

Floral forecasts: Predicting shifts in monarch nectar resources

Erin Posthumus
Partnerships & Projects Manager
USA National Phenology Network



Pollinator Restoration Needs



Project goal:

Provide climate-informed guidance to those working on pollinator restoration

Three key needs identified by stakeholders:

- Information on what to plant to support specific pollinators
- Information on seed processing and planting
- Information on bloom and seed timing for local areas, and how climate change will impact timing



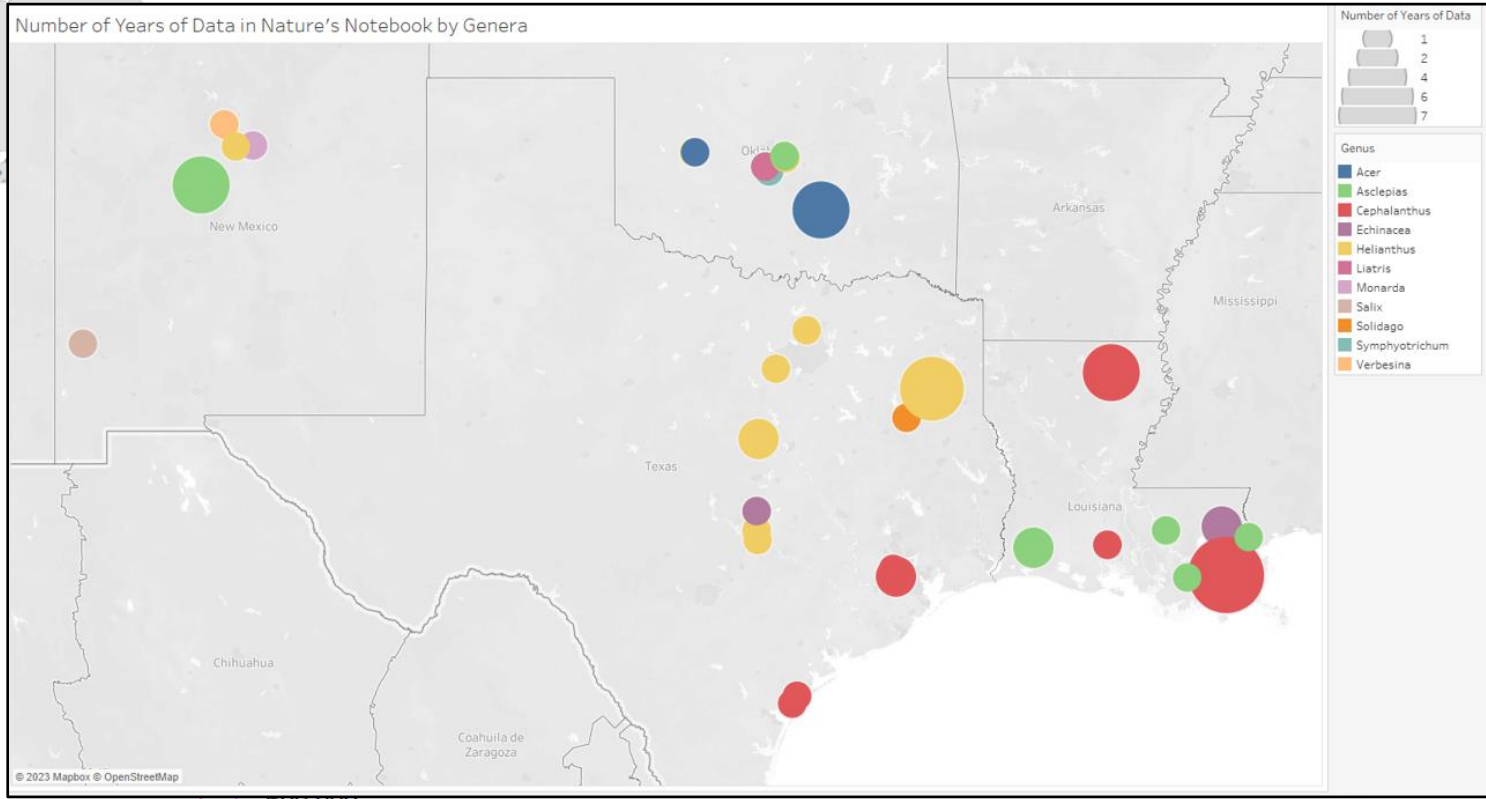
SOUTH CENTRAL
CLIMATE ADAPTATION SCIENCE CENTER



Data Collection Platform



- > 27,400 active observers
- > 20,000 active sites
- > 34 million records



Phenology Data Collection Protocols

Asclepias angustifolia

Do you see...	Date:
Time:	
Initial growth	y n ? ____
Young leaves	y n ? ____
Leaves	y n ? ____
Flowers or flower buds	y n ? ____
Open flowers	y n ? ____
Fruits	y n ? ____
Ripe fruits	y n ? ____
Recent fruit or seed drop	y n ? ____
Check when data entered online:	<input type="checkbox"/>
Comments:	

FLOWERS

Flowers or flower buds
One or more fresh open or unopened flowers or flower buds are visible on the plant. Include flower buds or inflorescences that are swelling or expanding, but do not include those that are tightly closed and not actively growing (dormant). Also do not include wilted or dried flowers.
[More...](#)

How many flowers and flower buds are present? For species in which individual flowers are clustered in flower heads, spikes or catkins (inflorescences), simply estimate the number of flower heads, spikes or catkins and not the number of individual flowers.

- Less than 3
- 3 to 10
- 11 to 100
- 101 to 1,000
- More than 1,000

Open flowers
One or more open, fresh flowers are visible on the plant. Flowers are considered "open" when the reproductive parts (male stamens or female pistils) are visible between or within unfolded or open flower parts (petals, floral tubes or sepals). Do not include wilted or dried flowers.
[More...](#)

What percentage of all fresh flowers (buds plus unopened plus open) on the plant are open? For species in which individual flowers are clustered in flower heads, spikes or catkins (inflorescences), estimate the percentage of all individual flowers that are open.

- Less than 5%
- 5-24%
- 25-49%
- 50-74%
- 75-94%
- 95% or more

FRUITS

Fruits
One or more fruits are visible on the plant. For *Asclepias angustifolia*, the fruit is narrow and pod-like and changes from green to tan or brown and splits open to expose seeds with fluff. Do not include empty fruits that have already dropped all of their seeds.
[More...](#)

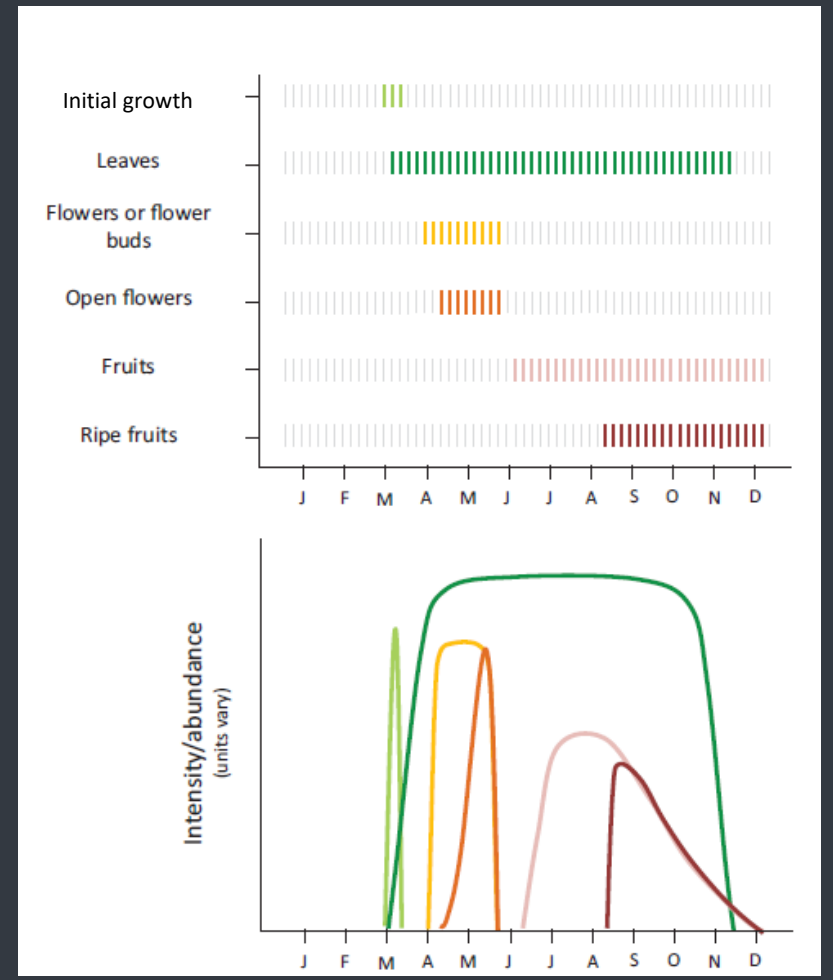
How many fruits are present?

- Less than 3
- 3 to 10
- 11 to 100
- 101 to 1,000
- More than 1,000

Ripe fruits
One or more ripe fruits are visible on the plant. For *Asclepias angustifolia*, a fruit is considered ripe when it has turned tan or brown and has split open to expose seeds with fluff. Do not include empty fruits that have already dropped all of their seeds.
[More...](#)

What percentage of all fruits (unripe plus ripe) on the plant are ripe?

- Less than 5%
- 5-24%
- 25-49%
- 50-74%
- 75-94%
- 95% or more




Nectar Connectors Data Collection Campaign

- Milkweeds (*Asclepias* spp.)
- Blazing stars (*Liatris* spp.)
- Asters (*Symphyotrichum* spp.)
- Goldenrods (*Solidago* spp.)
- Joe Pye Weed (*Eutrochium fistulosum*)
- Lanceleaf coreopsis (*Coreopsis lanceolata*)
- Lupines (*Lupinus* spp.)
- Bee balm/bergamot (*Monarda* spp.)
- Black-eyed Susan (*Rudbeckia hirta*)
- Coneflowers (*Echinacea* spp.)
- Sunflowers (*Helianthus* spp.)
- Prairie clovers (*Dalea* spp.)
- Thistles (*Cirsium* spp.)
- Cardinal flower (*Lobelia cardinalis*)
- Golden Alexanders (*Zizia aurea*)
- Baccharis (*Baccharis halimifolia*)
- Butterflybush (*Buddleja davidii*)

Nectar Connectors campaign

nature's notebook
A project of the USA-NPN



Greetings!

This year's Nectar Connectors campaign has come to a close. We hope that you have enjoyed watching the flowers on your plants this year.

Your observations are important for helping us to understand where and when flowers are available for monarchs and other pollinators.

These data will help to shine a light on any potential mismatches that are occurring between pollinators and the plants on which they depend.

We hope that you will join us again next year for the Nectar Connectors campaign! Your reports on the same plants over multiple years are really valuable to help us understand how nectar plants are responding to changes in climate.


What you are reporting on nectar plants

This year, 255 observers reported on Nectar Connectors species. These observers submitted data at 228 sites, up from 201 last year. The most observed species across the country were common milkweed (*Asclepias syriaca*), butterfly milkweed (*Asclepias tuberosa*), eastern purple coneflower (*Echinacea purpurea*), wild bergamot (*Monarda fistulosa*), and blackeyed Susan (*Rudbeckia hirta*).

We have 45 Local Phenology Programs tracking Nectar Connectors species this year, up from 40 last year. The 10 LPPs submitting the most records this year are below. We also had 145 individual observers. Thanks to you all for your efforts - every record that you submit is valuable!

Local Phenology Program	# records
Southeastern Virginia Phenology Network	1939
Mohonk Preserve	1525
Minnesota Valley National Wildlife Refuge	1333
Vassar College	1162
UNC Asheville	1134
Neal Smith National Wildlife Refuge	1106
Ben Franklin School	1025
Earthwise Aware	977
BSU FSEEC	965
Bayou Sauvage National Wildlife Refuge	902

The map below indicates the sites where you reported on Nectar Connectors species this year. The colors of the dots indicate when the average first date of open flowers was reported at that site, with earlier dates in yellow and later dates in green. The shape of the dots represents the different genera of nectar plants.

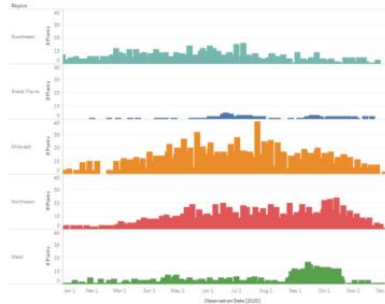


Generally, your reports of first flowers in the Southeast were early or late in the year, corresponding with the time when monarchs are migrating through the region. In the Midwest and Northeast, you reported onset of flowering throughout the spring, summer, and fall, in the West, your reports were generally early in the year.

To get a better idea of how many flowers were available at different times of the year, we can look at the number of individual plants with open flowers by region.

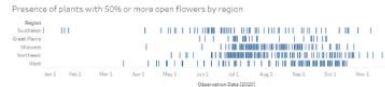
- in the Southeast, flowers were available throughout the year.
- in the Great Plains, a higher number of plants with flowers occurred in the summer.
- in the Midwest and Northeast, flowers were available for much of the year but the highest number of plants with flowers occurred in the summer and fall.
- in the West, flowers were available most of the year with a peak in the fall.

Number of plants with open flowers by region

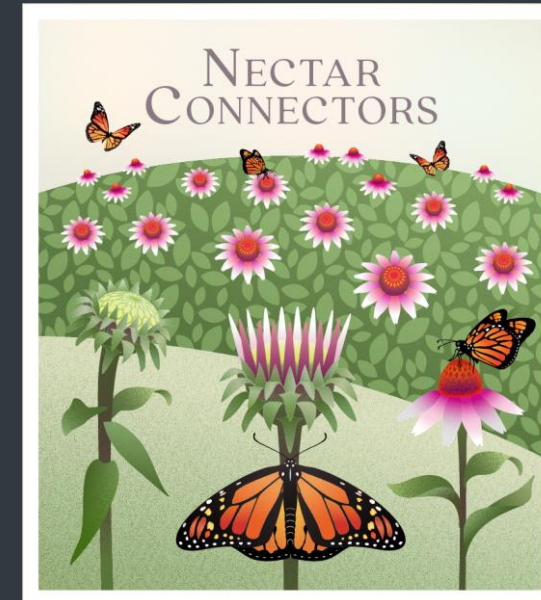


In addition to reporting whether or not flowers on your plants are open, we also ask you what percent of flowers are open. The graph below shows when you reported 50% or more open flowers. The pattern is consistent with those above - more flowers are available in the summer months, especially in northern regions. Southern regions and the West have flowers more consistently available in the spring and fall.

Presence of plants with 50% or more open flowers by region



You can explore these results on our [Nectar Connectors Campaign Results dashboard](#).



Projected changes in flowering and fruiting timing

Echinacea purpurea -
Open flowers onset
Flowering peak onset
etc.



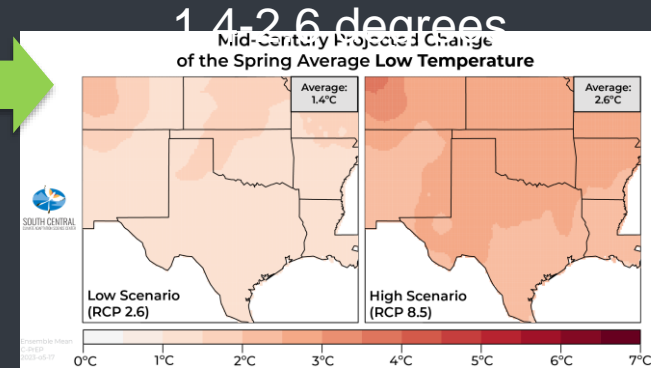
Simple Linear Models
to identify climate
cues:

- Spring Tmin
- Spring Tmax
- Winter Tmin
- Winter Tmax
- Spring Precip
etc.

Linear Mixed
Effects Models,
with latitude
as variable

Effect size:
-5.2
days/degree

Projected shift in
Spring Tmin by mid-
Century:



Projected
shift in
open
flowers
onset:

7.28-13.52
days
earlier

Used all data from
Nature's Notebook,
filtered for "Days Since
Prior No" < 14

Species	Life Cycle Stage	Projected shift by mid-Century (2036-2065)
eastern purple coneflower, <i>Echinacea purpurea</i>	Open Flowers Onset	7-14 days earlier
	Flowering Peak Onset	6-11 days earlier
	Ripe Fruit Onset	2-10 days earlier
	Fruit Peak Onset	7-13 days earlier
	Fruit Peak Duration	9-17 days longer

Time to Restore project information

ArcGIS StoryMaps

Time to Restore

Connecting People, Plants, and Pollinators

August 15, 2023



Time to Restore: Oklahoma



SUPPORTING POLLINATOR RESTORATION

When restoring land to support pollinators, managers aim to select a mix of species that support pollinators throughout their periods of activity. This guide provides information on the timing of flowering and fruiting of nectar plants in Oklahoma and information on which species are most suitable for future climate conditions.

SHIFTS IN PHENOLOGY OF NECTAR PLANTS

Multiple factors can influence the timing of flowering, including warmth, freeze events, winter chill, rainfall, and daylength. Generally, researchers have documented earlier flowering in many flowering plants (United Nations Environment Programme, Frontiers 2022).

RESTORATION IN ACTION IN OKLAHOMA

Several organizations and community groups are involved in pollinator restoration in Oklahoma. Tribal Alliance for Pollinators (TAP) provides training, technical assistance, and native plants to tribal partners who are restoring monarchs and pollinator habitat on their lands. TAP is currently assisting fourteen tribes in Oklahoma with native plant restoration. TAP's online library of native plant restoration resources are available to the public at www.TribalAllianceForPollinators.com.

Oklies for Monarchs, an initiative of Oklahoma Monarch & Pollinator Collaborative, provides education and resources for pollinator habitat to residents statewide including what to plant, where to buy, and custom seed mixes, as well as best management practices for rangelands and rights-of-ways. Each of these resources and much more can be found at okliesformonarchs.org.

While little phenology research has been carried out in the region, authors of studies in other locations have reported a large shift in the timing of events, such as common milkweed, *Asclepias syriaca*, in the Midwest and Northeast shifting 7 days earlier with each °F warming (Howard 2018). Other research found a different pattern between spring and fall-flowering species in the Southeastern Coastal Plain, with spring species flowering 3-4 days earlier per °F of warming. In the same study, fall flowering shifted slightly earlier with warmer spring temperatures and later with warmer summer temperatures at a rate of 2 days per °F (Pearson 2019). Under experimental warming, flowering of prairie plants occurred 2-10 days earlier (Wittington et al 2015).

FUTURE CLIMATE IN OKLAHOMA

The following are projections for the South Central region for mid-century (2036-2065; Dixon et al 2020); ranges represent the low (Representative Concentration Pathway 2.6) and high (RCP 8.5) emissions scenarios.

- Average high temps increase 2.6-5.2°F
- Average low temps increase 2.2-4.6°F, particularly in Western OK
- Increase of 10.5-24.3 very hot days over 100°F, particularly in Western OK
- Increase of 2.1-4 heatwaves a year
- Decrease of 13-26.1 days below freezing
- Decrease in 0.1-4.3% in total annual rainfall
- Increase in the amount of 1 day (0.1 in) and 5 day (0.4-1.7 in) rainfall, particularly in Eastern OK
- Increase in dry spell length by 0.1-1.2 days in Western OK

More climate projections from the SC CASG can be found at: southcentralclimate.org/resources/climate-projections.

TIME TO RESTORE: OKLAHOMA

OCTOBER 2023

PEAK IN FLOWERING TIMING – SILVER MAPLE, ACER SACCHARINUM

Number of Open Flowers (Y-axis) vs. Month (X-axis)

We compiled data collected via iNaturalist and Nature's Notebook on flowering and seed timing in Time to Restore priority species. The graph at left shows the timing of open flowers as well as the peak in activity for silver maple, *Acer saccharinum*, in Oklahoma.

Top: Presence records contributed to iNaturalist, which show the magnitude of observations collected on this species across 2019-2023. Middle: Number of open flowers observed in Nature's Notebook 2020-2022. Bottom: Proportion of open flowers in Nature's Notebook 2019-2023.

FLOWERING AND SEED TIMING – PRESENT AND FUTURE

constant buttonbush (*Cephalanthus occidentalis*)

Proportion of Open Flowers (Y-axis) vs. Month (X-axis)

constant milkweed (*Asclepias tuberosa*)

Proportion of Open Flowers (Y-axis) vs. Month (X-axis)

silver maple (*Acer saccharinum*)

Proportion of Open Flowers (Y-axis) vs. Month (X-axis)

This calendar displays data collected in OK, TX, and LA.

Based on our national-scale analysis of climate cues combined with climate projections from the SC CASG, we project the following changes to life cycle stages by mid-century (2036-2065):

Common buttonbush, *Cephalanthus occidentalis*
Open flowers onset - 5-10 days earlier
Flowering peak onset - 3-5 days earlier

Common sunflower, *Helianthus annuus*
Open flowers onset - 9-19 days earlier
Flowering peak onset - 10-20 days earlier, may depend on latitude

Silver maple, *Acer saccharinum*
Open flowers onset - 2-16 days earlier, may depend on latitude
Flowering peak onset - 7-13 days earlier
Ripe fruit onset - 7-13 days earlier
Fruit peak onset - 3-5 days earlier

Species	Life Cycle Stage	Projected shift
Silver maple (<i>Acer saccharinum</i>)	Open Flowers Onset	0.2-1.4 days earlier
	Flowering Peak Onset	0.4-1.4 days earlier
	Fruit Peak Onset	0.4 days earlier
Common milkweed (<i>Asclepias tuberosa</i>)	Open Flowers Onset	1.0-2.0 days earlier
	Flowering Peak Onset	1.0-2.0 days earlier
	Fruit Peak Onset	1.0-2.0 days earlier
Common buttonbush (<i>Cephalanthus occidentalis</i>)	Open Flowers Onset	0.4-1.4 days earlier
	Flowering Peak Onset	0.4-1.4 days earlier
	Fruit Peak Onset	0.4-1.4 days earlier

References:

Dixon, K.W., A.M. Wootton, M.L. Nairn, L. Lanamati, D.J. Adams-Smith, C.E. Whitlock, C.F. Galbraith, R.A. McPherson, 2020. South Central Climate Projections Evaluation Project (C-PEP), South Central Climate Adaptation Science Center, Norman, Oklahoma, USA. doi.org/10.21429/1296-d847

Howard, A.F. 2018. *Asclepias syriaca* (Common Milkweed) flowering date shift in response to climate change. Sci Rep 8:17802. doi.org/10.1038/s41598-018-30152-2

Pearson, W.D. 2019. Spring- and fall-flowering species show diverging phenological responses to climate in the Southwest USA. Int J Biometeorol 63, 481–492. doi.org/10.1007/s00484-019-01670-0

Wittington, H. R., D. Tibbitts, P. D. Wragg, and J. S. Powers. 2015. Phenological responses of prairie plants vary among species and year in a three-year experimental warming study. *Ecosphere* 6(10):208. doi.org/10.1890/ES15-00070.1

United Nations Environment Programme 2022. *Frontiers* 2022: Noise, Biases and Mismatches – Emerging Issues of Environmental Concerns. Nairobi.

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CONTACT:
USA National Phenology Network
1311 East 4th Street,
Tucson, AZ 85721
info@usamnpn.org
usamnpn.org/TimeToRestore

Future work

- Additional data collection on priority species to fill in gaps, calendars and models at a more local level
- Expansion of project to Texas
- Bring in herbarium data to increase temporal depth of data
- Updated project info sheets and planting palette tool
- Replication of this work outside the South Central region

Contact:

Erin Posthumus

Partnerships & Projects Manager

Erin@usanpn.org

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