



SYNCHRONOUS FIREFLIES

Predicting Mating Display Great Smoky Mountain National Park
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SYNCHRONOUS FIREFLIES

- *Photinus carolinus* is the first species found in North America
- The most dense & popular display is in Great Smoky Mountain National Park
- Peak occurs for about one week sometime from end-May to mid-June
- Dictated by temperature patterns



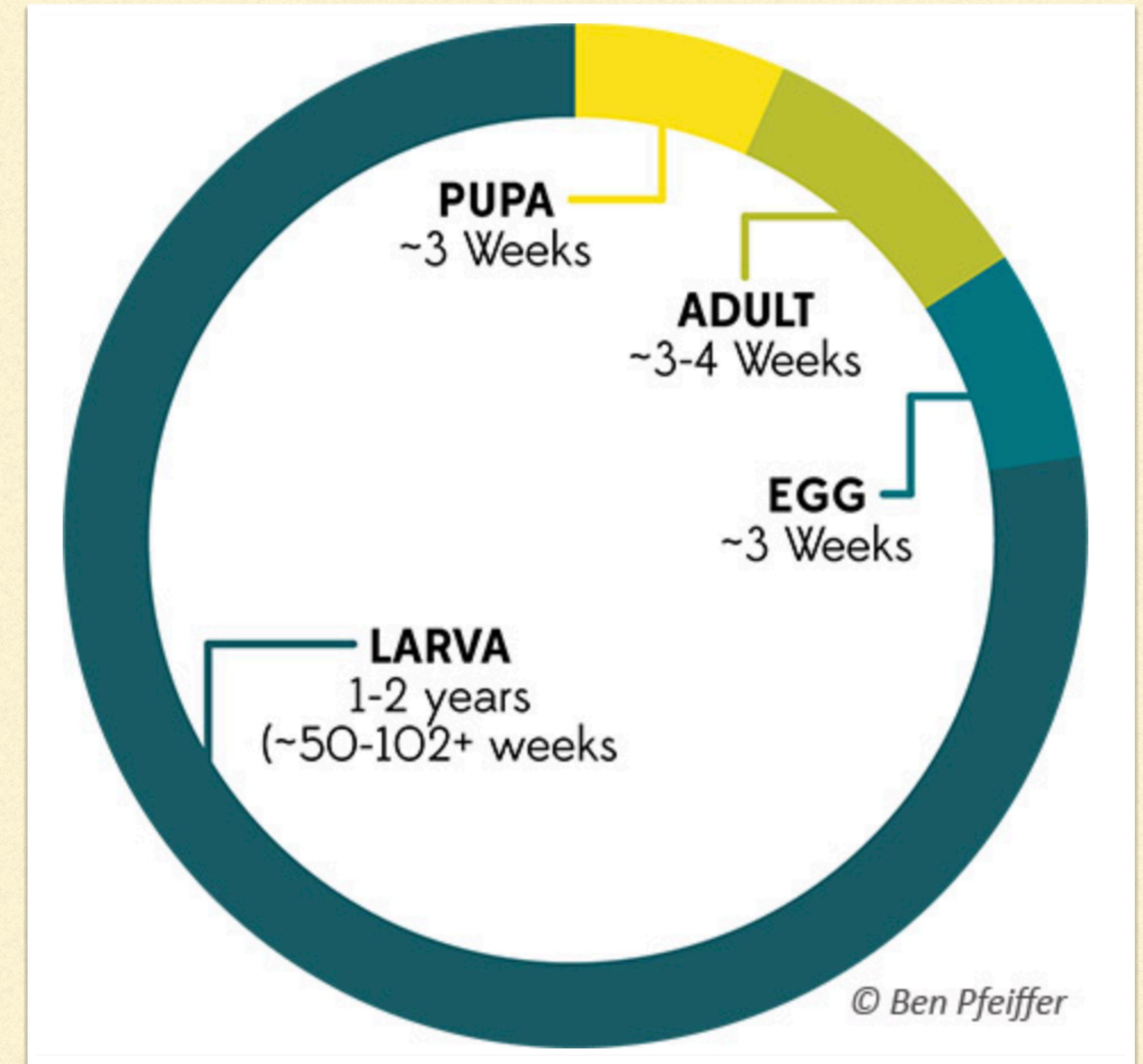
GREAT SMOKY MOUNTAIN NATIONAL PARK



- Spans Tennessee and North Carolina
- Prime firefly viewing area is Elkmont
- In 2004, an estimated 25,000 visitors came to “view The Light Show” [!]
- NPS has created a lottery for viewing the firefly display

PHOTINUS CAROLINUS

- Males flash 4 - 8 flashes together
- Allow 8 - 12 second pause
- Female response during this dark pause
- Synchronicity to protect from predators
 - Female of photuris genus mimic female photinus and devour males
- Firefly life cycle helps determine effects of weather on mating display



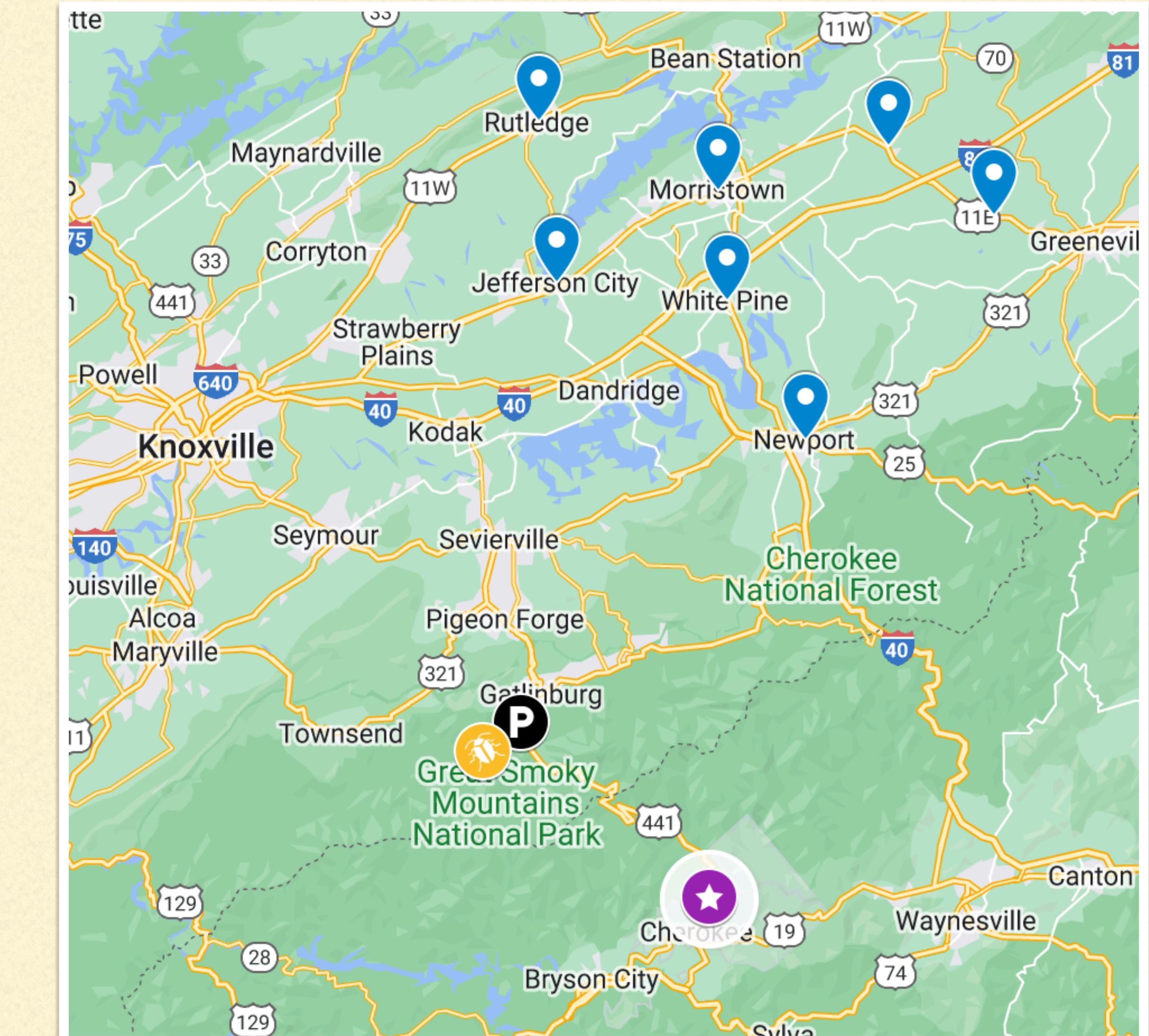
DATA COLLECTION

- **WEATHER DATA**

- Climate Data Search from NOAA
<https://www.ncdc.noaa.gov/cdo-web/search>
- I used TN weather stations in blue

- **FIREFLY MATING SEASON DATA**

- 2014 - 2023: from NPS
- 1993 - 2005: Lynn Faust research



FAUST PAPER

1506

ENVIRONMENTAL ENTOMOLOGY

Vol. 38, no. 5

Table 1. Calendar dates and modified growing degree-day values for four landmark phenological events of *P. carolinus* for 1993 through 2005

Year	Male emergence		Good display		Female emergence		Peak display	
	Date	mGDD	Date	mGDD	Date	mGDD	Date	mGDD
1993	June 3	809	June 11	960	June 16	1,044	June 19	1,099
1994	May 31 ^a	922	June 9	1,075	June 14	1,154	June 13	1,136
1995	May 23 ^a	890	June 3	1,069	June 12	1,224	June 6	1,118
1996	May 28 ^a	814	June 5	932	June 13	1,046	June 13	1,046
1997	May 24	776	June 12	990	June 19	1,099	June 21	1,134
1998	May 24 ^a	791	June 2	954	June 5	1,012	June 11	1,080
1999	May 24 ^a	820	June 7	1,036	June 7	1,036	June 9	1,076
2000	May 21	895	June 1	1,062	June 9	1,182	June 9	1,182
2001	May 22 ^a	800	June 4	956	June 4	956	June 12	1,086
2002	May 24 ^a	922	May 30	1,019	June 3	1,092	June 3	1,092
2003	May 20	854	May 28	958	June 5	1,065	June 8	1,114
2004	May 21	797	May 31	960	June 4	1,020	June 4	1,020
2005	May 31	812	June 8	931	June 10	964	June 15	1,042
Mean	May 24	838.6	June 5	992.5	June 9	1,068.8	June 11	1,094.2

- Faust & scouts obtain firefly data
- Obtain weather data from NOAA
- Used this to find best fit equation for using mGDD (degree days)

A photograph of a forest at night, filled with the bright, glowing lights of fireflies. The lights create a path of light through the dark, silhouetted trees, illuminating the forest floor and the canopy above. The overall atmosphere is mysterious and magical.

DATA ANALYSIS

ATTEMPTING TO CORRELATE EARLIER WEATHER WITH JUNE MATING SEASON DATES

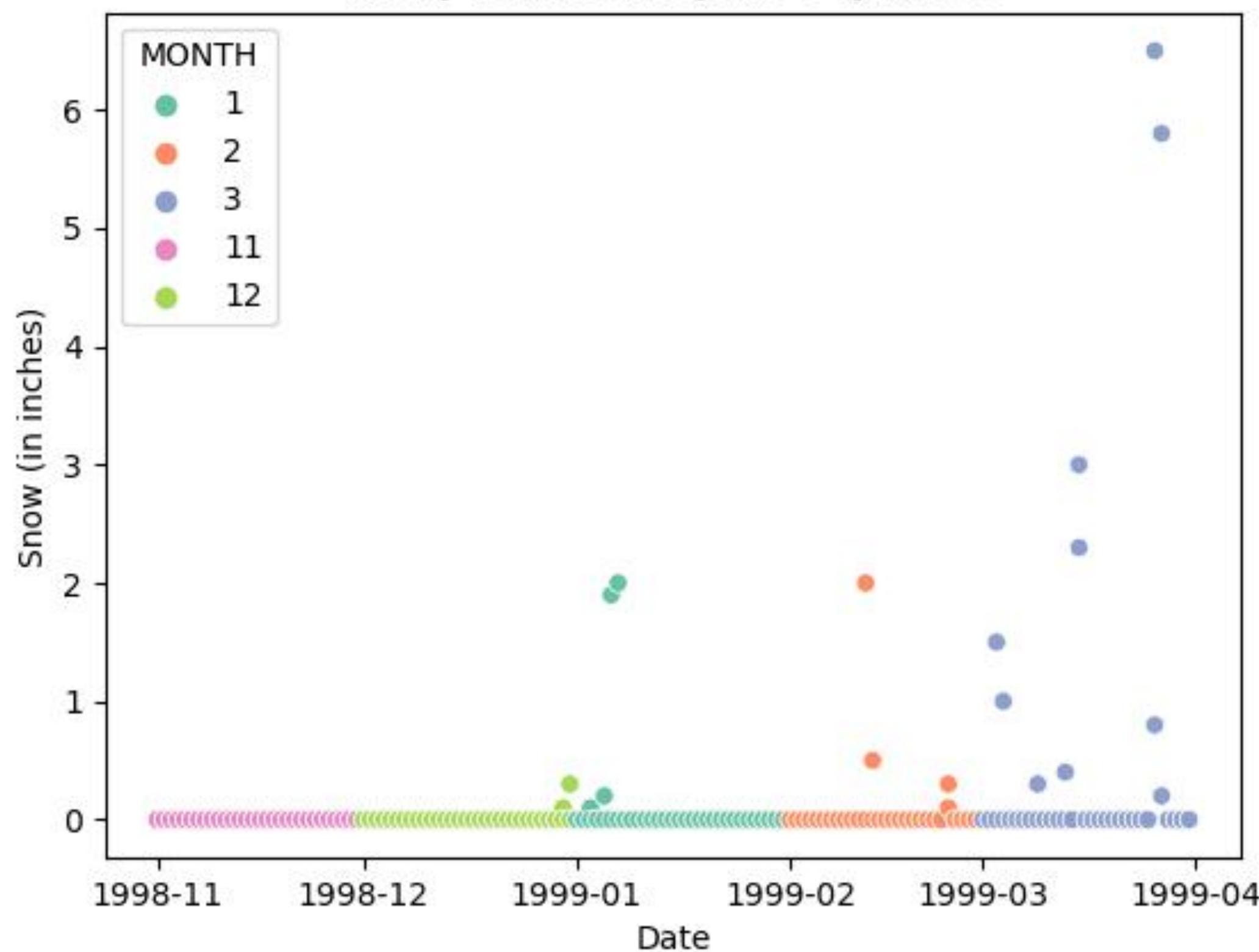
WINTER

Effect of snowfall on mating season length. May also be a factor in “start” date.

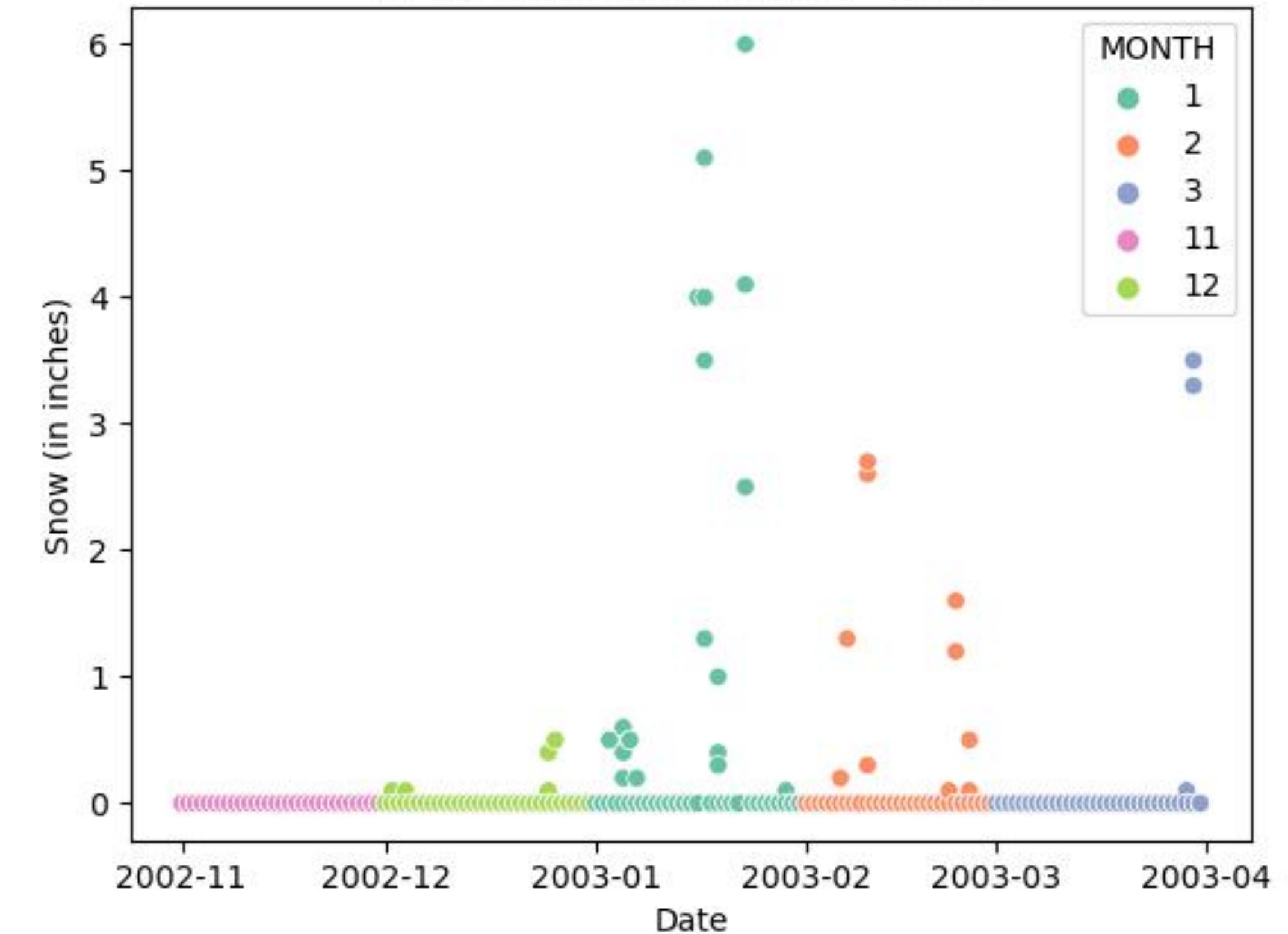
- Short season in 1999: June 7 - June 10 (4 days)
 - One of the latest “start” dates - average start is June 3
- Long season in 2003: May 28 - June 9 (13 days)
 - This is also our earliest “start” date for peak season

WINTER

Snowfall Winter 1998-1999: November - March
Firefly Peak Dates June 6 - June 10



Snowfall Winter 2002-2003: November - March
Firefly Peak Dates May 28 - June 9



WINTER

```
winter_9899.groupby("MONTH") [ ["TMIN", "TMAX"] ].describe()
```

MONTH	TMIN									TMAX								
	count	mean	std	min	25%	50%	75%	max	count	mean	std	min	25%	50%	75%	max		
1	62.0	34.725806	12.168448	13.0	26.00	35.5	46.00	62.0	62.0	52.306452	12.360154	23.0	44.25	55.0	59.75	76.0		
2	56.0	35.071429	8.895059	17.0	28.00	36.5	41.25	58.0	56.0	53.250000	10.276628	33.0	48.25	54.0	59.00	75.0		
3	62.0	35.629032	7.663484	25.0	30.00	33.0	40.00	53.0	62.0	56.112903	8.661399	40.0	50.00	58.0	62.75	72.0		
11	83.0	41.698795	7.628149	25.0	37.00	42.0	47.00	57.0	83.0	61.204819	7.961430	41.0	57.00	62.0	67.00	76.0		
12	70.0	38.471429	10.389127	20.0	29.25	39.5	46.50	59.0	70.0	53.342857	13.328498	30.0	43.00	51.0	67.00	74.0		

```
winter_0203.groupby("MONTH") [ ["TMIN", "TMAX"] ].describe()
```

MONTH	TMIN									TMAX								
	count	mean	std	min	25%	50%	75%	max	count	mean	std	min	25%	50%	75%	max		
1	124.0	25.177419	11.112176	0.0	17.00	24.0	34.00	50.0	122.0	39.795082	10.381116	15.0	33.0	39.0	46.75	62.0		
2	112.0	32.241071	8.556380	12.0	28.75	32.0	38.25	49.0	112.0	46.276786	9.698342	21.0	40.0	45.0	52.00	75.0		
3	124.0	41.137097	8.604531	24.0	33.00	42.5	48.00	60.0	124.0	63.959677	8.363101	42.0	59.0	65.0	70.00	78.0		
11	120.0	36.383333	9.051843	18.0	29.00	36.0	43.00	59.0	120.0	53.050000	8.884743	34.0	49.0	53.0	56.00	77.0		
12	119.0	30.268908	7.495419	16.0	25.00	30.0	37.00	44.0	119.0	47.554622	8.272578	30.0	41.0	48.0	54.00	68.0		

Similar to snowfall, impact of cold on season start & length seems most apparent closer to mating season.

Since firefly larva are protected from elements, these impacts may be on more sensitive pupa stage.

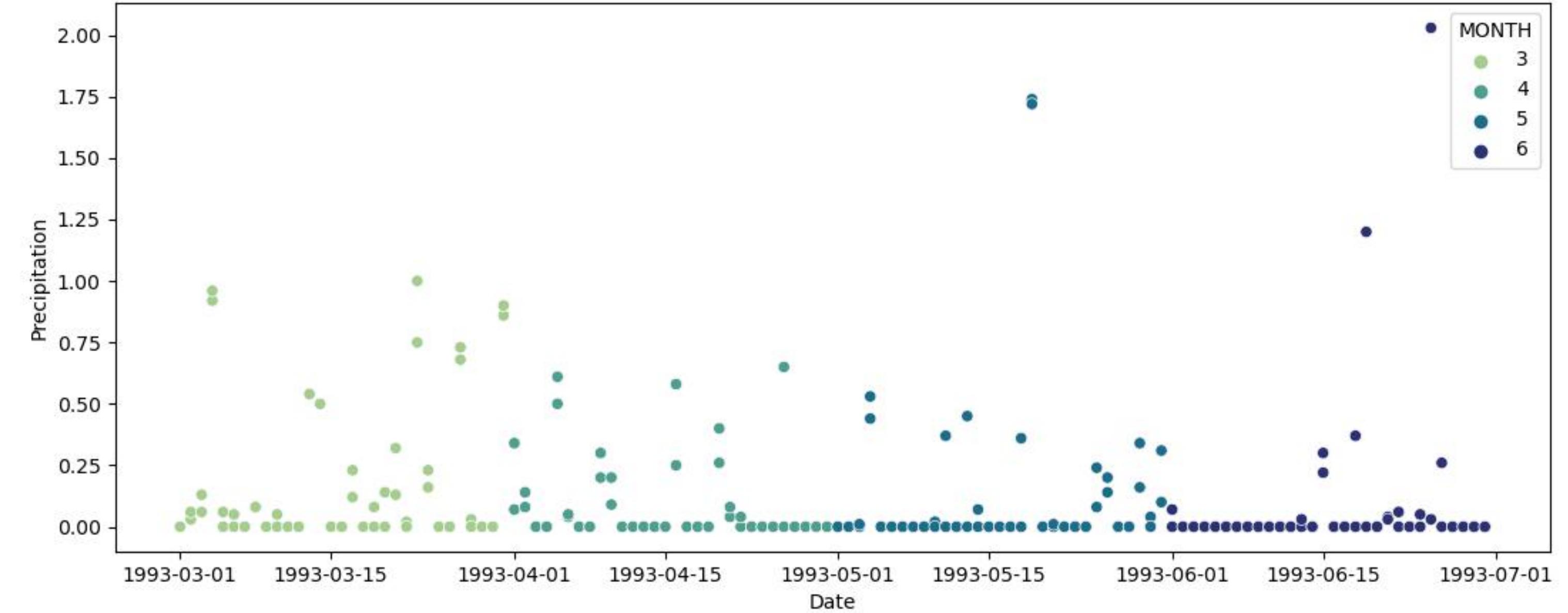
Best to focus in on the months of April, May, and June as fireflies move into pupa and then adult stages.

SPRING

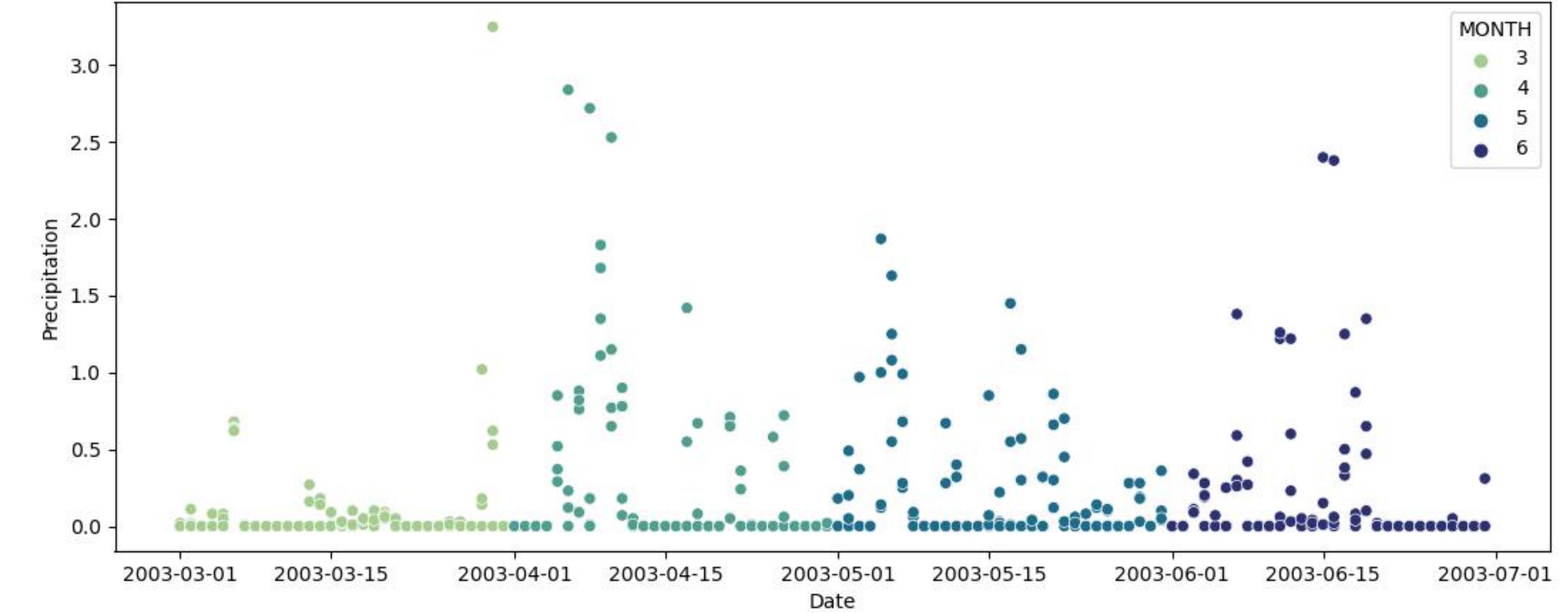
Effect of spring rain on “start” date. March - June bundled into Spring designator.

- Late season in 1993: June 11 - June 20 (10 days)
 - Average start is June 3
- Early season in 2003: May 28 - June 9 (13 days)
 - Previously noted, also longest season

Precipitation in the Spring of 1993: March - June
Firefly Peak June 11 - June 20



Precipitation in the Spring of 2003: March - June
Firefly Peak May 28 - June 9

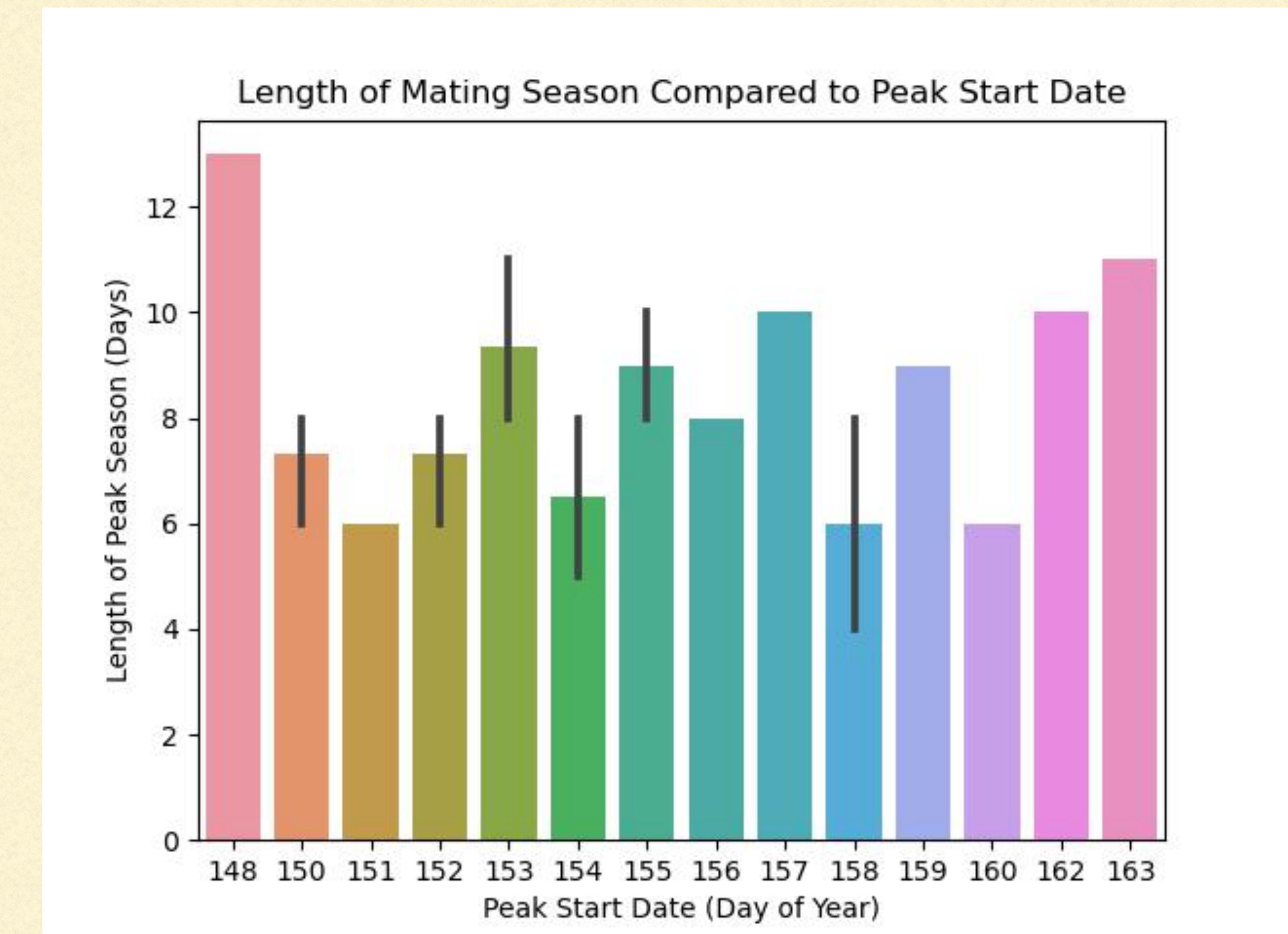


SEASON START VS. LENGTH

Original goal was to focus only on the mating season display start date.

As analysis developed, variations in mating season length stood out as interesting.

No obvious relationship between start date and length. Will want to do further analysis separately.

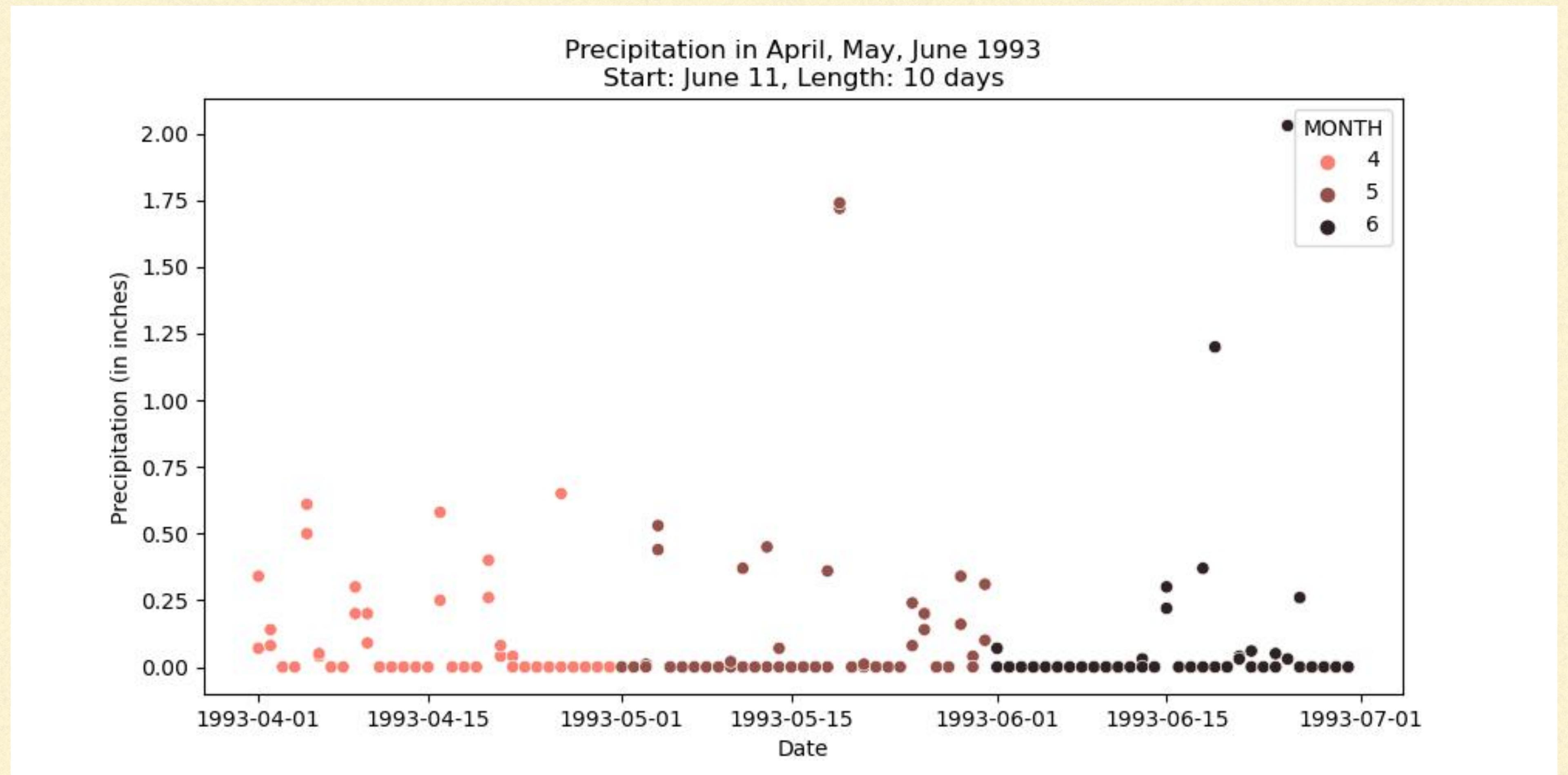


LATE SPRING

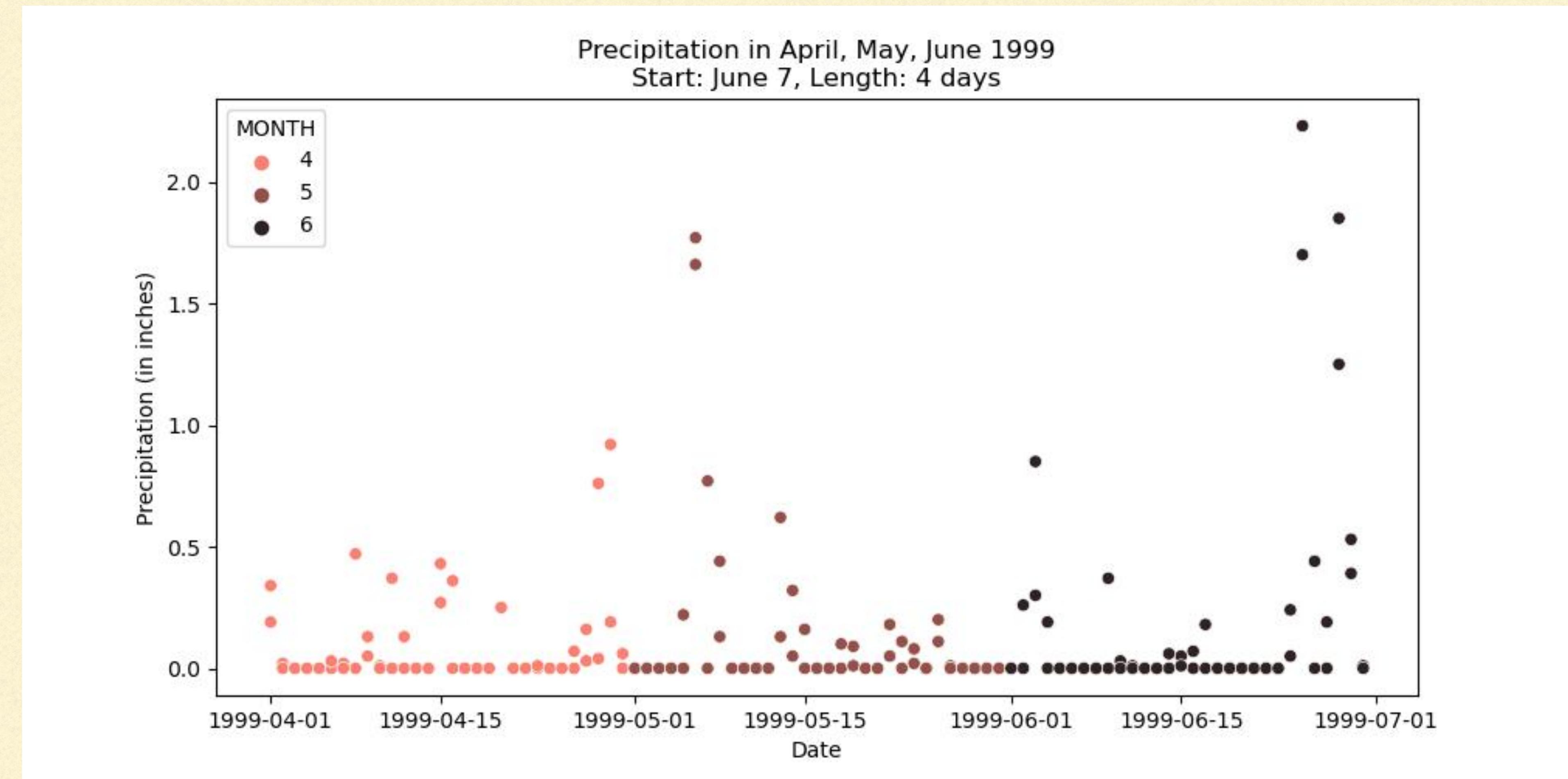
Zooming in further. Looking at late spring April - June; firefly pupa - adult stage. Precipitation seems to be a factor, examining impact on “start” and length

	START DATE	LENGTH
1993 LATE	June 11	10 days
1999 SHORT	June 7	4 days
2003 EARLY & LONG	May 28	13 days

LATE SPRING: LATE START



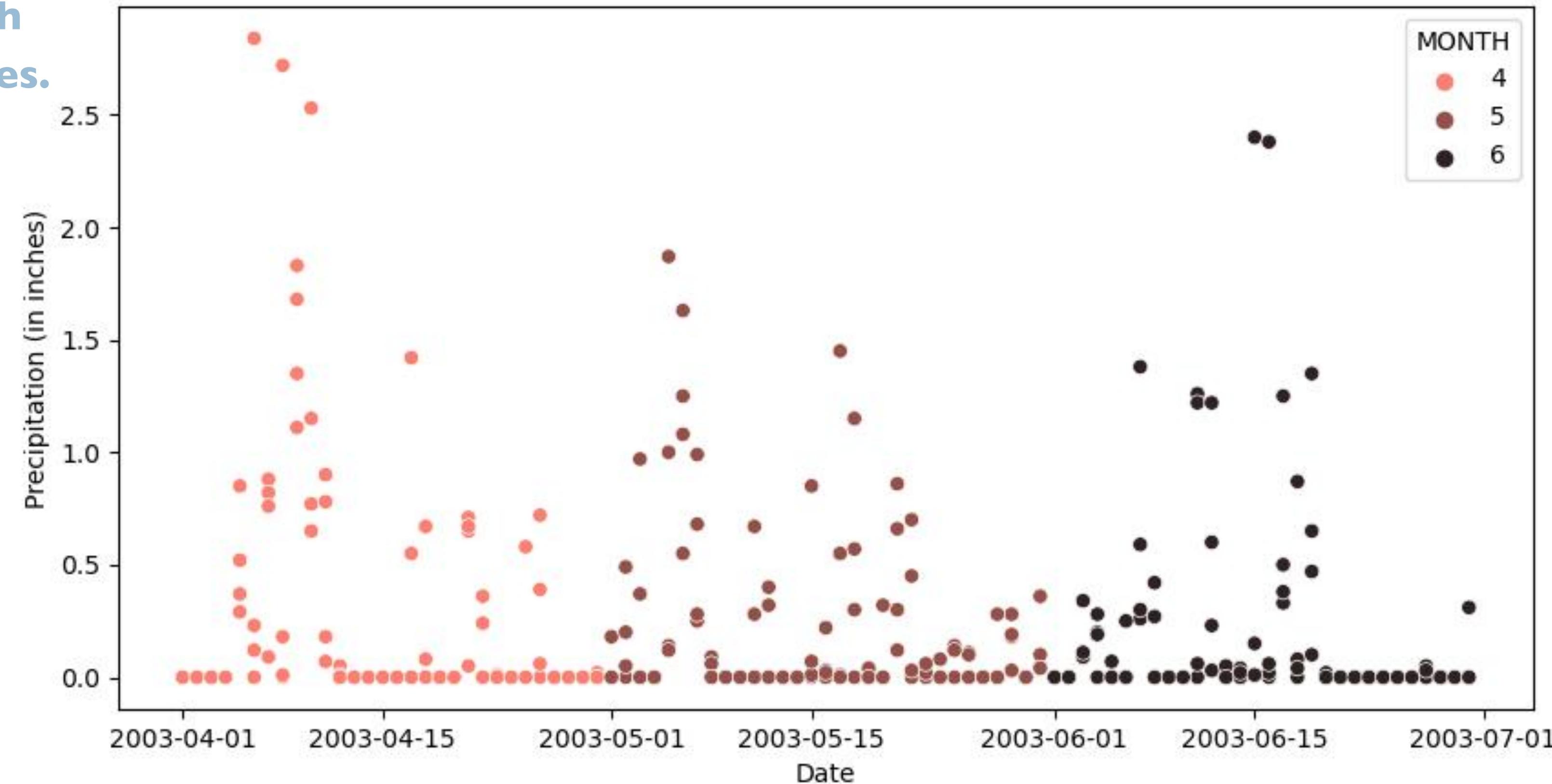
LATE SPRING: SHORT



LATE SPRING: EARLY & LONG

* **NOTE: maximum precipitation much higher, at 2.5 inches.**

Precipitation in April, May, June 2003
Start: May 28, Length: 13 days



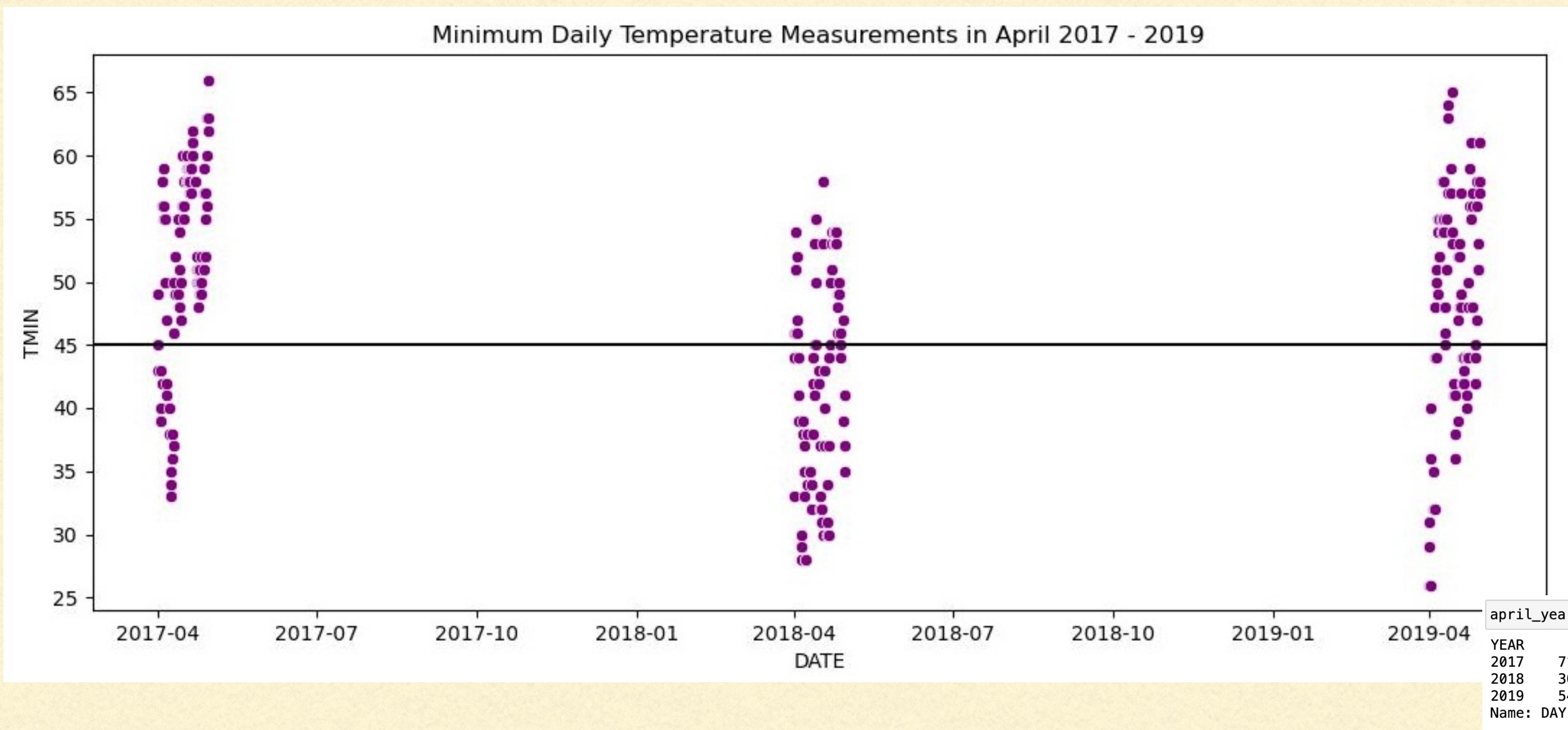
DEGREE DAYS

Current firefly peak date estimations use Degree Days, which is a comparison of the average daily measurement vs. the average set point for that location. Degree Day base for March & April is 45F.

```
fireflies.query('YEAR ==(2017,2018,2019)')
```

	YEAR	START_MONTH	START_DAY	END_MONTH	END_DAY	LENGTH	START_DOY	END_DOY
4	2019	5	30	6	6	8	150	157
5	2018	6	7	6	14	8	158	165
6	2017	5	30	6	6	8	150	157

DEGREE DAYS



As seen earlier, minimum daily temperature seems to have the biggest impact in start day variation.

DEGREE DAYS

```
april_years_789.groupby("YEAR")['TMIN'].describe()
```

	count	mean	std	min	25%	50%	75%	max
YEAR								
2017	89.0	51.584270	7.841917	33.0	48.00	52.0	58.0	66.0
2018	85.0	41.600000	8.304044	28.0	34.00	42.0	49.0	58.0
2019	86.0	48.325581	8.827020	26.0	42.25	49.5	55.0	65.0

```
april_years_789.groupby("YEAR")['TAVG'].describe()
```

	count	mean	std	min	25%	50%	75%	max
YEAR								
2017	30.0	62.833333	7.090953	47.0	59.50	64.0	67.00	76.0
2018	30.0	54.533333	7.842120	39.0	49.25	56.0	59.00	69.0
2019	30.0	60.966667	8.185283	40.0	58.50	62.5	66.75	72.0

```
april_years_789.groupby("YEAR")['TMAX'].describe()
```

	count	mean	std	min	25%	50%	75%	max
YEAR								
2017	89.0	74.224719	9.236480	47.0	68.00	76.0	81.0	93.0
2018	85.0	65.270588	10.038483	42.0	60.00	66.0	73.0	83.0
2019	86.0	72.232558	9.688895	48.0	67.25	75.0	79.0	86.0

2017 & 2019: start May 30
2018: start June 6

See a correlation between all temperature measurements (AVG, MIN, MAX) for April of this 3 year span and the start date. Warmer days in 2017 & 2019 for an earlier start date vs cooler measurements in 2018 for a later start.

NEXT STEPS



- Plot larger scale firefly season data vs weather date, particularly April precipitation, to look for further patterns
- Degree days reign supreme for predicting start date, but other weather patterns may help study mating season length
- Season length prediction can also help NPS plan logistics
- Further research could examine if season length corresponds to firefly populations



WORKS CITED

- [1]: Faust, Lynn F., and Paul A. Weston. "Degree-day prediction of adult emergence of *Photinus carolinus* (Coleoptera: Lampyridae)." *Environmental Entomology*, vol. 38, no. 5, 1 Oct. 2009, pp. 1505–1512, <https://doi.org/10.1603/022.038.0519>.
- [2] Wikipedia contributors. "Photinus carolinus." Wikipedia, The Free Encyclopedia. Wikipedia, The Free Encyclopedia, 17 Feb. 2024. Web. 5 May. 2024.
- [3] "Facts about Fireflies & Lightning Bugs." Firefly.org, www.firefly.org/facts-about-fireflies.html.
- [4] "Synchronous Fireflies - Great Smoky Mountains National Park (U.S. National Park Service)." www.nps.gov, www.nps.gov/grsm/learn/nature/fireflies.htm Gatlinburg, Mailing Address: 107 Park Headquarters Road, and TN 37738

IMAGES USED

TITLE: <https://www.nps.gov/grsm/learn/news/park-announces-synchronous-firefly-viewing-dates-for-2022.htm>

SLIDE 2: <https://www.gatlinburgtnguide.com/blog/events/synchronous-fireflies-elkmont-great-smoky-mountains/>

SLIDE 3: <https://www.rvtrader.com/blog/2021/11/15/rv-trader-travel-spotlight-great-smoky-mountains-national-park/>

SLIDE 4: <https://www.firefly.org/facts-about-fireflies.html>

SLIDE 7, 21 & 22: <https://www.terragalleria.com/blog/photographing-the-great-smoky-mountains-synchronous-fireflies/>
