Gulf Coast Phenology Trail 2020 Annual Report

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USGS science for a changing world

Red maple by @ G. Bishop

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Introduction

The Gulf Coast contains rich and varied ecosystems including pine savannas, forests, shorelines, and open marshes. Phenology, or the study of timing of recurring life cycle events in plants and animals and their relationship to the environment, is an indicator of species response to climate change. The Gulf Coast Phenology Trail, (hereafter referred to as the Trail), was established in 2016 as a citizen science-driven, long-term monitoring program with the goal to gain a better understanding of the effects of climate change on plants and animals along the northern Gulf Coast from Louisiana to Alabama. Funding to establish the Trail and to monitor plants was provided by the U.S. Fish and Wildlife Service's Inventory and Monitoring Initiative. Support and coordination was provided by the staff at USA National Phenology Network located at the University of Arizona.

Project Description

The Trail considers both site-specific and larger-scale questions of interest. To address regional-scale questions, a set of core species, shared by most sites along the Trail, was selected in 2017. In addition, each of the 12 partners selected a list of species (Appendices B and C) for a total of 34 plants, 18 birds, 2 reptiles, 1 mammal, and 4 insects to monitor to address site-specific questions of interest. The data collected by observers can be used by researchers and land managers who are interested in understanding the effects of climate change on plants and animals. To achieve educational and outreach objectives, we invited college students, school students, and local citizen scientists to participate in monitoring. Through their participation these groups gained field experience and knowledge of phenology data collection.

The Trail uses the USA National Phenology Network's *Nature's Notebook* as a tool for training, education, outreach, data collection, analysis and reporting.

The program includes:

- Making repeat observations on the same individual plants or animal species at a site over time
- Making repeat observations at least once per week during the growing season
- Making observations for a least one growing season
- Making observations for more than one calendar year

Methods and Results

At all partner sites along the Trail the protocols outlined by *Nature's Notebook* (www.naturesnotebook.org) were followed. We set up partner sites in the *Nature's Notebook* interface for citizen scientists to use when collecting phenology data along the Trail. Individual training on how to use the *Nature's Notebook* mobile application was provided upon request by the Local Phenology Leader or the Trail Coordinator. On rare occasions paper data collection was preferred and hard copies of data sheets were provided to citizen scientists for data

collection. Data sheets were turned in and the data were entered manually by the site lead as time permitted.

Locations of Gulf Coast Phenology Trail Partner sites active in 2020 are represented on the map below (Fig 1).

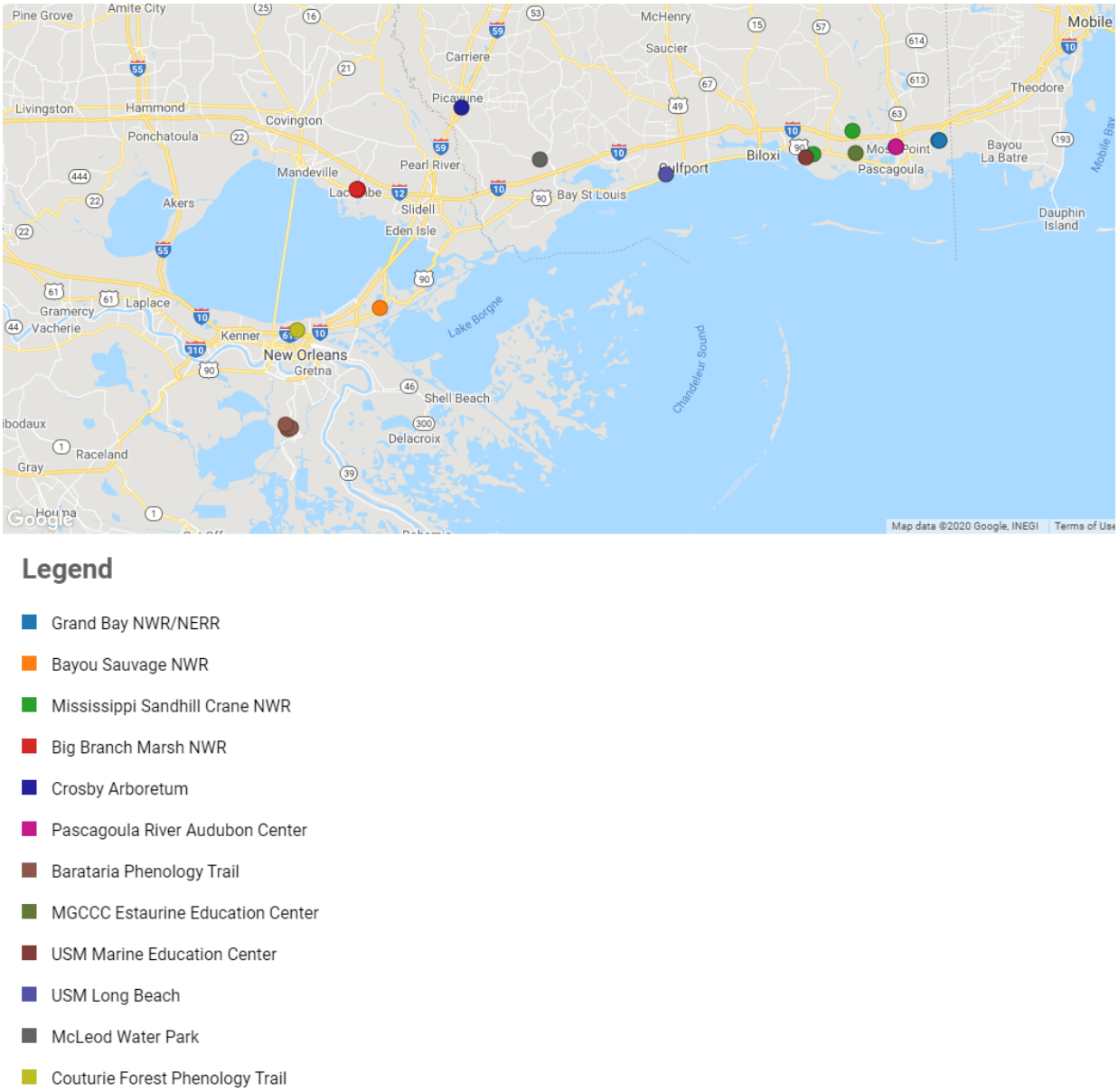


Figure 1. Map of Gulf Coast Phenology Trail Partners active in 2020.

Primary Questions

Four primary questions were developed to drive the need for data collection on the Trail:

1-1. Does phenology of native Gulf Coast plants change over time under a changing climate?

Table 1. 2020 by the Numbers
63,870 Phenology Observations
21 Sites
34 Plant Species Observed
25 Animal Species Observed
55,211 Plant Observations
4,092 Animal Observations

2020 was the fourth year of data collection on the Trail and we can compare patterns in our data to see whether they reflect the impact of climate change.

In 2020, volunteer observers were impacted by the Covid-19 Pandemic and a series of hurricanes including Delta, Laura, and Zeta causing damage to boardwalks and destroying a variety of plants. Some sites such as Mississippi Gulf Coast Community College in Mississippi and Barrataria Unit in Louisiana were closed from mid-March to mid-September. Observations at McLeod Park in Kiln, Mississippi were suspended for the reminder of 2020 because of trail damage. Accordingly, overall observations--63,870 records were lower in 2020 compared to 88,528 records in 2019. These observations represented 34 plant species and 25 animal species.

However, despite the unique circumstances in 2020, when possible we continue to observe the focal species so that we can have some data to see whether phenology in these species is changing over time. Having focal species also allows us to make comparisons of the same species across Trail locations. Our native focal species are red maple (*Acer rubrum*), red bay (*Persia borbonia*), wax myrtle (*Morella cerifera*), and yaupon holly (*Ilex vomitoria*) and a non-native species, Chinese tallow (Sa*pium sebiferum*).

Our ability to answer the question of how phenology is changing depends on having observations on the same individual plants over many years. In 2020 5 sites monitored Chinese tallow (*Triadica sebifera*), 11 sites monitored red maple (*Acer rubrum*), 7 sites monitored wax myrtle (*Morella cerifera*), 8 sites monitored red bay (*Persia borbonia*), and 9 sites monitored yaupon holly (*Ilex vomitoria)* (Table 2).

Table 2. Number of individual plants and sites for each focal species in 2017-2020

Plants	2017 # Plants and Sites	2018 # Plants and Sites	2019 # Plants and Sites	2020 # Plants and Sites
Chinese tallow	5/7	11/7	11/7	10/5
Red maple	36/7	29/10	50/15	42/11
Wax myrtle	29/5	26/8	39/13	25/7
Red bay	18/4	17/7	29/9	23/7
Yaupon holly	13/5	22/7	33/9	34/9

Chinese Tallow

Figure 2. From left to right, Chinese tallow catkins, immature seed pods and ripe seed pods. *Photos © G. Bishop*

The University of Arkansas Research and Extension Service reported in their website UAEx.edu., "Chinese tallow tree-Invasive plant", that the Chinese tallow seeds can remain dormant for up to five years. Warren Conway from the Texas Tech University completed a 2002 study, "Avian use of Chinese Tallow Seeds in Coastal Texas'' that includes information on the spread of seeds by Yellow Rumped-Warblers (The Southwestern Naturalist 47(4):550 DOI:10.2307/3672658). Michael J. Baldwin from Louisiana Tech University completed his 2005 master's thesis on "Winter Bird Use of the Chinese Tallow Tree in Louisiana," that also looks at the dispersal of Chinese tallow Chinese tallow, an introduced plant to North America in the 1700s, displaces native plant species. Our study reports on the observations of the emergence of Chinese tallow seeds. Because of climate change that is predicted to increase drought conditions in southeastern states, it is valuable to understand the phenology of Chinese tallow, which is drought resistance to better manage this species.

Initial shoot or leaf growth peaked in early February in 2017, mid-March in 2018 and 2019, and in mid-April in 2020 (Fig. 3). All years except 2019 saw continued reports of initial growth through the fall months. In all years, Chinese tallow flowering peaked in mid-May, though the proportion of yes records was much lower in 2019 (Fig. 4). First reported ripe fruit was variable in the four years, with observers reporting the earliest fruit in 2018 (Fig. 5.)

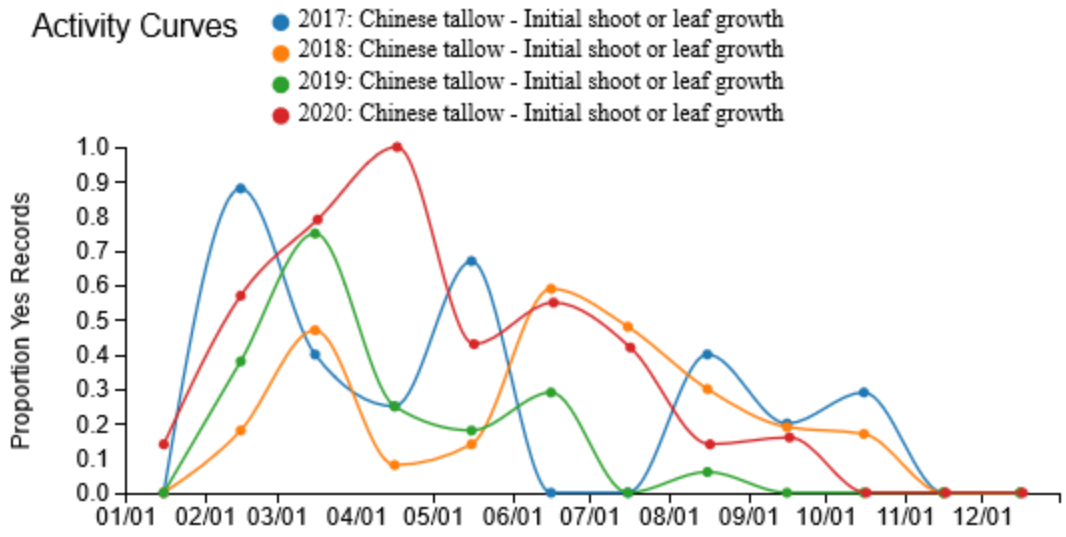


Figure 3. Activity curve showing the proportion of individual Chinese tallow with "yes" records reported for initial shoot or leaf growth 2017-2020.

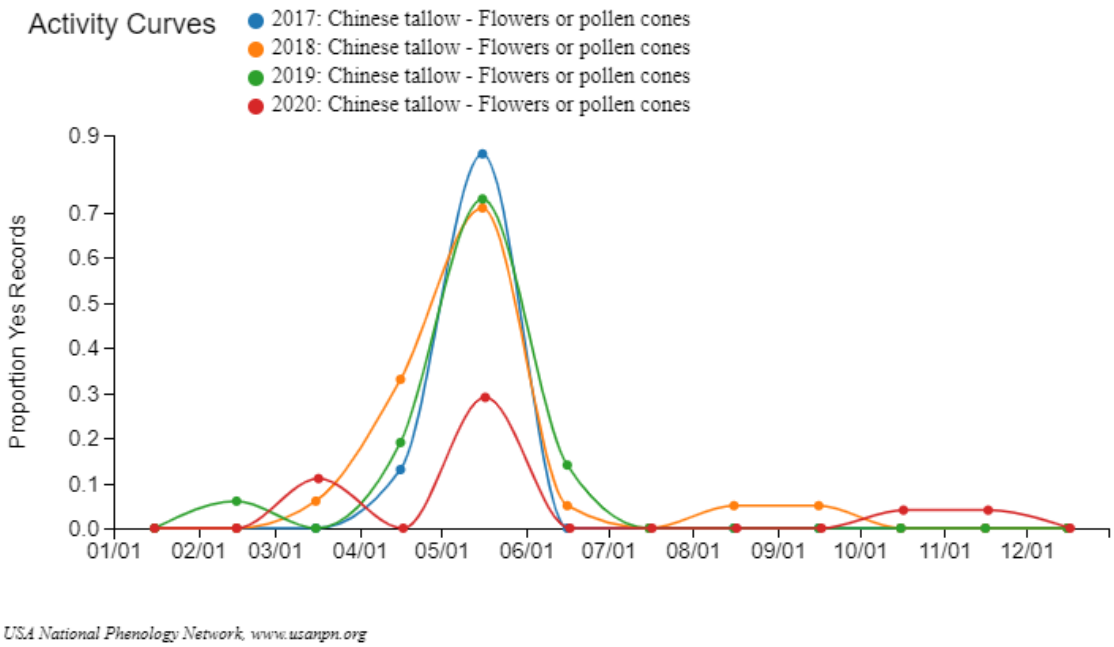


Figure 4. Activity curve showing the proportion of individual Chinese tallow with "yes" records reported for flowers or flower buds in 2017-2020.

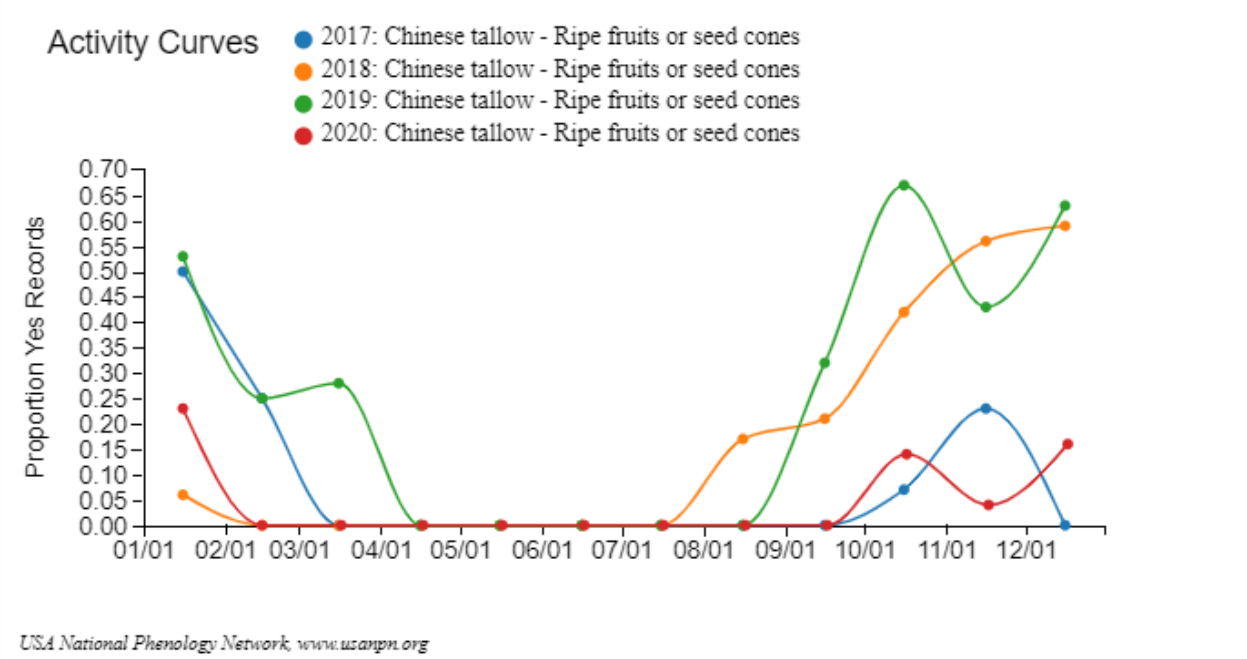


Figure 5. Activity curve showing the proportion of individual Chinese tallow trees with "yes" records report for ripe fruit in 2017-2020.

Red Maple

Figure 6. From left to right, red maple buds, blossoms, and winged seeds. *Photos © G. Bishop*

Red maples are the top observed plant species in the United States among *Nature's Notebook* observers. In red maple, the flower blossoms before the trees leaf out. Interestingly, in 2020 we have observed flower buds emerging as early as November. Red maple seeds (samaras) are used by a number of wildlife species (USDA NRCS 2006). The peak in open flowers occurred in mid-February in 2017, 2018, and 2019, but peaked in early January in 2020 (Fig. 7). The peak of samara production was in mid-March in all four years (Fig. 8). Initial growth of leaves in red maples peaked in mid-March in all four years (Fig. 9).

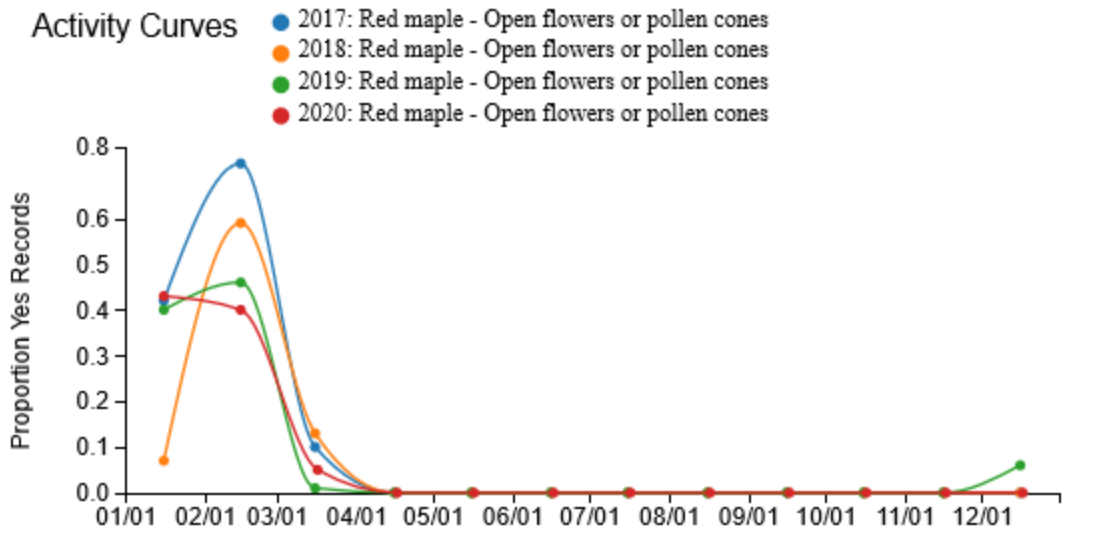


Figure 7. Activity curve showing the proportion of individual red maple trees with "yes" records reported for open flowers in 2017-2020.

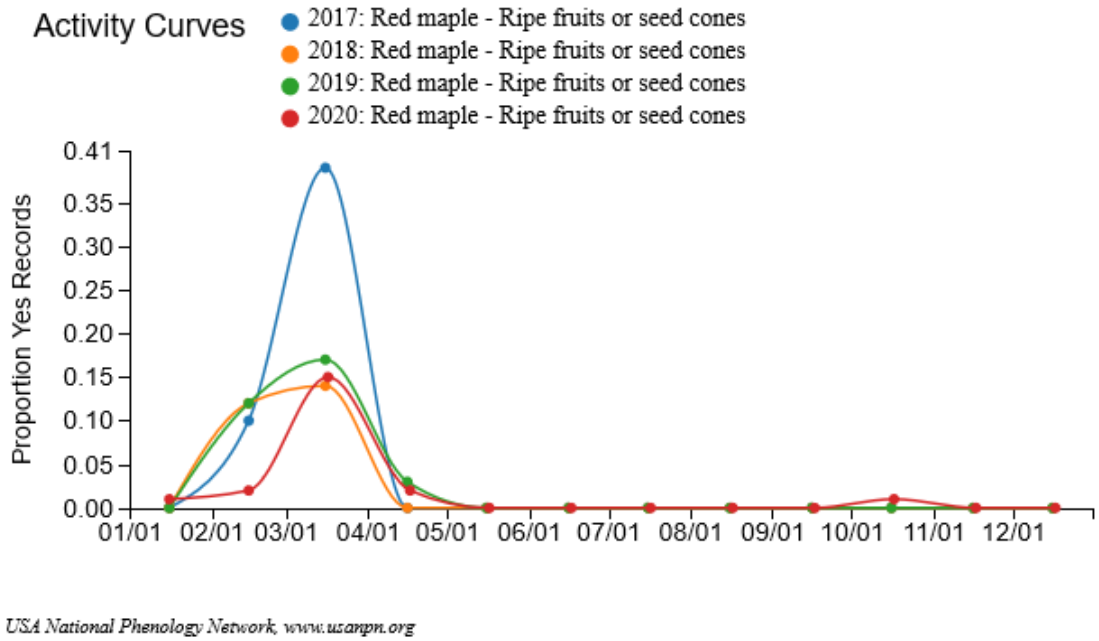


Figure 8. Activity curve showing the proportion of individual red maple trees with "yes" records reported for ripe fruits 2017-2020.

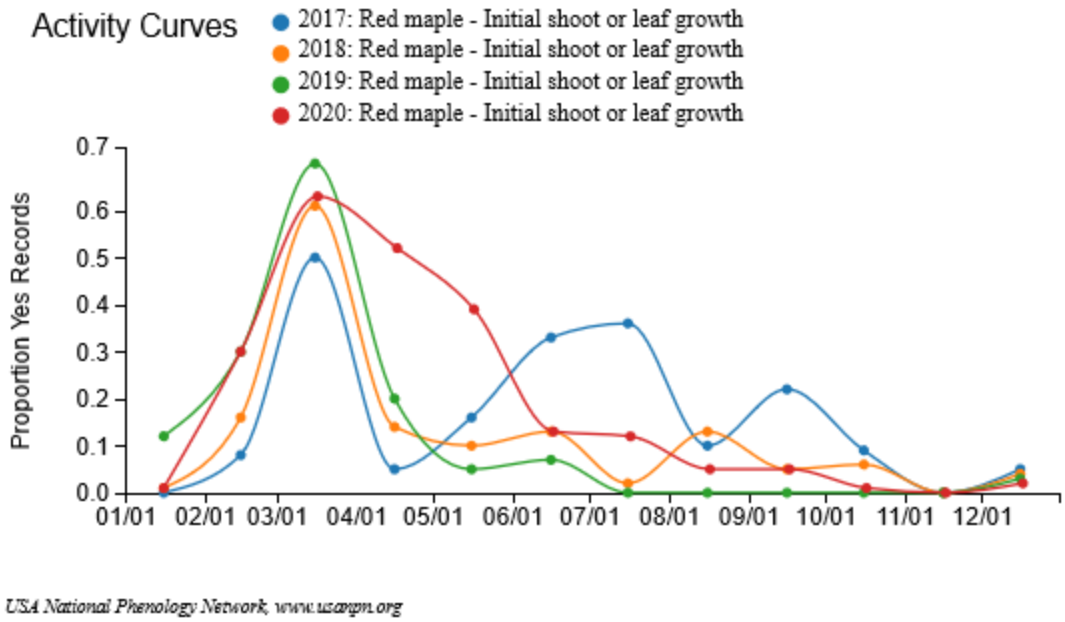


Figure 9. Activity curve showing the proportion of individual red maple trees with "yes" records reported for initial shoot or leaf growth 2017-2020.

Wax Myrtle

Figure 10. From left to right, wax myrtle male flower, female flower, immature berries, leaf buds. *Photos © G. Bishop*

Wax myrtle is dioecious, with male and female flowers occurring on different plants. Only the female flowers produce berries. On the Trail, leaf buds and new leaves emerged throughout the year especially when a terminal end is removed by browsers or by mechanical means. For that reason observing flower development and berry development was more important than observing budding leaves or new leaf development. In all years (2017-2020) wax myrtle flowers peaked in mid-March (Fig. 11). The peak of wax myrtle ripe fruits development was mid-October in 2017, end of December in 2018, and mid-November in 2019 and 2020. (Fig. 12).

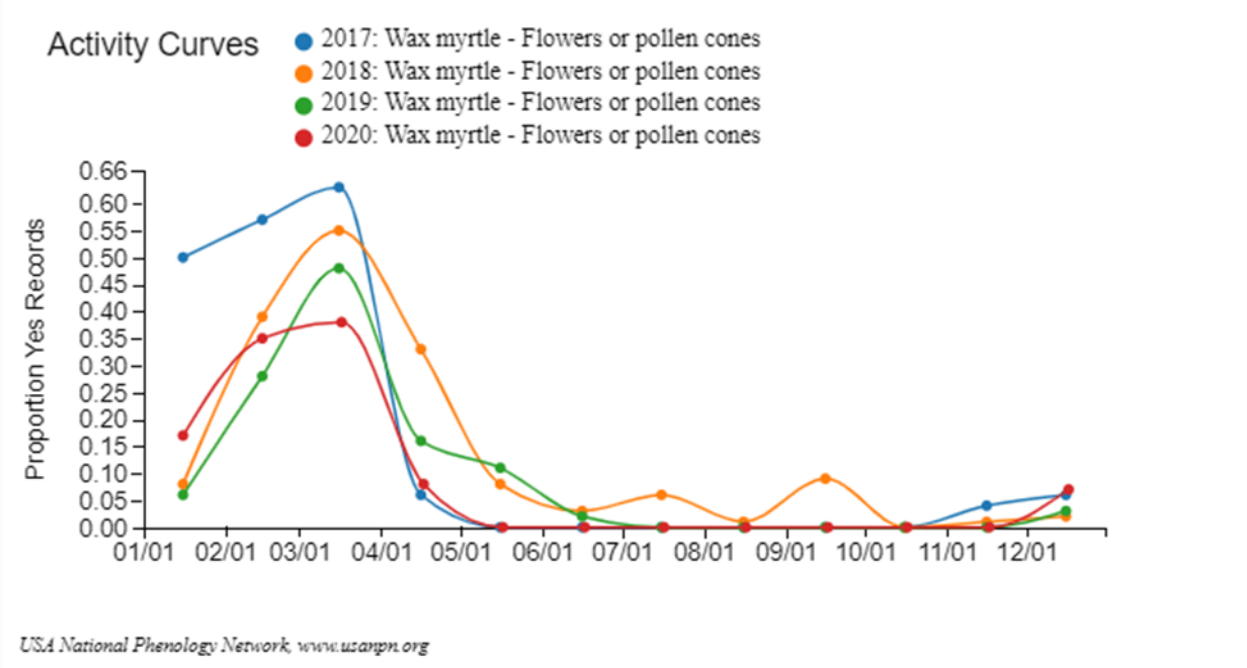


Figure 11. Activity curve showing the proportion of individual wax myrtle with "yes" records reported for flowers or flower buds 2017-2020.

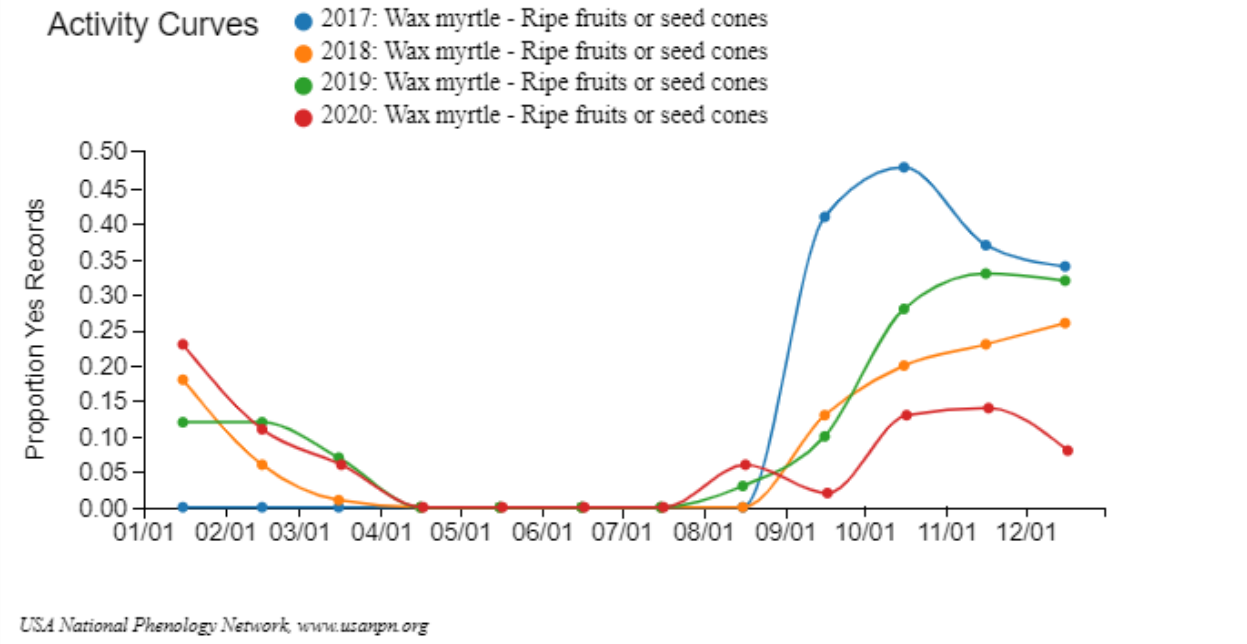


Figure 12. Activity curve showing the proportion of individual wax myrtle with "yes" records reported for ripe fruits and seeds in 2017 -2020.

Redbay

Figure 13. From left to right, redbay new leaves and breaking leaf buds, redbay leaf galls. *Photos © G. Bishop*

Our phenology observations of redbay will help us to see what trees are affected by laurel wilt, which is caused by a fungal symbiont of the exotic red bay ambrosia beetle. One known red bay death was reported infected with the laurel wilt and died on the Pine Forest Restoration Trail in Gautier, Mississippi but another mature red bay was added because it was observed was over 100 drupes. The peak in initial growth for redbay occurred in mid-March in 2018, 2019, and 2020; the record for 2017 was incomplete (Fig. 14) We observed a peak in flowering in mid-April in 2017, 2018. And 2020 and the end of May in 2019 (Fig. 15). The peak of redbay fruits (drupes) for 2017, 2018, and 2019 was mid-October, but occurred in mid-August for 2020 (Fig. 16). While laurel wilt is present at Grand Bay NWR/NERR, in 2020 redbay plants produced over 100 fruits on plants there as well as at Pascagoula River Audubon and Crosby Arboretum.

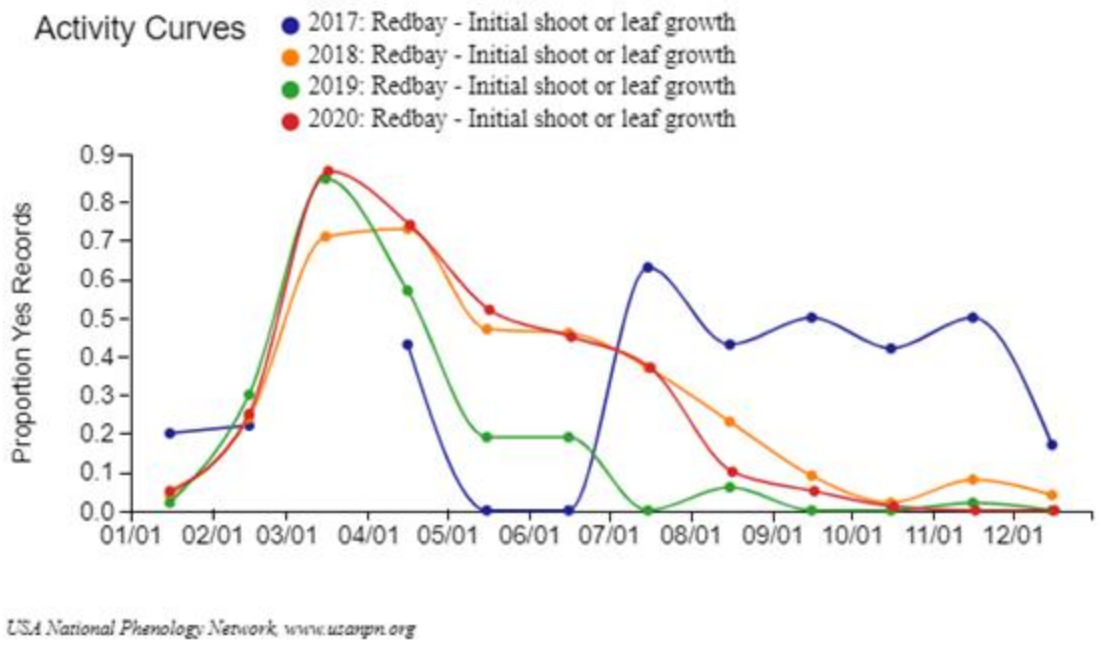


Fig. 14. Activity curve showing the proportion of individual redbay with "yes" records reported for initial growth in 2017 -2020.

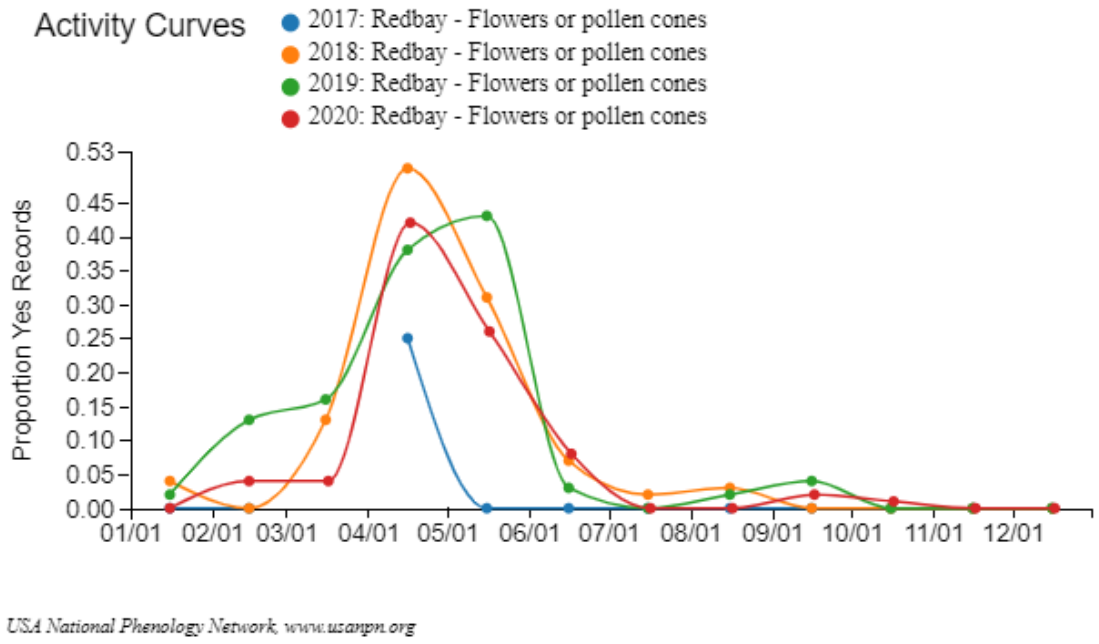


Figure 15. Activity curve showing the proportion of individual redbay with "yes" records reported for flowers or flower buds in 2017 -2020

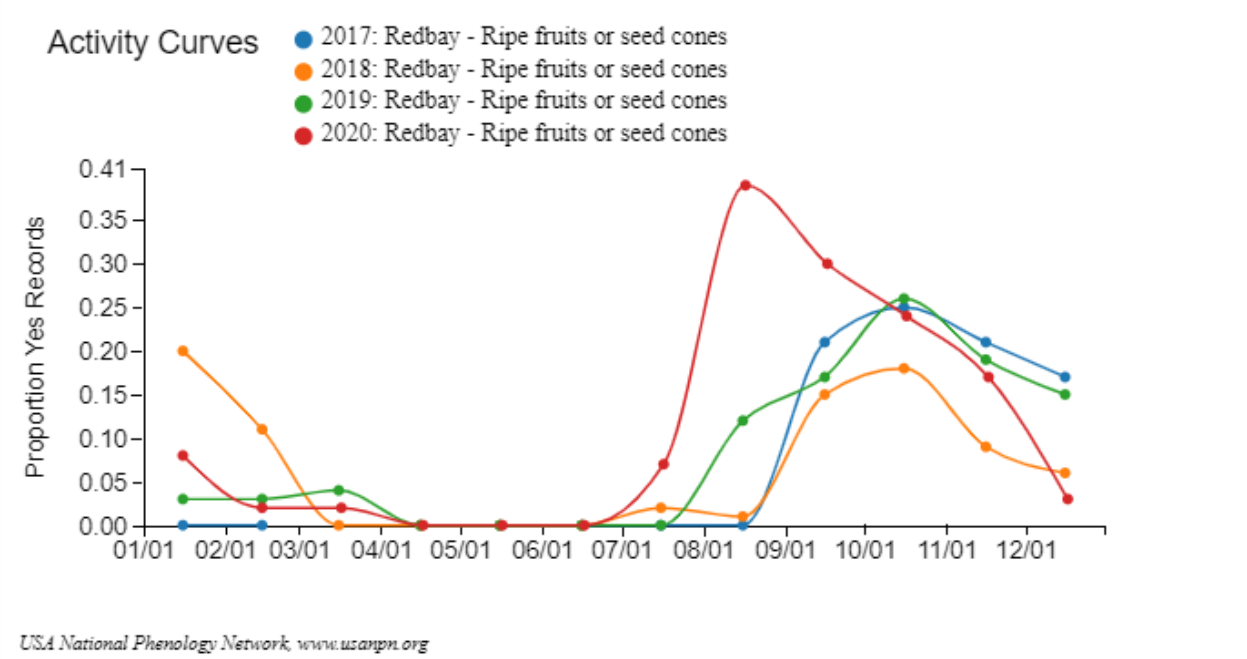


Figure 16. Activity curve showing the proportion of individual redbay with "yes" records reported for ripe fruits in 2017 -2020

Yaupon Holly

Figure 17. From left to right, female yaupon holly in bloom and with ripe berries. *Photos © G. Bishop*

Another dioecious focal plant on the Trail is yaupon holly. Yaupon hollies are one of the few plants that contain caffeine and are used to make teas. A new company, Mississippi Tea, collects yaupon holly leaves from the wild and dries them for tea. The yaupon holly leaf development can occur almost year round. For our reports, we focus on the peaking of flower development and berries. Yaupon holly flowers peaked at the end of April in 2017 and 2018 and in early March in 2019 and 2020. (Fig. 18). The peak of ripe fruits was from mid-January to mid-February in all four years. (Fig. 19).

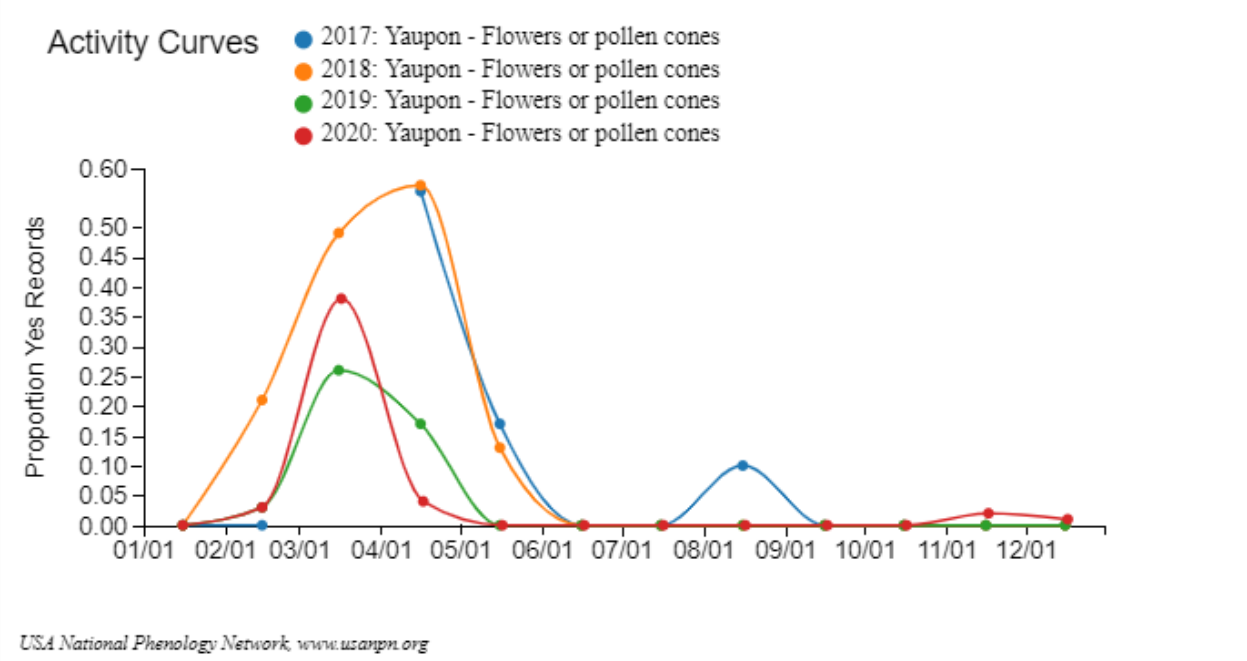


Figure 18. Activity curve showing the proportion of individual yaupon holly trees with "yes" records reported for flowers or flower buds in 2017 -2020.

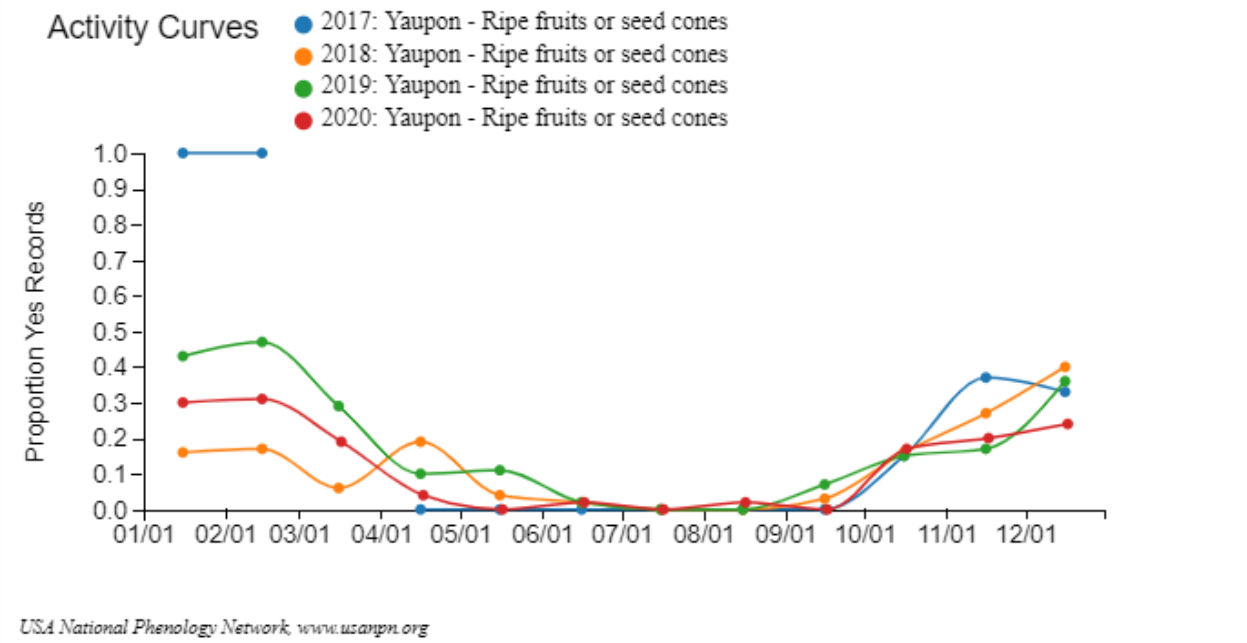


Figure 19. Activity curve showing the proportion of individual yaupon holly trees with "yes" records reported for ripe fruit in 2017 -2020.

1-2. Does phenology of Gulf Coast plants differ between native and non-native plants?

Figure 20. From left to right, red maple leaves, Chinese tallow leaves. *Photos © G. Bishop*

Some invasive species have a competitive advantage over native plants in that they are able to leaf out earlier in the spring than native plants and hold onto their leaves longer; this phenomenon is known as Extended Leaf Phenology. Invasive Chinese tallow and native red maple are two focal species monitored on the Trail that are deciduous. For the past four years, initial growth in red maples peaked in mid-March while Chinese tallows peaked at different times: mid-May in 2017, mid-June in 2018, mid-March in 2019, and mid-April in 2020 (Figs. 21, 22, 23, 24). In all years, both plants also showed initial leaf growth later in the year after the first initial flush of leaves. Several of the red maples and Chinese tallow were cut and emerged from their root stocks and likewise several plants were initially impacted by prescribed fires but later sprouted.

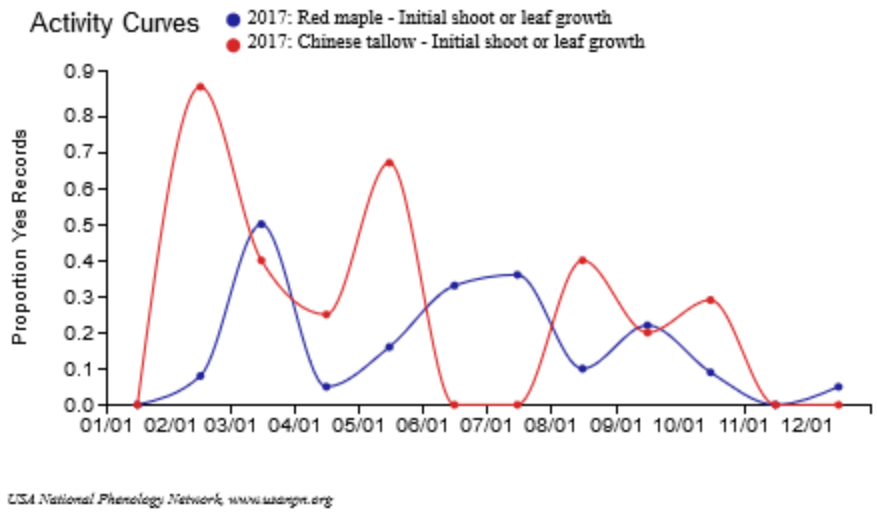


Figure 21. Activity curve showing the proportion of individual Chinese tallow trees with "yes" records reported for initial shoot or leaf growth compared to red maple in 2017.

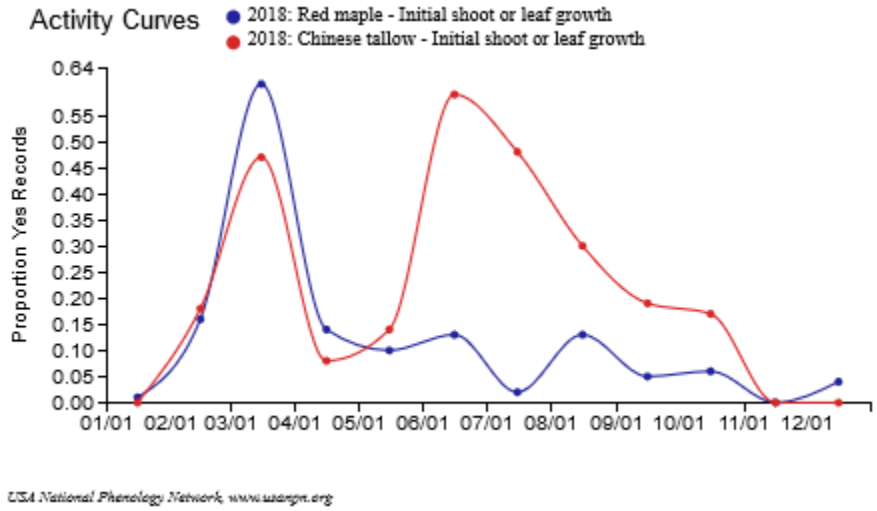


Figure 22. Activity curve showing the proportion of individual Chinese tallow trees with "yes" records reported for initial shoot or leaf growth compared to red maple in 2018.

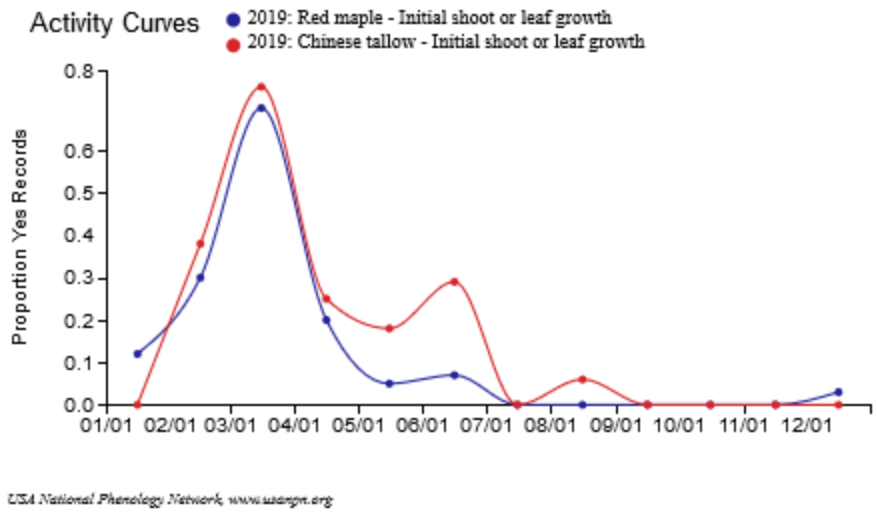


Figure 23. Activity curve showing the proportion of individual Chinese tallow trees with "yes" records reported for initial shoot or leaf growth compared to red maple in 2019.

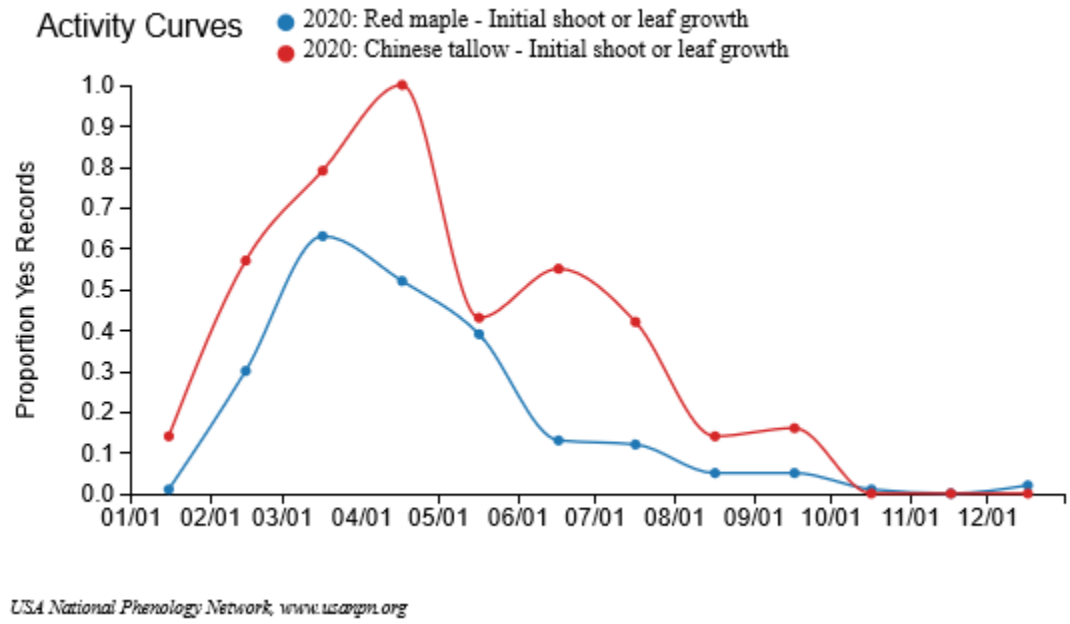


Figure 24. Activity curve showing the proportion of individual Chinese tallow trees with "yes" records reported for initial shoot or leaf growth compared to red maple in 2020.

The timing of flowering was different between Chinese tallow and red maple, with the peak in red maple flowering occurring two months earlier than in Chinese tallow (Fig. 25, 26, 27, 28). Red maple flowers peaked in early January (2017, 2019, 2020) or mid-February (2018) while Chinese tallow flowers peaked in mid-May for all years (2017-2020).

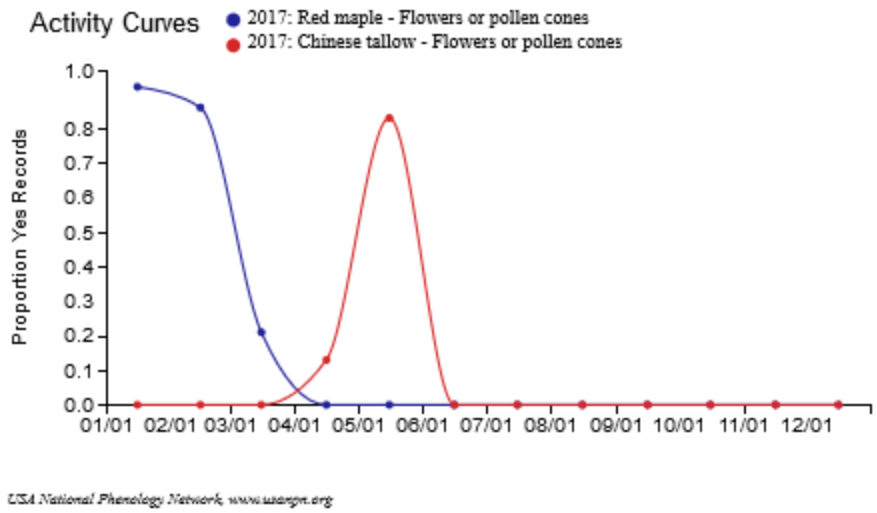


Figure 25. Activity curve showing the proportion of trees with a “yes” reported for flowers or flower buds for Chinese tallow and red maple in 2017.

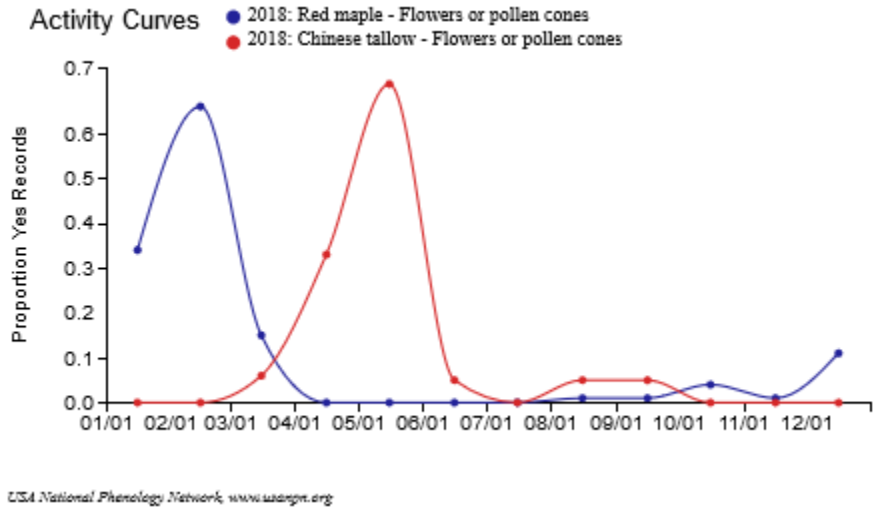


Figure 26. Activity curve showing the proportion of trees with a “yes” reported for flowers or flower buds for Chinese tallow and red maple in 2018.

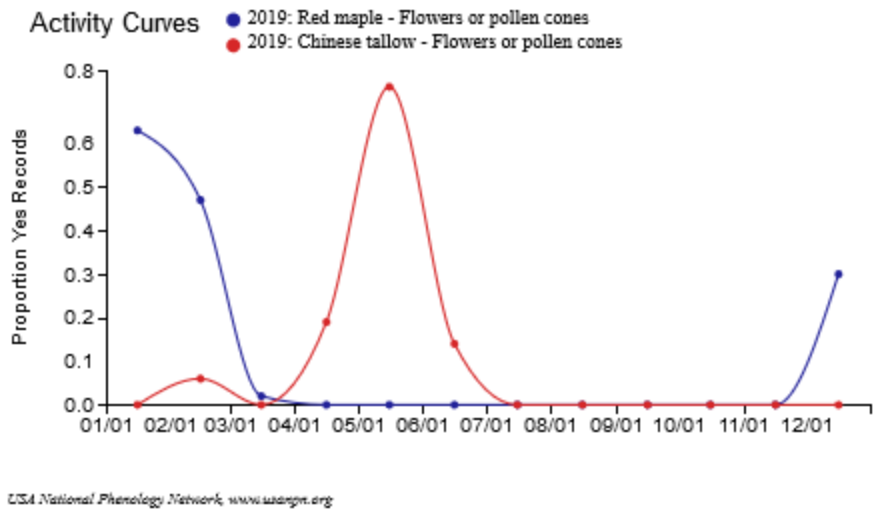


Figure 27. Activity curve showing the proportion of trees with a "yes" reported for flowers or flower buds for Chinese tallow and red maple in 2019.

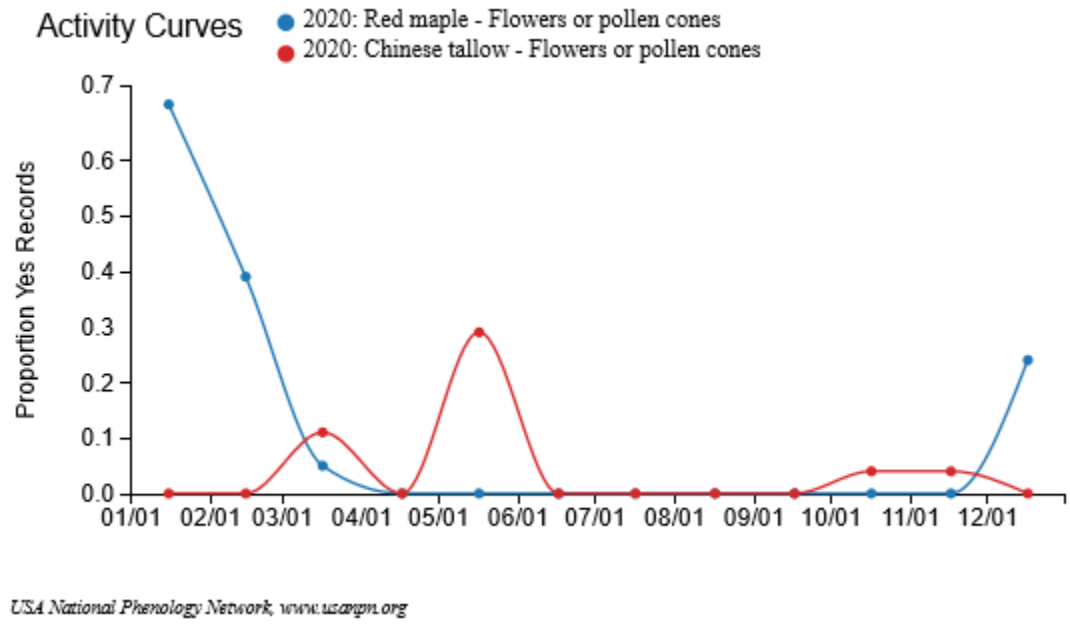


Fig. 28. Activity curve showing the proportion of trees with a "yes" reported for flowers or flower buds for Chinese tallow and red maple in 2020.

1-3. Does the phenology of native plant pollinators match native plant phenology over time under a changing climate?

Figure 29. Monarch butterflies on eastern baccharis. Photo ©Chris Feurt at Grand Bay NWR/NERR on November 3, 2019. Eastern Baccharis in bloom. Photo @Gbishop

Monarch butterflies and eastern baccharis were chosen to answer the question: does the phenology of native plant pollinators match native plant phenology over time under a changing climate? Although we have recorded some data for three years (2018-2020), we still cannot adequately answer the question. In 2018 and 2019, we recorded the flowering of eastern baccharis (*Baccharis hamlimifolia*) and the activity of monarch butterflies (*Danaus plexippus*) at Bayou Sauvage National Wildlife Refuge, Mississippi Sandhill Crane National Wildlife Refuge, and the Barataria National Preserve. Additional sites, including Big Branch NWR, Grand Bay NEER, Crosby Arboretum were added in 2020. The fall peak in flowering of eastern baccharis overlaps with the fall activity of monarch butterflies (Fig. 30, 31, 32), though we did not record flowers in the monarchs' summer period of activity. No sightings of monarchs were recorded in 2020 so this butterfly is relying on other nectar sources during the summer season. Except for 2020, we regularly reported our sightings of monarchs and gulf fritillary butterflies to managers of the National Wildlife Refuges along the Trail. Our reports inform them about the timing of activity of these important pollinators and their nectar plants.

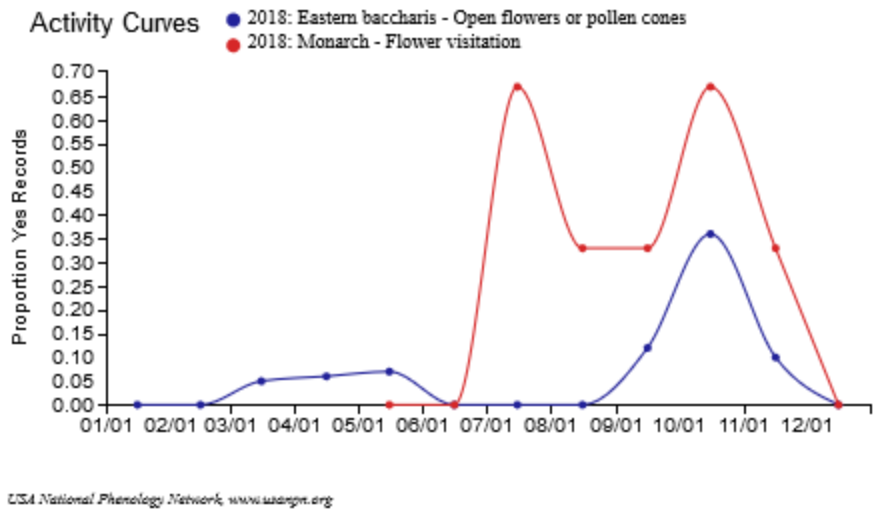


Figure 30. Activity curve showing the proportion of "yes" records for monarch butterflies and open eastern baccharis flowers in 2018.

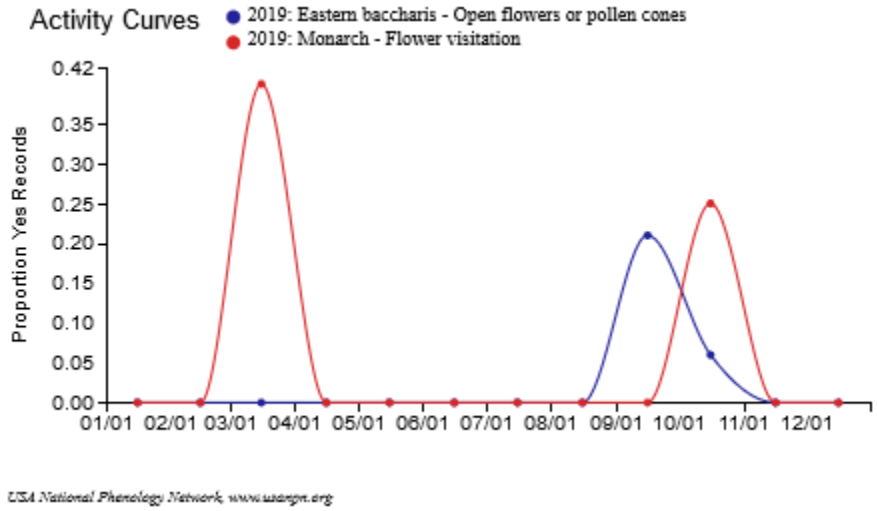


Figure 31. Activity curve showing the proportion of "yes" records for monarch butterflies and open eastern baccharis flowers in 2019.

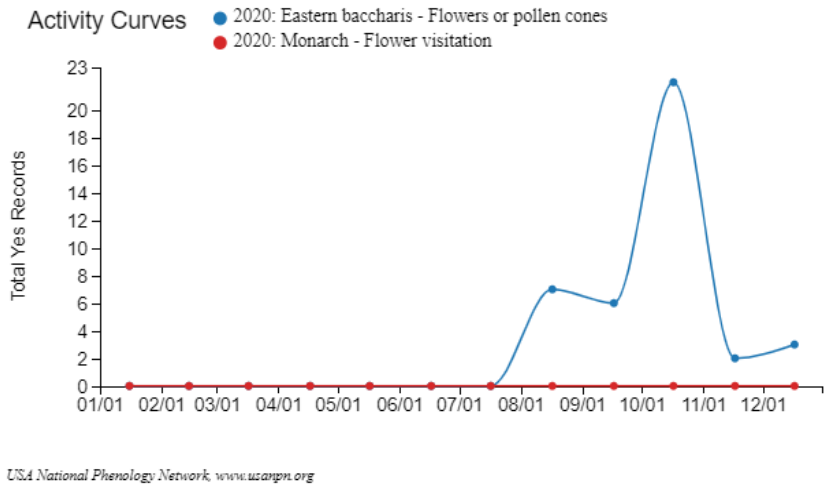
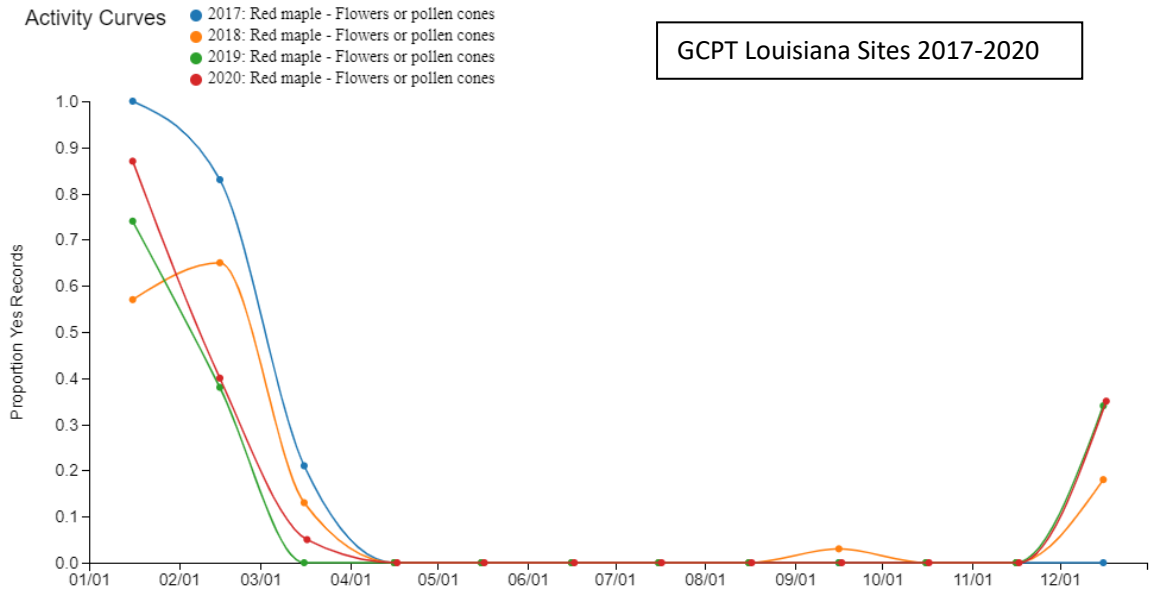


Figure 32. Activity curve showing the proportion of "yes" records for monarch butterflies and open eastern baccharis flowers in 2020

1-4. Is there an East-West gradient in the timing of certain focal species from Louisiana to Alabama?

Western locations on the Trail typically have warmer winter temperatures than those at eastern locations, as reflected in the weather summary from the New Orleans National Weather Station compared with the Gulfport, Mississippi or Mobile, Alabama Weather Station. At Louisiana sites, red maple flowering peaked in early January in 2017, 2019, and 2020 and in mid-February in 2018 (Fig. 33). At Mississippi sites, red maple flowering peaked in mid-February in 2017, 2018, and 2019, and peaked in early January in 2020 (Fig. 33).



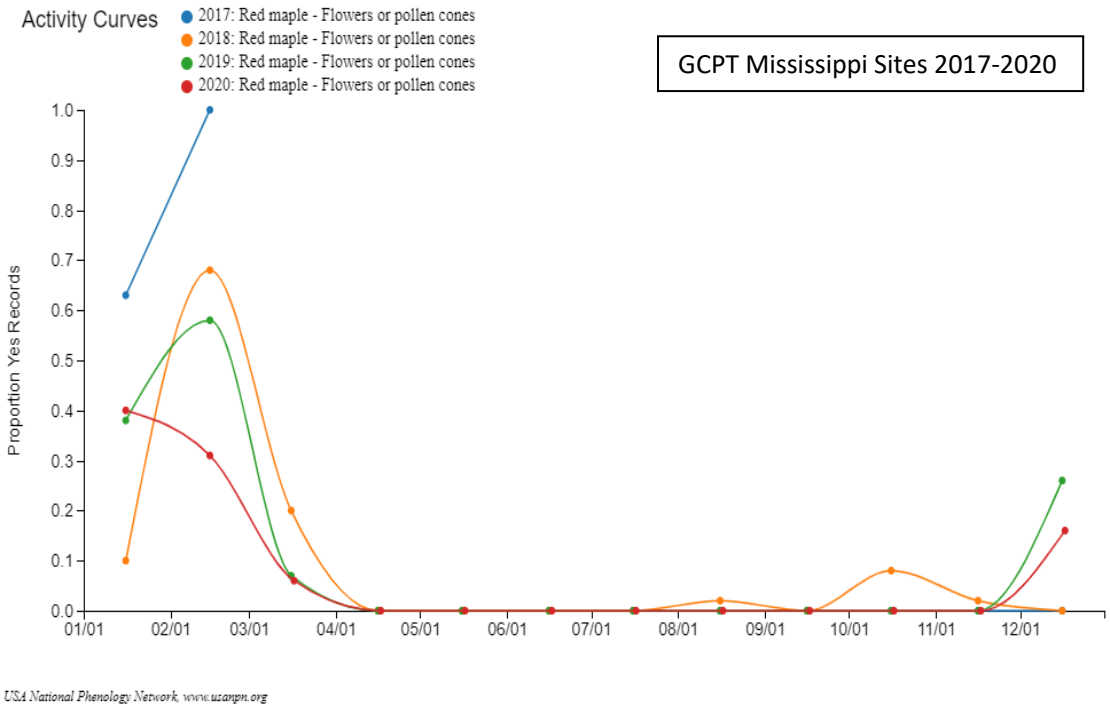


Figure 33. West-East comparison of the proportion of "yes" records reported for red maple flowers or flower buds in 2017, 2018, and 2019 for Louisiana sites (top) and Mississippi sites (bottom).

Secondary Questions

2-1. What is the variation in phenology in similar habitats across the Trail?

We are interested in the amount of variation in life cycle events including breaking leaf buds and open flowers across individual plants and sites on the Trail. A comparison of two Trail sites with savannah habitat – Grant Bay NWR/NERR and Mississippi Sandhill Crane NWR – shows that the peak in initial growth in Chinese tallow varied by several months at the two different sites in 2019 (Fig. 34) and was slightly more similar between the two sites in 2020 (Fig. 35).

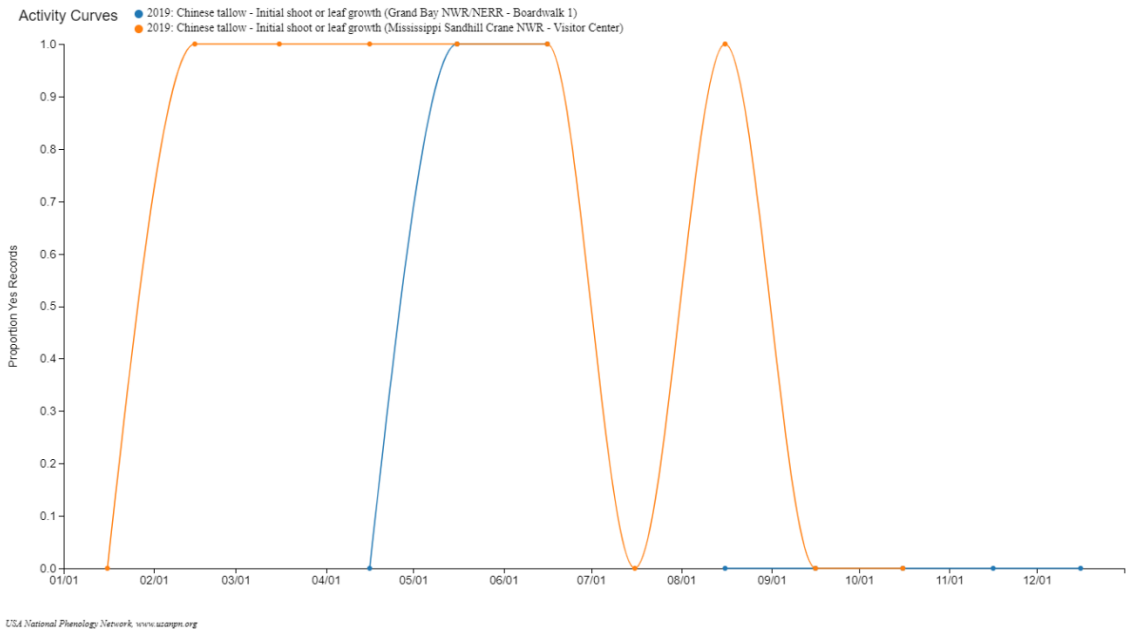


Figure 34. Activity curve showing the proportion of trees with a "yes" reported for initial growth in Chinese tallow at Grand Bay NWR/NERR and Mississippi Sandhill Crane NWR in 2019.

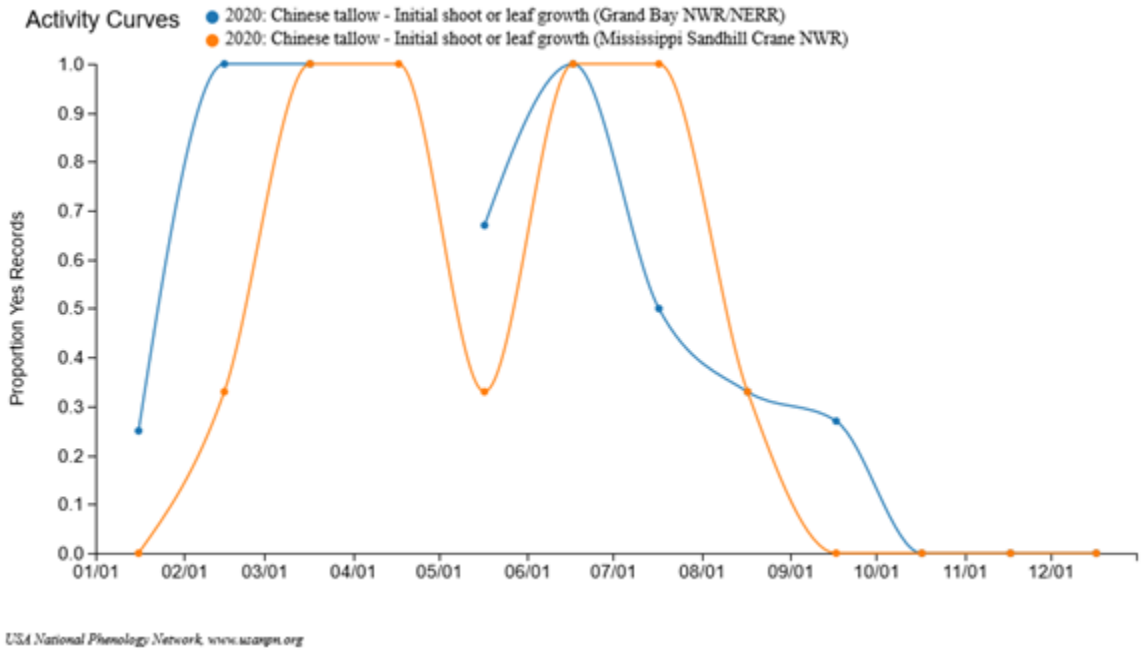


Figure 35. Activity curve showing the proportion of trees with a "yes" reported for initial growth in Chinese tallow at Grand Bay NWR/NERR and Mississippi Sandhill Crane NWR in 2020.

For red maple, the peak in initial growth was very different between the Grand Bay NERR/NWR and Mississippi Sandhill Crane NWR sites in 2019 (Fig. 36), and more similar in 2020 (Fig. 37).

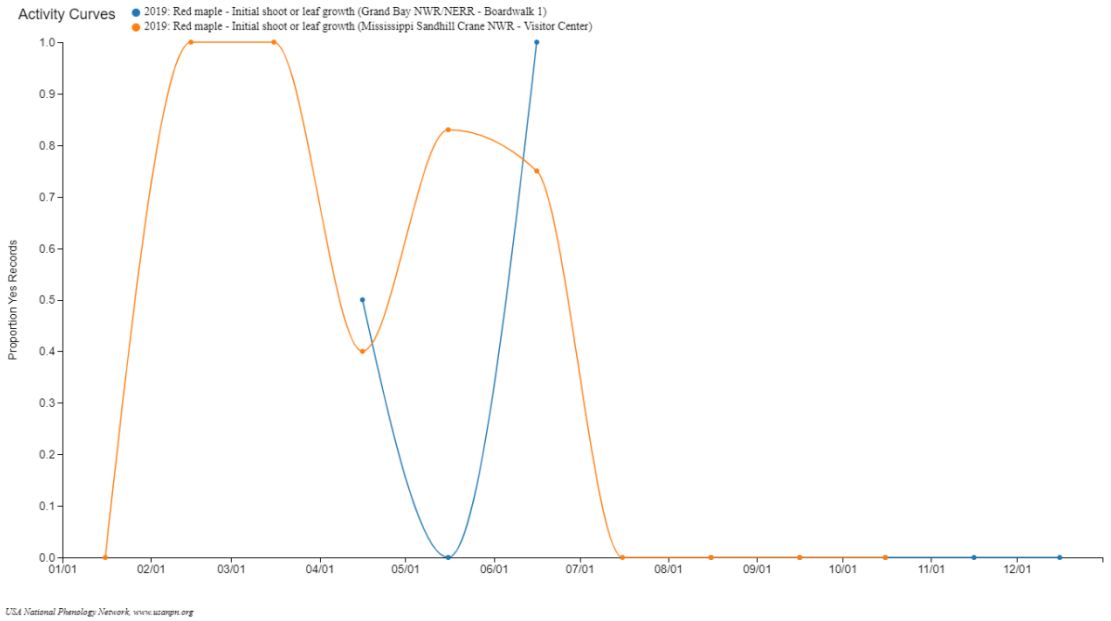


Figure 36. Activity curve showing the proportion of trees with a "yes" reported for initial growth in red maple at Grand Bay NWR/NERR and Mississippi Sandhill Crane NWR in 2019.

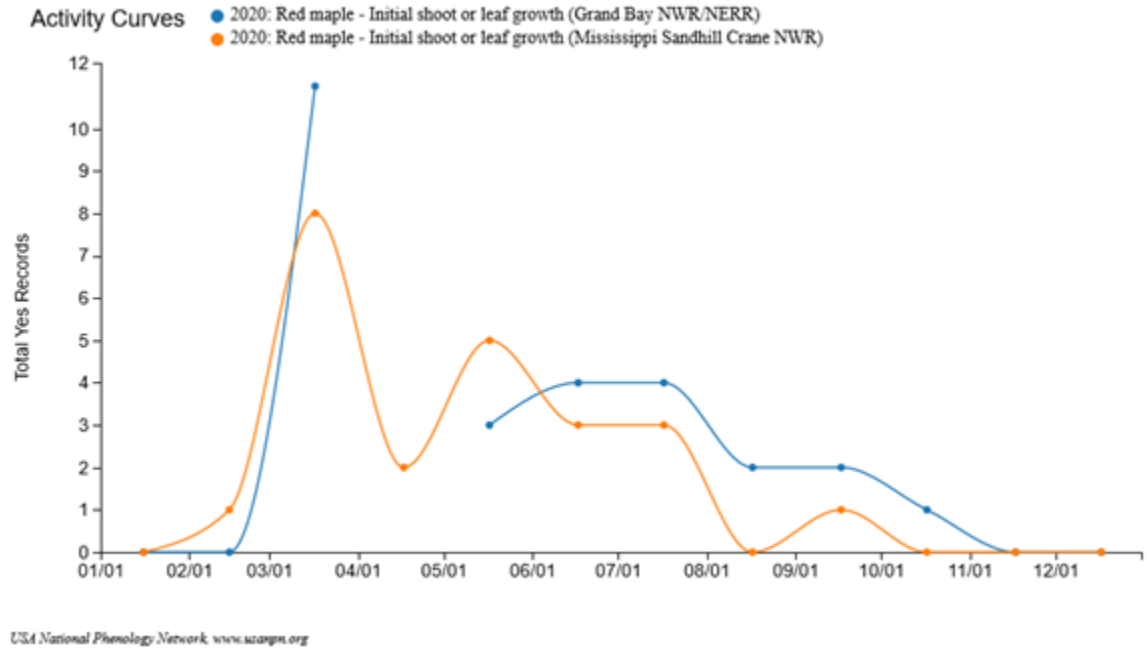


Figure 37. Activity curve showing the proportion of trees with a "yes" reported for initial growth in red maple at Grand Bay NWR/NERR and Mississippi Sandhill Crane NWR in 2020.

2-2. Does phenology of focal species differ between areas that have been disturbed by fire, storm, etc.?

Three of the sites, Grand Bay NWR/NERR, Mississippi Sandhill Crane NWR, and The Crosby Arboretum, manage savannah habitats which include prescribed fires and mechanical clearing. There were two prescribed fires in March and May in 2020 at Grand Bay in 2020; no prescribed fires at the Mississippi Sandhill Crane NWR's Visitor Center Trail, and no prescribed fires at The Crosby Arboretum. After subsequent years of data collection, we will be able to compare the phenology of these plants before and after disturbance.

2-3. How is the arrival and departure of migrating animals, such as purple martin, shifting in response to a changing climate?

Figure 38. Left – Purple Martins, Photo by Jeff Goff. Right – broken Purple Martin gourd pole, Photo © Gbishop.

According to Audubon website's, Purple Martins migrate from the Amazon River basin in South America returning in February to the Southeast United States. There they depend on human supplied housing, including gourds, to build their nests. Hurricane Zeta's winds in October 2020, knocked over the Grand Bay NERR's Purple Martin pole with 14 gourds that needed to be replaced in 2021 in time for the Purple Martin scouts to return.

Currently our limited data do not present a clear picture for answering this question about Purple Martins. However, based on the graph (Fig. 39) Purple Martins were recorded in mid-February in 2017, 2018, and 2019. Of the past four years, the longest duration of Purple Martin activity was recorded in 2018. Purple Martins are observed at the Grand Bay NWR/NERR where a pole with gourds is located and at Pascagoula River Audubon Center. We plan to record more data on this species in subsequent years.

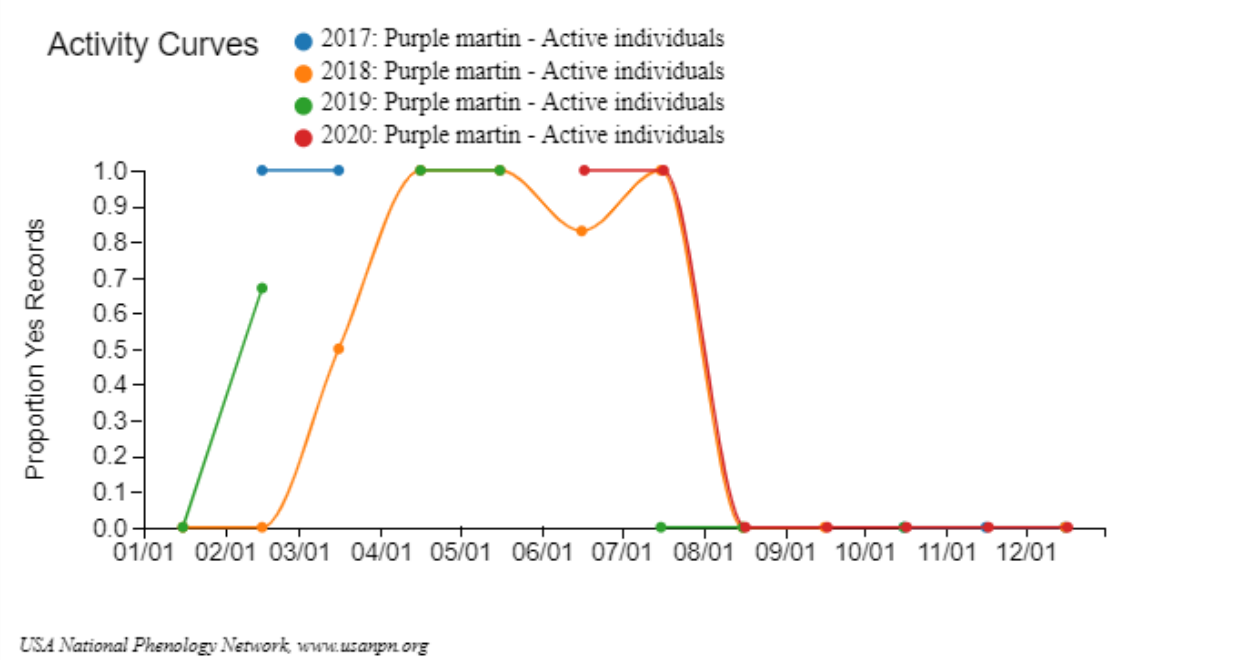


Figure 39. Activity curve for Purple Martin Active Individuals from 2017-2020.

Weather Data Summary

New Orleans, Louisiana

In 2020, all twelve months were warmer in New Orleans than the 30-year normal (1981-2010). Across months, the average temperature was 3.3 degrees higher. Tropical Storms Cristobal (June 7) and Marco (August 25), and Hurricane Zeta (October 28) made landfall near the New Orleans area. According to The Times Picayune online article on the 2020 hurricane season, five storms made landfall in Louisiana in the 2020 hurricane season, breaking the state record for the most strikes in a single season. Although half the months were wetter and the half were dryer, the average rainfall for New Orleans was 9.30 inches wetter than the 30-year normal rainfall average in the New Orleans, LA recording location (Table 3 and 4).

Table 3. Temperature summary table for New Orleans, Lou Weather Station in 2020 Departure from 30-year normal is based on years 1981-2010 (NOAA 2020).

Month 2020	Average Temperature (F) (red indicates warmer than 30Yr Normal)	30yr Normal Temperature (F)
January	59.9	53.4
February	61.0	56.7
March	73.1	62.6
April	72.7	69.1
May	77.9	76.1
June	83.7	81.5
July	85.5	83.3
August	84.4	83.3
September	79.7	79.7
October	74.1	71.3
November	67.3	62.7
December	56.5	55.6
Annual Mean	73.0	69.7

Table 4. Precipitation summary table for New Orleans, Lou. Weather Station in 2020. Departure from 30-year normal is based on years 1981-2010 (NOAA 2020).

Month 2020	Total Precipitation (in.) (Red indicates higher than 30Yr Normal)	30yr Monthly Normal Total Precipitation (in.).
January	4.41	5.15
February	3.94	5.30
March	1.06	4.55
April	5.41	4.61
May	8.36	4.63
June	10.16	8.01
July	15.22	5.93
August	6.28	5.98
September	1.78	4.97
October	4.68	3.54
November	6.39	4.49
December	4.06	5.24
Annual Total	71.75	62.45

Gulfport, Mississippi

In 2020, ten months out of twelve were warmer in Gulfport than the 30-year normal (1981-2010). Tropical Storms Cristobal (June 7) Marco (August 24) and Hurricane Zeta (October 28) impacted the Mississippi Gulf Coast. Across months, the average temperature was 2.2 degrees warmer than normal. Although June and July received more rain than the average for the 30-year normal in this Mississippi recording location. (Table 5 and 6). In 2020 in Gulfport there was a total of 56.02 inches or 8.66 inches less than the 30-year average in precipitation.

Table 5. Temperature summary table for Gulfport, Miss. Weather Station in 2019. Departure from 30-year normal is based on years 1981-2010 (NOAA 2020). (NOAA April 1, 2020).

Month	Average Temperature (F) (red indicates warmer than 30Yr Normal)	30yr Normal Temperature (F))
January	55.3	50.8
February	56.4	53.8
March	69.4	50.1
April	68.7	57.4
May	74.1	74.3
June	80.6	80.3
July	82.3	82.4
August	83.4	82.4
September	78.4	78.2
October	72.3	69.2
November	64.8	60.3
December	52.3	53.1
Annual Mean	69.8	67.6

Table 6. Precipitation summary table for Gulfport, Miss. Weather Station in 2020. Departure from 30-year normal is based on years 1981-2010 (NOAA 2020).

Month	Total Precipitation (in.). Red indicates higher than Normal	30yr Total Precipitation (in.).
January	3.68	5.19
February	3.86	5.23
March	0.22	5.99
April	2.64	4.56
May	2.76	5.11
June	11.72	6.39
July	14.28	7.21
August	4.53	6.28
September	2.14	5.63
October	2.95	3.55
November	3.08	4.64
December	4.16	4.90
Annual Total	56.02	64.68

Mobile, Alabama

In 2020, seven months out of twelve were warmer in Mobile than the 30-year normal (1981-2010). Across months, the average temperature was 1.9 degrees higher. Although Hurricane Salley (September 16) impacted the Alabama panhandle the storm had minimal impact on Grand Bay NERR. Perception was wetter than normal for four months and dryer than normal for eight months in the Mobile, Alabama area. Overall, the average precipitation amount was 7.75 less in 2020 than the 30-year normal (Table 7 and 8).

Table 7. Temperature summary table for Mobile, Ala. Weather Station in 2019. Departure from 30-year normal is based on years 1981-2010 (NOAA 2020).

Month	Average Temperature (F) (red indicates warmer than 30Yr Normal)	30yr Normal Temperature (F)
January	53.5	50.4
February	55.5	53.8
March	68.3	60.2
April	67.3	66.4
May	72.3	74.1
June	79.4	79.8
July	81.0	81.8
August	81.5	81.6
September	76.3	77.5
October	70.8	68.4
November	63.0	59.6
December	50.9	52.4
Annual Mean	68.3	67.2

Table 8. Precipitation summary table for Mobile, Ala. Weather Station in 2019. Departure from 30-year normal is based on years 1981-2010 (NOAA 2020).

Month	Total Precipitation (in.) (Red indicates higher than 30Yr Normal)	30yr Total Precipitation (in.).
January	4.57	5.65
February	5.01	5.12
March	0.97	6.14
April	3.51	4.79
May	5.56	5.14
June	9.70	6.11
July	8.89	7.25
August	4.37	6.96
September	5.77	5.11
October	3.54	3.69
November	1.90	5.13
December	4.61	5.06
Annual Total	58.40	66.15

Education and Outreach

Figure 40. Bayou Gardens. Photo courtesy Sue Wilder

Barataria Training. Photo courtesy Liz Marchio

Before the Covid-19 Pandemic in 2020 closed sites in March and kept volunteers and visitors from social gatherings we participated in two in-person events. One was a training session led by the Trail Coordinator, Gail Bishop, at the Barataria Unit of the Jean Lafitte National Historical Park and Preserve in Barataria, Louisiana where over 20 interested volunteers attended the training at the unit's education facility. The second event, "Bayou Gardens" was at the Southeastern Louisiana National Wildlife Refuge Complex headquarters on February 28, 2020 when we had a Trail booth operated by the Trail Coordinator, Gail Bishop, and volunteer Jennifer Buchanan.

The Trail coordinator, Gail Bishop, participated USFWS National Conservation Training Center's Citizen Science online course, and presented a brief PowerPoint presentation on the Trail to inspire National Wildlife Refuges as well as other units within DOI to start their own phenology monitoring programs.

Trail Coordinator Gail Bishop met the faculty advisor, Dr. Linda Nix, for the Pine Restoration Trail at the Mississippi Gulf Coast Community College Gautier Campus. Dr. Nix planned to have students make observations as part of their course work.

Lessons Learned 2020

1. After four years of data collection, we can see a pattern for some species. For example, based on two focal plants, yaupon holly and wax myrtle, it is easier to produce activity cures based on seed production because these two species will grow new leaves if branches are clipped or nibbled on by animals. Red maple seems to produce flowers about the same time every year although some locations, especially in Louisiana, produce them earlier than eastern Mississippi. The challenges of 2020 made it difficult to maintain data collection at

the same frequency as in previous years. Despite the hiatus, citizen scientists continued to make observations not only for their own edification but to ensure the data collected would continue to provide future insight into plant reactions to climate change.

2. The 2021 hurricane season is predicted to be active again as it was in 2020. We will see how tropical storms and hurricanes impact our partners' operations.

3. The challenges of 2020 put prescribed fires on hold for the most part, which inadvertently gave volunteers the time to locate all plants which were burned in past years.

4. Several seemingly healthy plants such as wax myrtle at different sites died in 2020. Perhaps a disease or weather conditions were contributing factors. Long term monitoring will help answer that question.

5. Certainly a global pandemic impacted recruiting and training volunteers, however retention of long-term volunteers helped keep observations ongoing. When questioned why some volunteers continued to make observations, most replied their connection with "their plants," individual curiosity and education, and the need to participate in the program. Workshops and/or field trips should begin again for current volunteer observers. These activities provide opportunities to network and maintain engagement in the program.

6. We have deepened our focus on pollinators, especially butterflies such as monarch butterflies, as well as nectar or host plants they need to continue their life cycles or migration. Learning what plants can provide nutrition such as eastern baccharis is important. Our observations will also allow better understanding of any mismatch between plants with early maturation that impacts the pollinators.

7. According to several partner managers, educational opportunities for students and the public are of high value.

8. Create multiple training opportunities for citizen scientists rather than create a sustained network of volunteers which is an original goal. Many volunteers move on to other opportunities.

Summary and Next Steps

We continue to work toward the long-term goals for the Gulf Coast Phenology Trail:

- Promote the increased use of *Nature's Notebook* for collecting local phenology data along the Gulf Coast
- Create a sustained network of citizen scientists for 7-10 years (launched in 2017)
- Provide insights through the knowledge gained from the phenology data collected
- Develop local partnerships across the Gulf Coast to establish sites that address local climate change and conservation issues while strengthening the overall mission of the Gulf Coast Phenology Trail.

We will continue to strive to meet our long-term goals and make needed adjustments when necessary. We realize that annual reports are based on observations made by citizen scientists and not based on laboratory conditions. Using the *Nature's Notebook* protocol provides standards that are used to evaluate the reactions of species to changing climatic conditions.

Location of Project Components

All data is entered online via *Nature's Notebook* and is stored in the USA-NPN National Phenology Database, available for download at www.usanpn.org/results/data. Project documentation and resources for plant and animal identification are available at. Additionally, Trail fliers for public distribution, NPN Botany Primers, Trail supplies, and displays are housed locally at the coordinator's office.

References Cited

2020 hurricane season officially ends; here are the records it set | Hurricane Center | nola.com Accessed online May 22, 2021.

"Avian use of Chinese Tallow Seeds in Coastal Texas"--2002 study by Warren Conway from Texas Tech University. Available at The Southwestern Naturalist 47(4):550 DOI:10.2307/3672658). Accessed online May 10, 2021.

Chinese Tallow, Texas Invasive Species Institute. Available at http://www.tsusinvasives.org/home/database/triadica-sebifera. Accessed online June 11, 2020.

"Chinese tallow tree-Invasive plant"available at the University of Arkansas Research and Extension Service's website UAEx.edu. Accessed online May 10, 2021.

Mississippi Trees 2nd Edition, 2012, John D. Hodges, David L. Evans, and Linda W. Garnett. Mississippi Forestry Commission, Jackson, Mississippi.

" Purple Martin, *Progne subis*, " Available at ww.audubon.org/field-guide/bird/purple-martin. Accessed May 17, 2021

USDA NRCS National Plant Data Center & the Biota of North America Program. 2006. Red Maple Plant Guide. Available at https://plants.usda.gov/plantguide/pdf/pg_acru.pdf. Accessed online June 11, 2020.

"Winter Bird Use of the Chinese Tallow Tree in Louisiana--2005 master's thesis,"Michael J. Baldwin from Louisiana Tech University.

Appendix A. Partner and Observation Sites 2020

Partner	Site_ID	Site_Name	State	Latitude	Longitude	# Records	# Observers
Grand Bay NWR/NERR	28745	Boardwalk 1	MS	30.42939	-88.4286	1939	2
Mississippi Sandhill Crane NWR	26079	Visitor Center	MS	30.45158	-88.6555	2460	3
Mississippi Sandhill Crane NWR	28590	Fontainbleau Unit Nature Trail	MS	30.39778	-88.7572	6039	7
Pascagoula River Audubon Center (PRAC)	28353	PRAC-Boat Launch Trail	MS	30.41477	-88.5425	2887	3
Pascagoula River Audubon Center	28354	PRAC-Trail 2	MS	30.41479	-88.5426	1096	3
Pascagoula River Audubon Center	28357	PRAC Front Lawn	MS	30.41472	-88.5418	927	3
Mississippi Gulf Coast Community College -Gautier	29265	Pine Restoration Trail	MS	30.400648	-88.64506	1099	2
Big Branch Marsh NWR	25151	Main Parking Lot	LA	30.32165	-89.9369	5307	4
Big Branch Marsh NWR	25168	Entrance Road	LA	30.32005	-89.936	1919	5
Big Branch Marsh NWR	25506	Azalea Trail	LA	30.31894	-89.9377	4430	4
Big Branch Marsh NWR	30648	Bog Trail	LA	30.3217	-89.9382	1368	4
Bayou Sauvage NWR	25901	Boardwalk	LA	30.05377	-89.8805	14488	3
Jean LaFitte NHP&P Barataria Preserve	27474	Visitor Center Trail	LA	29.78447	-90.1148	766	5
Jean LaFitte NHP&P Barataria Preserve	27475	Palmetto Trail	LA	29.78381	-90.1176	1067	3
Jean LaFitte NHP&P Barataria Preserve	27476	Ring Levee Trail	LA	29.78527	-90.1102	2130	6
Jean LaFitte NHP&P Barataria Preserve	27477	Bayou Coquille Trail	LA	29.79382	-90.1225	2501	4
Crosby Arboretum	28830	Phenology Journey	MS	30.50215	-89.6668	1638	4
USM Marine Education Center	30971	Osprey Point Nature Trail	MS	30.39134	-88.776	3081	3
McLeod Park	32959	Nature Trail	MS	30.391338	-88.775955	822	3
USM-Long Beach	33862	Bayou Bear Path	MS	30.353952	-89.136215	1939	2
New Orleans City Park	33401	Couturie Forest Phenology Trail	LA	30.004747	-90.09421	1400	9

Appendix B. 2020 Plant Monitoring Number of Species

BARP -Barataria Preserve (Jean LaFitte NPP)
BS-Bayou Sauvage
BBM-Big Branch
CR-The Crosby Arboretum
USM-MEC-Marine Ed. Ctr
MSC-Miss.Sandhill
MP -McLeod
NOCP- City Park
USM-LB-Long Beach Campus
GB-Grand Bay NWR/NERR

Species	BARP	BS	BBM	CR	GB	MP	MSC	MGCCC	NOLA-CP	PRAC	USM-LB	USM-MEC	TOTAL
American beautyberry	1		5				2		1			2	11
American Elm		2											2
American sycamore									2			1	3
American Witchhazel													
Bald cypress	5	3							2				10
Black cherry			1										1
Black willow		3							1				4
Boxelder	3												3
Chinese tallow	2	2			3		1	2					10
Common buttonbush	2												2
Common hackberry		2							1				3
Common persimon		2											2
Eastern baccharis	3	3					3	2		1			12
Eastern poison ivy	3												3
Elliott's blueberry				3									3
Flowering dogwood							1						1
Honeylocust	1								1				2
Live oak	3	2							1				6
Longleaf pine				1			3				7		11
Mountain azalea				3			3						6
Pitcher Plant				2				1					3
Possumhaw	4												4
Red buckeye										3			3
Red maple	5	7	9	2	5	3	5	4	1	2	1	4	48
Redbay			2	4	4	2	5	3	2	2		4	28
Southern magnolia			3						1				4
Sugarberry	1												1
Sweetbay						1	2				3		6
Sweetgum	4	2							1				7
Trumpet creeper	4												4
Water tupelo	2												2
Wax myrtle	4		4	4	3	2	5	3		4		3	36
Virginia crownbeard	2												2
Yaupon holly			4	3	4	4	6	3		4		4	32
TOTAL													

Appendix C. 2020 Animal Monitoring

BARP -Barataria Preserve (Jean LaFitte NPP)
BS-Bayou Sauvage
BBM-Big Branch
MSC-Miss.Sandhill

PRAC Pascagoula River Audubon Center Species	BARP	BS	BBM	CR	GB	MSC	PRAC	TOTAL Sites
Birds (records)								
American Robin ((624)		x			x	x		3
Bald Eagle (247)	x				x			2
Blue Jay (224)						x		1
Carolina Wren (?)	x							1
Chimney Swift (?)							x	1
Eastern Bluebird (531)					x	x	x	3
Henslow Sparrow (256)								
Hooded Warbler (?)								1
Northern Mockingbird (80)						x		1
Northern Parulla (?)	x							1
Osprey (524)					x	x		2
Purple Martin (112 by Gail)					x		x	2
Red-bellied Woodpecker (51)								
Ruby-crowned Kinglet (?)							x	1
Ruby-throated Hummingbird (?)							x	1
Sandhill Crane (288)						x		1
Tufted Titmouse (224)						x		1
Yellow Rumped Warbler (416)		x					x	2
Insects (Records)								
Gulf fritillary (637)		x			x			2
Bumblee (396)					x			1
Honeybee (?)					x			2
Monarch (1.395)		x	x	x	x			4
Mammals (Records)								
Fox Squirrel					x			1
Reptiles (Records)								
American Alligator (38)	x							1
Box Turtle (?)					x			1
TOTAL Species	3	4	1			7	6	

Appendix D. Number of monthly site visits by Partner.