Ecoblitz Weather & Flowering Phenology

Eriko Sakamura, Alec Brooks, Seth Miller

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Winter Snow Analysis

Stats

Table 1: Correlation Matrix SNOW_WC ~ TEMP_AVERAGE

Year	Fall	Winter	Spring
2021	-0.4873247	0.3311611	-0.6954612
2022	NA	0.0572723	0.0249896
2023	0.1379338	-0.3367648	-0.1822224

Table 2: ANOVA Fall (SNOW_WC ~ factor(YEAR))

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	1.061058	0.5305291	49.33138	0
Residuals	186	2.000317	0.0107544	NA	NA

Table 3: TukeyHSD Fall (SNOW_WC ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	-0.0095238	-0.0531787	0.0341311	0.8639202
2023-2021	0.1539683	0.1103133	0.1976232	0.0000000
2023-2022	0.1634921	0.1198371	0.2071470	0.0000000

Table 4: ANOVA Winter (SNOW_WC ~ factor(YEAR))

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	9359.261	4679.63025	222.0825	0
Residuals	234	4930.752	21.07159	NA	NA

Table 5: TukeyHSD Winter (SNOW_WC ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	6.598734	4.875964	8.321505	0

	diff	lwr	upr	p adj
2023-2021	15.343038	13.620267	17.065809	0
2023-2022	8.744304	7.021533	10.467074	0

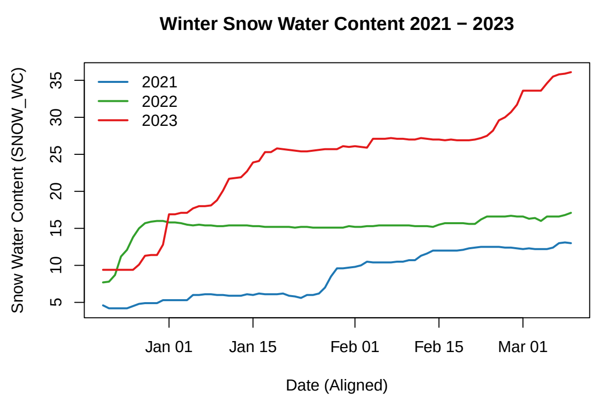
Table 6: ANOVA Spring (SNOW_WC ~ factor(YEAR))

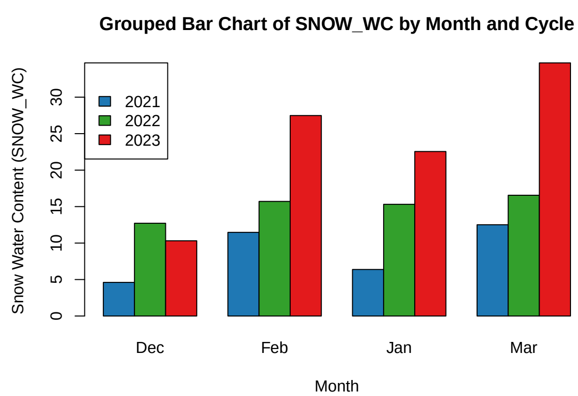
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	39489.240	19744.620	1124.153	0
Residuals	183	3214.211	17.564	NA	NA

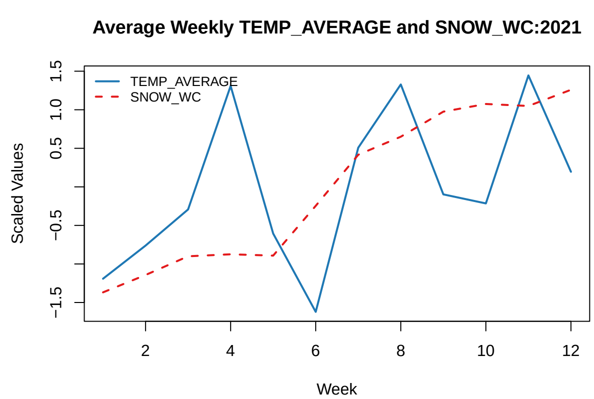
Table 7: TukeyHSD Spring (SNOW_WC ~ factor(YEAR))

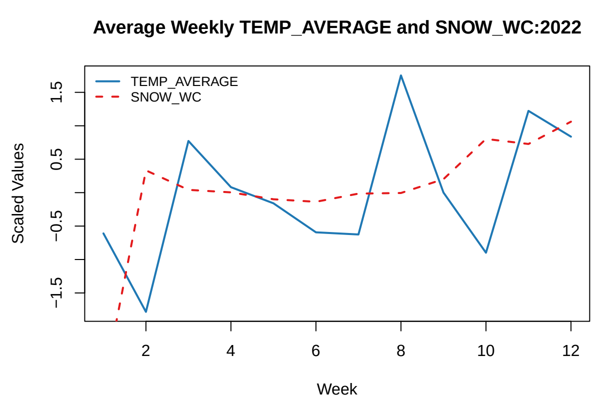
	diff	lwr	upr	p adj
2022-2021	5.272581	3.493958	7.051203	0
2023-2021	33.206452	31.427829	34.985074	0
2023-2022	27.933871	26.155249	29.712493	0

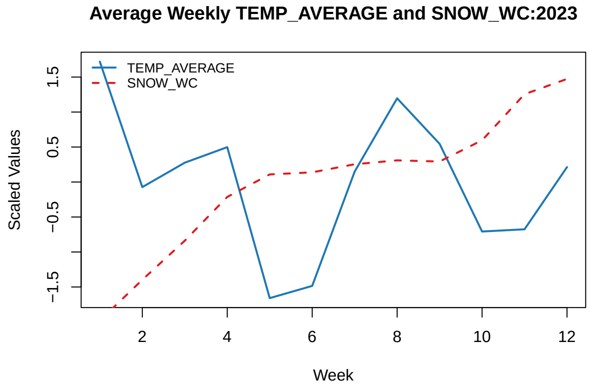
Plots











Conclusion

The results of our ANOVA and Tukey HSD tests indicate that snow water content (SNOW_WC) was significantly different across the years 2021, 2022, and 2023, with 2023 showing a much higher snowfall than the previous two years. The extremely small p-values ($p < 2e\text{-}16$) suggest that these differences are not random chance but rather a real and substantial change in snowfall patterns. The statistical significance of YEAR used as a predictor variable indicates that winter snowpack and temperatures play a critical role in shaping ecological conditions for the following spring bloom season, particularly through nighttime low temperatures that regulate seed germination and soil moisture from slow snowmelt. Given that spring bloomers are more sensitive to these factors, the sharp increase in snowpack and the colder temperatures in 2023 likely created conditions that influenced which species germinated and overall blooming cycles. In contrast, fall bloomers are better adapted to extreme conditions, including drought and high temperatures, meaning their germination remains more stable over multiple years despite fluctuations in winter precipitation and temperatures. These findings reinforce that winter conditions primarily influence spring bloom dynamics, while fall species tend to exhibit greater resilience to annual weather variation.

Temperature Analysis

Seasonal

Stats

Table 8: ANOVA Spring TEMP_AVERAGE ~ factor(YEAR))

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	444.0833	222.04167	3.578801	0.0298794
Residuals	183	11353.9758	62.04358	NA	NA

Table 9: Tukey Spring (TEMP_AVERAGE ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	0.1774194	-3.165458	3.5202971	0.9913670
2023-2021	-3.1854839	-6.528362	0.1573939	0.0654317
2023-2022	-3.3629032	-6.705781	-0.0200254	0.0482772

$P = 0.0299$, $p < 0.05$ significant 2023 is different

Table 10: ANOVA Spring TEMP_MAX ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	1035.624	517.8118	4.670196	0.0105154
Residuals	183	20290.274	110.8758	NA	NA

Table 11: Tukey Spring (TEMP_MAX ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	-0.6290323	-5.097828	3.8397632	0.9408623
2023-2021	-5.2903226	-9.759118	-0.8215271	0.0156669
2023-2022	-4.6612903	-9.130086	-0.1924949	0.0386952

P = 0.0105, significant 2023 is different

Table 12: ANOVA Spring TEMP_MIN ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	132.2258	66.11290	1.444864	0.238455
Residuals	183	8373.5645	45.75718	NA	NA

Table 13: Tukey Spring (TEMP_MIN ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	0.983871	-1.886921	3.8546628	0.6974276
2023-2021	-1.080645	-3.951437	1.7901467	0.6476309
2023-2022	-2.064516	-4.935308	0.8062757	0.2082135

P = 0.238, NOT significant All same/similar

Table 14: ANOVA Fall TEMP_AVERAGE ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	734.0511	367.02554	5.645152	0.0041783
Residuals	183	11897.9395	65.01606	NA	NA

Table 15: Fall (TEMP_AVERAGE ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	4.1774194	0.7554005	7.5994382	0.0121575
2023-2021	-0.0725806	-3.4945995	3.3494382	0.9986162
2023-2022	-4.2500000	-7.6720188	-0.8279812	0.0104769

P $<$ 0.05, P = 0.00418, significant, 2022 is different

Table 16: ANOVA Fall TEMP_MAX ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	1191.946	595.9731	5.94926	0.003139
Residuals	183	18332.210	100.1760	NA	NA

Table 17: Tukey Fall (TEMP_MAX ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	3.790323	-0.4573783	8.038023	0.0908995
2023-2021	-2.354839	-6.6025396	1.892862	0.3914470
2023-2022	-6.145161	-10.3928622	-1.897460	0.0022303

P = 0.00314 significant 2022 is different

Table 18: ANOVA Fall TEMP_MIN ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	646.0968	323.0484	5.960566	0.0031059
Residuals	183	9918.1613	54.1976	NA	NA

Table 19: Tukey Fall (TEMP_MIN ~ factor(YEAR))

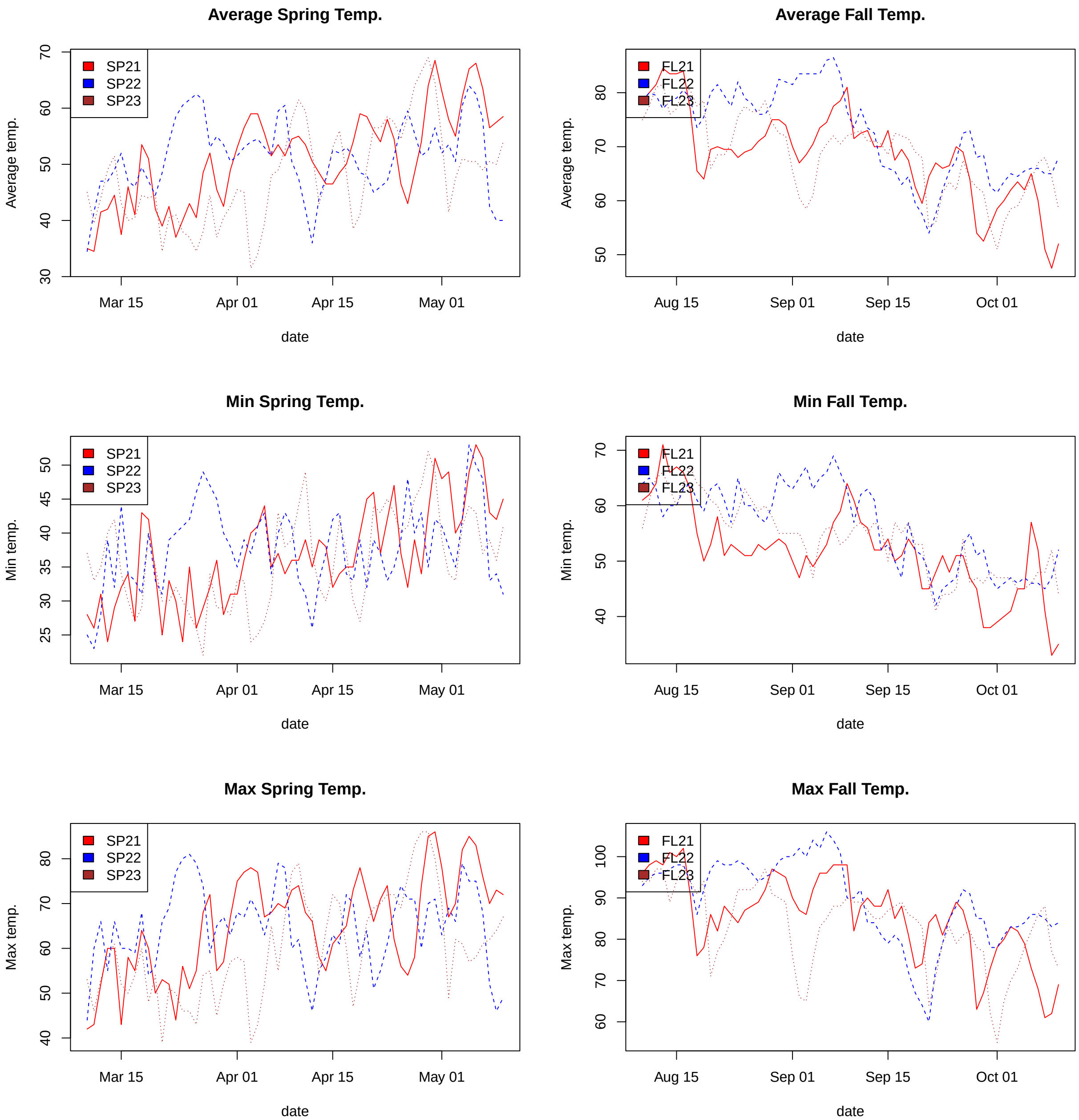
	diff	lwr	upr	p adj
2022-2021	4.564516	1.440149	7.6888836	0.0019882
2023-2021	2.209677	-0.914690	5.3340448	0.2190695
2023-2022	-2.354839	-5.479206	0.7695287	0.1788433

P = 0.00311 significant, 2022-2021 is different??

Table 20: Mean Temperatures for Spring and Fall (2021-2023)

Year	Spring_Mean_Temp	Fall_Mean_Temp
2021	51.10484	68.74194
2022	51.28226	72.91935
2023	47.91935	68.66935

Plots



Week 1 Temperature Analysis

Stats

Table 21: ANOVA Spring week 1 - TEMP_AVERAGE ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	618.4524	309.2262	7.273873	0.0048391
Residuals	18	765.2143	42.5119	NA	NA

Table 22: Tukey Spring week 1 - ANOVA(TEMP_AVERAGE ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	-7.857143	-16.75181	1.037524	0.0888148
2023-2021	-13.214286	-22.10895	-4.319619	0.0036348
2023-2022	-5.357143	-14.25181	3.537524	0.2978214

P = 0.000484, P < 0.05 significant, 2021 is different with 90% sig level

Table 23: ANOVA Spring week 1 - TEMP_MAX ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	1245.81	622.90476	8.787058	0.0021739
Residuals	18	1276.00	70.88889	NA	NA

Table 24: Tukey Spring week 1 - ANOVA(TEMP_MAX ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	-11.428571	-22.91443	0.057288	0.0512770
2023-2021	-18.714286	-30.20015	-7.228426	0.0016276
2023-2022	-7.285714	-18.77157	4.200145	0.2635155

P = 0.00217, significant, 2021 is different with 90% sig level

Table 25: ANOVA Spring week 1 - TEMP_MIN ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	209.1429	104.5714	2.904762	0.080667
Residuals	18	648.0000	36.0000	NA	NA

Table 26: Tukey Spring week 1 - ANOVA(TEMP_MIN ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	-4.285714	-12.47085	3.8994172	0.3941497
2023-2021	-7.714286	-15.89942	0.4708458	0.0666534
2023-2022	-3.428571	-11.61370	4.7565601	0.5446789

P = 0.0807, NOT significant, 2023-2021 is different

Table 27: ANOVA Fall week 1 TEMP_AVERAGE ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	487.1667	243.58333	12.04297	0.0004789
Residuals	18	364.0714	20.22619	NA	NA

Table 28: Tukey Fall week 1 - ANOVA(TEMP_AVERAGE ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	-5.428571	-11.56381	0.7066672	0.0881956
2023-2021	-11.785714	-17.92095	-5.6504757	0.0003220
2023-2022	-6.357143	-12.49238	-0.2219042	0.0415794

P < 0.05, P = 0.000479, significant, 2023 is different

Table 29: ANOVA Fall week 1 TEMP_MAX ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	1469.2381	734.61905	14.39533	0.0001845
Residuals	18	918.5714	51.03175	NA	NA

Table 30: Tukey Fall week 1 Max - ANOVA(TEMP_MAX ~ factor(YEAR))

	diff	lwr	upr	p adj
2022-2021	-8.857143	-18.60243	0.888144	0.0785563
2023-2021	-20.428571	-30.17386	-10.683285	0.0001240
2023-2022	-11.571429	-21.31672	-1.826142	0.0187604

P = 0.000185 significant, 2023 is different

Table 31: ANOVA Fall week 1 TEMP_MIN ~ factor(YEAR)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(YEAR)	2	35.42857	17.714286	1.910959	0.1767732
Residuals	18	166.85714	9.269841	NA	NA

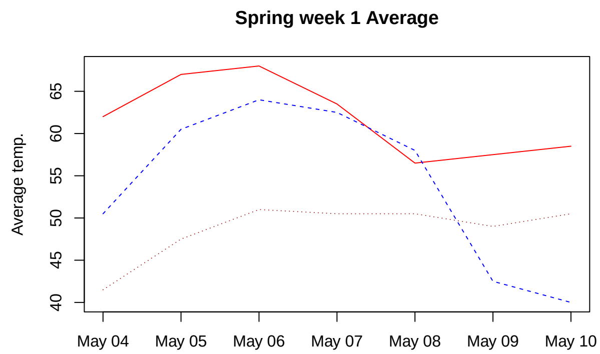
Table 32: Tukey Fall week 1 Min - ANOVA(TEMP_MIN ~ factor(YEAR))

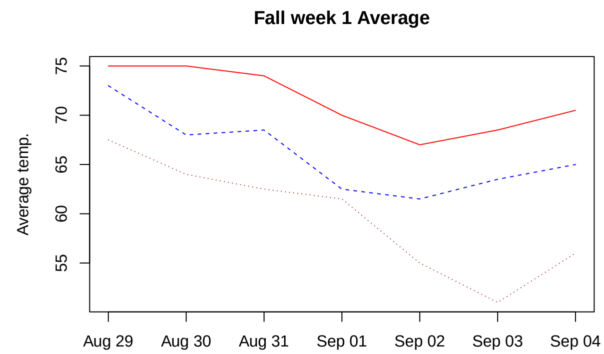
	diff	lwr	upr	p adj
2022-2021	-2.000000	-6.153465	2.153465	0.4520604
2023-2021	-3.142857	-7.296322	1.010608	0.1587432

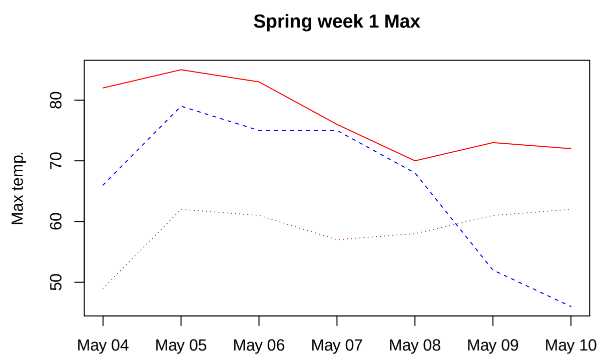
	diff	lwr	upr	p adj
2023-2022	-1.142857	-5.296322	3.010608	0.7652385

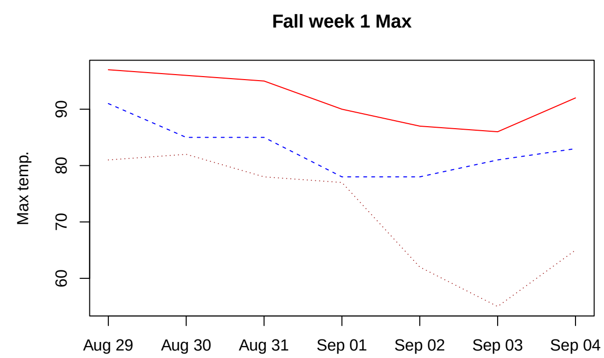
P = 0.177 NOT significant, All same

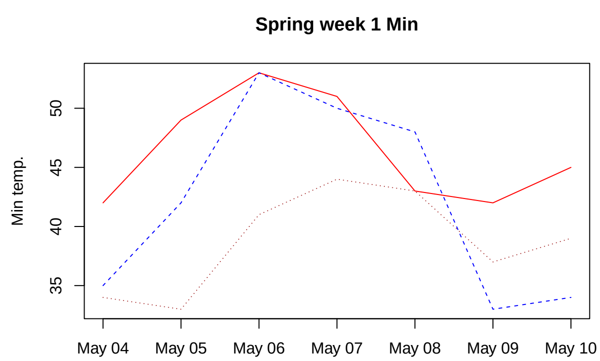
Plots

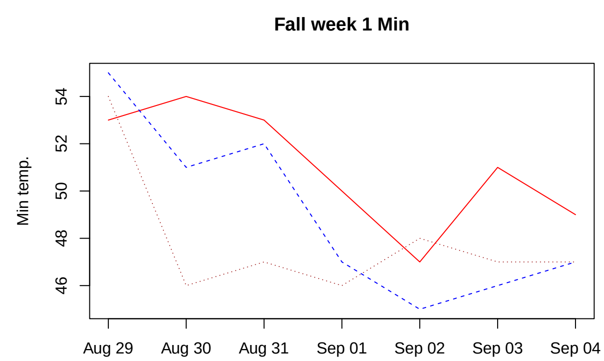












Conclusion

Our temperature analysis reveals that Spring 2023 was significantly colder than previous years, with average and maximum temperatures showing a notable decline, particularly in Week 1. This suggests that spring species were impacted by colder temperatures and (in conjunction with the snow fall analysis) heavy snowfall, likely delaying growth. As spring bloomers are more sensitive to winter conditions, variation in nighttime low temperatures and soil moisture retention from slow snowmelt could explain the shifts in bloom timing and species. However, our analysis did not identify clear trends between temperature and total plant volume across years, suggesting that there may be an ecological threshold where additional moisture does not always lead to increased plant germination and growth. In contrast, fall temperatures fluctuated, with 2022 being significantly warmer than both 2021 and 2023, yet these variations did not disrupt fall bloom patterns. Since fall species are more adapted to germinating in harsh conditions—including high temperatures and low precipitation—their bloom cycles appear more consistent despite annual shifts in seasonal climate variables. These findings support the idea that spring bloomers experience more variability in response to weather patterns, whereas fall species exhibit greater resilience to changing environmental conditions.