MONITORING CLIMATE & PHENOLOGY at Paul Smith's College

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RESEARCH ARTICLE

Once and future changes in climate and phenology within the Adirondack uplands (New York, USA)

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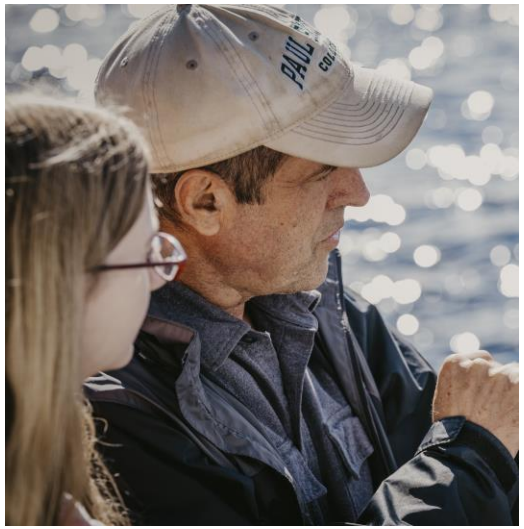


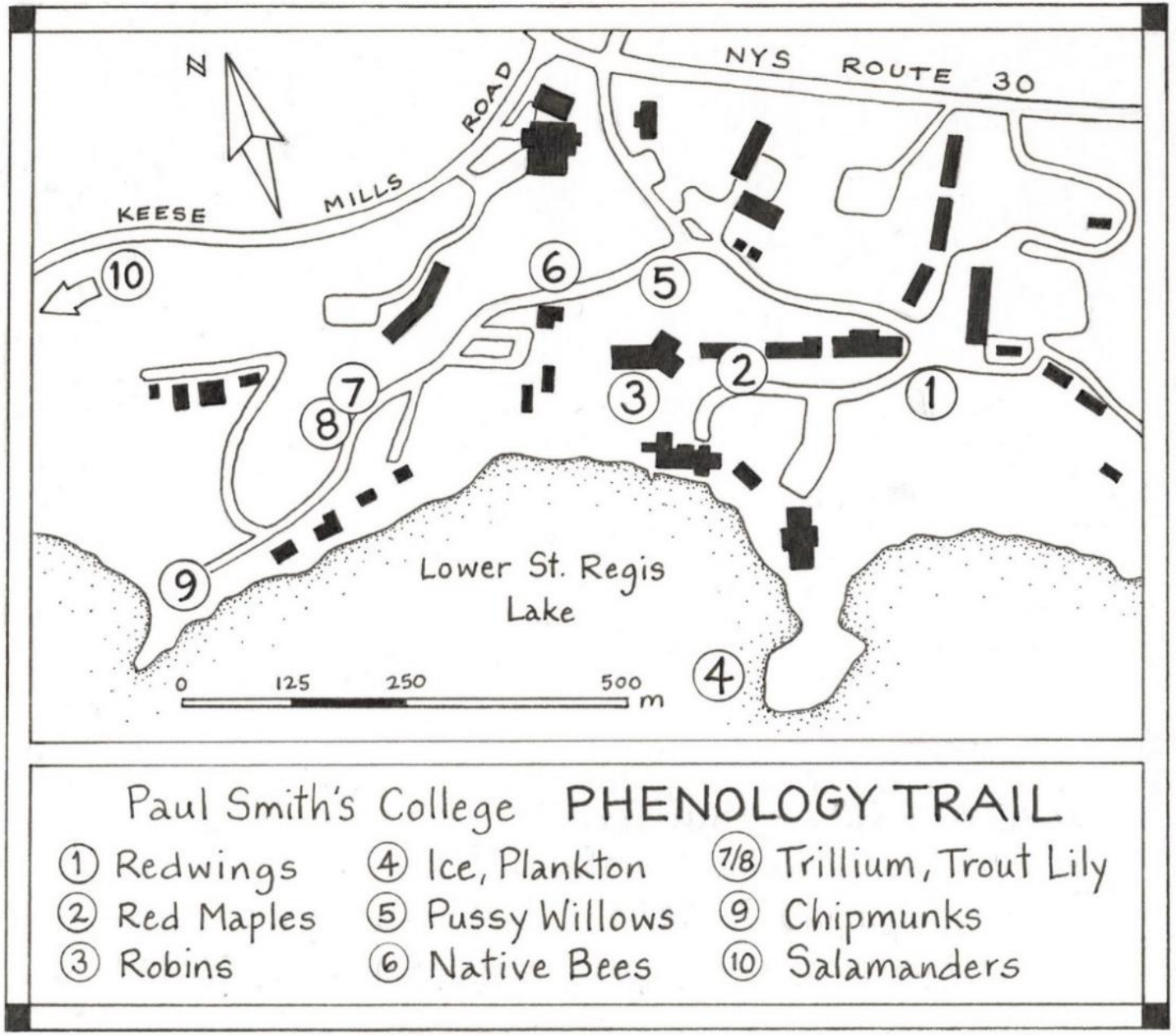
PLOS CLIMATE

FREE ACCESS AT: https://journals.plos.org/climate/article?id=10.1371/journal.pclm.0000047

What is PHENOLOGY?

It's the study of seasonal behavior in plants and animals; when they sprout, migrate, flower, or breed, and how climate affects them.

We've been studying it here since 1990.



Our science students and faculty monitor phenology on campus

PHENOLOGY can also include the study of other events such as the timing of ice cover on lakes or seasonal changes in water temperatures.

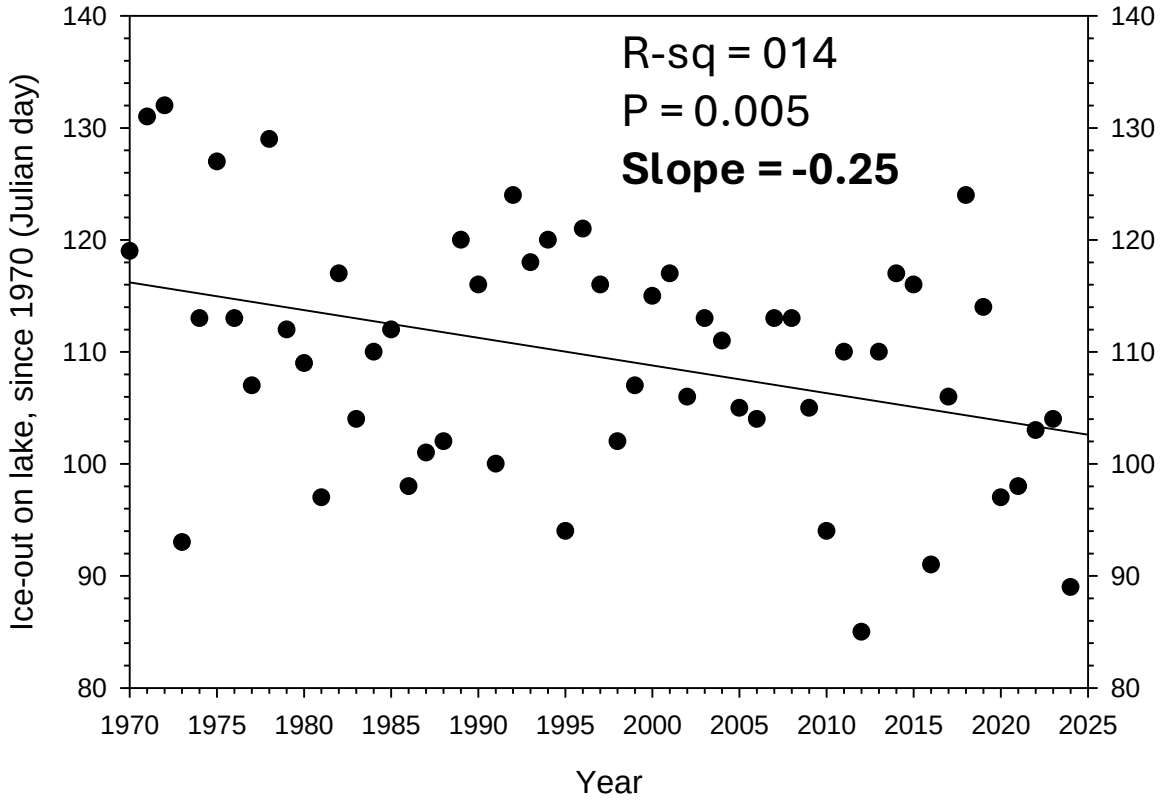
Shifting dates of **ice-out** and **freeze-up** are among the most visually obvious effects of warming in our region.

FALL PHENOLOGY

Monitoring by students in our Biology 111 labs shows that Lower Saint Regis Lake has **WARMED** 2 **degrees C** in October since the 1990s.

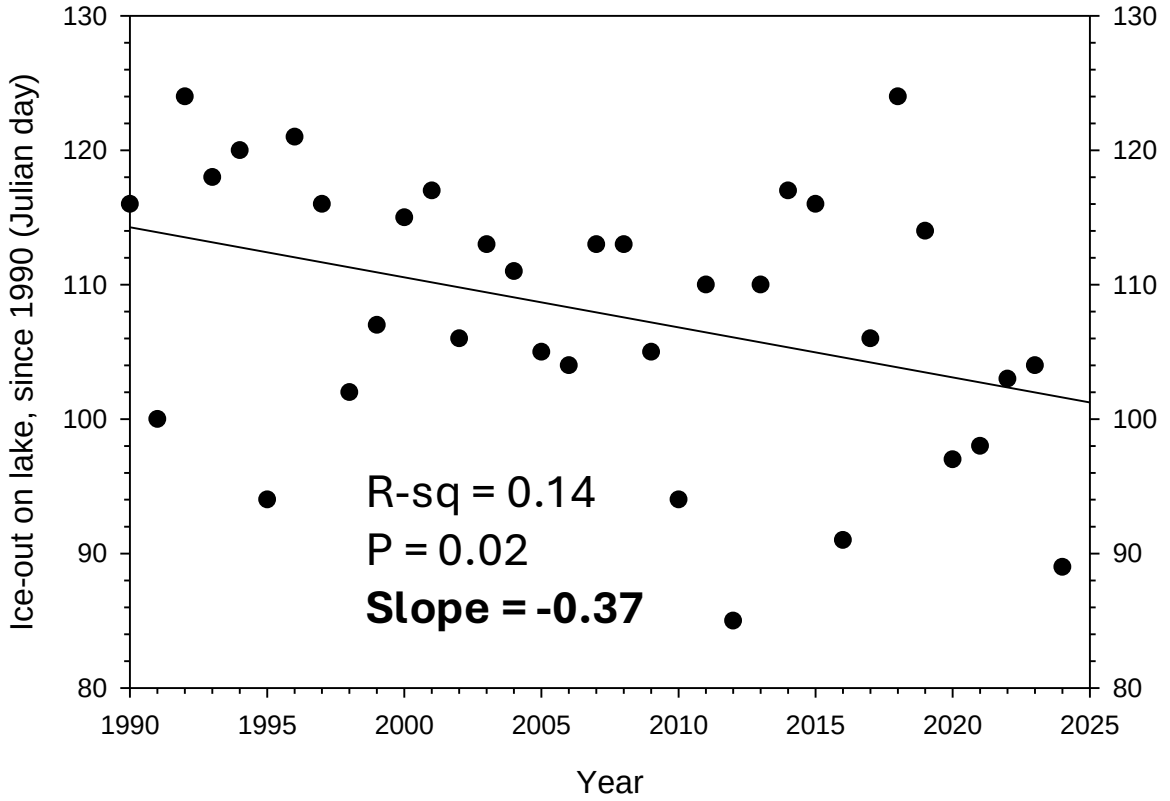
LOWER ST. REGIS LAKE: ICE-OUT (1970-2024)

Spring ice-out contests and monitoring since 1970 show that the lake thaws **two weeks earlier**, on average.



MORE RECENT CHANGES IN ICE-OUT DATES

Since our study began in **1990**, the trend toward earlier ice-out dates has **accelerated** to 3-4 days/decade.

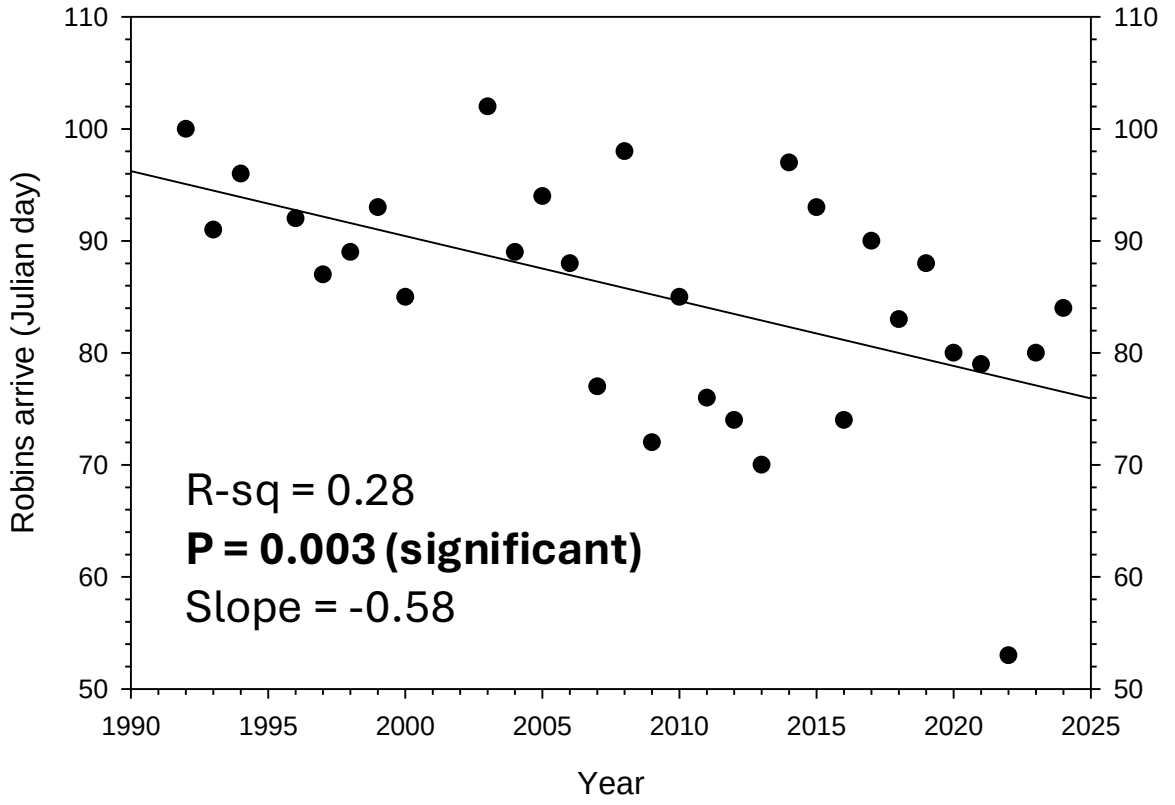


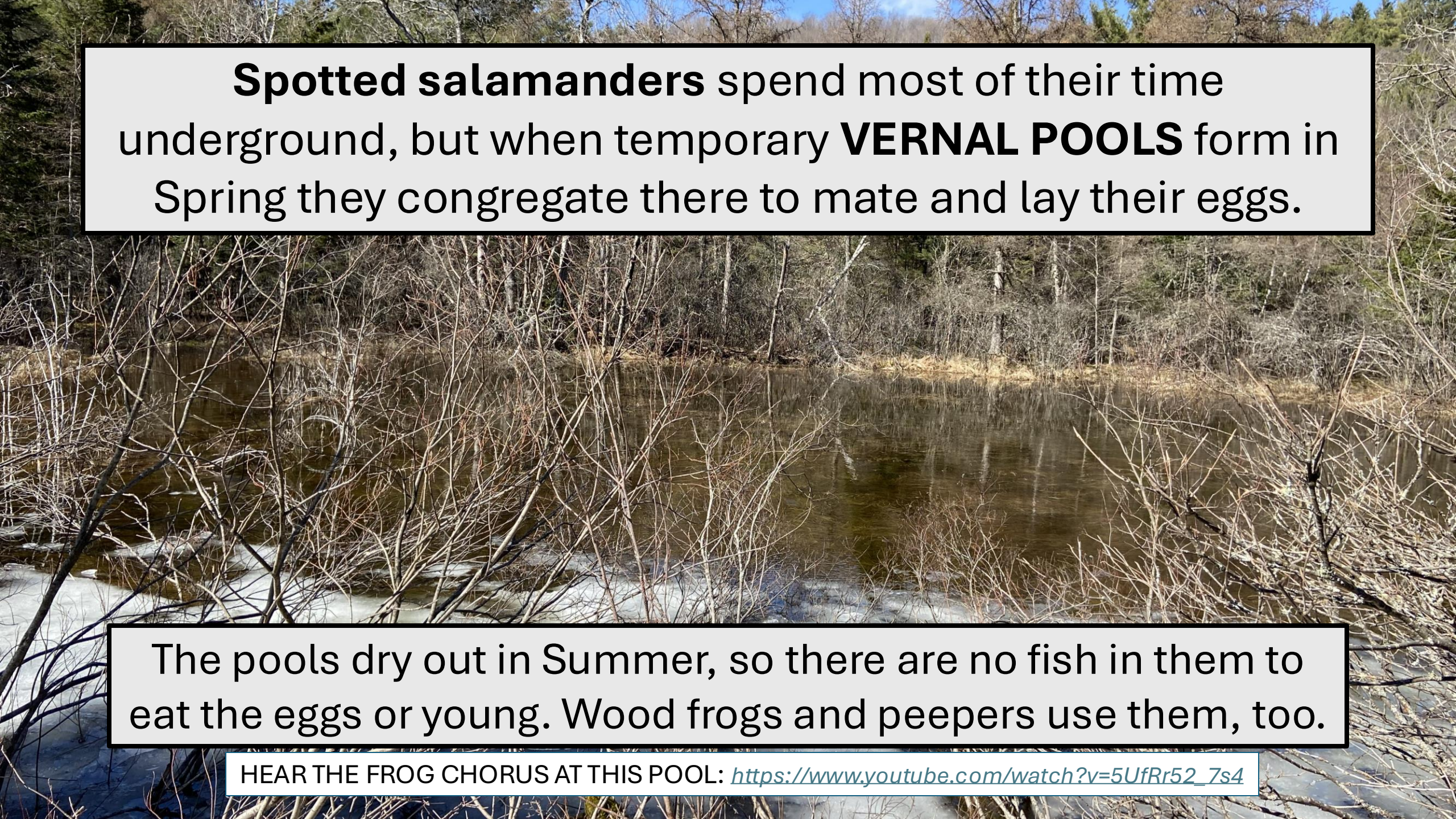
VIDEO: https://www.youtube.com/watch?v=8UxfuE4mRpo


IS ANIMAL AND PLANT PHENOLOGY
ALSO CHANGING ON CAMPUS?

ROBIN MIGRATION (1992-2024)

Male robins arrive on our campus **20 days earlier,** on average, to establish territories before the females arrive.





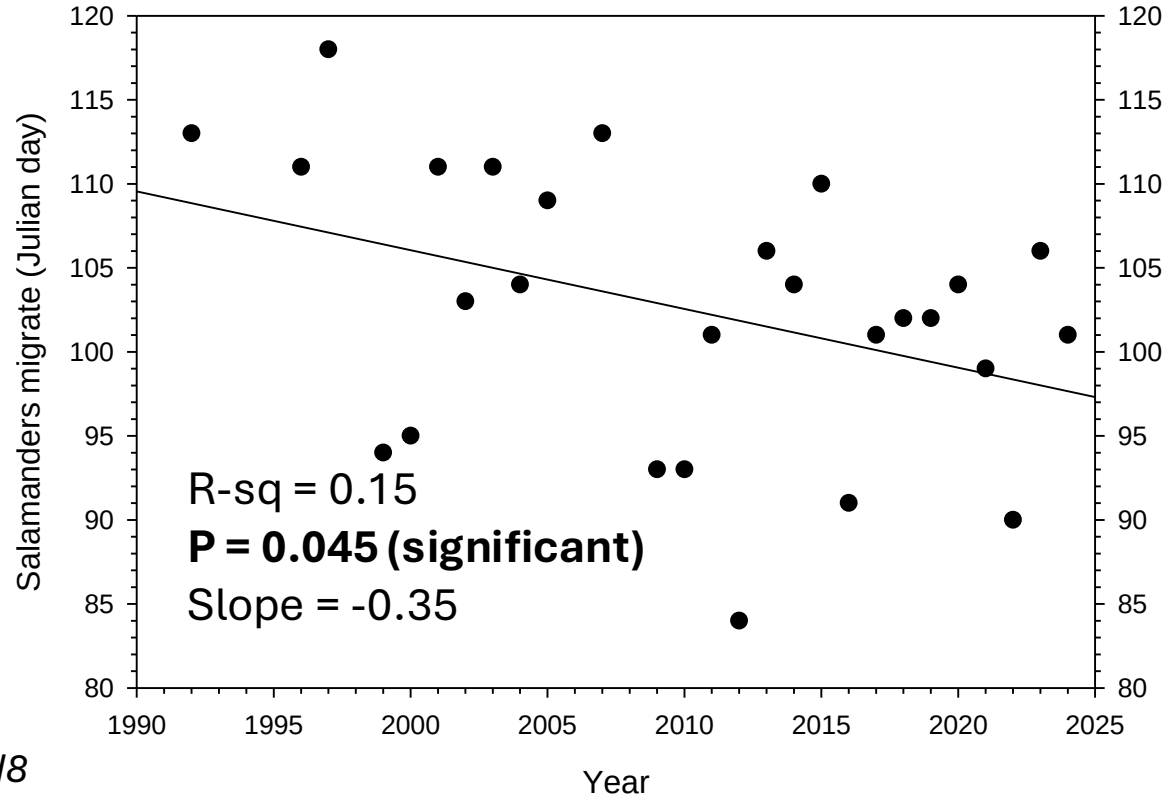
Spotted salamanders spend most of their time underground, but when temporary **VERNAL POOLS** form in Spring they congregate there to mate and lay their eggs.

The pools dry out in Summer, so there are no fish in them to eat the eggs or young. Wood frogs and peepers use them, too.

HEAR THE FROG CHORUS AT THIS POOL: https://www.youtube.com/watch?v=5UfRr52_7s4

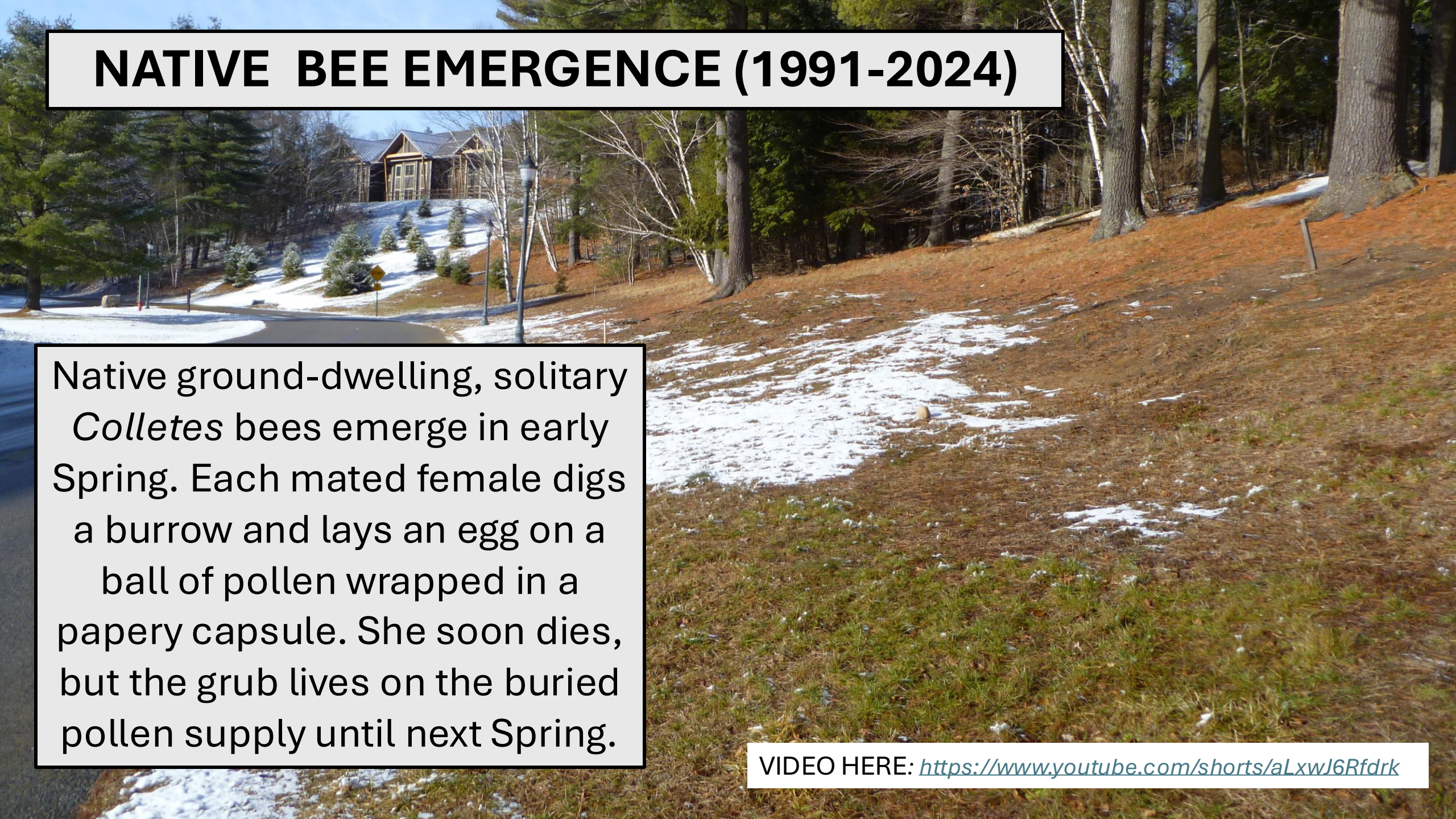
SALAMANDER MIGRATION (1992-2024)

Spotted salamanders migrate at night to their breeding pools along Keese Mills Road **12 days earlier**, on average.



VIDEO HERE: *https://www.youtube.com/shorts/NgRcaq-gVd8*

NATIVE BEE EMERGENCE (1991-2024)

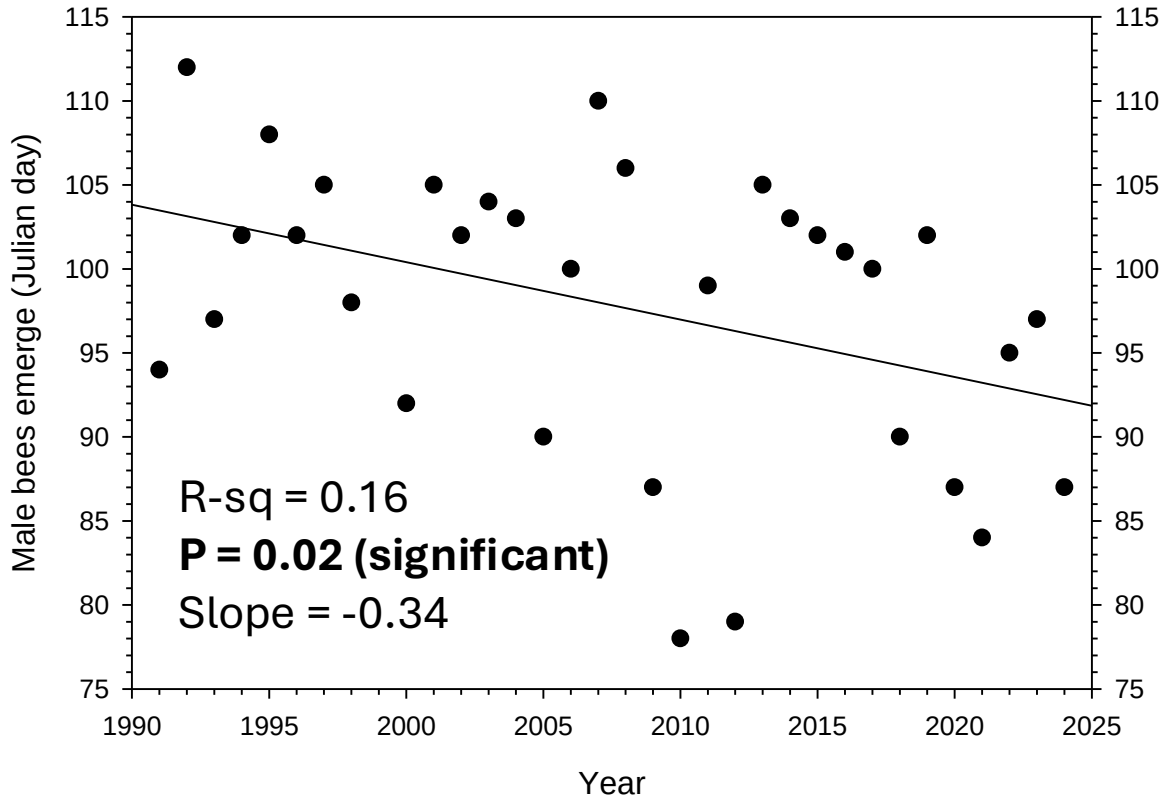


Native ground-dwelling, solitary *Colletes* bees emerge in early Spring. Each mated female digs a burrow and lays an egg on a ball of pollen wrapped in a papery capsule. She soon dies, but the grub lives on the buried pollen supply until next Spring.

VIDEO HERE: https://www.youtube.com/shorts/aLxwJ6Rfdrk

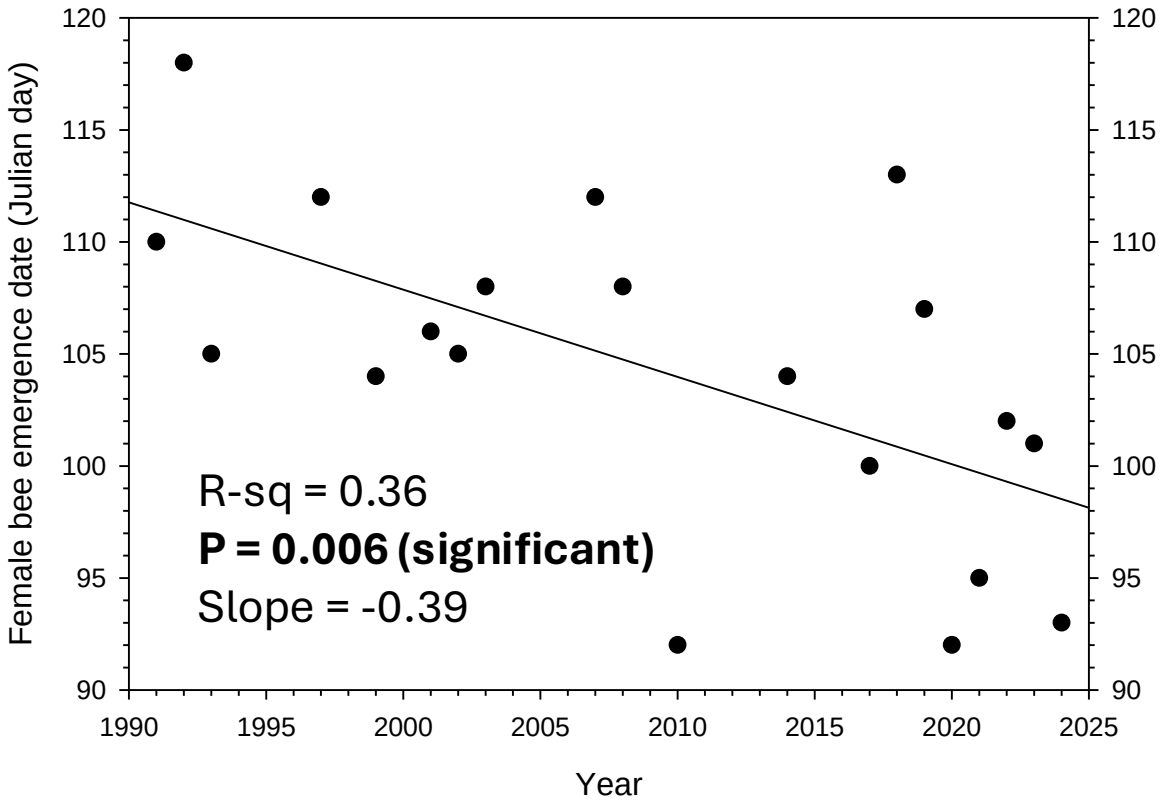
MALE BEE EMERGENCE (1991-2024)

The male bees emerge first from the south-facing slope of Essex Hill, **12 days earlier**, on average



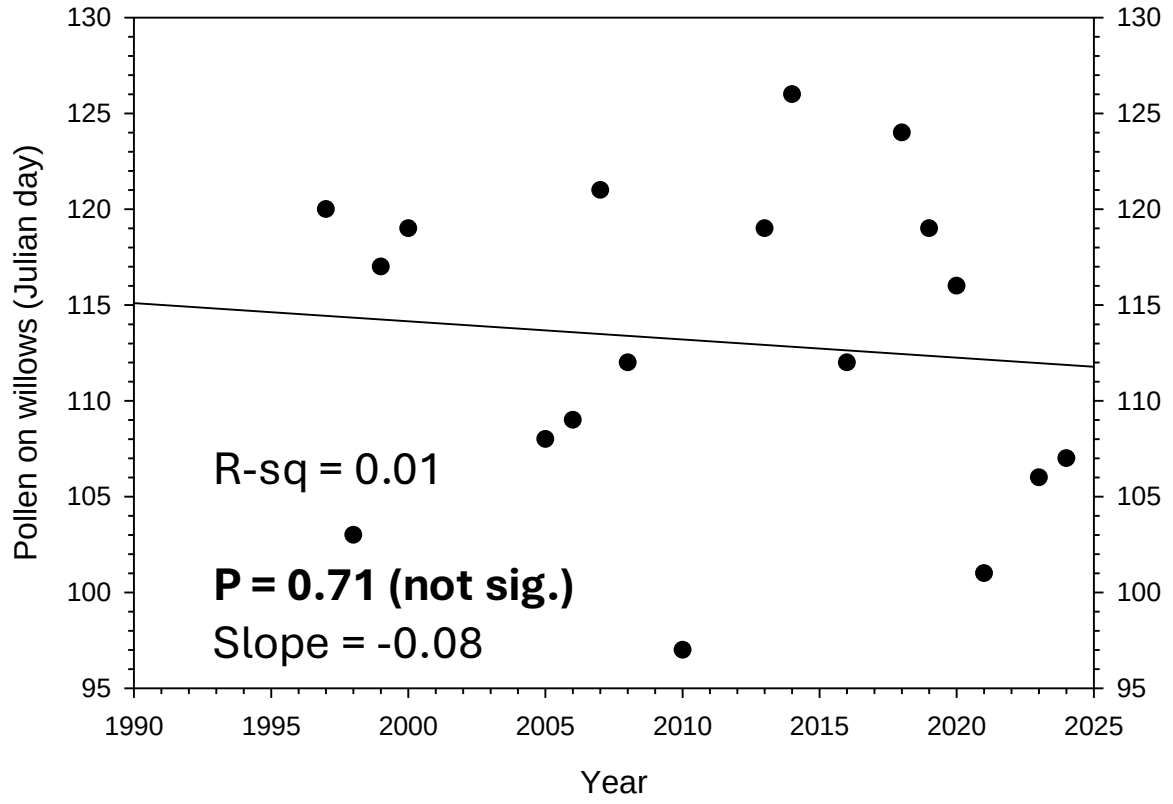
FEMALE BEE NESTING (1991-2024)

The female bees emerge next and begin to dig their nesting-burrows, **13 days earlier**, on average.



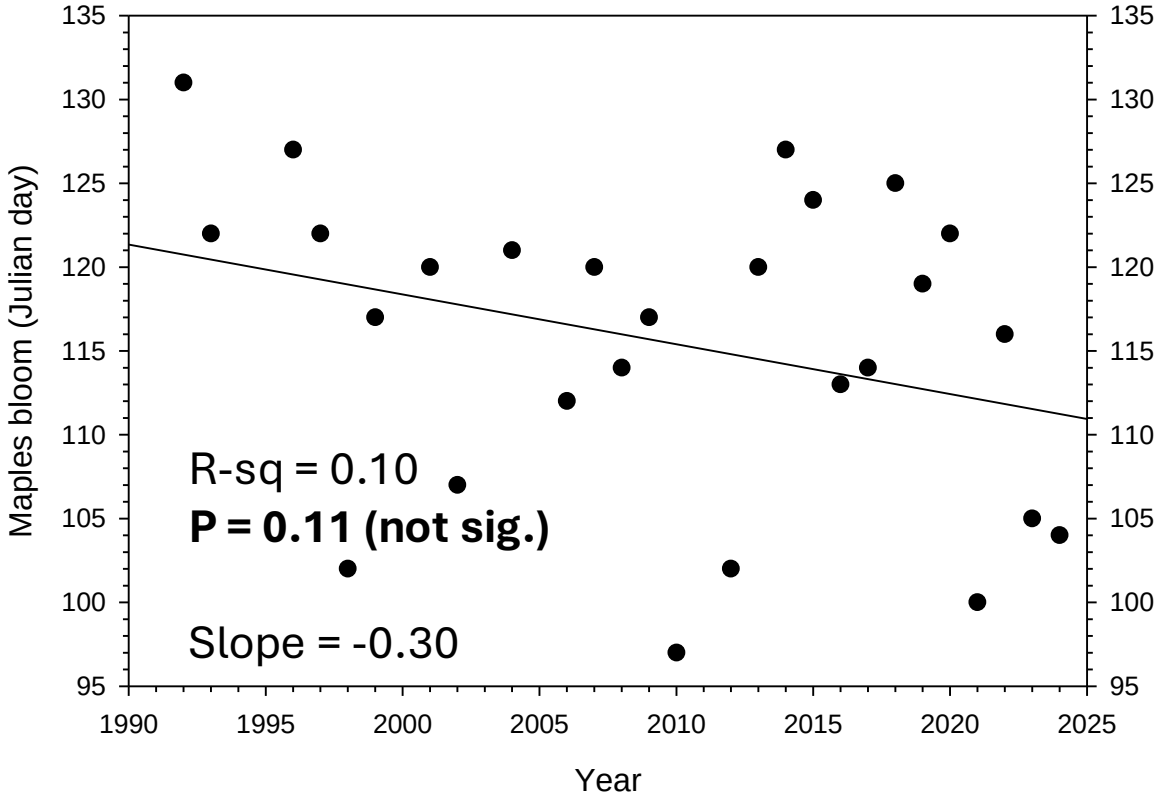
PUSSY WILLOW POLLEN (1997-2024)

No significant change in production dates for pussy willow pollen, the main food source for *Colletes* bees.



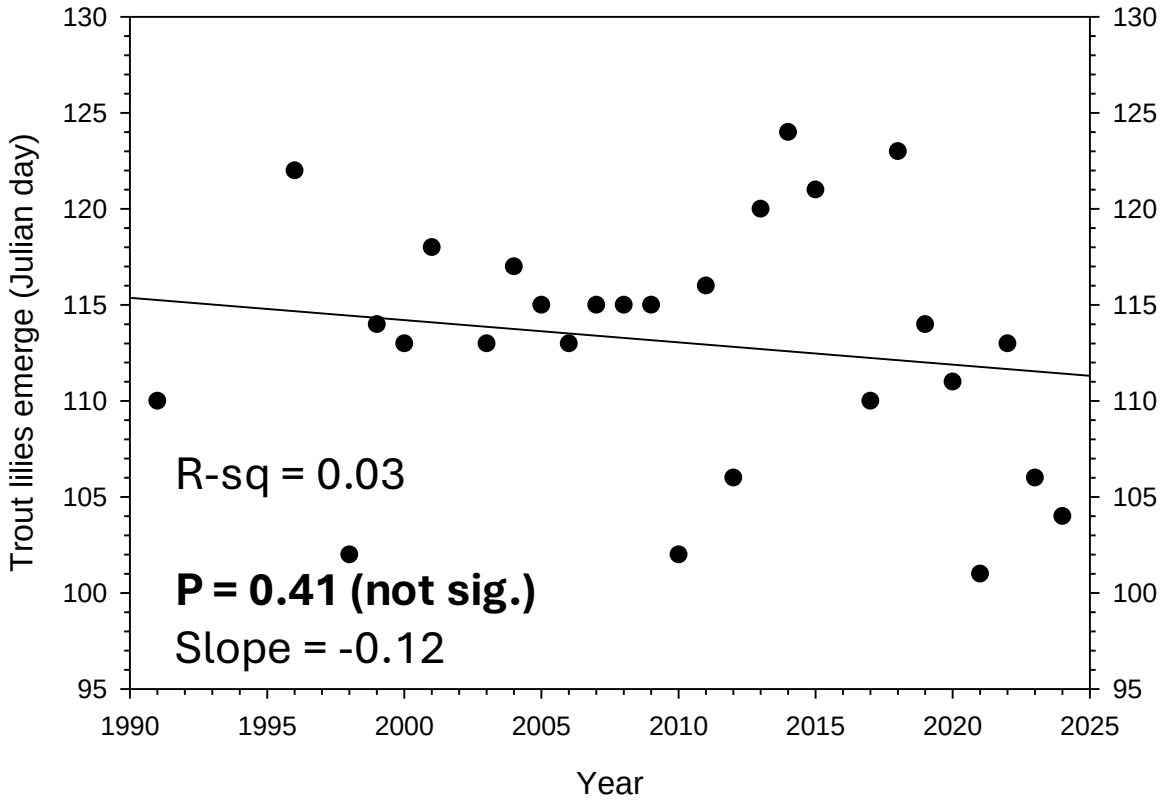
RED MAPLES BLOOMING (1992-2024)

No significant change in flowering dates for red maples, a potential back-up food source for the bees.



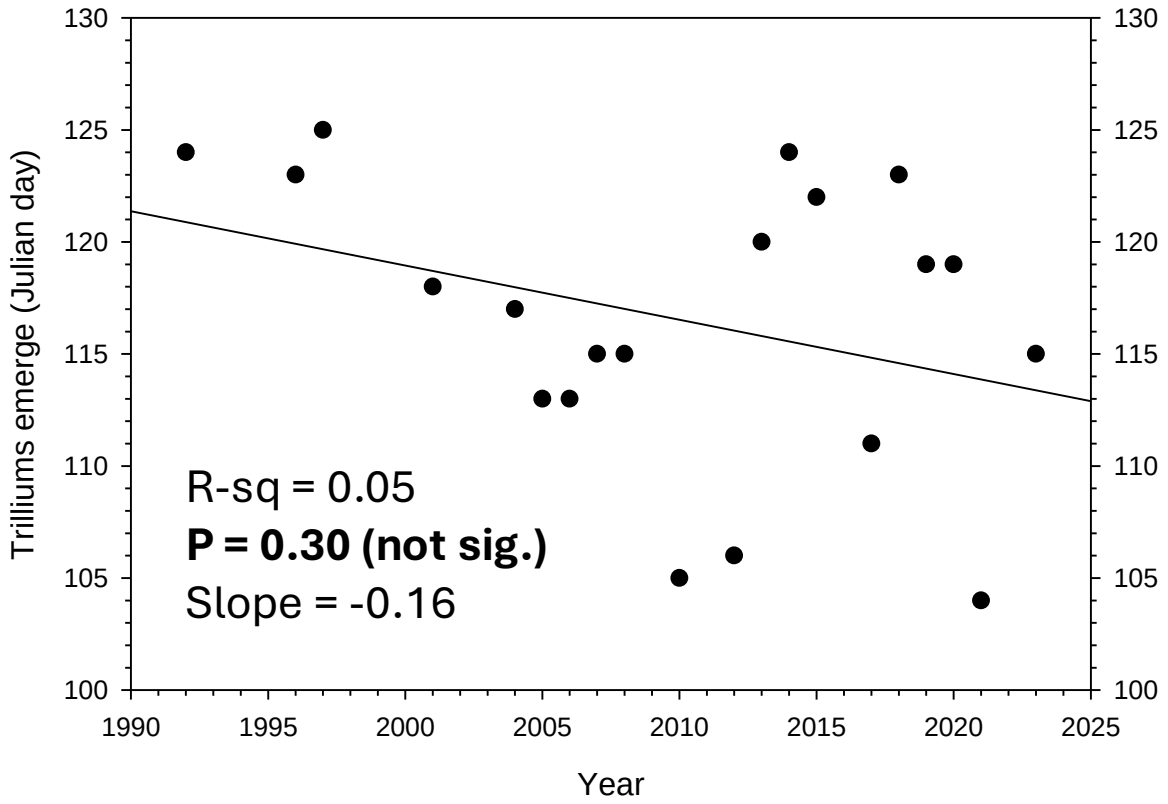
TROUT LILIES SPROUTING (1991-2024)

No significant change in sprouting dates for trout lilies on Essex Hill.



TRILLIUM SPROUTING (1992-2024)

No significant change in sprouting dates for purple *Trillium* on Essex Hill.



SUMMARY: 1990-2024

For the ANIMALS and ICE:
Phenology dates have shifted
2-3 weeks EARLIER, on average

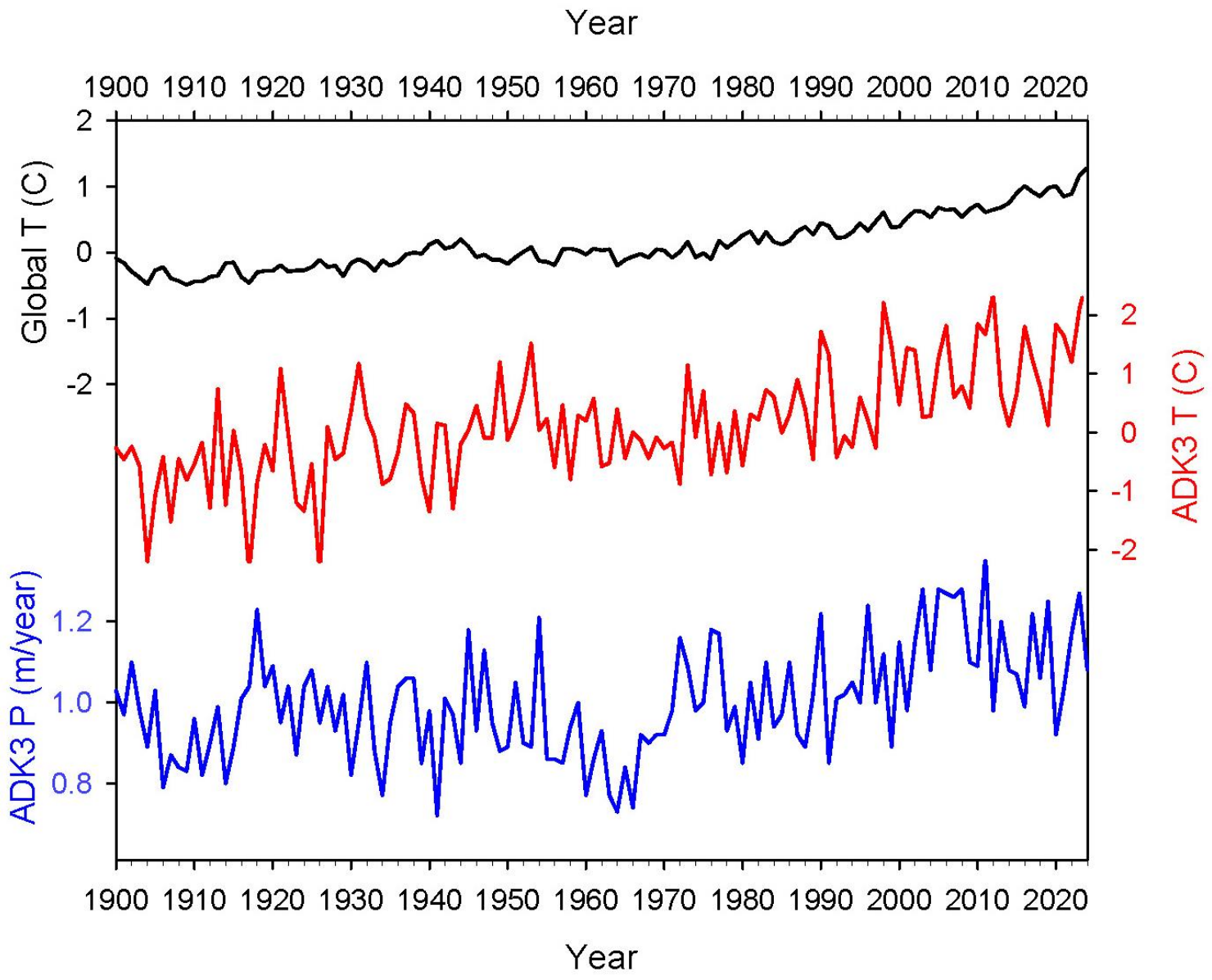
For the PLANTS:
Phenology dates have NOT changed
in such a consistent fashion

WHY is our local Spring phenology CHANGING?

The simplest answer seems to be that our **CLIMATE** is also changing.

If Spring is coming earlier as a result of shorter, milder winters, then we might expect some or all of the **PHENOLOGY** dates to shift earlier, too.

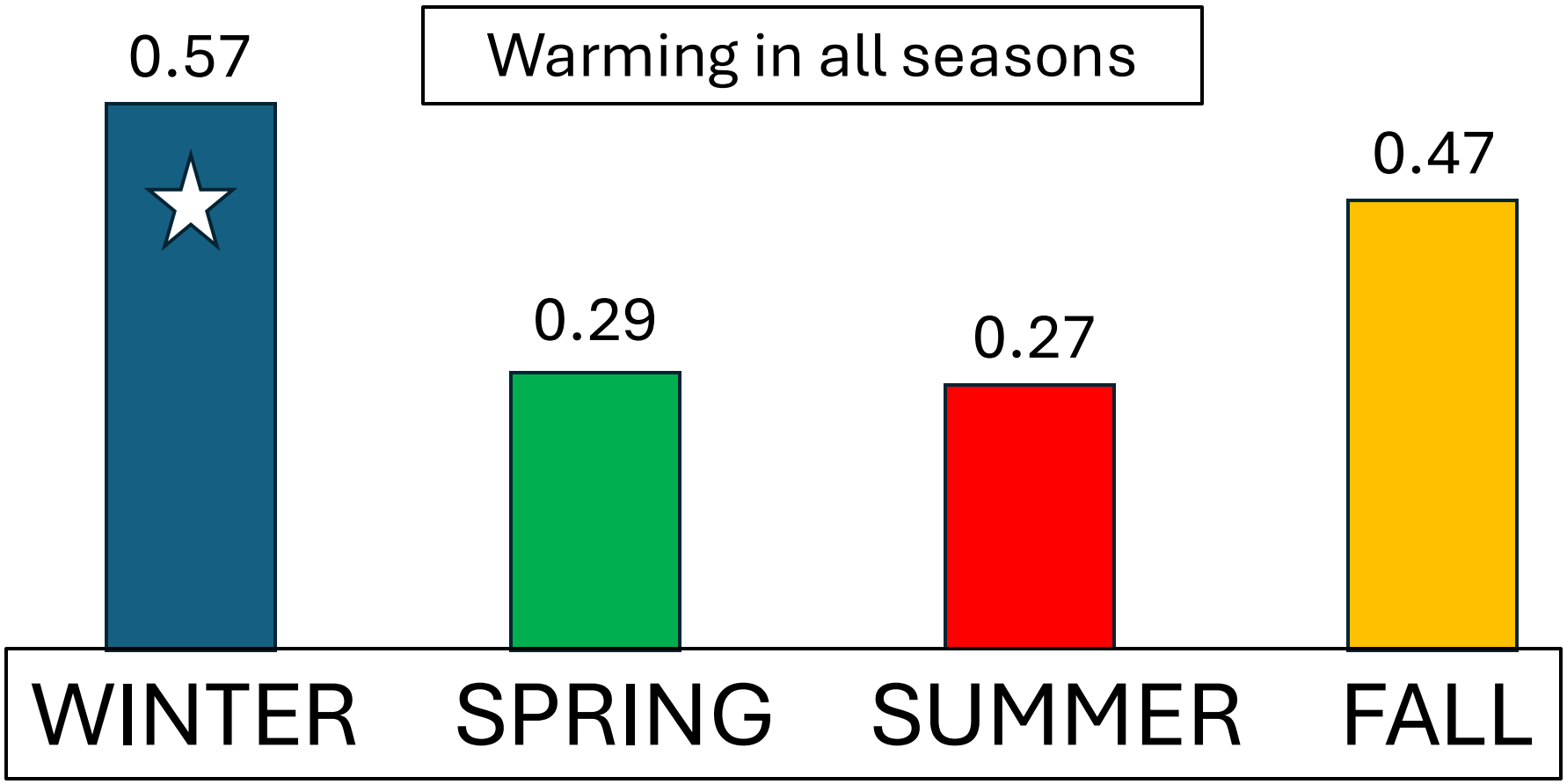
But - what do our local climate records show?



The Adirondacks are indeed **warming** faster than the **global** average, but at varying rates in different seasons and time frames.

It has also become **wetter** here on average, especially since 1970.

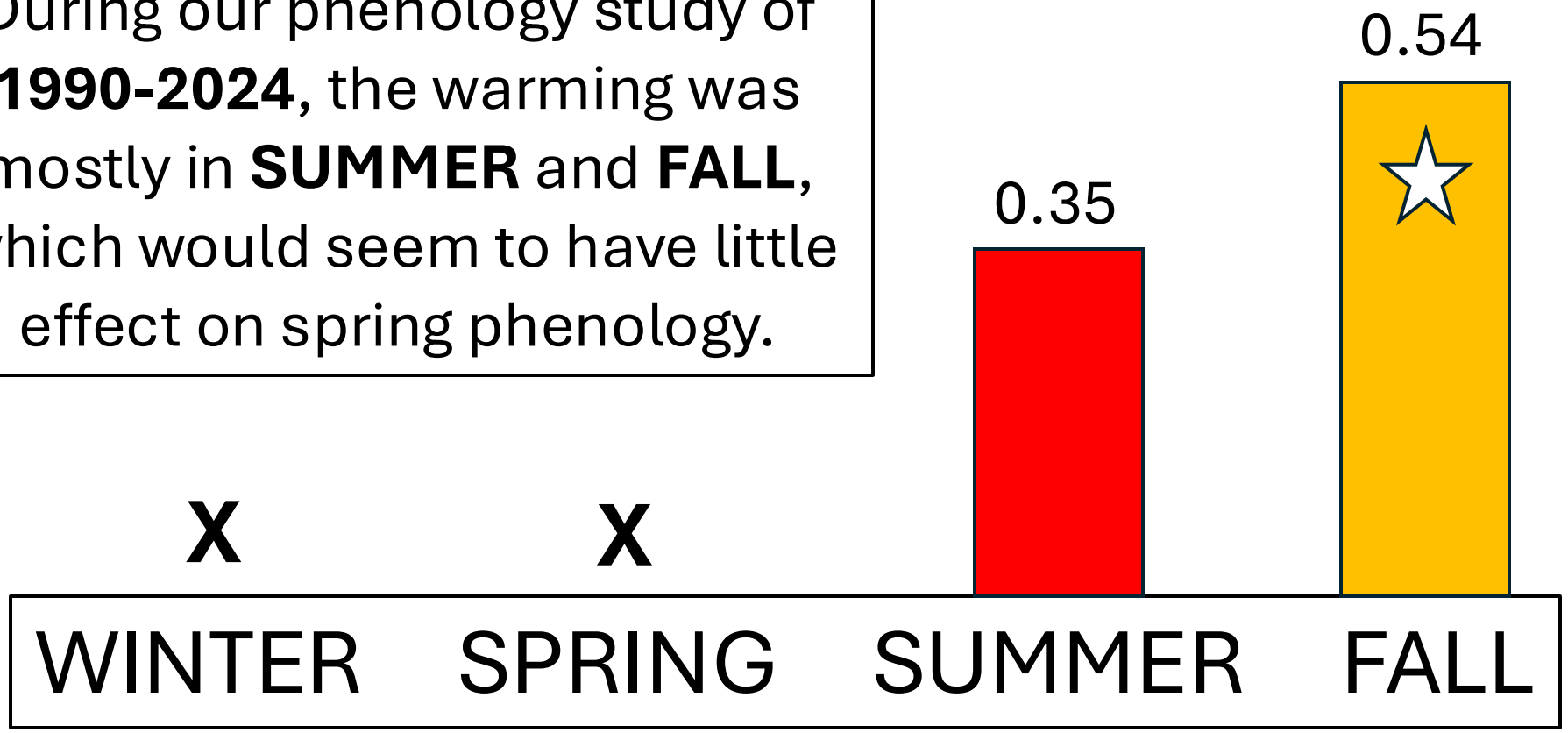
SEASONAL WARMING RATES (1970-2024)



degrees C per decade

SEASONAL WARMING RATES (1990-2024)

During our phenology study of **1990-2024**, the warming was mostly in **SUMMER** and **FALL**, which would seem to have little effect on spring phenology.



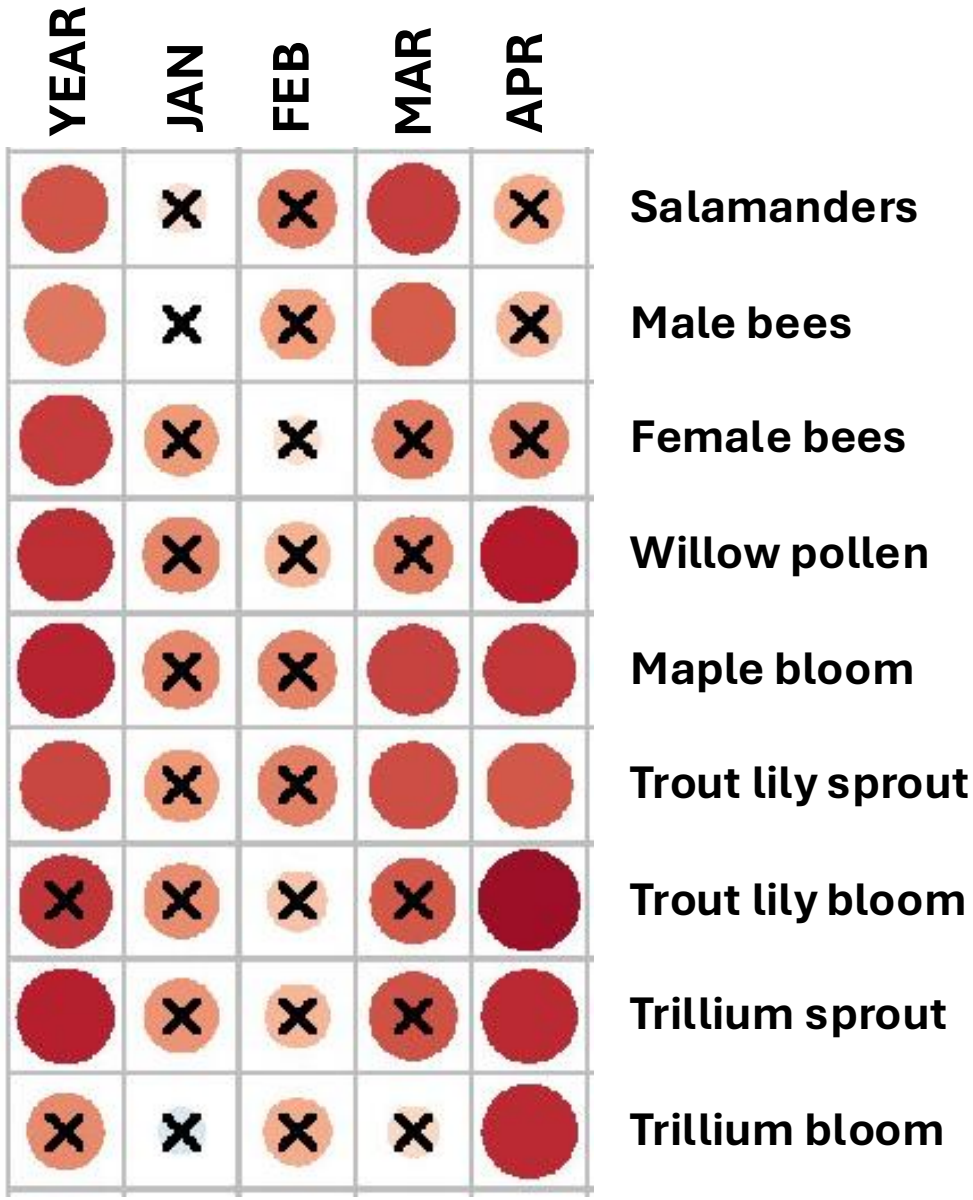
degrees C per decade

PSC students studying a salamander breeding pool

A MYSTERY TO SOLVE

Winter and Spring have NOT warmed consistently since 1990, which might explain why the **PLANTS** in our study did not change their phenology much, either.

But then, why did the **ANIMAL** and **ICE** dates shift earlier?



What to expect in a WARMER FUTURE?

Most phenology dates shifted **earlier** in single years when Winter and Spring months were **warmer** than usual (plain red circles), but different species shifted by differing amounts.

If Winter and Spring become as mild as models suggest, some phenology could shift another **1-3 weeks earlier** by 2100 AD.

DETAILS AT: https://journals.plos.org/climate/article?id=10.1371/journal.pclm.0000047

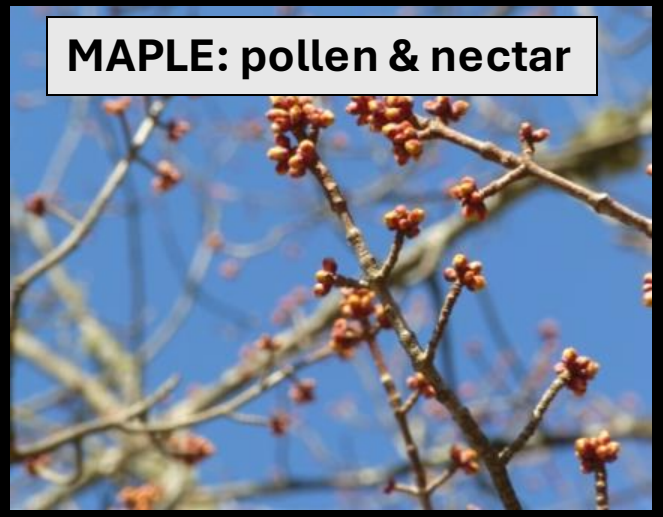
RISK OF "ECOLOGICAL *MISMATCH*?"

If plant and animal phenology changes by differing amounts, ecological relationships could be disrupted. For instance, the short-lived bees might have **LESS TIME** to gather willow pollen for their **egg capsules.**

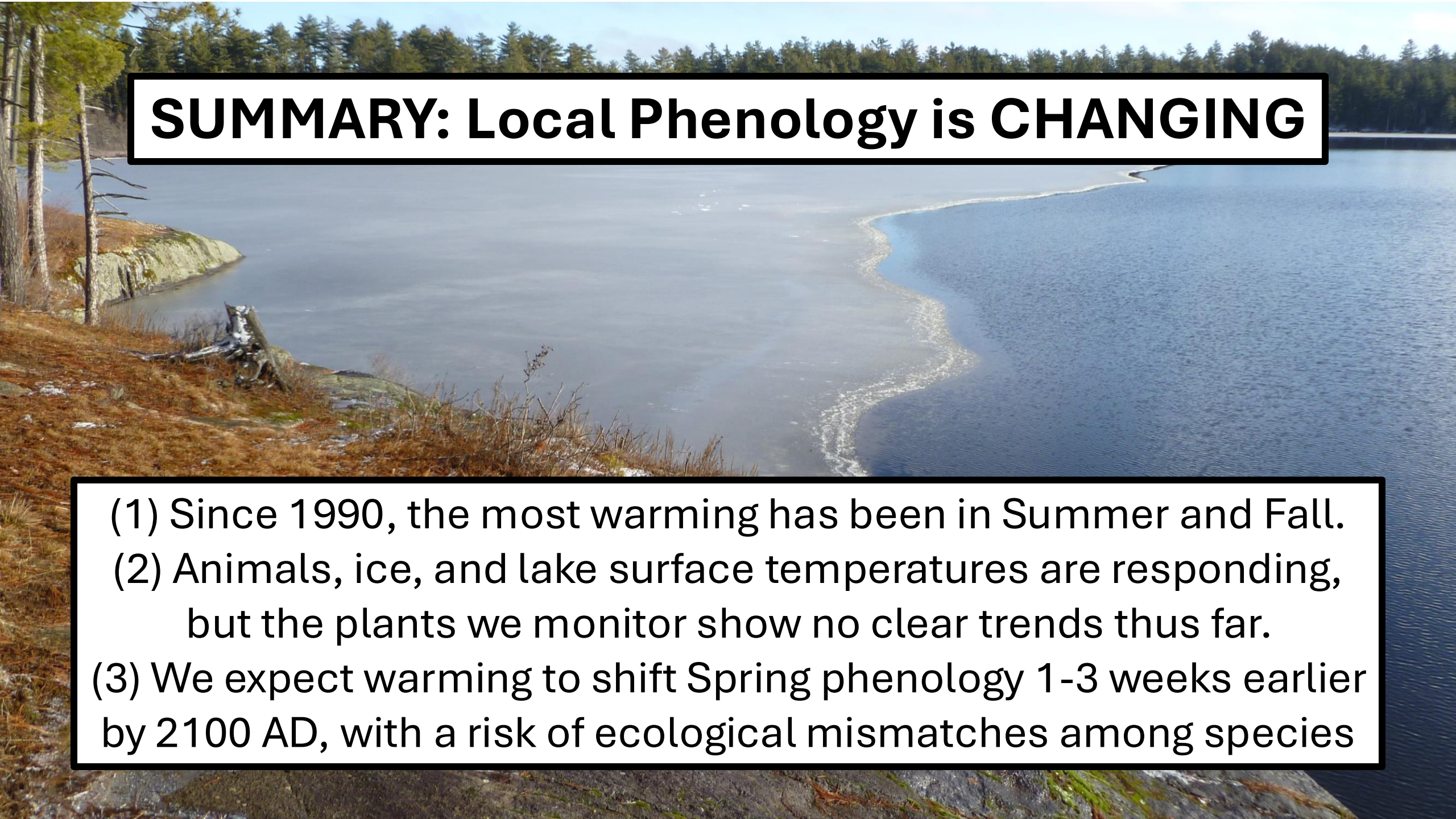
EXAMPLE: Unusually warm MARCH, 2012

The bees emerged ca. 2 weeks EARLIER than usual

WILLOWS and MAPLES had no pollen or nectar yet.
Only the ALDERS had pollen, but alder yields no NECTAR



Bees were seen landing on alder catkins, which have no nectar for the adults to eat. It is also not clear if alder pollen is a suitable substitute for use in their egg capsules.



SUMMARY: Local Phenology is CHANGING

(1) Since 1990, the most warming has been in Summer and Fall.
(2) Animals, ice, and lake surface temperatures are responding, but the plants we monitor show no clear trends thus far.
(3) We expect warming to shift Spring phenology 1-3 weeks earlier by 2100 AD, with a risk of ecological mismatches among species

MONITORING of phenology and climate is ONGOING at Paul Smith's College.

This joint research project involves students and faculty in the Introductory Biology labs, Science of Climate Change classes, and staff of our Adirondack Watershed Institute.

https://www.paulsmiths.edu/

PAUL SMITH'S COLLEGE
ADIRONDACK WATERSHED INSTITUTE

https://www.adkwatershed.org/

FOR MORE INFORMATION
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ADDITIONAL RESOURCES

New York State Climate Impacts Assessment:
https://nysclimateimpacts.org/explore-the-assessment/new-york-states-changing-climate/

Climate impacts and model projections for the Adirondack-Champlain region: Stager, J.C. and M. Thill. 2010. Climate change in the Champlain basin: What natural resources managers can expect and do. Report for The Nature Conservancy: https://www.researchgate.net/publication/280204504_Climate_Change_in_the_Champlain_Basin_What_natural_resource_managers_can_expect_and_do

Adirondack phenology and climate monitoring at Paul Smith's College: Stager *et al.,* 2022. Once and future changes in climate and phenology within the Adirondack uplands (New York, USA). *PLoS Climate*. https://journals.plos.org/climate/article?id=10.1371/journal.pclm.0000047

Lake ice phenology in the central Adirondacks: Beier, C.M., J.C. Stella, M. Dovčiak, S.A. McNulty, 2012. Local climatic drivers of changes in phenology at a boreal-temperate ecotone in eastern North America. *Climatic Change*, DOI: 10.1007/s10584-012-0455-z

USA National Phenology Network:
https://www.usanpn.org/about/phenology#:~:text=Phenology%20is%20the%20study%20of,animals%2C%20and%20other%20living%20things

Ice-out dates for Lower Saint Regis Lake (1970-2024)

YEAR	ICEOUT	YEAR	ICEOUT	YEAR	ICEOUT
1970	119	1990	116	2010	94
1971	131	1991	100	2011	110
1972	132	1992	124	2012	85
1973	93	1993	118	2013	110
1974	113	1994	120	2014	117
1975	127	1995	94	2015	116
1976	113	1996	121	2016	91
1977	107	1997	116	2017	106
1978	129	1998	102	2018	124
1979	112	1999	107	2019	114
1980	109	2000	115	2020	97
1981	97	2001	117	2021	98
1982	117	2002	106	2022	103
1983	104	2003	113	2023	104
1984	110	2004	111	2024	89
1985	112	2005	105		
1986	98	2006	104		
1987	101	2007	113		
1988	102	2008	113		
1989	120	2009	105		

RAW DATA TABLES

All dates are listed as numerical **JULIAN DATES**, in which each day of the year is assigned a sequential number from 1 to 365 in normal years and 1 to 366 in leap years.

For example:
January 1 is “1”
December 31 is “365” or “366.”

https://people.biology.ucsd.edu/patrick/julian_cal.html

ANIMAL PHENOLOGY DATA

YEAR	MBEE	YEAR	MBEE		YEAR	FBEE		YEAR	SALAM	YEAR	SALAM		YEAR	ROBIN	YEAR	ROBIN
1991	94	2012	79		1991	110		1992	113	2018	102		1992	100	2015	93
1992	112	2013	105		1992	118		1996	111	2019	102		1993	91	2016	74
1993	97	2014	103		1993	105		1997	118	2020	104		1994	96	2017	90
1994	102	2015	102		1997	112		1999	94	2021	99		1996	92	2018	83
1995	108	2016	101		1999	104		2000	95	2022	90		1997	87	2019	88
1996	102	2017	100		2001	106		2001	111	2023	106		1998	89	2020	80
1997	105	2018	90		2002	105		2002	103	2024	101		1999	93	2021	79
1998	98	2019	102		2003	108		2003	111				2000	85	2022	53
2000	92	2020	87		2007	112		2004	104				2003	102	2023	80
2001	105	2021	84		2008	108		2005	109				2004	89	2024	84
2002	102	2022	95		2010	92		2007	113				2005	94		
2003	104	2023	97		2014	104		2009	93				2006	88		
2004	103	2024	87		2017	100		2010	93				2007	77		
2005	90				2018	113		2011	101				2008	98		
2006	100				2019	107		2012	84				2009	72		
2007	110				2020	92		2013	106				2010	85		
2008	106				2021	95		2014	104				2011	76		
2009	87				2022	102		2015	110				2012	74		
2010	78				2023	101		2016	91				2013	70		
2011	99				2024	93		2017	101				2014	97		

PLANT PHENOLOGY DATA

YEAR	WILLOW		YEAR	MAPLE	YEAR	MAPLE		YEAR	TRLILY	YEAR	TRLILY		YEAR	TRILL	YEAR	TRILL
1997	120		1992	131	2016	113		1991	110	2015	121		1992	124	2021	104
1998	103		1993	122	2017	114		1996	122	2017	110		1996	123	2023	115
1999	117		1996	127	2018	125		1998	102	2018	123		1997	125	2024	119
2000	119		1997	122	2019	119		1999	114	2019	114		2001	118		
2005	108		1998	102	2020	122		2000	113	2020	111		2004	117		
2006	109		1999	117	2021	100		2001	118	2021	101		2005	113		
2007	121		2001	120	2022	116		2003	113	2022	113		2006	113		
2008	112		2002	107	2023	105		2004	117	2023	106		2007	115		
2010	97		2004	121	2024	104		2005	115	2024	104		2008	115		
2013	119		2006	112				2006	113				2010	105		
2014	126		2007	120				2007	115				2012	106		
2016	112		2008	114				2008	115				2013	120		
2018	124		2009	117				2009	115				2014	124		
2019	119		2010	97				2010	102				2015	122		
2020	116		2012	102				2011	116				2017	111		
2021	101		2013	120				2012	106				2018	123		
2023	106		2014	127				2013	120				2019	119		
2024	107		2015	124				2014	124				2020	119		