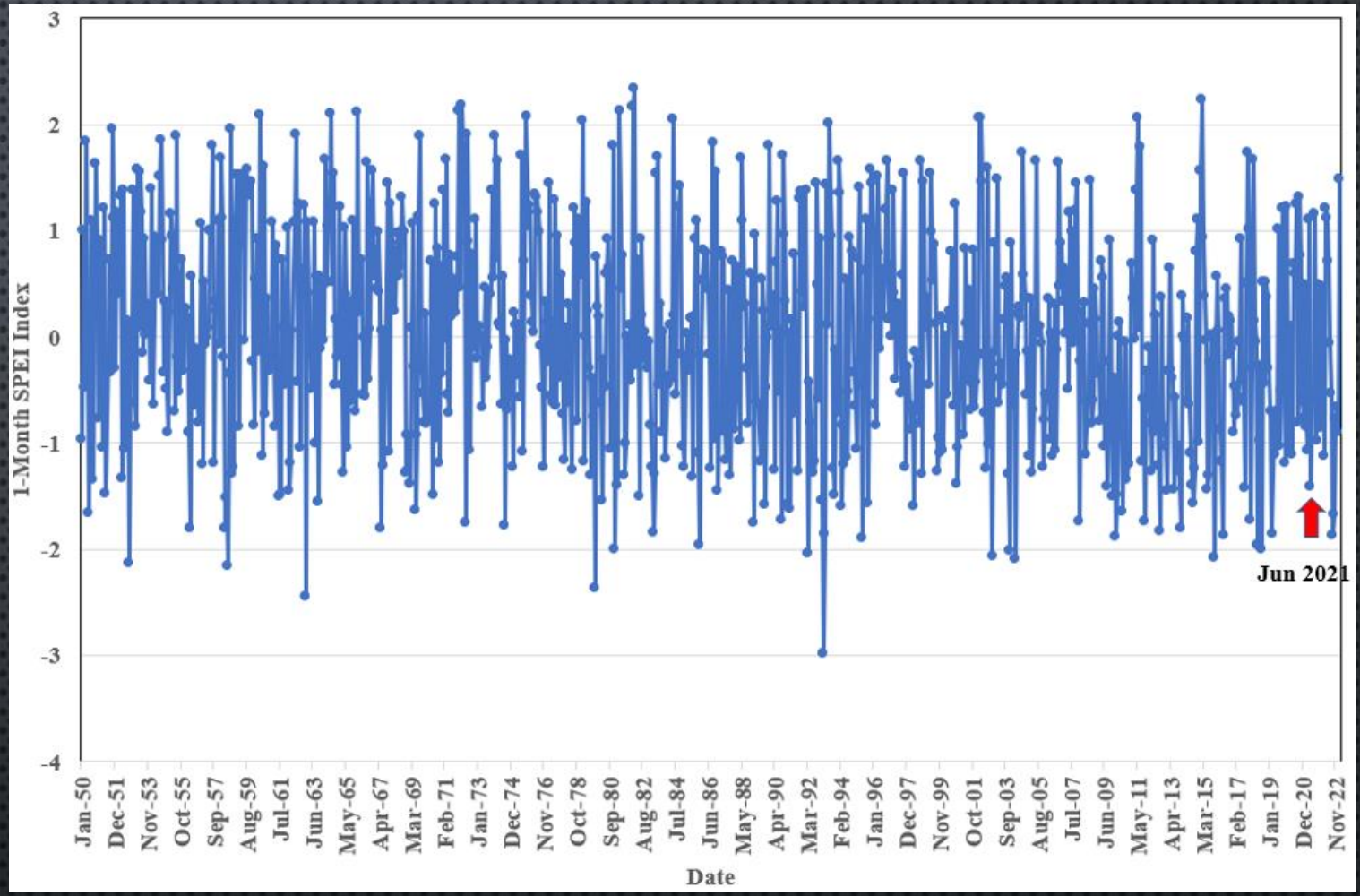
An example of soil water potential as it relates to **soil water content** on a silt loam textured soil at Bob's Inga Lake research site. At about -1.5MPa, soil water became limiting.

Per Grossnickle, root elongation for newly planted conifers ceases at about -0.065 MPa, and it is generally accepted that soil water below -0.2 MPa is limiting to conifer growth.

For spruce species, severe drought stress occurs at about -2.0 to -3.0 MPa)

Standardised Precipitation-Evapotranspiration Index (SPEI)

- This information is used for determining the onset, duration, and magnitude of **drought** conditions relative to normal conditions.
- An SPEI value of zero would indicate no change relative to historical values. Values higher than **-0.5 are non-drought, -1.5 to -1 can be interpreted as moderate drought, -2 to -1.5 as severe drought, and values below -2 as extreme drought**.
- The impact of such variables depends on timing, duration, intensity, and developmental stage.



Monthly SPEI values from 1950 to 2022 with the data point for June, 2021, the month of the heat dome, indicated with a red arrow (~-1.5). Applicable to the area of the SBSmc2BL Trial. Source: Environment Canada. Courtesy Bob Sagar.

Analysis - Weather Variables

Soil water content (m3/m3)
Air temperature
Relative Humidity
Rainfall
(Windspeed)
Every hour (15 min)

Although May was a cold month in 2021 at this site (average temp of 6.7 degrees), the heat dome in June also resulted in unprecedented high temperatures and extraordinary vapour pressure deficits, and rainfall was relatively low (about 3x lower than 2022). The temperature extremes at this site were slightly lower than FID0 and rainfall in June was low but nearly twice as high as FID0, so it it expected that seedling survival might be slightly better, although any differences in soil moisture levels (which are unknown) would influence this. As was the case in FID0, relative humidity was also somewhat lower on average than in other years. The combination of low rainfall in June and July (and likely low soil moisture), and extreme vapour pressure deficit, likely resulted in some seedling mortality.

Example of a summary of weather influence at one site for 2021 in the SBSmc2BI trial.

Summary Stats 2019	*May 1 to Aug 31*	Summary Stats 2020	*May 1 to Aug 31*	Summary Stats 202
Average Daily Temp (*C)	12.0	Average Daily Temp (*C)	10.2	Average Daily Ter
Min Avg Daily Temp (*C)	3.7	Min Avg Daily Temp (*C)	2.8	Min Avg Daily Ter
Max Avg Daily Temp (*C)	21.4	Max Avg Daily Temp (*C)	19.7	Max Avg Daily Ter
Days Where Temp Dropped <0	0	Days Where Temp Dropped <0	5	Days Where Temp Drop
First Frost After Aug 31	Sept. 26	First Frost After Aug 31	Oct. 8	First Frost After
Max Temp	27.8	Max Temp	26.4	Ma
Date of Max Temp	Aug. 5	Date of Max Temp	Jul. 30	Date of Ma
Average Daily Temp June (*C)	11.0	Average Daily Temp June (*C)	9.1	Average Daily Temp Ju
Average Daily Temp July (*C)	12.9	Average Daily Temp July (*C)	12.3	Average Daily Temp Ju
Average Daily Temp August (*C)	13.3	Average Daily Temp August (*C)	11.1	Average Daily Temp Augu
Average Daily RH (%)	65.7	Average Daily RH (%)	69.3	Average Daily
Min RH (%)	15.2	Min RH (%)	19.9	Min
Date of Min RH	May. 28	Date of Min RH	May. 12	Date of
Max RH (%)	95.6	Max RH (%)	96.0	Max
Total Rainfall (mm)	198.6	Total Rainfall (mm)	220.8	Total Rainfa
No. Days w/>1mm Rain	39	No. Days w/>1mm Rain	46	No. Days w/>1m
No. Days w/Rain	57	No. Days w/Rain	62	No. Days
Total Rainfall June (mm)	44.4	Total Rainfall June (mm)	61.2	Total Rainfall Jun
Total Rainfall July (mm)	86.8	Total Rainfall July (mm)	62.8	Total Rainfall Jul
Total Rainfall August (mm)	31.6	Total Rainfall August (mm)	64.6	Total Rainfall Augus
Average VPD June (kPa)	0.50	Average VPD June (kPa)	0.38	Average VPD Jun
Average VPD July (kPa)	0.43	Average VPD July (kPa)	0.46	Average VPD Jul
Average VPD August (kPa)	0.60	Average VPD August (kPa)	0.39	Average VPD Augus
Maximum VPD June (kPa)	2.19	Maximum VPD June (kPa)	1.57	Maximum VPD Jun
Maximum VPD July (kPa)	1.82	Maximum VPD July (kPa)	2.15	Maximum VPD Jul
Maximum VPD August (kPa)	2.39	Maximum VPD August (kPa)	1.76	Maximum VPD Augus
Date of Max VPD	Aug. 5	Date of Max VPD	Jul. 30	Date of M
Avg Daily Wind Speed (m/sec)	1.50	Avg Daily Wind Speed (m/sec)	1.84	Avg Daily Wind Speed (
Max Gust Speed (m/sec)	13.6	Max Gust Speed (m/sec)	13.6	Max Gust Speed (
Avg Daily Radiation (W/m2)	809	Avg Daily Radiation (W/m2)	784	Avg Daily Radiation (
Max Radiation (W/m2)	1277	Max Radiation (W/m2)	1277	Max Radiation (

Weather statistics generated for the SBSmc2BL for each of 3 benchmark sites for 4 years. 31 summary statistics.

Analysis - Weather Variables Con't

EH South Open 2022	
01/06/22 - 31/08/22	
Average Temp (*C)	17.0
Min Temp (*C)	0.1
Days < 0 Degrees	0.0
First Frost	None til after Sept 9
Max Temp (*C)	38.3
Date of Max Temp	07/28/22 03:26:09 PM
Average Temp June (*C)	12.6
Average Temp July (*C)	19.0
Average Temp August (*C)	19.2
Average RH (%)	61.4
Min RH (%)	11.8
Max RH (%)	100.0
Total Rainfall (mm)	84.8
No. Days w/>1mm Rain**	16.0
No. Days of Rain	29.0
Total Rainfall June (mm)	45.8
Total Rainfall July (mm)	28.8
Total Rainfall August (mm)	10.2
Average VPD June (kPa)	0.6
Average VPD July (kPa)	1.3
Average VPD August (kPa)	1.3
Maximum VPD June (kPa)	4.0
Maximum VPD July (kPa)	5.4
Maximum VPD August (kPa)	4.7
Date of Max VPD	07/29/22 05:11:09 PM

May Frost			
EH South Shade		EH South Open	
-0.85	1-May	-3.006	1-May
0.00	8-May	-0.451	6-May
-1.10	9-May	-0.648	7-May
0.00	10-May	-1.299	8-May
-2.83	11-May	-1.015	9-May
-0.68	13-May	-1.727	10-May
-1.16	14-May	-5.357	11-May
-0.06	17-May	-0.143	12-May
-0.70	20-May	-0.958	13-May
-1.90	21-May	-1.814	14-May
-0.34	22-May	-0.817	17-May
-0.26	28-May	-0.591	19-May
12.0	No. Days	-2.537	20-May
-0.82	Average	-3.956	21-May
		-2.947	22-May
		-0.676	26-May
		-2.247	28-May
		17.0	No. Days
		-1.78	Average

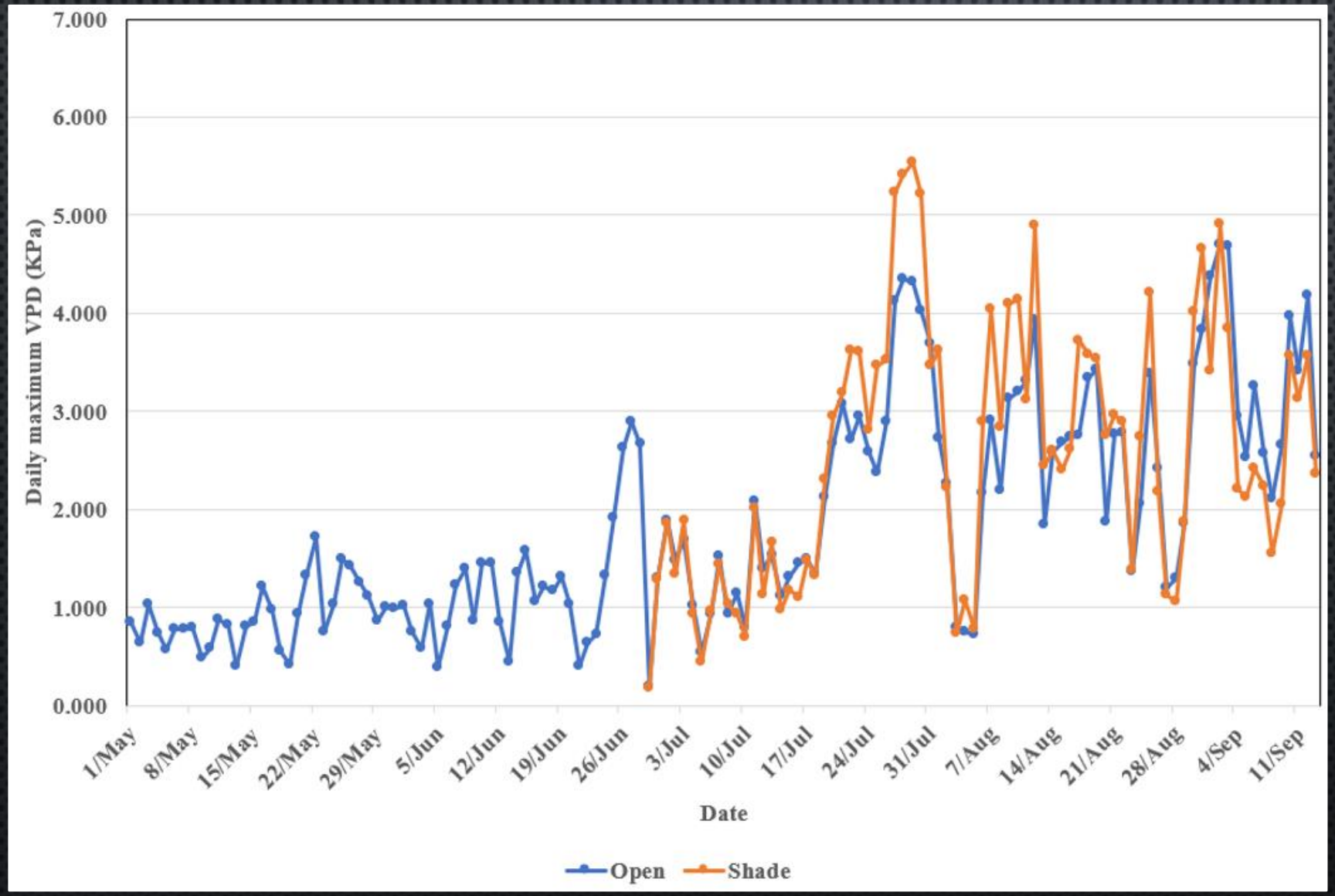
EH South Shade 2022 (4 probes)	
June Average Water Content (m3/m3)	0.086
July Average Water Content (m3/m3)	0.136
August Average Water Content (m3/m3)	0.069

EH South Rips 2022 (4 probes)	
June Average Water Content (m3/m3)	0.047
July Average Water Content (m3/m3)	0.119
August Average Water Content (m3/m3)	0.040

EH South Non-Rips 2022 (4 probes)	
June Average Water Content (m3/m3)	0.102
July Average Water Content (m3/m3)	0.107
August Average Water Content (m3/m3)	0.032

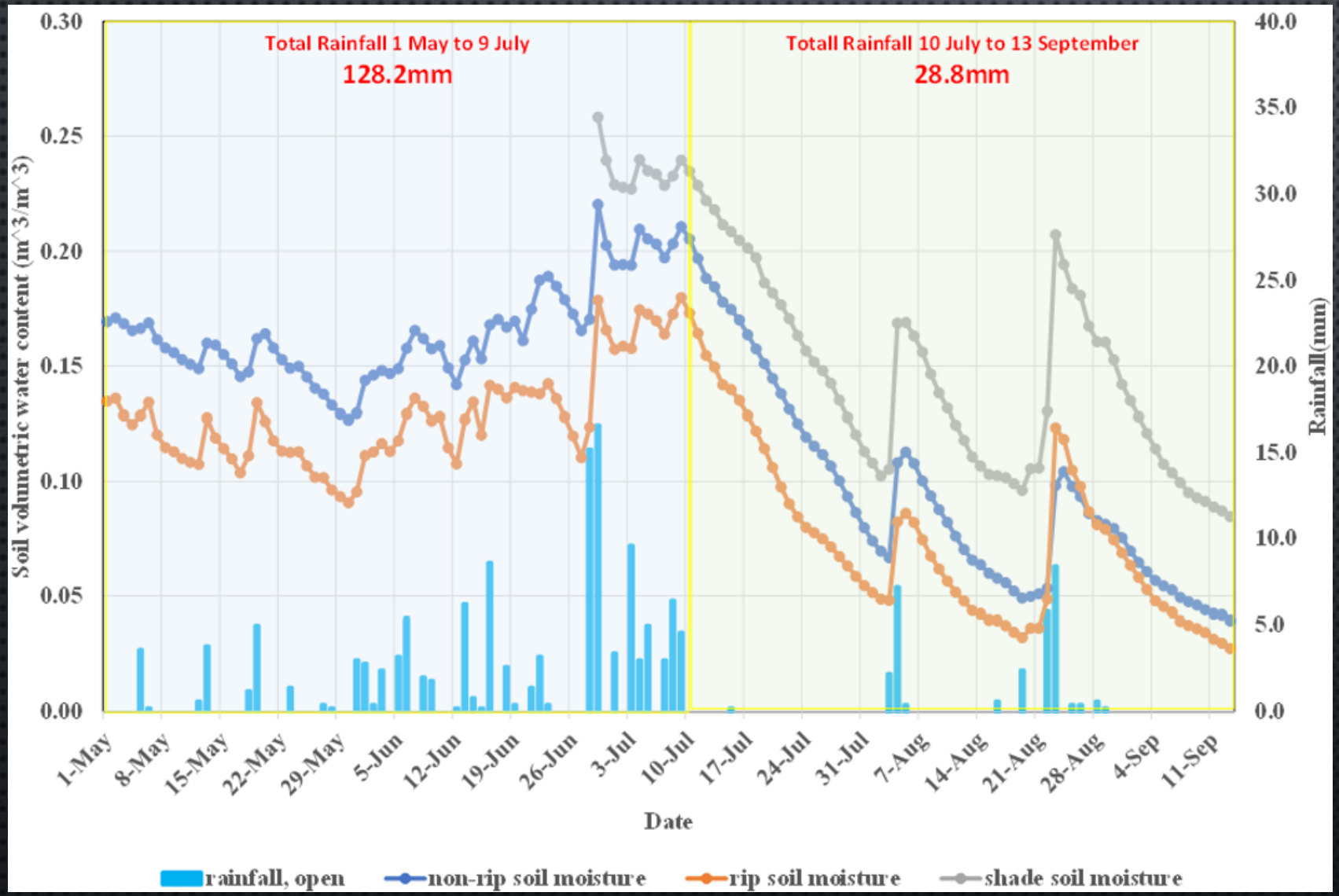
Similar weather statistics generated for all the IDFdk3. Only 1 year. Also had soil moisture data!

Analysis Weather Variables Con't



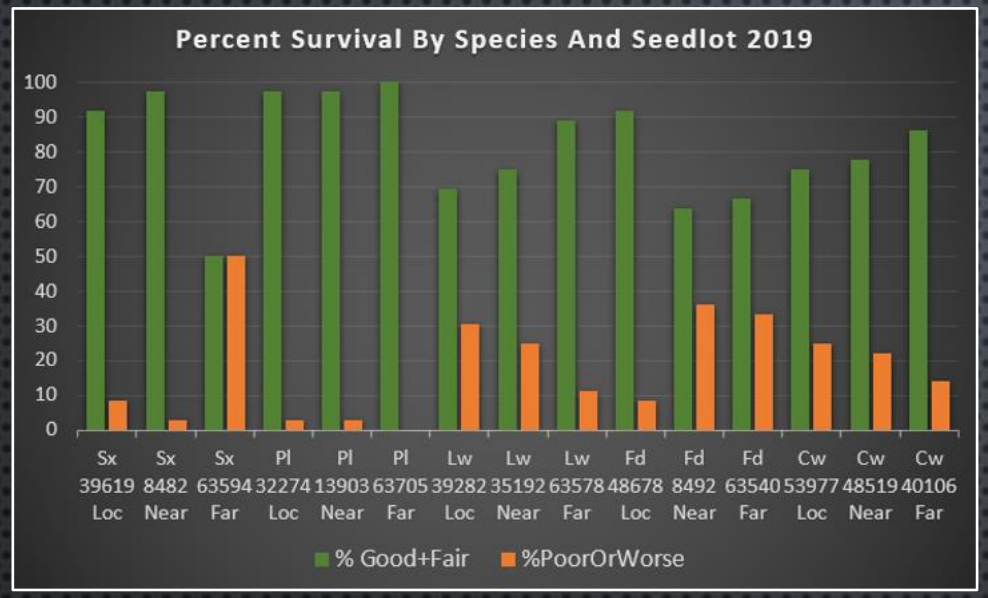
- Maximum daily vapour pressure deficit in the shade area versus the open area at the Hanceville Mid site in the IDFdk3 trial.
- Recall that anything above about 2 indicates marginal conditions for seedlings.
- At some sites VD was almost 9!

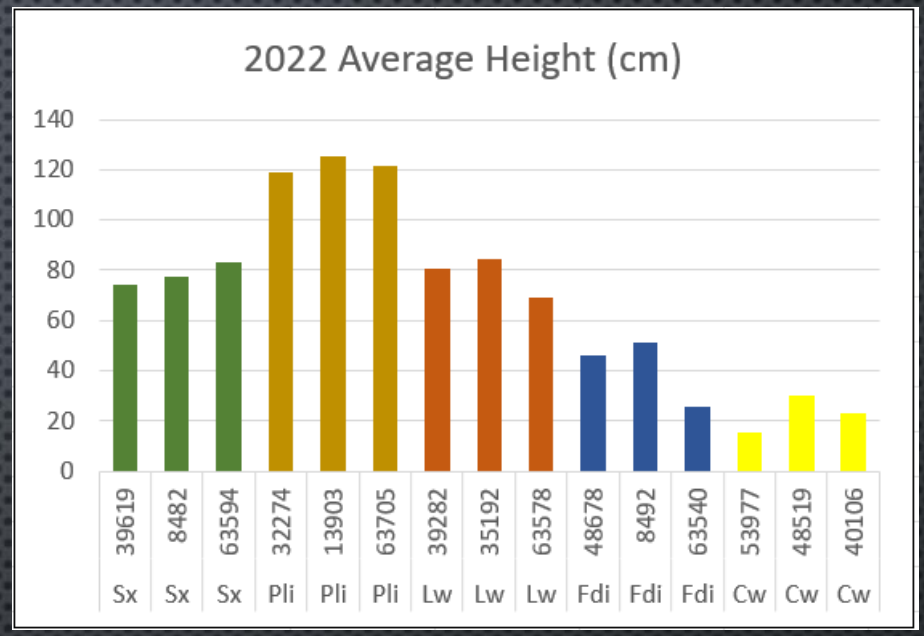
Analysis Weather Variables Con't



- Rainfall levels and associated soil moisture levels in ripped, non-ripped, and shade areas at the Hanceville Mid site.
- Recall the relationship between soil water content and hydrological potential (in this case on clay enriched soils) where hydrological dysfunction was possible at <0.2 m3/m3
- Courtesy of Bob Sagar

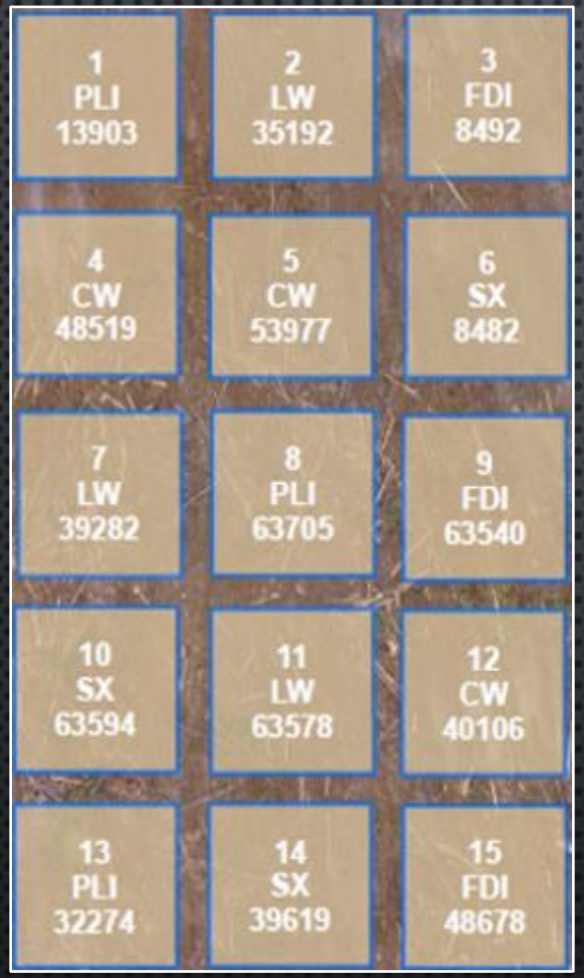
Analysis - Survival Variables



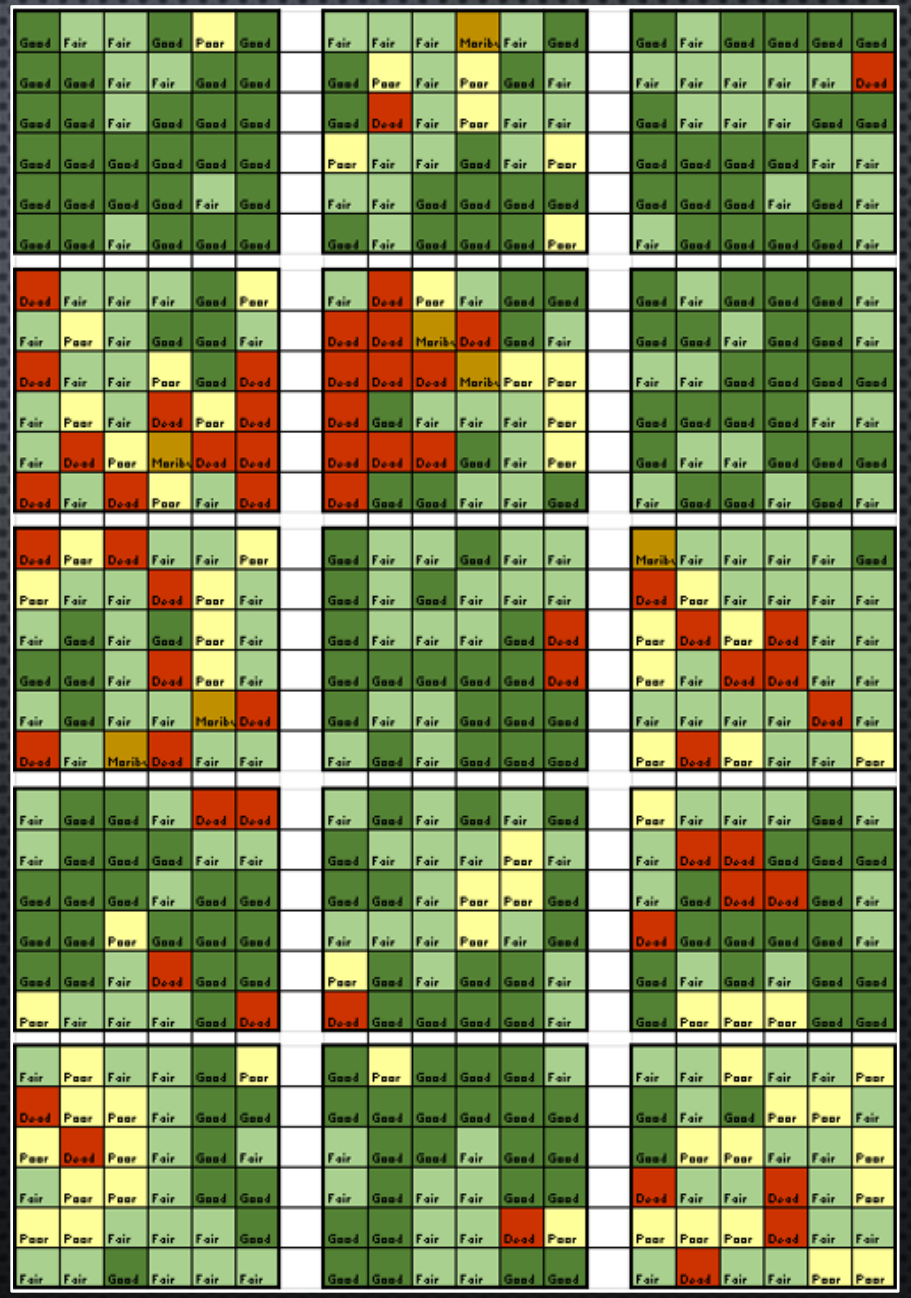


	Sx 39619 Local	Sx 8482 Near	Sx 63594 Far	Pli 32274 Local	Pli 13903 Near	Pli 63705 Far	Lw 39282 Local	Lw 35192 Near	Lw 63578 Far	Fdi 48678 Local	Fdi 8492 Near	Fdi 63540 Far	Cw 53977 Local	Cw 48519 Near	Cw 40106 Far	Average All Spp/ Sites
FID 0: Augier	97	97	78	97	100	100	67	50	61	94	83	39	8	8	39	68
FID 2: Mesic	100	92	97	100	89	81	22	42	25	75	83	25	58	61	86	69
FID 2: Wet	97	100	100	94	100	97	36	53	64	50	61	22	81	53	69	72
FID 6: Maxan	100	100	100	100	100	94	89	78	75	86	86	25	0	6	33	71
FID 7: Mesic	94	100	89	97	97	97	92	92	94	92	92	58	22	8	28	77
FID 9: Demo	94	94	92	100	97	97	72	81	78	75	75	42	78	42	56	78
FID 9: Dry	97	100	89	94	100	94	75	94	97	89	97	78	61	67	86	88
FID 9: Mesic	92	100	100	100	100	94	64	67	86	86	92	28	53	69	36	78
FID 15: Maxan	100	100	97	100	94	97	94	86	81	31	94	61	69	31	78	81
FID 11: Frost	99	98	99	99	99	100	30	23	26	30	57	28	6	1	1	53
Average By Seedlot	97	98	94	98	98	95	64	67	69	71	82	41	44	35	51	74
Average w/o FID 11	97	98	94	98	98	95	68	71	73	75	85	42	48	38	57	76

Analysis - Survival Variables Con't

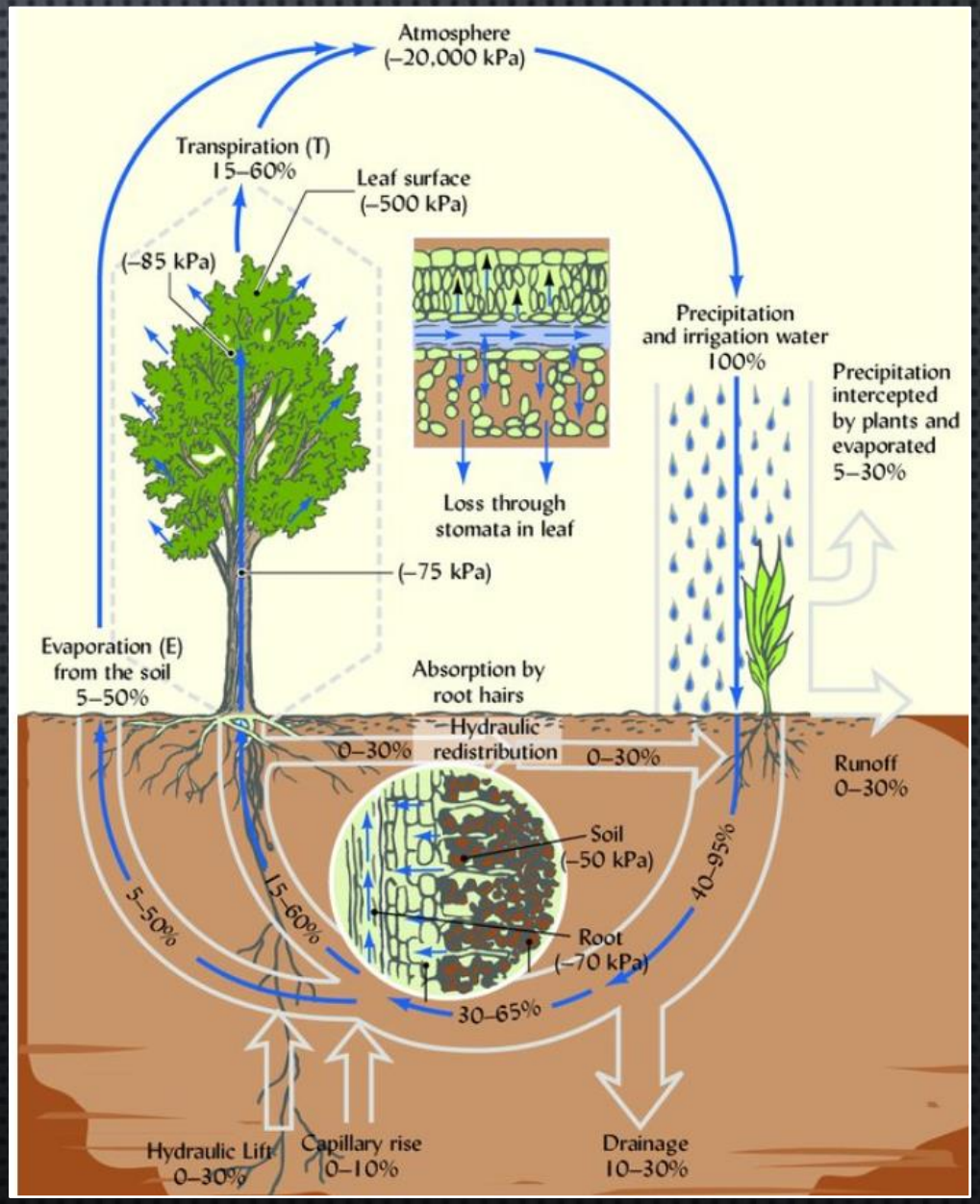


A heat map of the trial at FID 9 Dry showing seedling condition in the fall of 2022 by species and seedlot



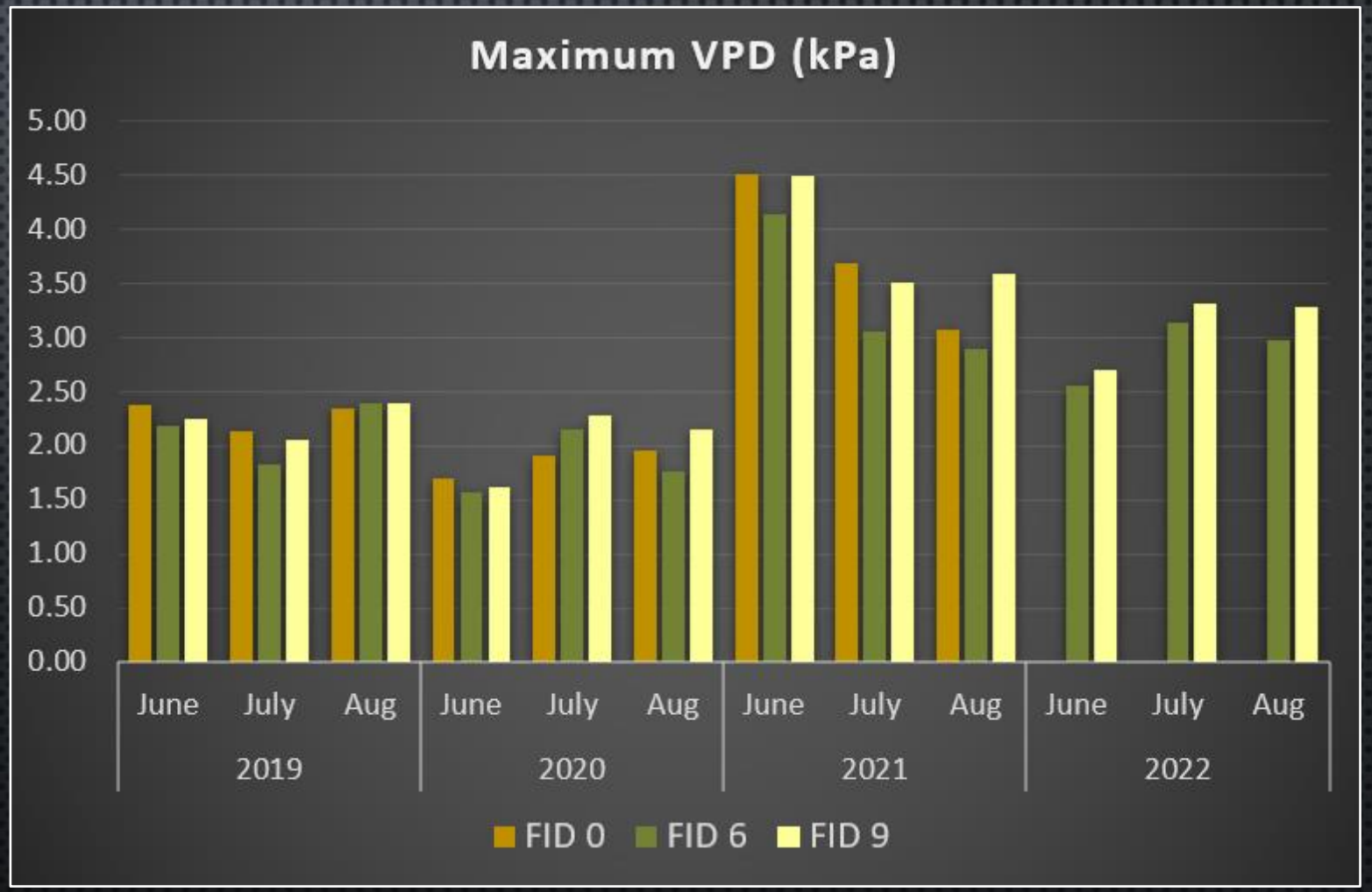
Preliminary Findings **SBSmc2BL - Weather**

- There are many weather factors affecting this process including **rainfall and soil moisture**, level of **solar radiation** (causing photosynthesis), and **air temperature and relative humidity**.
- The growth and survival of seedlings is thus heavily dependent on weather conditions (timing, duration, intensity, and developmental stage).
- Over the five growing seasons since planting in 2019, weather conditions at the **SBSmc2BL** project were usually favourable with a few notable exceptions. Unfavourable weather events affecting all sites included, the heat dome of 2021, low rainfall in June in 2023, 2021, and (2019), and high rainfall in June 2022.



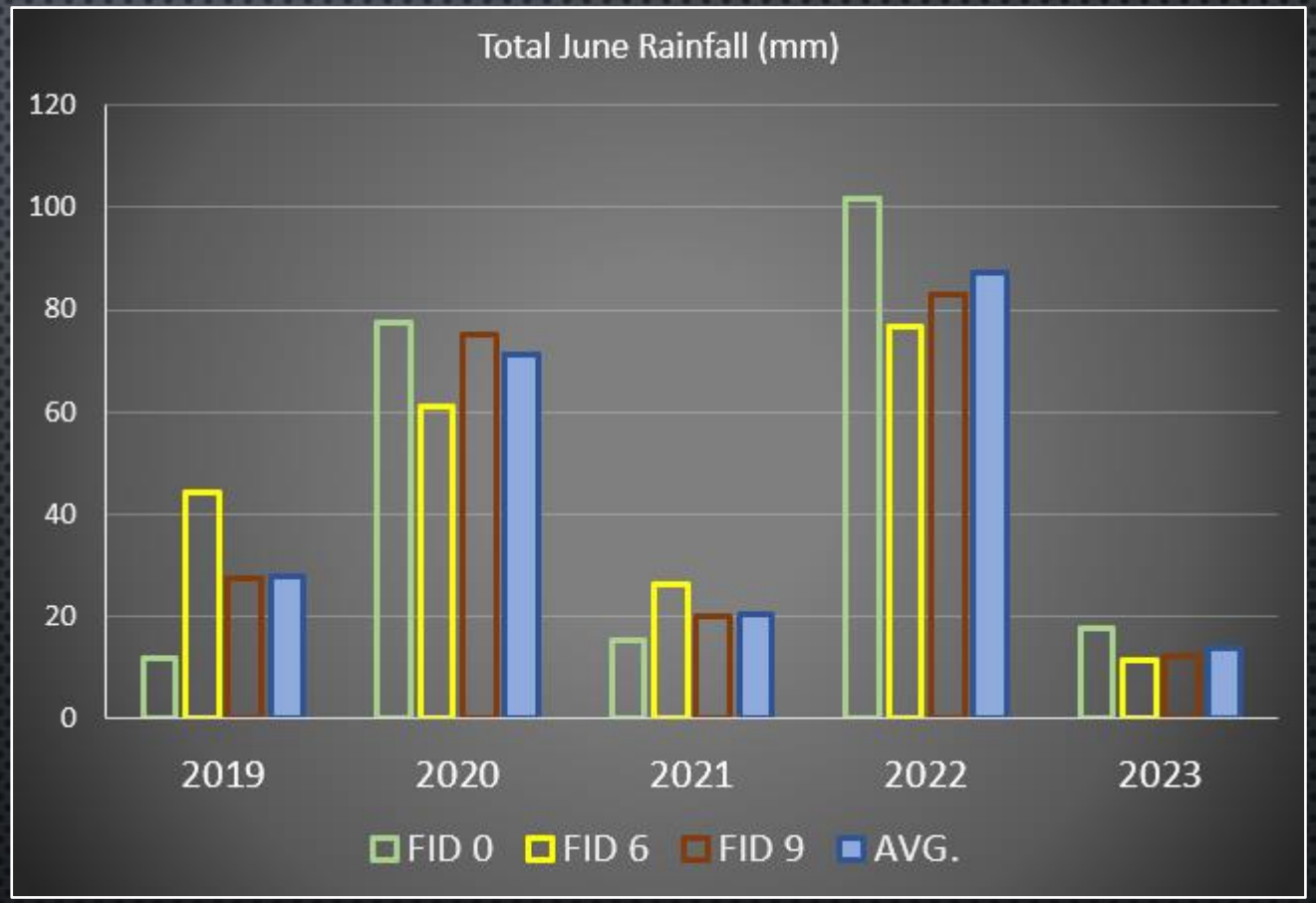
Preliminary Findings **SBSmc2BL - VPD**

- **Monthly** average VPD levels are generally **less than 1 kPa.**
- Weather data revealed that air temperature must be quite high (~30 degrees) at the same time relative humidity is low (~40%) to get high VPD levels, and that **VPD can be high at any time during the growing season**.
- Maximum VDP is more important. The **heat dome** in late June of 2021 resulted in VPD values for three consecutive days (27th, 28th, and 29th) with 5 hours/day of VPD >4 kPa!
- In **2023** (not shown) highest VDPs were **3.7** (FID 0, June), **3.7** (FID 6, Aug), and **4.1** (FID 9, Aug)



Preliminary Findings **SBSmc2BL - Rainfall**

- June rainfall (peak growing season) from year to year can be highly variable.
- On average 2022 was 4 to 6x wetter than in 2021 and 2023 respectively.
- During the heat dome in 2021, at FID 9, total rainfall was only 20mm very likely causing hydrologic dysfunction.
- In June of 2022, between 83 and 102 mm of rain fell possibly leading to seedling mortality at the FID 2 wet site where soils may have been saturated for prolonged periods, but beneficial at the FID 9 Dry site.
- Average **Total** rainfall in 2023 for the 3 benchmark sites, was only 40% to 66% of the average in other years. (May 1st to Aug 31st - not shown in the chart)

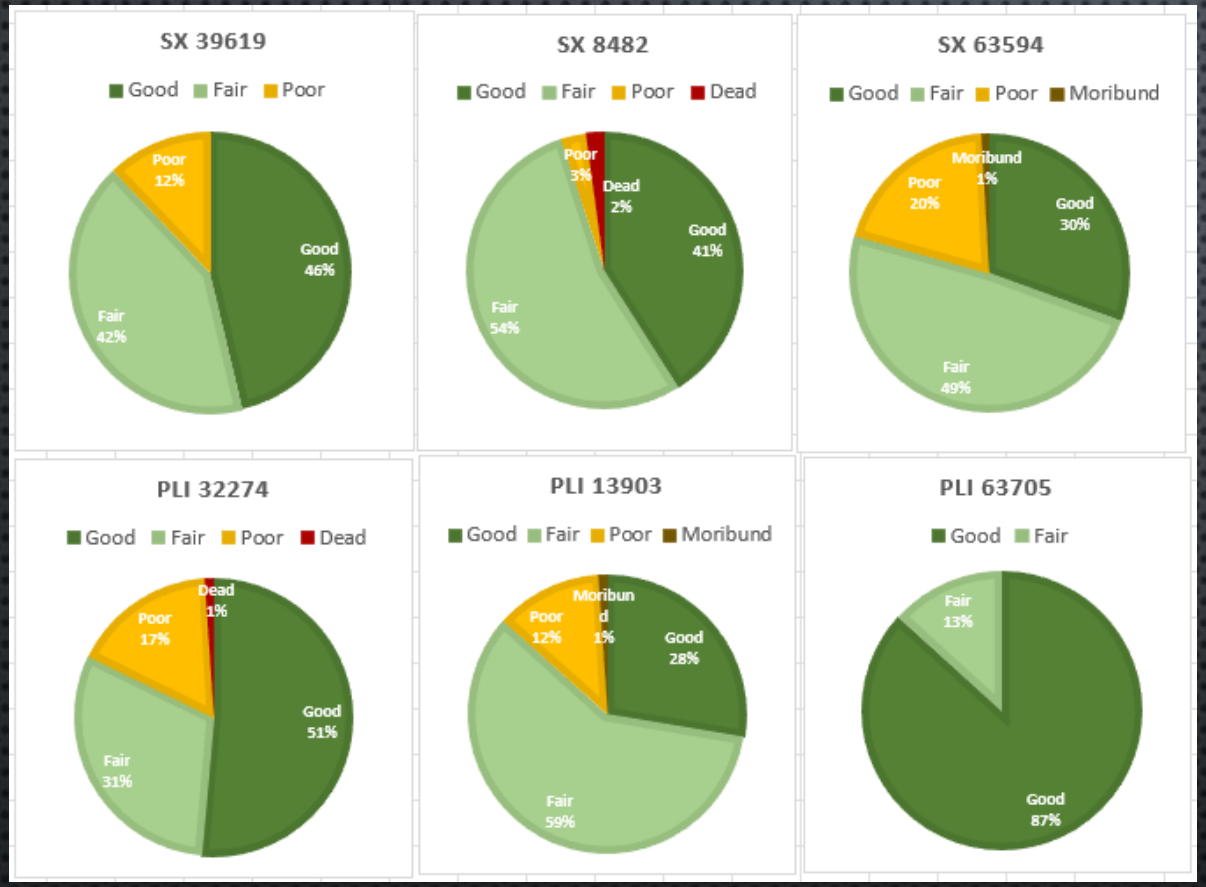


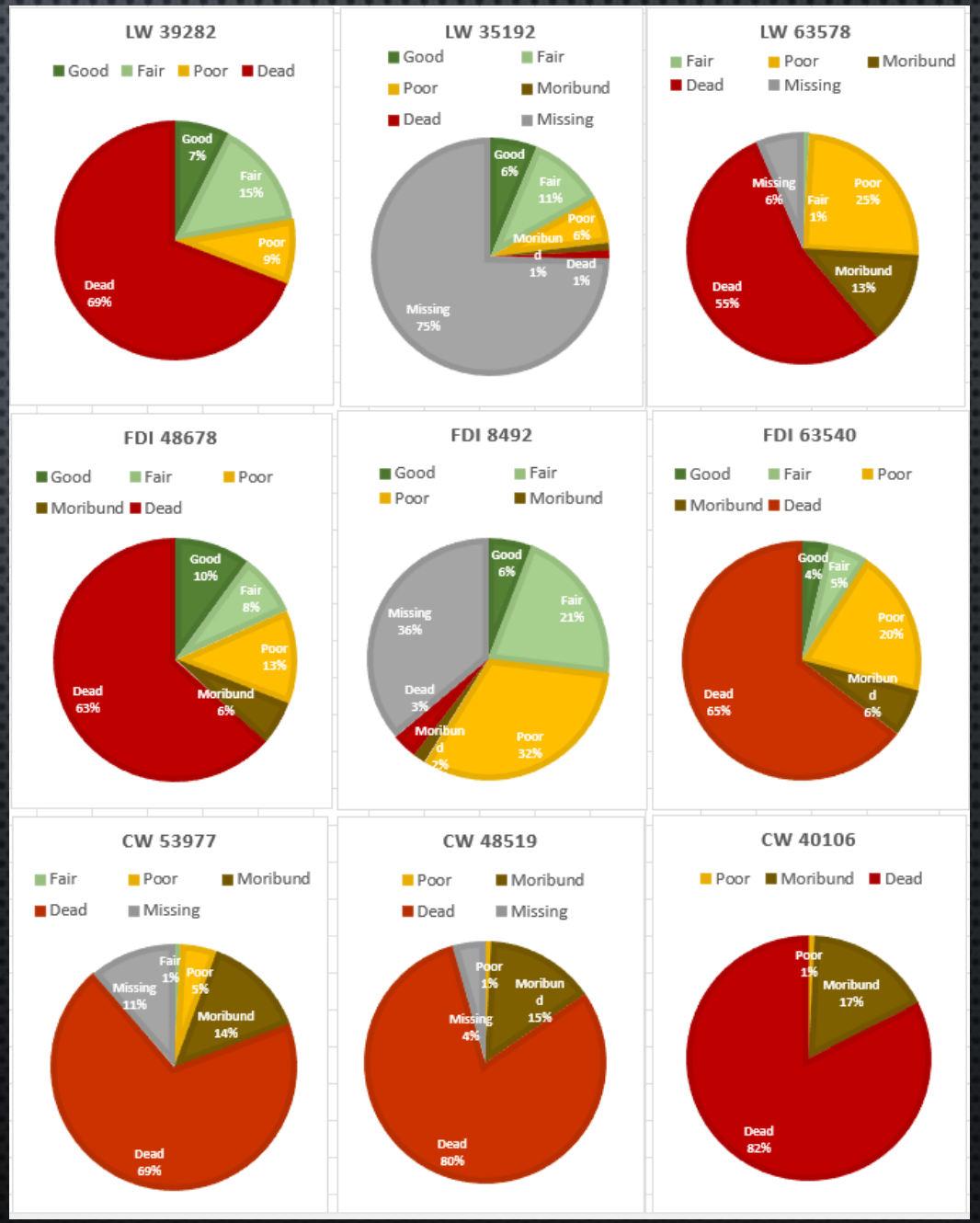
Preliminary Findings **SBSmc2BL - Frost**

- Growing season frost not a major concern at the benchmark sites.
- **Frost days in May generally less than 16 but few less than -4 deg C over the 5 year period**.
- No frost days less than -4 in June, July, or Aug at any benchmark sites.
- Date of bud flush important in determining frost impact but generally not a problem if > -4 deg C.
- FID 11, a site chosen because it was frost prone, experienced major mortality from frost.

- **FID11 frost damage**
- **January of 2020 the low temperature at this site was -41.6 C**
- In May 2020, 2021, and 2022, there were 7, 8, and 21 days where min. temperature fell below -3 deg C
- **8 of 9 Fd, Lw, and Cw seedlots had <30% surivival**.

Prelim Findings **SBSmc2BL – Frost Con't**





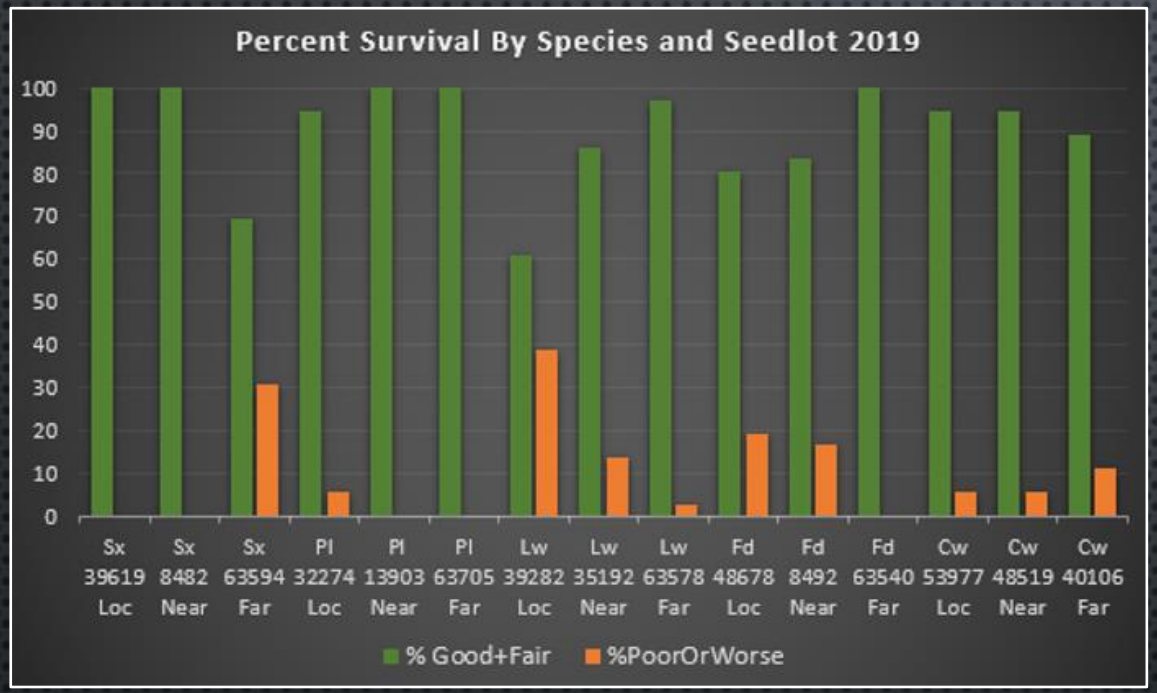
Sx and Pl seedling condition (left) versus Lw, Fd, and Cw, seedling condition (right) at FID 11 (the frost site) after the **2022** growing season by seedlot.

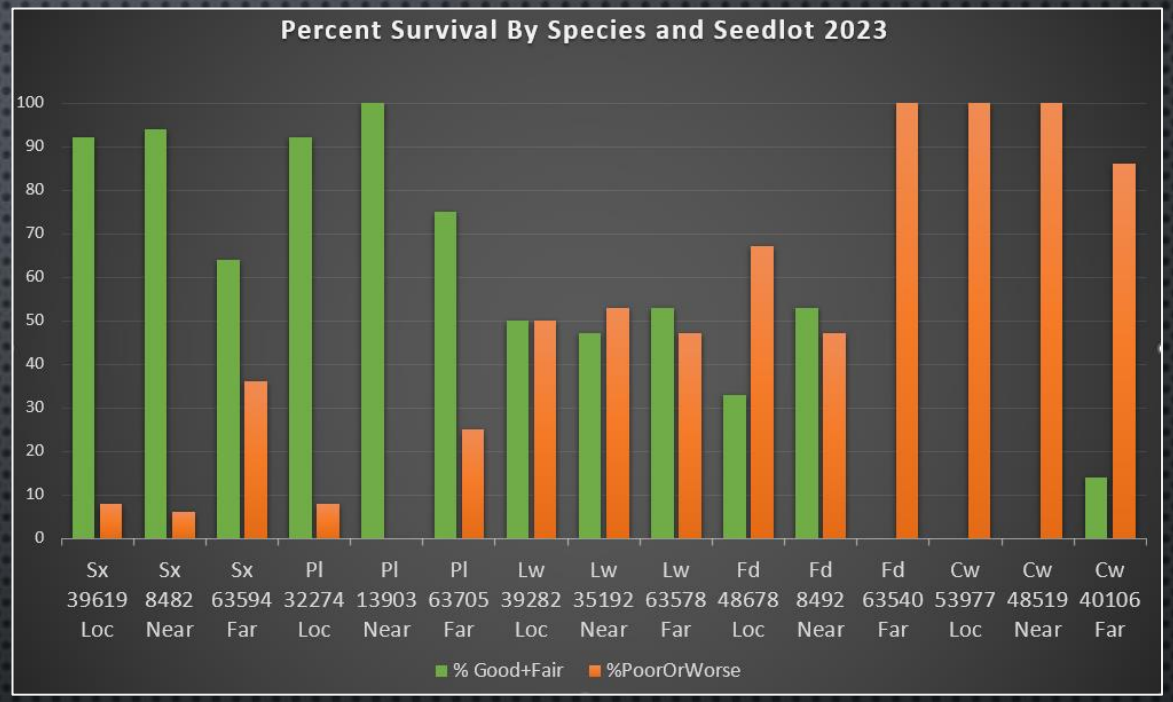
Preliminary Findings **SBSmc2BL – Survival**

	Sx 39619 Local	Sx 8482 Near	Sx 63594 Far	Pli 32274 Local	Pli 13903 Near	Pli 63705 Far	Lw 39282 Local	Lw 35192 Near	Lw 63578 Far	Fdi 48678 Local	Fdi 8492 Near	Fdi 63540 Far	Cw 53977 Local	Cw 48519 Near	Cw 40106 Far	Average All Spp/ Sites
FID 0: Augier	97	97	78	97	100	100	67	50	61	94	83	39	8	8	39	68
FID 2: Mesic	100	92	97	100	89	81	22	42	25	75	83	25	58	61	86	69
FID 2: Wet	97	100	100	94	100	97	36	53	64	50	61	22	81	53	69	72
FID 6: Maxan	100	100	100	100	100	94	89	78	75	86	86	25	0	6	33	71
FID 7: Mesic	94	100	89	97	97	97	92	92	94	92	92	58	22	8	28	77
FID 9: Demo	94	94	92	100	97	97	72	81	78	75	75	42	78	42	56	78
FID 9: Dry	97	100	89	94	100	94	75	94	97	89	97	78	61	67	86	88
FID 9: Mesic	92	100	100	100	100	94	64	67	86	86	92	28	53	69	36	78
FID 15: Maxan	100	100	97	100	94	97	94	86	81	31	94	61	69	31	78	81
FID 11: Frost	99	98	99	99	99	100	30	23	26	30	57	28	6	1	1	53
Average By Seedlot	97	98	94	98	98	95	64	67	69	71	82	41	44	35	51	74
Average w/o FID 11	**97**	**98**	**94**	**98**	**98**	**95**	**68**	**71**	**73**	**75**	**85**	**42**	**48**	**38**	**57**	76

Survival percent (including good, fair, and poor trees) by seedlot and site after the **2022** growing season. Red highlighted cells indicate less than 1000 surviving stems/ha

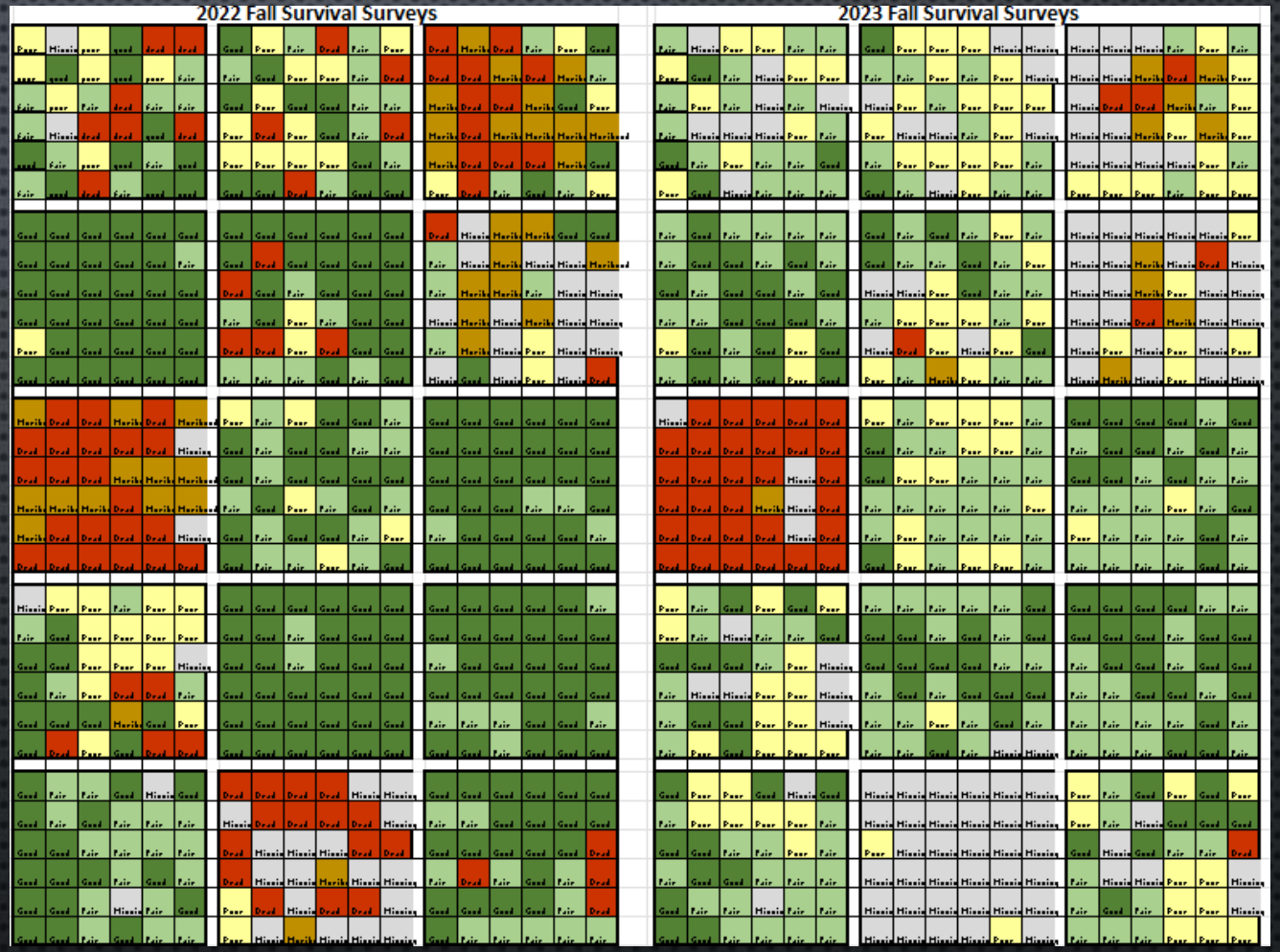
Preliminary Findings **SBSmc2BL - Survival**





Survival at FID 6 showing survival levels by species, seedlot, and condition for 2019 (establishment) and 2023 (after five growing seasons). The patterns evident at FID 6 were similar to the other benchmark sites.

Preliminary Findings **SBSmc2BL - Survival**



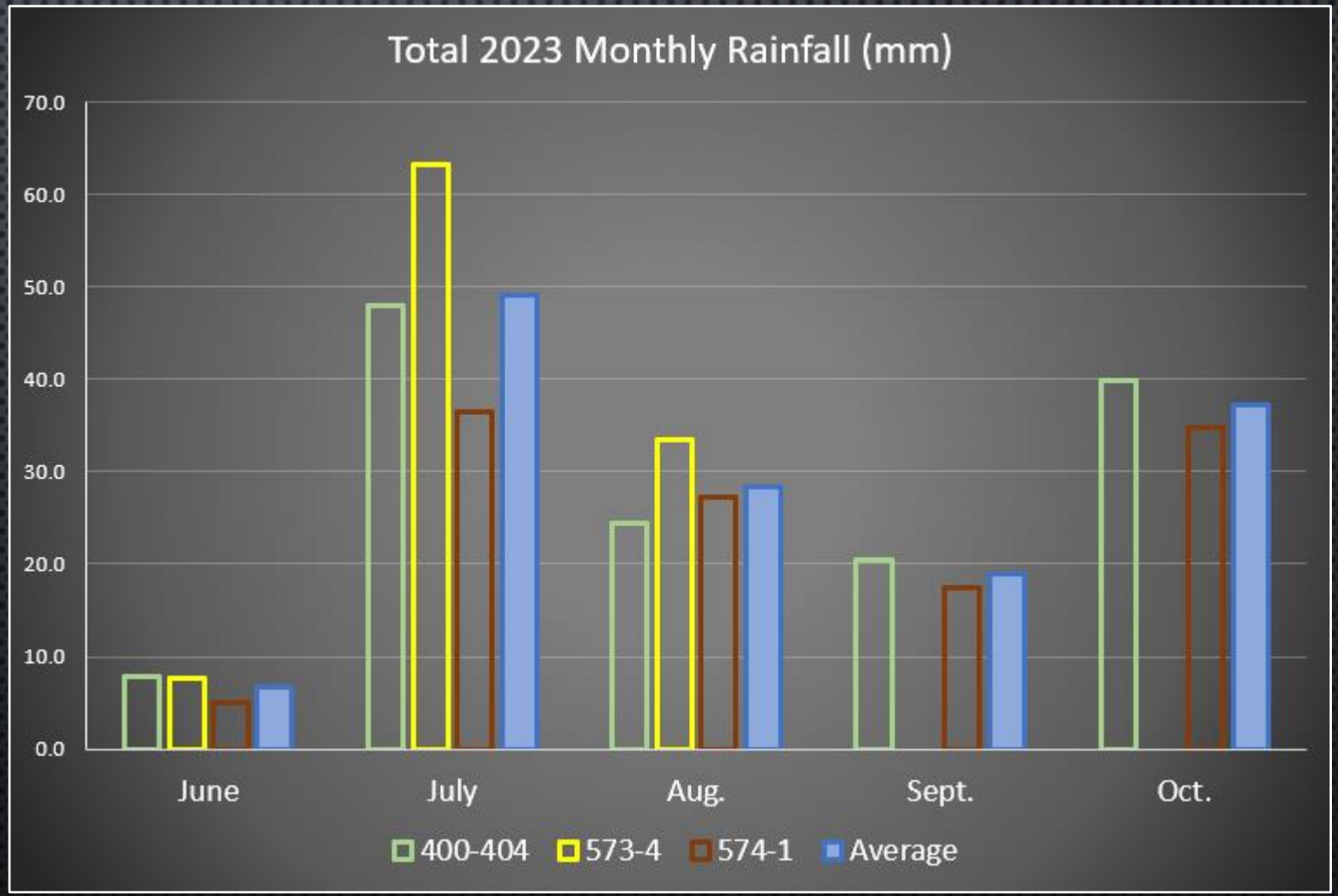
Survival at FID 6 showing survival levels by species, seedlot, and condition 2022 versus 2023. Not a good year for seedling condition with a decrease for all species.

Primary Conclusions **SBSmc2BL – Survival (2022 data)**

- Hybrid spruce (Sx) and lodgepole pine (Pl) seedlots have generally performed much better than the other species with less than 10% variation between seedlots.
- With novel species (Fd, Lw, Cw) variation between seedlots was as much as 60% and site quality seemed to play an important role, however, “local” Lw did not perform better than “far”. With Fd local was significantly better than far, and with Cw, there was no consistent pattern.
- Novel species, including Cw, performed best on the dry site (FID9dry) with 61 to 86% survival and worst on the frost site (1 to 57% survival).
- Spruce and pine are the most frost tolerant species and Pl 63705 (far), Sx 8482 (near) and Sx 39619 (local) are the most tolerant seedlots.
- No significant decrease in survival rates for any of the species from 2020 to 2022, even with the 2021 heat dome where VPD levels were above 4 kPa. When seedlings are already well established, they are likely more resilient to disruptive weather events, however, even after five growing seasons, when drought occurs (2023), there will be continued seedling loss.
- Sx and Pl are likely the most drought resistant species with 6 or 7 % better survival than Lw or Fd but closer to 24% (on average) better than Cw. The best seedlots on dry sites are Sx 8482 (near), Pl 13903 (near), Lw 63578 (far), Fd 8492 (near), and Cw 40106 (far).
- The survival of Lw and Fd on the wet site (FID2Wet) was poor varying from 36% to 64% for Lw and 22% to 61% for Fd. Cw survival was better than both Lw and Fd varying from 53% to 81% depending on seedlot. Overall survival for Sx was nearly 100%, while Pl survival varied from 94% to 100%.
- As a result of this project we can better predict survival rates in the SBSmc2 for these new species and seedlots, and how many seedlings might need to be established to meet reforestation objectives.

Preliminary Findings **SBSmc2_Fire - Rainfall**

- July had an adequate pulse of rain but June was half as much as Burns Lake and nowhere near the typical 60 to 80mm
- May was also dry and had some very high Temps and VPD (see below).
- Swimming 3 wks after ice left
- Recall VDP above 2 mean stressful conditions for planted seedlings



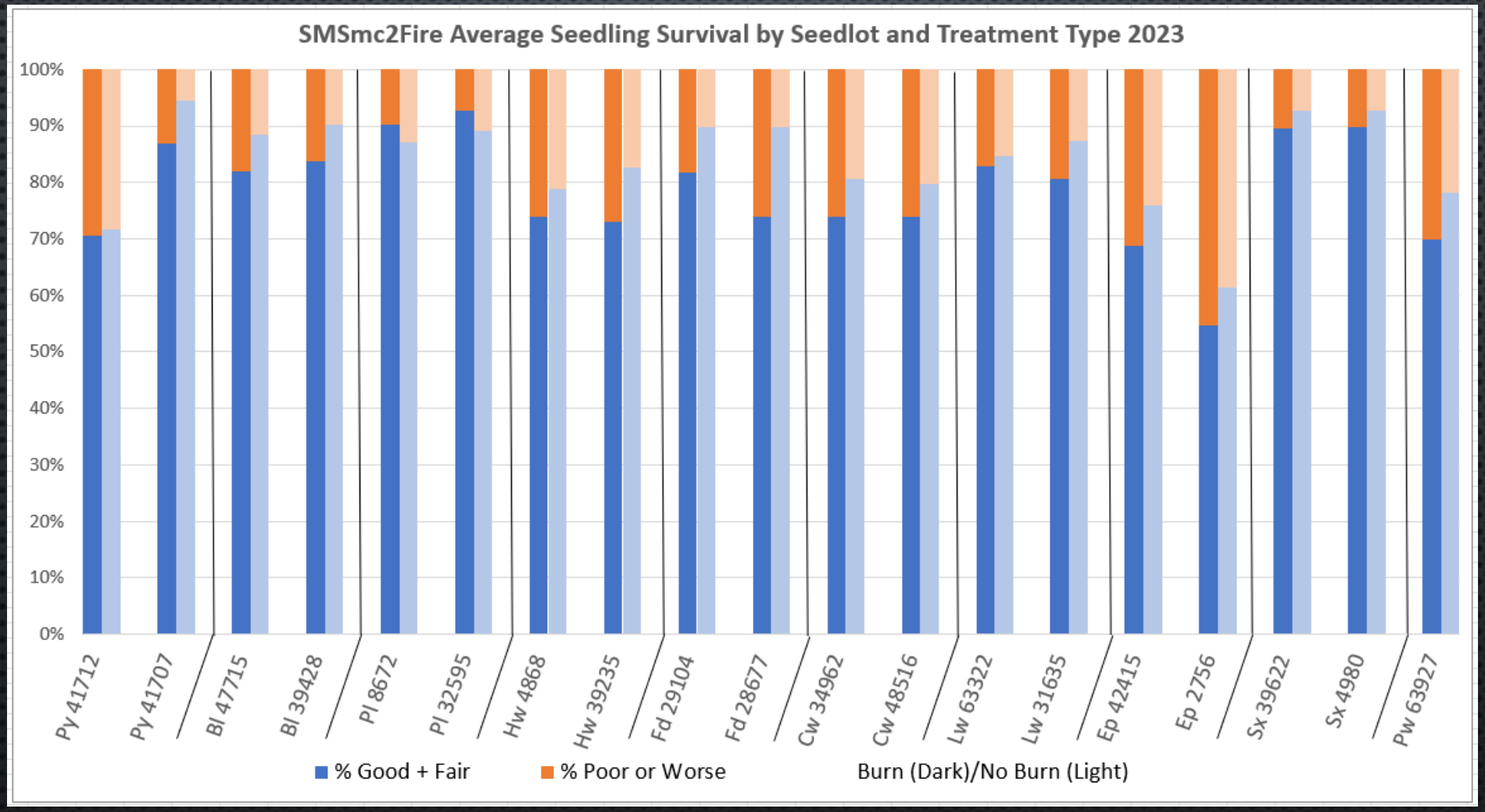
Temp/RH/VPD on May 15th			
	400-404	573-4	571-1
Temp (C)	29.8	29	28.2
RH (%)	~12	15.9	~19
VPD (kPa)	3.6	3.3	2.9

Preliminary Findings **SBSmc2_Fire – Soil Moisture**

June July August Sept June July August Sept

- Example for 574-001, two probes in each of four trial block in both burned and unburned areas
- Recall from the work done by Grossnickle and Sagar that, on some soils soil moisture becomes limiting at about 0.2 m3 of water/m3 of soil, so even on these relatively moist sites, there was likely some drought stress during the growing season.
- These graphs also reveal the risk incurred delaying planting into the mid summer.
- This type of data may be useful for the provincial drought working group initiative as well.

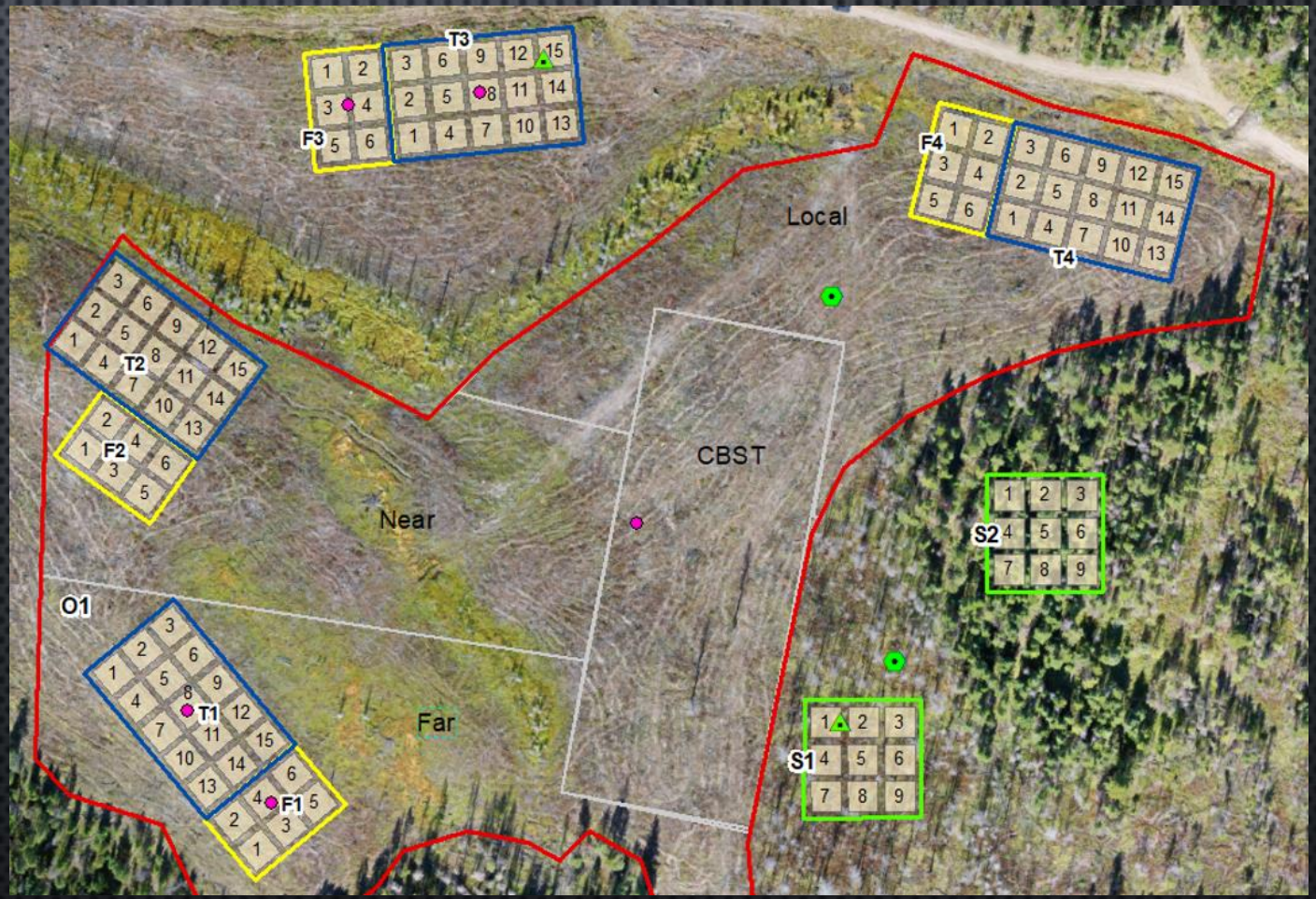
Year 1 Growing Season **SBSmcFire - Survival**



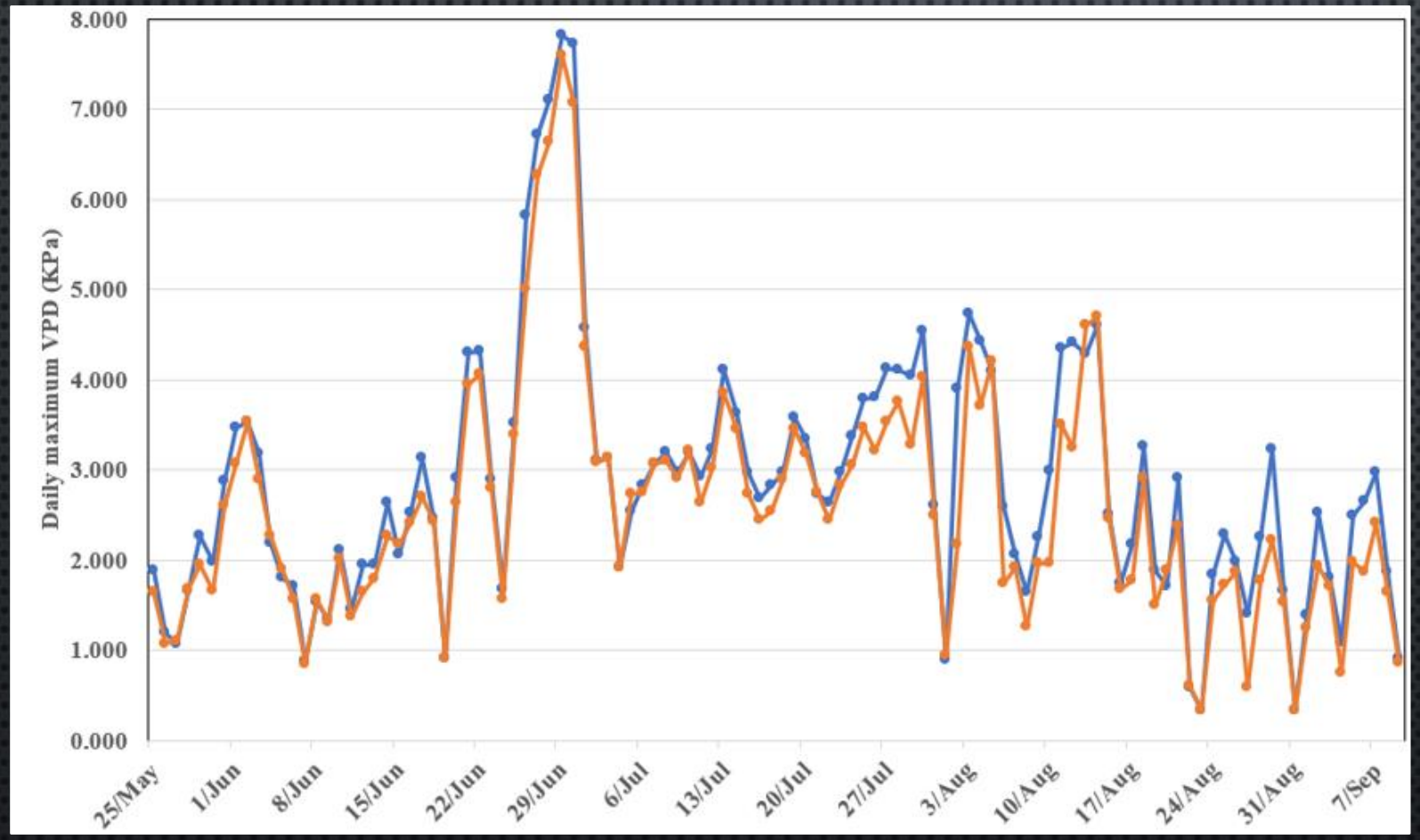
Average survival over 3 sites by species, seedlot, and condition (one growing season) at Sept. 2023

2022 Preliminary Findings **IDFdk3 - Weather**

- More complex with 90 trial blocks vs 10 in the SBSmc2BL.
- 18 weather stations (2021 and 2022).
- Soil moisture data.
- Shade, ripping, wildfire severity, and fall planting (Fd only) as indep. variables
- Unlike the SBSmc2, conditions in the IDFdk3 after planting were extremely harsh with record high VPD, very low relative humidity, low rainfall until late in the growing season, relatively adverse soil conditions, and some brushy areas (fireweed and grass).



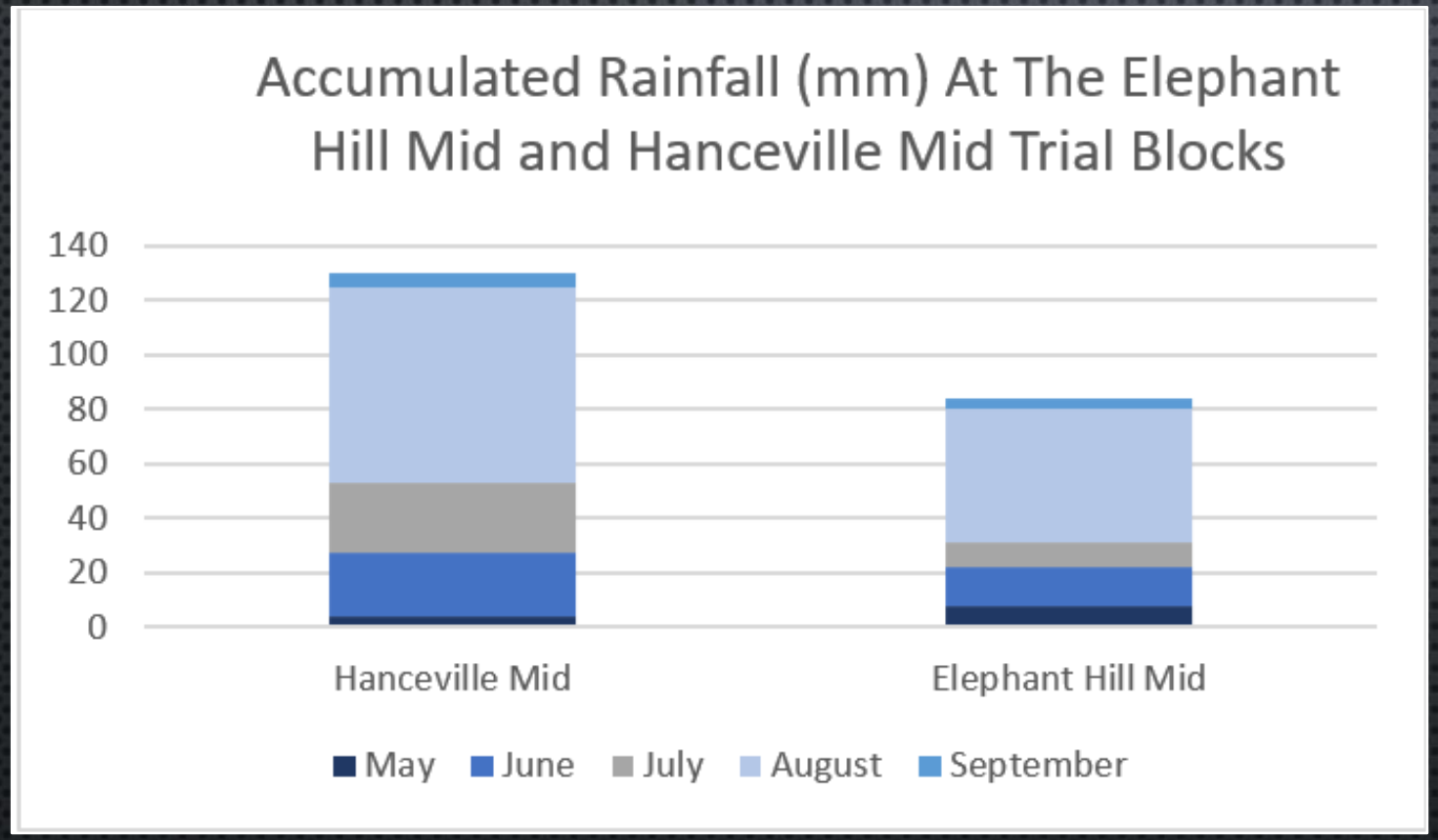
2022 Preliminary Findings **IDFdk3 – Temp and VPD**



Peak daily VPD in 2021 at the Elephant Hill South site at the shade (orange) and open (blue) weather stations (courtesy of Bob Sagar).

- Max temperatures in 2021 were much higher than in the SBSmc2Bl with peaks in June of between 40 and 45 deg C.
- RH at all the IDFdk3 sites was much lower than in the SBSmc2BL with daily min values below 20% throughout the growing season and as low as 13% during the heat dome (2021)
- VPD values were extremely high with the highest values at each site varying from 6.3 kPa to 8.1 kPa – avg 75% higher than in the SBSmc2BL.
- High VPDs persisted for 4 or 5 days with values above 5 kPa for 8 to 10 hours per day.
- More frost days in May in 2022 (13 to 19) than in the SBSmc2BL although few were colder than -3.

2022 Preliminary Findings **IDFdk3 – Rainfall/Moisture**



Accumulated rainfall in the 2021 growing season at the Hanceville Mid Open site (trial block with the best seedling survival) versus the Elephant Hill Mid Open site (trial block with the worst seedling survival).

- Total June rainfall in 2022 was three to four times higher than in 2021, the year of planting.
- No consistent difference between the amount of rain in the shade blocks versus the open blocks.
- • In 2021, the correlation between soil moisture levels and ripped areas and non-ripped areas, and shade and open areas was weak.
- In general, soil moisture was slightly higher in the un-ripped areas, and with respect to shade, there was no pattern.
- By late July, in both 2021 and 2022 soil moisture levels were very low at less than about 0.05 m3/m3, possibly indicating that soil moisture levels in June are most critical.

2022 Preliminary Findings **IDFdk3** -

Survival Survey - Mortality Rates (%) - Fall 2022

Trial Blocks

	Block	Site Prep	Burn Severity	Local Fdi 39243	Near Fdi 63754	Far Fdi 39481/ 53825	Local Lw 41045	Near Lw 53658	Far Lw 41041	Local Pg 54026	Near Pg 41712	Far Pg 43257	Local Pli 8268	Near Pli 63779	Far Pli 41097	Local Sz 3687	Near Sz 63772	Far Sz 30664
Hanceville Mid	T1		L	100%	53%	94%	50%	33%	50%	3%	6%	11%	0%	11%	0%	44%	11%	19%
	T2		H	56%	36%	67%	22%	33%	42%	8%	19%	0%	0%	0%	0%	11%	14%	22%
	T3	P	H	33%	22%	64%	19%	11%	22%	0%	0%	0%	0%	0%	0%	19%	11%	3%
	T4	P	L	31%	11%	42%	17%	8%	25%	0%	0%	6%	0%	0%	0%	8%	3%	22%
Hanceville East	T1		L	100%	89%	100%	100%	100%	100%	97%	100%	94%	94%	100%	100%	97%	100%	92%
	T2	P	L	100%	31%	100%	83%	72%	94%	14%	39%	42%	19%	19%	36%	86%	83%	83%
	T3		H	6%	31%	97%	78%	97%	75%	17%	64%	47%	92%	92%	75%	100%	100%	97%
	T4	P	H	17%	31%	100%	81%	61%	61%	44%	47%	39%	14%	19%	33%	83%	56%	75%
Hanceville West	T1	P	L	67%	42%	47%	22%	33%	31%	0%	19%	8%	11%	8%	6%	44%	31%	36%
	T2		L	89%	53%	89%	81%	67%	69%	17%	28%	14%	8%	25%	17%	44%	44%	47%
	T3		H	58%	97%	100%	97%	86%	97%	44%	53%	39%	50%	53%	83%	100%	81%	94%
	T4	P	H	25%	56%	83%	31%	42%	47%	6%	14%	19%	6%	3%	8%	64%	64%	39%
Gustafsen West	T1		L	50%	61%	39%	78%	86%	86%	36%	58%	22%	19%	6%	42%	92%	89%	86%
	T2	P	L	47%	67%	69%	78%	72%	89%	42%	42%	25%	17%	33%	31%	58%	39%	72%
	T3	P	H	39%	61%	36%	67%	69%	39%	11%	31%	39%	44%	28%	31%	86%	50%	83%
	T4		H	36%	53%	53%	92%	89%	92%	83%	56%	78%	92%	78%	67%	92%	100%	94%
Gustafsen East	T1	P	H	50%	58%	31%	72%	86%	83%	44%	39%	31%	42%	11%	33%	92%	67%	86%
	T2		H	28%	42%	56%	75%	81%	78%	36%	67%	44%	50%	22%	33%	94%	83%	83%
	T3		L	75%	58%	97%	81%	100%	92%	19%	53%	61%	8%	8%	22%	53%	42%	53%
	T4	P	L	19%	25%	67%	58%	44%	28%	42%	14%	19%	33%	11%	14%	100%	75%	83%
Gustafsen South	T1	P	H	97%	25%	64%	58%	39%	19%	25%	31%	14%	25%	31%	11%	75%	75%	42%
	T2		H	8%	33%	92%	53%	22%	39%	19%	36%	8%	33%	19%	6%	89%	53%	50%
	T3	P	L	86%	6%	3%	56%	31%	28%	25%	25%	0%	31%	19%	8%	47%	53%	47%
	T4		L	72%	61%	36%	36%	58%	67%	22%	25%	22%	22%	36%	36%	58%	44%	89%
EH North	T1	P	H	97%	69%	61%	75%	61%	39%	3%	11%	8%	11%	6%	11%	42%	33%	56%
	T2		H	100%	67%	86%	97%	92%	86%	61%	58%	25%	89%	78%	22%	100%	97%	92%
	T3		L	100%	53%	92%	100%	100%	97%	44%	44%	56%	75%	64%	86%	100%	100%	97%
	T4	P	L	97%	6%	14%	56%	33%	25%	0%	31%	6%	11%	6%	25%	39%	50%	67%
EH Mid	T1		L	89%	47%	58%	81%	89%	100%	31%	56%	67%	36%	25%	22%	83%	78%	64%
	T2	P	L	58%	3%	36%	22%	47%	83%	3%	28%	33%	17%	31%	36%	39%	14%	86%
	T3	P	H	86%	39%	28%	58%	69%	53%	36%	53%	33%	22%	3%	11%	92%	89%	75%
	T4		H	100%	97%	100%	94%	100%	100%	100%	97%	89%	97%	100%	100%	89%	92%	100%
EH South	T1	P	L	39%	72%	44%	83%	61%	81%	19%	33%	56%	58%	17%	22%	50%	64%	72%
	T2		L	11%	36%	25%	92%	53%	72%	39%	56%	42%	47%	53%	33%	69%	56%	36%
	T3	P	H	31%	28%	42%	67%	50%	44%	42%	64%	25%	17%	28%	11%	64%	53%	47%
	T4		H	67%	100%	78%	86%	94%	81%	67%	83%	61%	86%	75%	97%	92%	75%	97%

Shade Blocks

	Block	Burn Severity	Spring Local Fdi 39243	Early Fall Local Fdi 39243	Late Fall Local Fdi 39243	Spring Near Fdi 63754	Early Fall Near Fdi 63754	Late Fall Near Fdi 63754	Spring Far Fdi 39481/ 53825	Early Fall Far Fdi 39481/ 53825	Late Fall Far Fdi 39481/ 53825
	S1	L	61%	6%	11%	31%	0%	6%	86%	3%	6%
	S2	H	78%	0%	3%	97%	0%	0%	69%	100%	100%
	S1	L	69%	3%	3%	28%	0%	0%	83%	8%	3%
	S2	H	81%	11%	28%	89%	0%	0%	100%	19%	3%
	S1	L	0%	3%	0%	22%	6%	0%	64%	3%	17%
	S2	H	11%	3%	0%	25%	0%	0%	31%	0%	0%
	S1	L	22%	6%	6%	39%	14%	3%	78%	17%	14%
	S2	H	17%	22%	36%	22%	19%	22%	33%	11%	11%
	S1	H	3%	3%	0%	3%	0%	0%	3%	0%	0%
	S2	L	17%	3%	0%	6%	0%	3%	92%	0%	3%
	S1	H	83%	3%	6%	19%	3%	0%	94%	3%	0%
	S2	L	67%	8%	8%	42%	3%	11%	86%	17%	8%
	S1	H	72%	0%	0%	8%	0%	3%	3%	0%	0%
	S2	L	39%	0%	3%	28%	0%	0%	14%	6%	3%
	S1	L	69%	31%	11%	53%	44%	42%	89%	8%	3%
	S2	H	89%	0%	3%	17%	0%	0%	75%	6%	0%
	S1	H	58%	11%	17%	25%	14%	11%	78%	14%	44%
	S2	L	22%	3%	11%	50%	44%	11%	28%	3%	0%

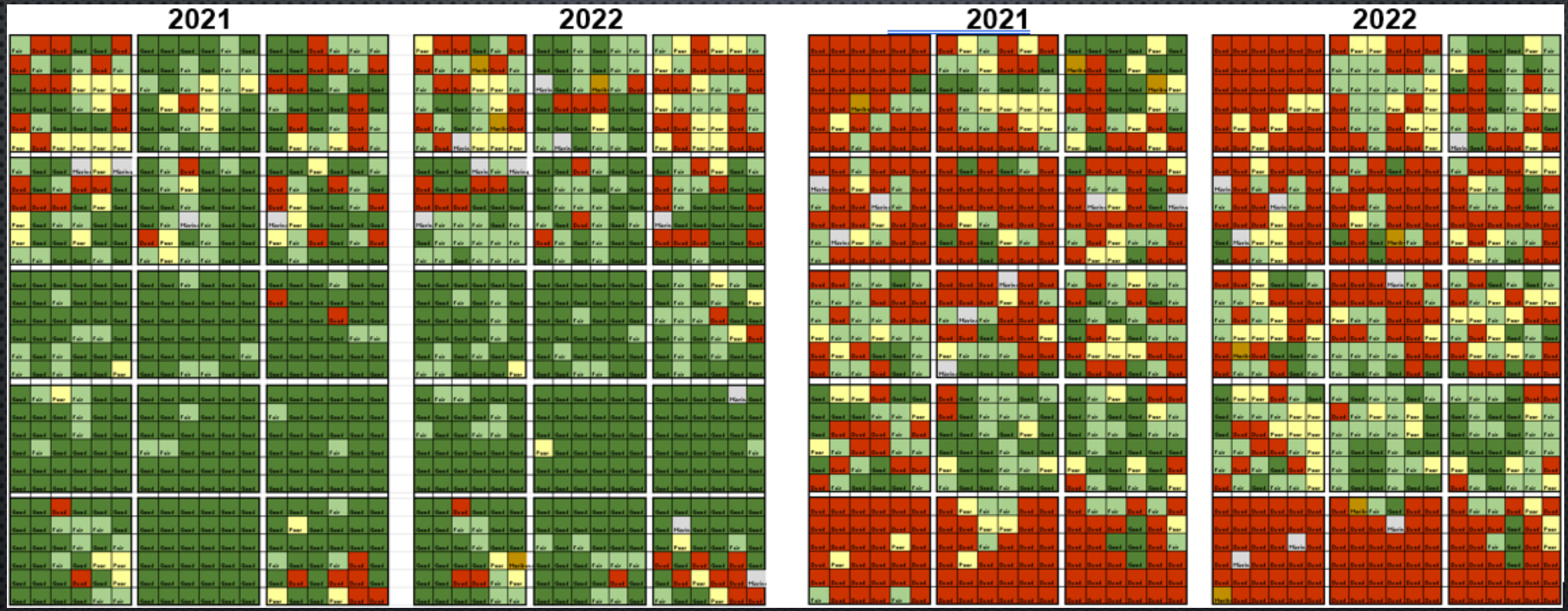
Fall Plant Blocks

	Block	Site Prep	Burn Severity	Early Fall Local Fdi 39243	Late Fall Local Fdi 39243	Early Fall Near Fdi 63754	Late Fall Near Fdi 63754	Early Fall Far Fdi 39481/5 3825	Late Fall Far Fdi 39481/53 825
	F1		L	0%	0%	6%	3%	0%	0%
	F2		H	0%	0%	0%	0%	3%	3%
	F3	P	H	0%	0%	0%	0%	0%	0%
	F4	P	L	0%	0%	0%	0%	0%	0%
	F1		L	0%	0%	3%	0%	0%	3%
	F2	P	L	0%	0%	0%	0%	0%	0%
	F3		H	0%	3%	0%	0%	3%	3%
	F4	P	H	0%	0%	0%	0%	0%	0%
	F1	P	L	3%	3%	0%	0%	0%	0%
	F2		L	0%	8%	6%	0%	6%	3%
	F3		H	0%	3%	0%	3%	0%	3%
	F4	P	H	0%	0%	0%	3%	0%	0%
	F1		L	6%	3%	0%	0%	8%	0%
	F2	P	L	0%	11%	3%	6%	0%	3%
	F3	P	H	50%	22%	33%	11%	17%	0%
	F4		H	3%	11%	0%	3%	11%	8%
	F1	P	H	0%	0%	0%	0%	0%	0%
	F2		H	0%	6%	3%	6%	0%	0%
	F3		L	0%	0%	0%	0%	3%	3%
	F4	P	L	0%	0%	0%	0%	0%	0%
	F1	P	H	0%	0%	0%	0%	0%	0%
	F2		H	0%	0%	0%	0%	0%	0%
	F3	P	L	0%	0%	0%	0%	0%	0%
	F4		L	0%	8%	0%	0%	0%	0%
	F1	P	H	0%	0%	3%	0%	0%	0%
	F2		H	6%	11%	3%	3%	3%	8%
	F3		L	19%	14%	6%	6%	0%	8%
	F4	P	L	6%	0%	0%	0%	8%	3%
	F1		L	3%	3%	0%	0%	0%	8%
	F2	P	L	3%	0%	0%	6%	0%	3%
	F3	P	H	0%	3%	8%	6%	3%	6%
	F4		H	0%	3%	14%	0%	8%	6%
	F1	P	L	0%	0%	0%	0%	0%	0%
	F2		L	0%	17%	11%	3%	8%	11%
	F3	P	H	0%	3%	0%	3%	0%	0%
	F4		H	14%	0%	0%	14%	17%	14%

81-100% mortality (extremely poor) | **61-80% mortality (very poor)** | **41-60% mortality (poor)** | **<40% (still stocked)**

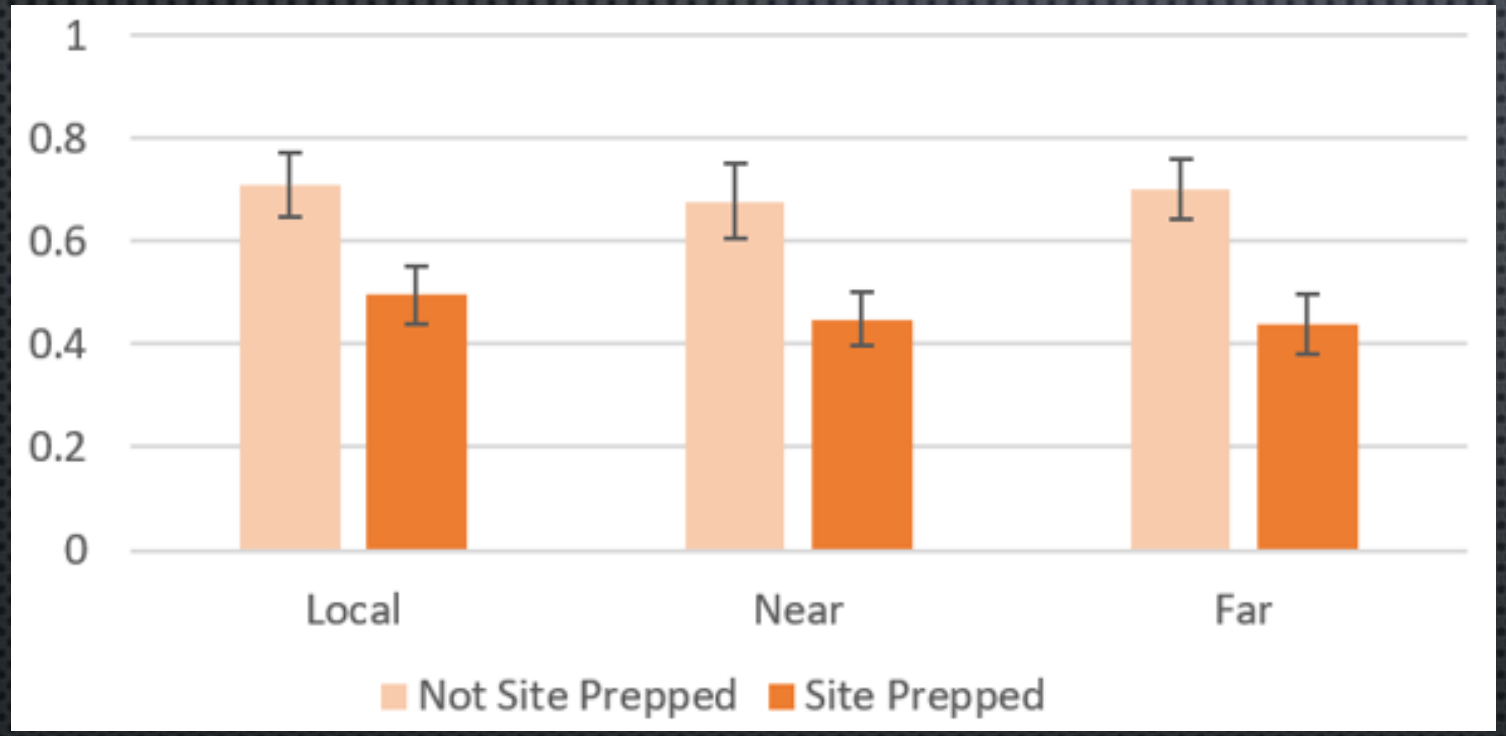
IDFdk3 project mortality rates (% of tree seedlings) in the fall of 2022, after 2 growing seasons

2022 Preliminary Findings **IDFdk3 - Survival**



Survival for Hanceville Mid Open (left 2 heat maps) and Elephant Hill Mid Open (right two heat maps). Top row is Fd, the second row is Lw, the third row is Py, the fourth row is Pl, and the fifth row is Sx; local, near and far respectively. The dark green cells mean good condition, light green means fair, yellow means poor, brown means moribund, red means dead, and grey means missing.

2022 Preliminary Findings **IDFdk3 – Site Preparation Effects**



Average Lw mortality by seed source across all sites in 2021 in ripped and non-ripped areas. The vertical axis is percent expressed as a decimal.

- Ripping was a significant factor in the survival of all five species, even those that were relatively poor performers such as Lw.
- Mortality was significantly lower, on average, across all sites by about 20% at ripped sites
- Reasons:
  - protection from direct desiccation by the sun,
  - a potential increase in soil moisture if seedlings are planted at the bottom of a rip,
  - ripping fractures the clay horizons,
  - ripping also breaks up the root mat of other vegetation (primarily grasses and fireweed) that strongly compete for soil moisture.

2022 Preliminary Findings **IDFdk3 – Fall Planting/ Overstory Shade**

An area of moderate overstory shade in the Gustafsen wildfire.

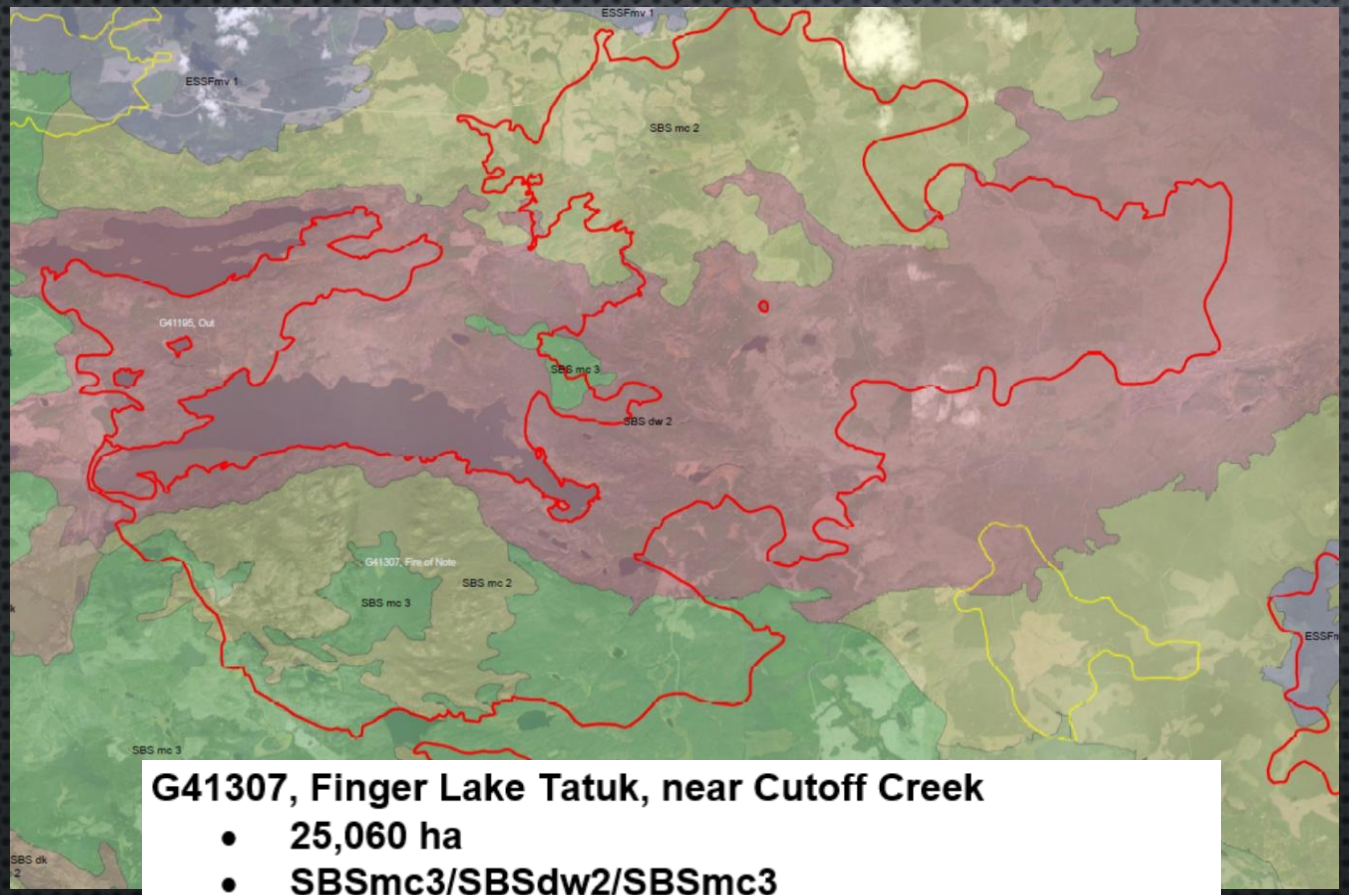
- The most significant factor in explaining survival levels in the IDFdk3 project was fall planting (Fd only).
- By the fall of 2022, seedlings planted in the fall of 2021 averaged 97% survival with little difference between seedlots.
- These seedlings did not experience the extreme VPD that the spring planted seedlings experienced.
- In 2021 the majority of the rainfall that fell in August, bringing soil moisture levels up to about 0.15 m3/m3, at a time when peak root elongation begins.
- Seedlings planted in the fall are in a good position to take advantage of spring/early summer 2022 soil moisture, because they can quickly couple with the hydrologic cycle.
- Survival of Fd planted in the spring, in a cutblock, versus under an overstory in the shade, revealed that the overstory significantly decreased mortality (on average by about 17%) when an anomalous event like the heat dome occurs. This relationship did not hold for fall planted seedlings.
- Shade levels in this trial were relatively low because most areas had been affected by wildfire so conclusions regarding shade must be judged with this proviso.

2022 Preliminary Conclusions **IDFdk3**

- The IDFdk3 environment offers more challenges in terms of weather and early seedling survival than the SBSmc2.
- VPDs in the range of 5 to 9 kPa can be expected to cause widespread mortality (up to 100%) with species such as Sx, Lw, and even Fd. The future frequency of such events is not known, but the potential for them, necessitates a hedging strategy if novel species and seedlot combinations are going to be planted as part of an assisted migration program.
- A significant proportion of future planting should include Pl and Py if novel species are envisioned. There are some Fd seedlots that could be included (with appropriate site preparation and possibly shade) but Sx should be avoided. Lw is also risky (although there is at least one seedlot that holds some promise).
- A hedging strategy should also include planting a significant proportion of Fd in the fall. This may also be true for other species but this was not tested in this project. The Grossnickle report titled *Best Management Practises for Fall Planting in the Interior of British Columbia* provides some excellent advice in this regard.
- Site preparation on sites with significant clay horizons should be ripped prior to planting and planting should be relatively deep within the rip if soil moisture is a concern. This project did not test soil ripping in an overstory environment but the ripping tooth manufactured for an excavator, that was developed for the IDFdk3 project, is well adapted to such a test.
- Although not thoroughly examined in this project to date, the use of Sx, Lw, and Fd may require careful site selection. Soil conditions will be addressed in this trial in 2023.

- A comprehensive statistical analysis is planned for all 3 projects after 5 growing seasons.

2024 Trial Design



G41307, Finger Lake Tatuk, near Cutoff Creek

- 25,060 ha
- SBSmc3/SBSdw2/SBSmc3
- Large variety of cutblocks in the NE side
- Access good outside park
- Out of control. Still a lot of active fire in this burn
- Under an evacuation order

Planting Configuration

1+0				2+0	
NEAR	FAR	NEAR	FAR	NEAR	FAR
Py	Py	Bl	Bl	Sx	Sx
Pl	Pl	Hw	Hw	Pl	Pl
Fd	Fd	Cw	Cw	Fd	Fd
Lw	Lw	Ep	Ep	Lw	Lw
Sx	Sx	Pw	Pw		

Species and seedlot in each trial block. Each plot has 36 trees.

Questions And Comments