Gulf Coast Phenology Trail 2019 Annual Report

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USA National Phenology Network

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USGS science for a changing world

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Introduction

The Gulf Coast contains rich and varied ecosystems including pine savannas, forests, shorelines, and open marshes. Despite the importance of the area not much is known about the phenology of southeastern plants. 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 refered 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 addition, each of the 12 partners selected a list of species (Appendix B Inventory) for a total of 33 plants, 16 birds, and 2 butterflies to monitor to address site-specific questions of interest. The data collected by observers will 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

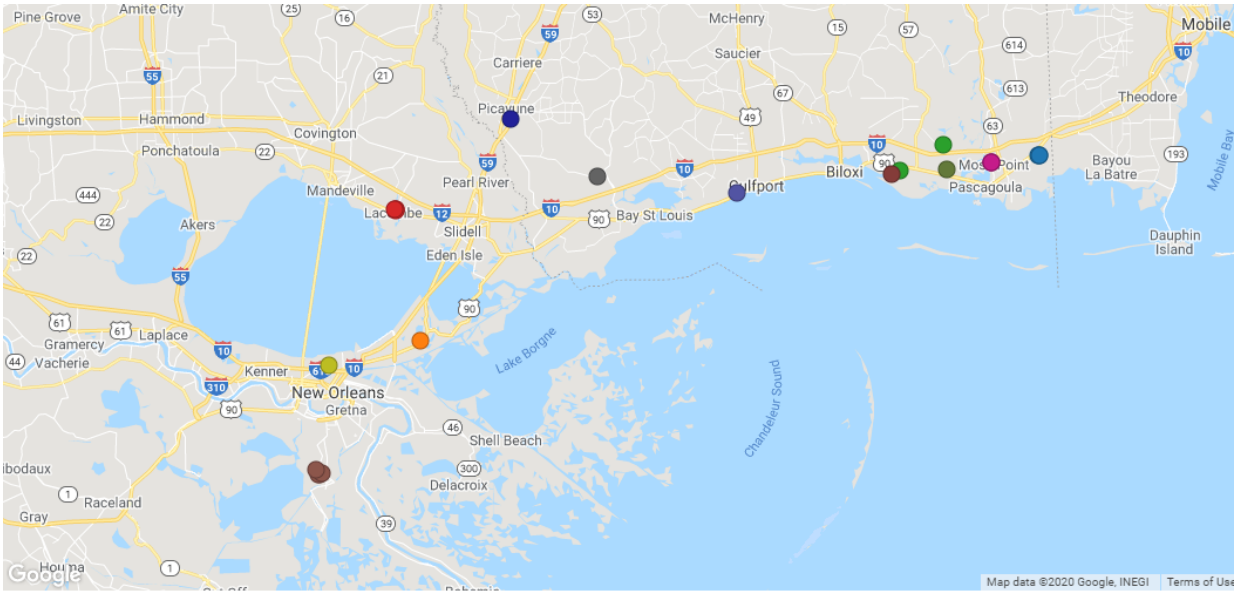
Methods and Results

At all partner sites along the Trail we followed the protocols outlined by *Nature's Notebook* (www. naturesnotebook.org). 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. Where paper data collection was preferred, 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.

Three additional partners, University of Southern Mississippi-Long Beach Campus in Harrison County, Miss.; McLeod Park in Hancock County, Miss.; and New Orleans City Park (Couturie Trail) in Orleans Parish, La, were added for a total of 12 partners along the Trail.

Locations of Gulf Coast Phenology Trail Partner sites active in 2019 are represented on the map below (Fig 1).



Legend

- Grand Bay NWR/NERR
- Bayou Sauvage NWR
- Mississippi Sandhill Crane NWR
- Big Branch Marsh NWR
- Crosby Arboretum
- Pascagoula River Audubon Center
- Barataria Phenology Trail
- MGCCC Estaurine Education Center
- USM Marine Education Center
- USM Long Beach
- McLeod Water Park
- Couturie Forest Phenology Trail

Figure 1. Observation locations monitored by one of the Gulf Coast Phenology Trail partners.

Primary Questions

We have four primary questions that 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?

2019 was our third year of data collection on the Trail. As we collect more years of data, we can start to look at patterns in our data to see whether they reflect the impact of climate change.

In 2019, 35 volunteer observers collected 59,303 observations at 21 sites (Box 1). These observations represented 33 plant species and 18 animal species.

Table 1. 2019 by the Numbers
59,303 Phenology Observations
12 Partners
35 Observers
21 Sites
33 Plant Species Observed
18 Animal Species Observed
55,211 Plant Observations
4,092 Animal Observations

We have a number of focal species that we encourage our Trail partners to observe so that we can have enough 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 2019, six sites monitored Chinese tallow

(*Triadica sebifera*), 13 sites monitored red maple (*Acer rubrum*), 10 sites monitored wax myrtle (*Morella cerifera*), 8 sites monitored red bay (*Persia borbonia*), and 8 sites monitored yaupon holly (*Ilex vomitoria;*Table 2).

Table 2. Number of individual plants and sites for each focal species in 2017, 2018, and 2019.

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

Chinese Tallow

Figure 2. From lef to right, Chinese tallow new growth, catkins and with immature seed pods. *Photos © G. Bishop*

Chinese tallow is a deciduous tree that sheds its leaves annually and is monoecious, with male and female flowers occurring on the same plant. This species was introduced into North America in the 1700s and has now spread primarily from North Carolina across to Texas and in California, displacing native species. According to the Texas Invasive Species Institute, Chinese tallow is able to use minimal water resources, grow in crowded areas, and block out native plant species. Because climate change is predicted to increase drought conditions in southeastern states which will cause further stress to native species, it is valuable to understand the phenology of Chinese tallow to better manage this species. For example, knowing when seeds are mature for dispersal is beneficial for resource managers who are tasked with reducing the numbers of this species (Mississippi Trees). In 2017, 2018, and 2019 Chinese tallow flowered starting in mid-March and peaked in May (Fig. 3). The peak for ripe fruit was in late November for 2017, mid-December for 2018, early October with a second peak in later in December for 2019 (Fig. 4).

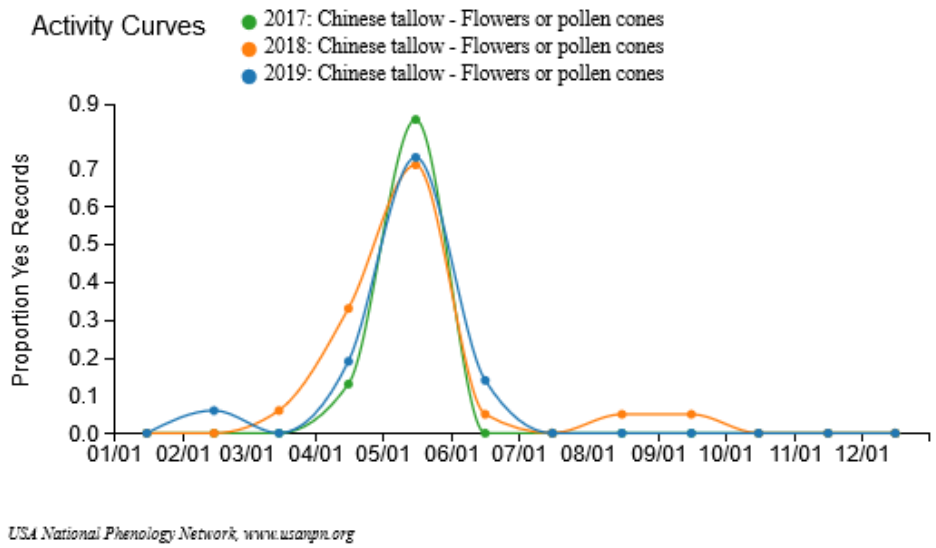


Figure 3. Activity curve showing the proportion of individual Chinese tallow with "yes" proportional records reported for flowers or flower buds in 2017 -2019.

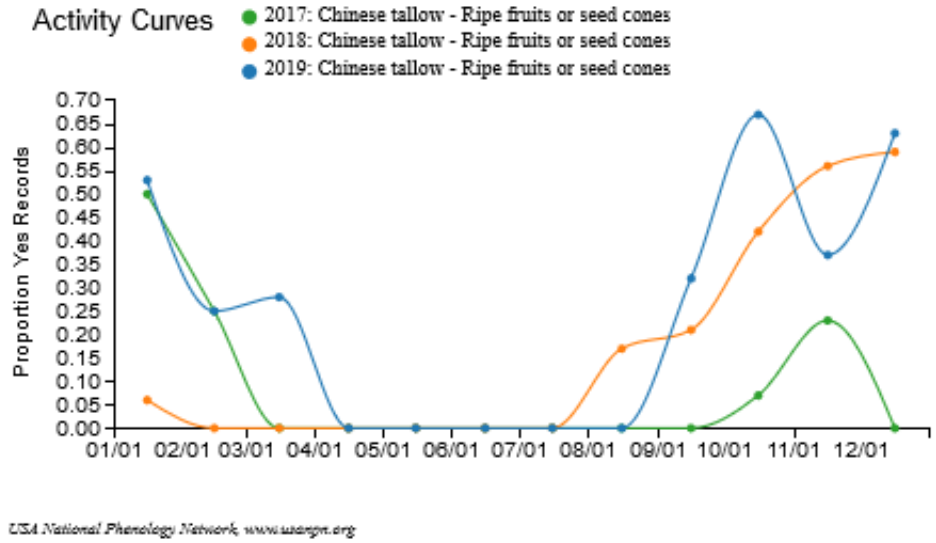


Figure 4. Activity curve showing the proportion of individual Chinese tallow trees with "yes" records report for fruit in 2017-2019.

Red Maple

Figure 5. From left to right, red maple blossoms, winged seeds, immature leaves. *Photos © G. Bishop*

Red maples are deciduous, can be monoecious or dioecious, with male and female flowers occurring on separate individual plants, and is hysteranthous, with flowers appearing before leaves. This species is the top observed species in the country by *Nature's Notebook* observers. Red maple seeds (samaras) are used by a number of wildlife species (USDA NRCS 2006). In both 2017 and 2018, the peak in flowering in red maples occurred in mid- to late-February. However in 2019 the highest number of trees flowered early in January (Fig. 4) The peak of samara production was in mid-March in 2017, 2018, and 2019 (Fig. 5)

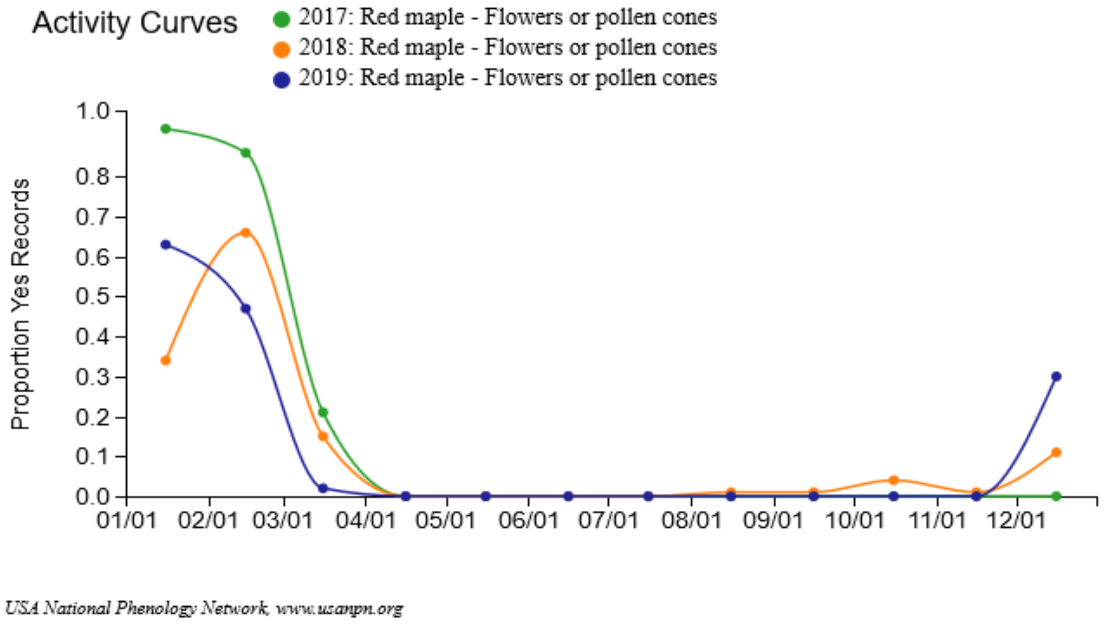


Figure 6. Activity curve showing the proportion of individual red maple trees with "yes" records reported for flowers or flower buds in 2017-2019.

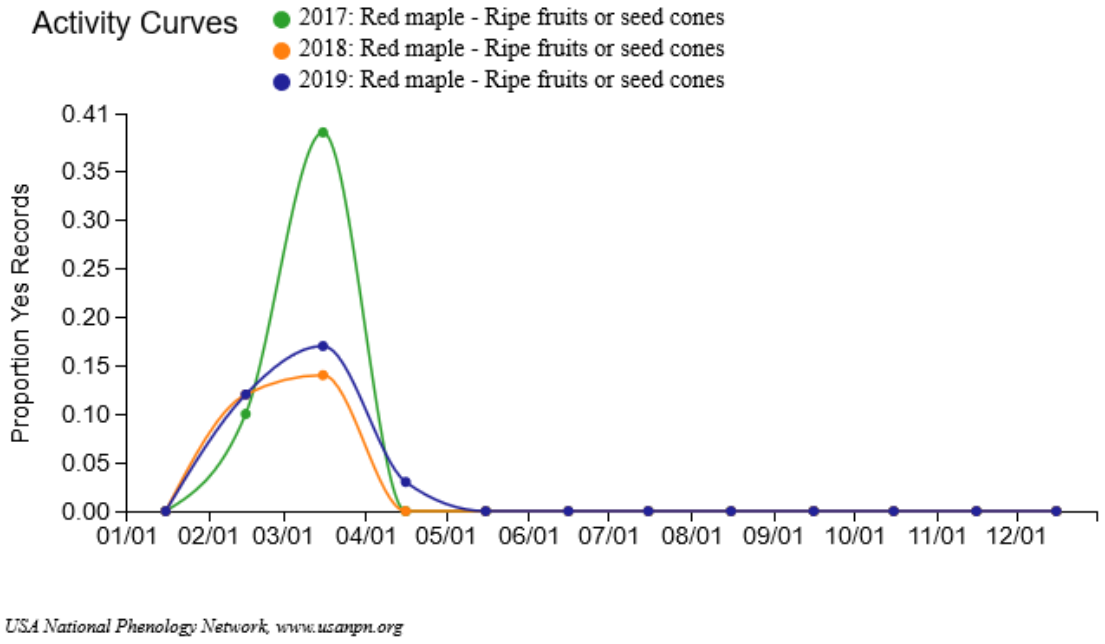


Figure 7. Activity curve showing the proportion of individual red maple trees with "yes" records reported for ripe fruits 2017-2019.

Wax Myrtle

Figure 8. From left to right, wax myrtle male flower, female flower, immature berries, leaf buds. *Photos © G. Bishop*

Wax myrtle is broadleaf evergreen native to the Southeastern U.S. This species can be monoecious or dioecious. On the Trail, leaf buds and new leaves continued to emerge throughout the year especially when a terminal end is removed by browsers or by mechanical means. In 2017 wax myrtle flowers peaked in mid-February but in 2018 and 2019 peaked in mid-March (Fig. 9). The peak of wax myrtle ripe fruits development was the end of October in 2017, end of December in 2018, and mid-November in 2019 (Fig. 10).

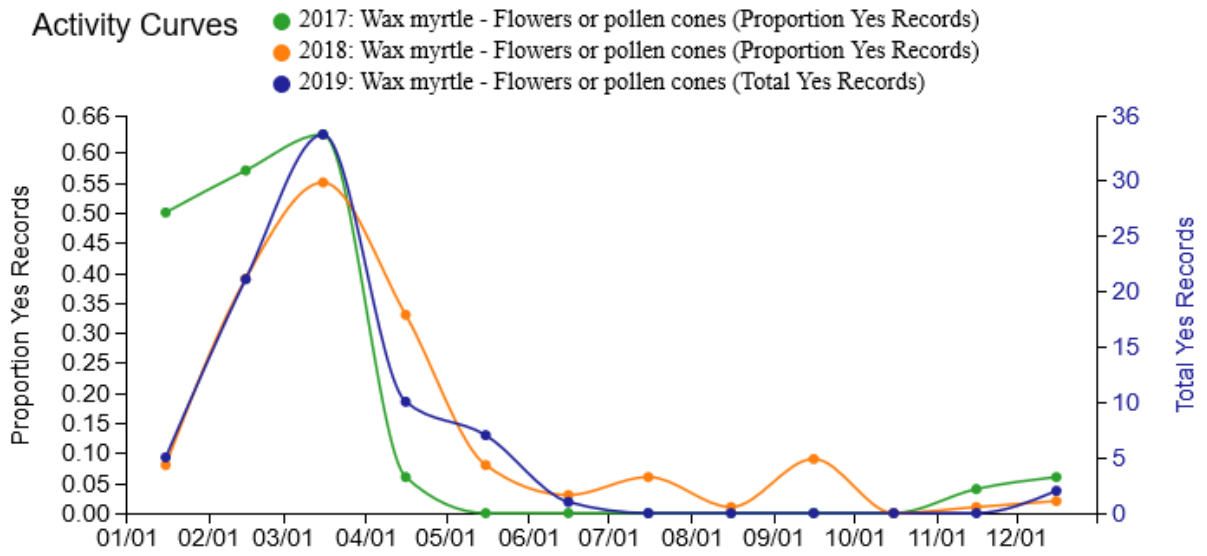


Figure 9. Activity curve showing the proportion of individual wax myrtle with "yes" records reported for flowers or flower buds in 2017 and 2018.

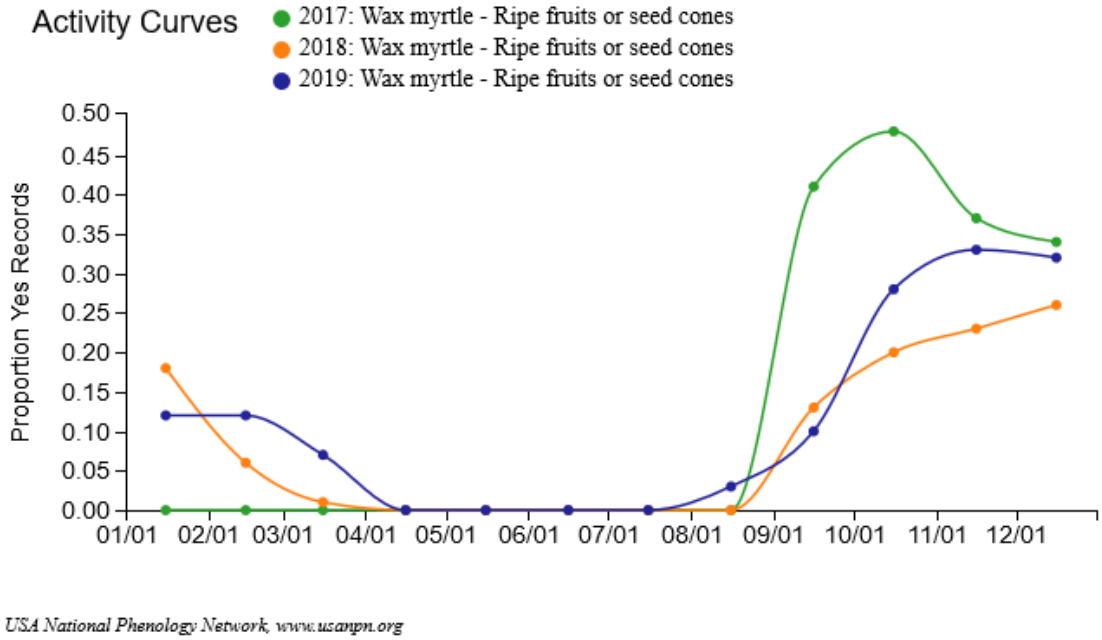


Figure 10. Activity curve showing the proportion of individual wax myrtle with "yes" records reported for flowers or flower buds in 2017 -2019

Red Bay

Figure 11. From left to right, redbay blossom, ripe drupe. *Photos © G. Bishop*

Redbay is a broadleaf evergreen native to the Southeastern U.S. and is monoecious. Our phenology observations of redbay will help us better understand how trees of this species are affected by laurel wilt, which is caused by a fungal symbiont of the exotic red bay ambrosia beetle. We observed a peak in flowering in mid-April in 2017 and 2018 and the end of May in 2019 (Fig. 12). The peak of redbay fruits (drupes) for 2017, 2018, and 2019 was mid-October (Fig. 13). Laurel wilt is present at Grand Bay NWR/NERR although red bay #3 continues to survive and it produced between 11-100 drupes in 2019. At the Pascagoula River Audubon Center, red bay #1 and reb bay #2 produced between 11-100 drupes each in 2019.

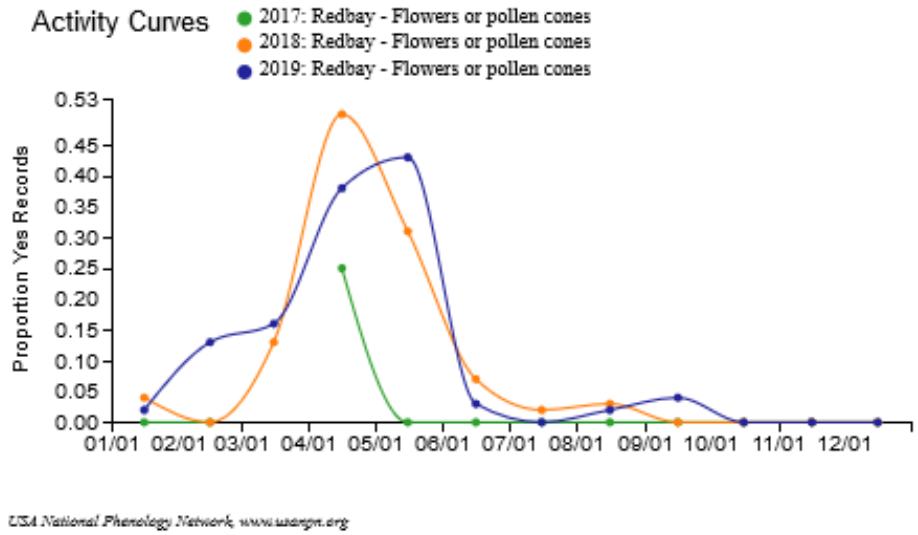


Figure 12. Acitivity curve for “yes” observations for red bay flowers in 2017-2018.

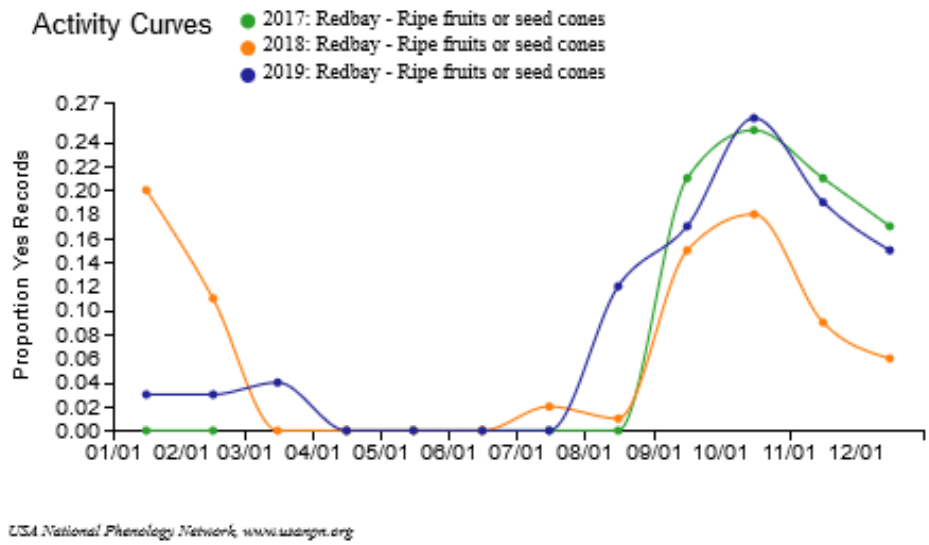


Figure 13. Acitivity curve for "yes" observations for red bay ripe fruits in 2017-2018.

Yaupon Holly


Figure 14. From left to right, female yaupon holly in bloom and with ripe berries. *Photos © G. Bishop*

Yaupon holly is a broadleaf evergreen native to the Southeastern U.S. and is dioecious. Only the female flowers produce berries. On the Trail, leaf buds and new leaves continue to emerge through the year especially when a terminal end is removed. Yaupon holly flowers peaked at the end of April in 2017 and 2018 and in early March in 2019 (Fig. 15). The peak of ripe fruits was in January in 2017, late December in 2018, and late February in 2019 (Fig. 16).

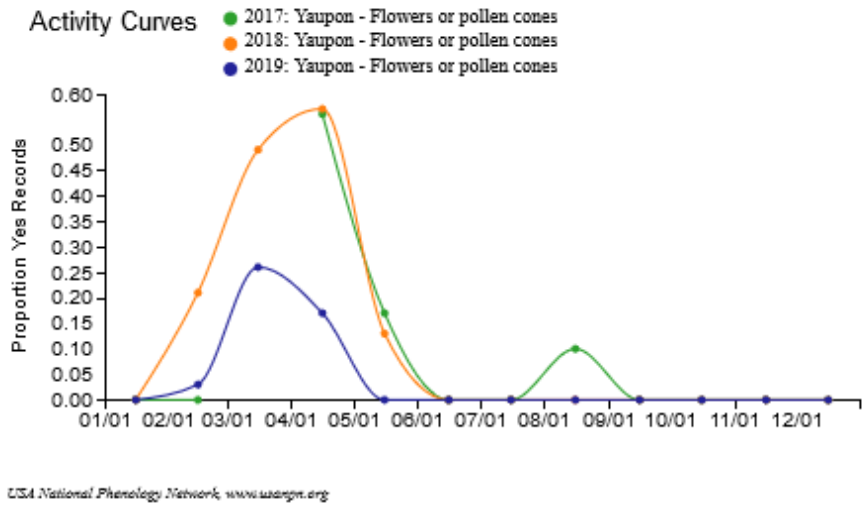


Figure 15. Activity curve showing the proportion of individual yaupon holly trees with "yes" records reported for flowers or flower buds in 2017 -2019.

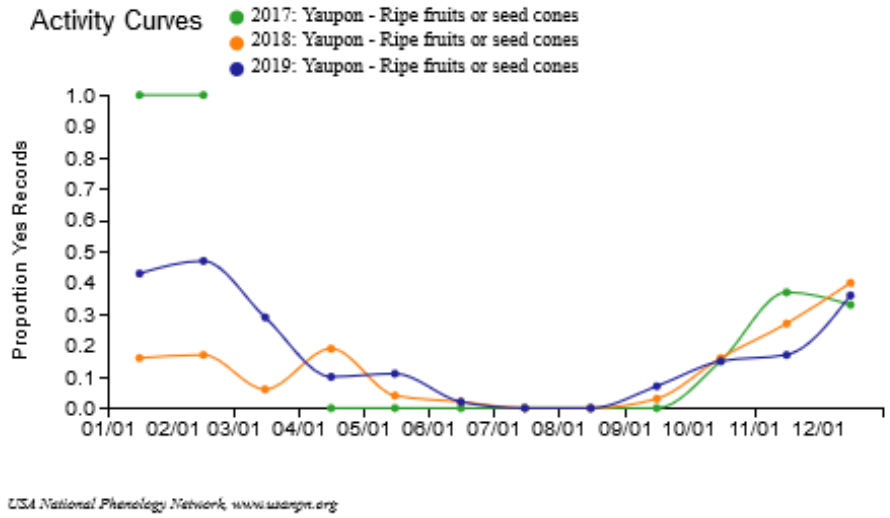


Figure 16. Activity curve showing the proportion of individual yaupon holly trees with "yes" records reported for ripe fruit in 2017 -2019.

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

Figure 17. From left to right, red maple leaves, Chinese tallow leaves. *Photos © G. Bishop*

Chinese tallow and red maple are the only two focal species monitored on the Trail that are deciduous. For the past three years, initial growth in red maples has peaked in mid-March (Fig. 18, 19, 20) while Chinese tallows have peaked at different times: mid-May in 2017, mid-June in 2018, and mid-March in 2019 (Fig. 18, 19, 20). In all years, both plants also showed initial leaf growth in February or March but had additional leaf growth throughout the year. Several of the red maples and Chinese tallow were cut and regrew. Several plants were initallly impacted by prescribed fires but later sprouted.

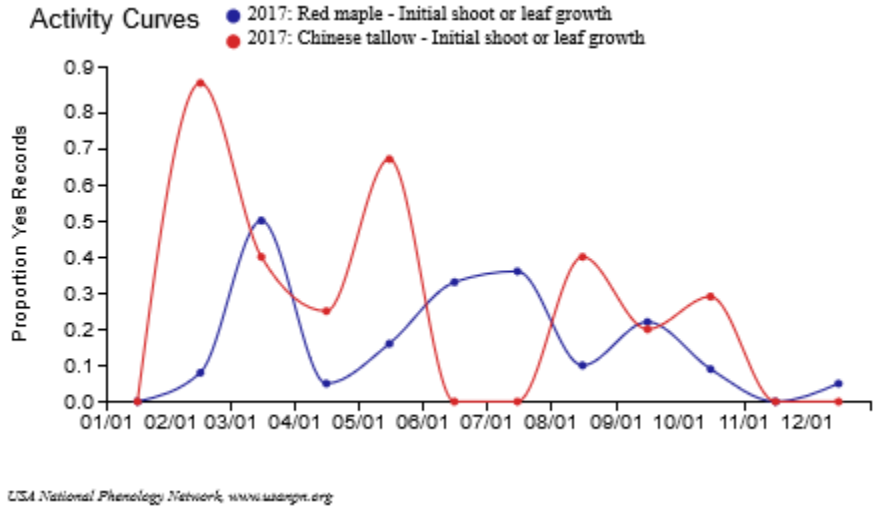


Figure 18. Activity curve showing the proportion of individual Chinese tallow trees with “yes” records reported for initial shoot or leaf growth compared to red maple in 2017.

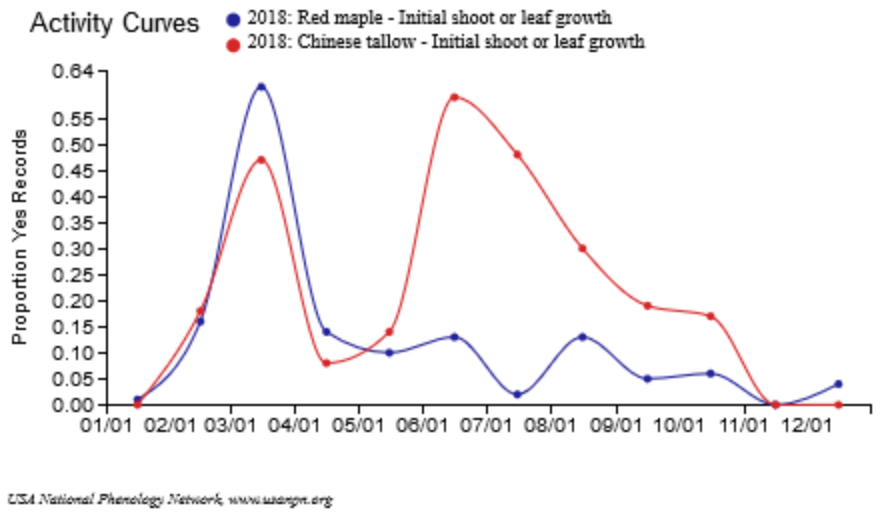


Figure 19. Activity curve showing the proportion of individual Chinese tallow trees with "yes" records reported for initial shoot or leaf growth compared to red maple in 2018.

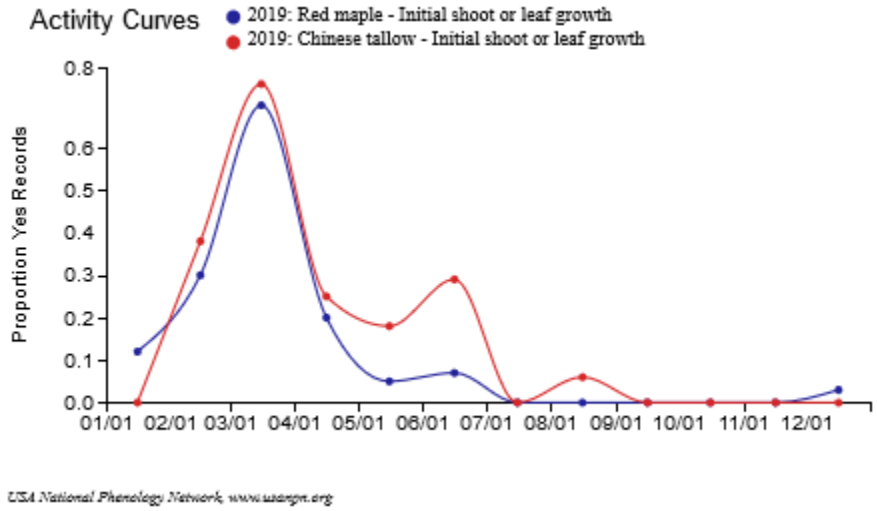


Figure 20. Activity curve showing the proportion of individual Chinese tallow trees with "yes" records reported for initial shoot or leaf growth compared to red maple in 2019.

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. 21, 22, 23). Red maple flowers peaked in early January (2017, 2019) or mid February (2018) while Chinese tallow flowers peaked in mid-May for all years (2017-2019).

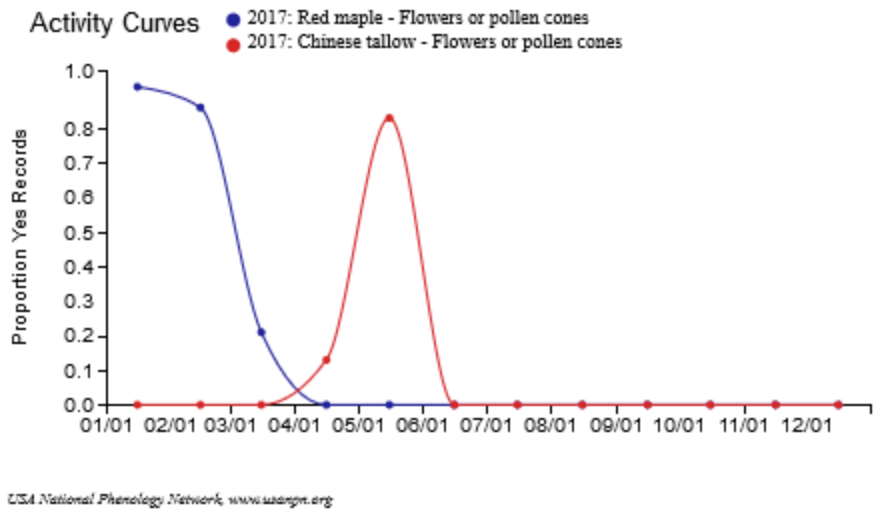


Figure 21. Activity curve showing the proportion of trees with a "yes" reported for flowers or flower buds for Chinese tallow and red maple in 2017.

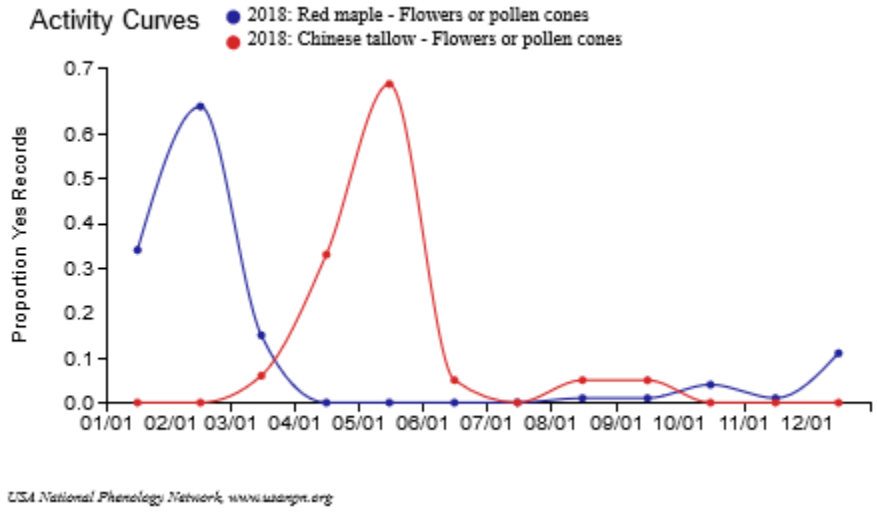


Figure 22. Activity curve showing the proportion of trees with a "yes" reported for flowers or flower buds for Chinese tallow and red maple in 2018.

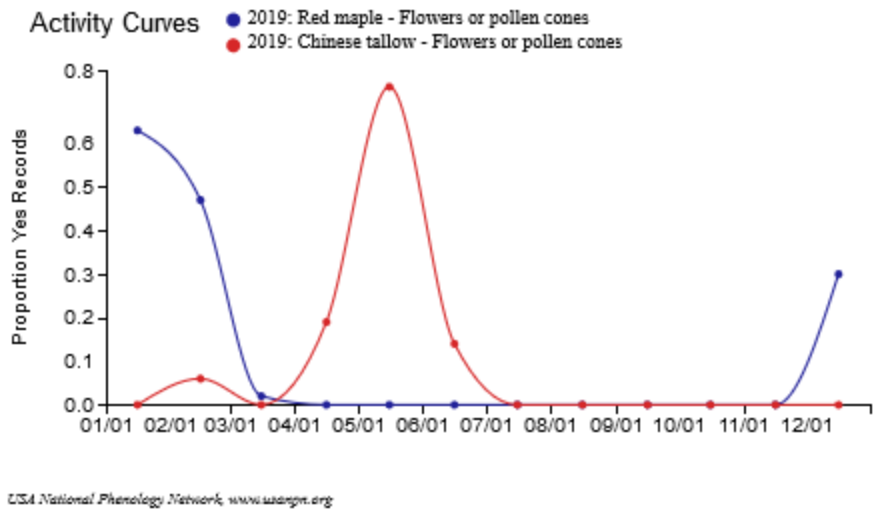


Figure 23. Activity curve showing the proportion of trees with a "yes" reported for flowers or flower buds for Chinese tallow and red maple in 2019.

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

Figure 24. Monarch butterflies on eastern baccharis. *Photo ©Chris Feurt at Grand Bay NWR/NERR on November 3, 2019.*

We will need many years of data before we can fully answer this 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. The fall peak in flowering of eastern baccharis overlaps with the fall activity of monarch butterflies (Fig. 25, 26), though we did not record flowers in the monarch's summer period of activity. Monarchs may be relying on other nectar sources during the summer season.

We regularly report 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.

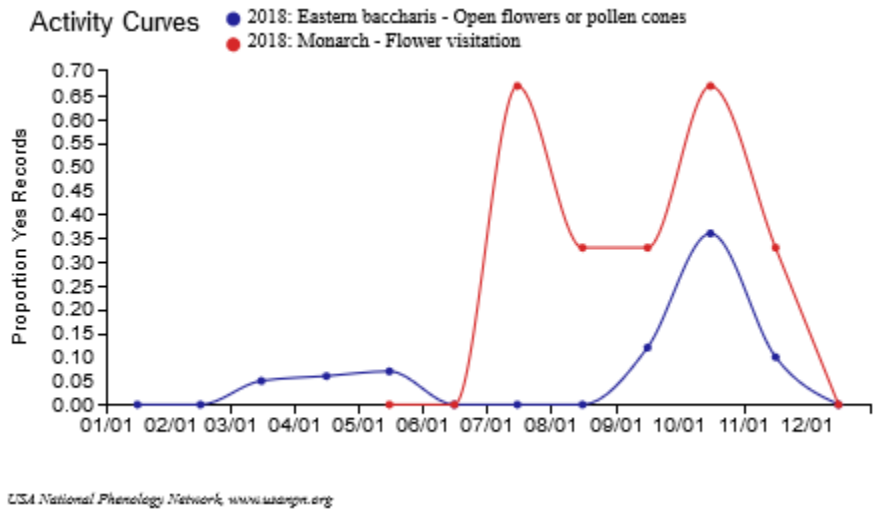


Figure 25. Activity curve showing the occurrence of monarch butterflies and occurrence of open eastern baccharis flowers in 2018.

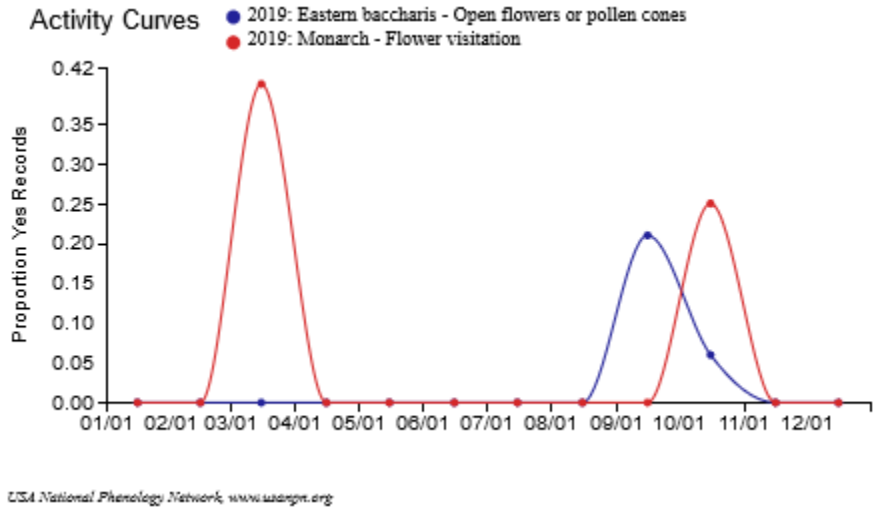


Figure 26. Activity curve showing the occurrence of monarch butterflies and occurrence of open eastern baccharis flowers in 2019.

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 Lousisana sites, red maple flowering peaked in early January in 2017 and 2019 and in mid-

February in 2018 (Fig. 27). At Mississippi sites, red maple flowering peaked in mid-February in all years.

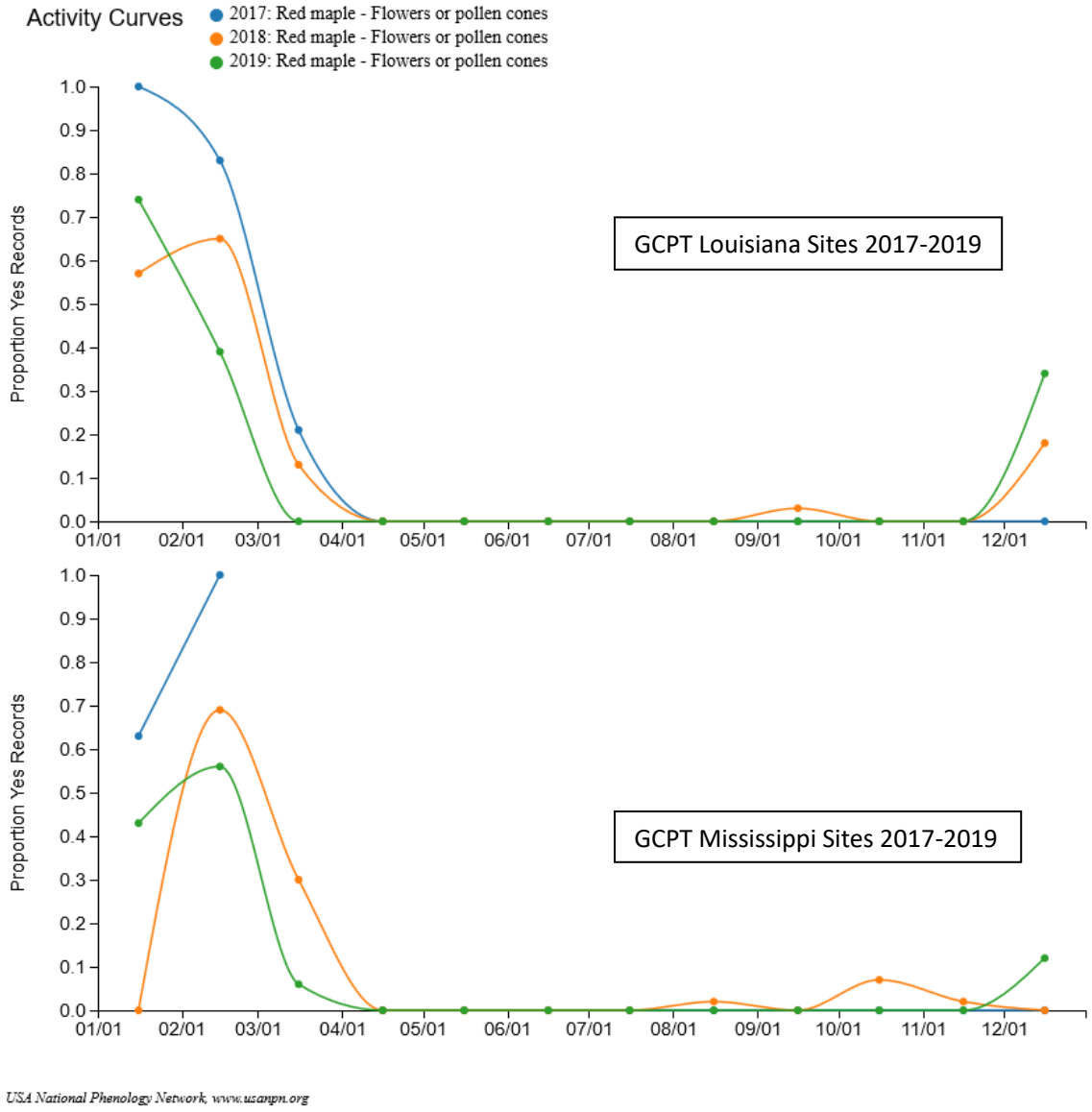


Figure 27. West-East comparison of the proportion of "yes" records reported for red maple flowers or flower buds in 2017, 2018, and 2019 for Louisiana sites (top) and Mississippi sites (bottom).

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 (Fig. 28) and red maple (Fig. 29) varied by

several months in 2019. Once we have additional years of data, we will be able to make statistical comparisons of phenology between sites.

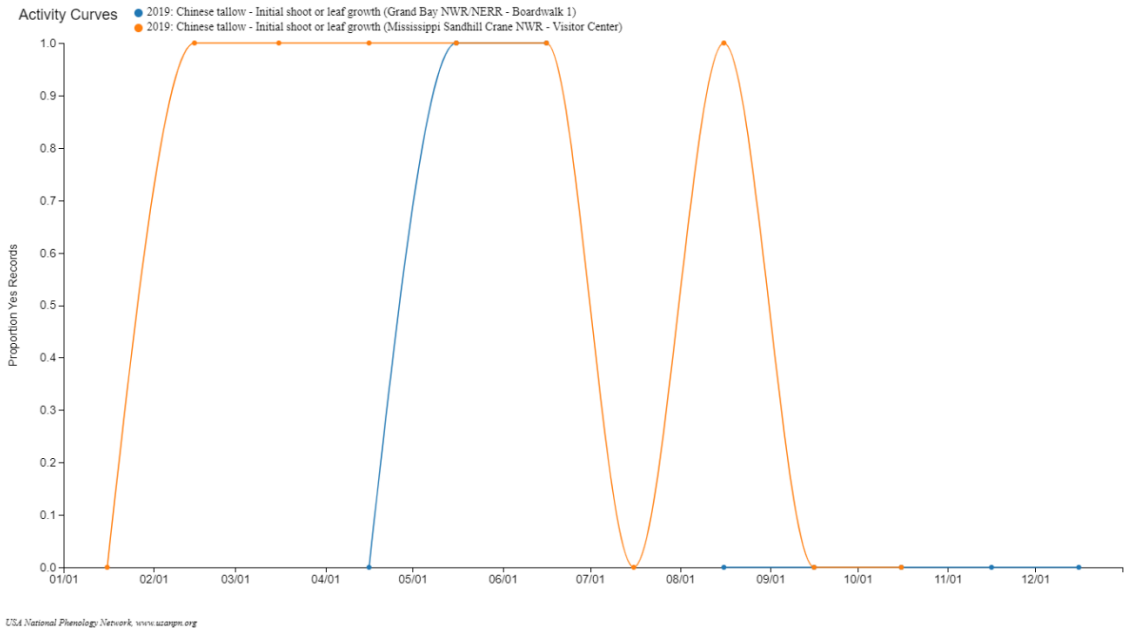


Figure 28. Activity curve showing the proportion of trees with a "yes" reported for initial growth in Chinese tallow at Grand Bay NWR/NERR and Mississippi Sandhill Crane NWR in 2019.

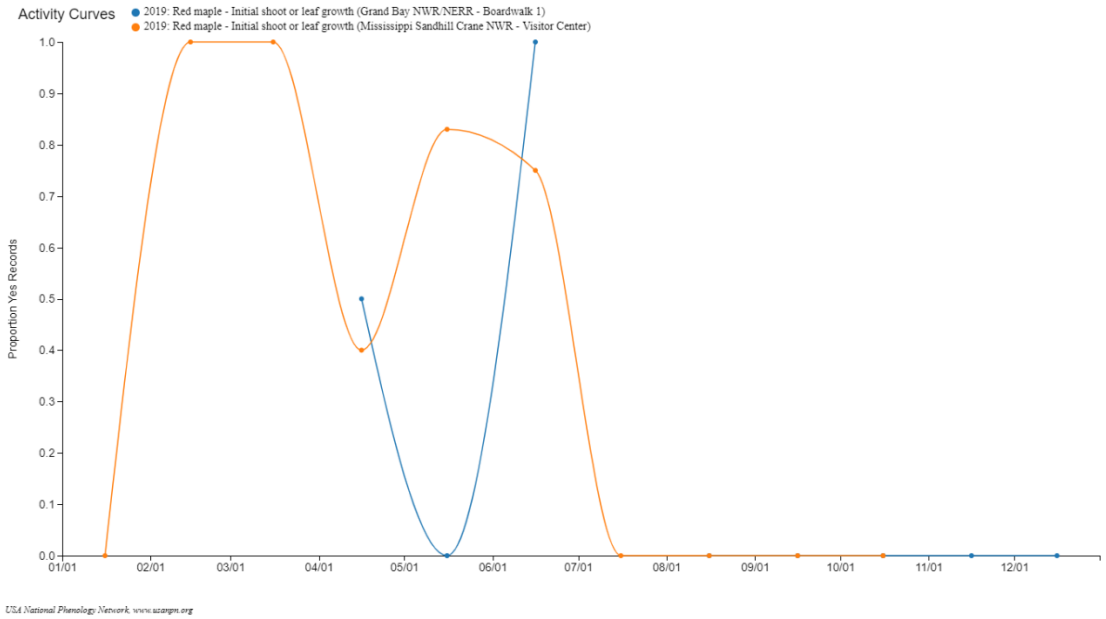


Figure 29. Activity curve showing the proportion of trees with a "yes" reported for initial growth in red maple at Grand Bay NWR/NERR and Mississippi Sandhill Crane NWR in 2019.

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

Two of the sites, Grand Bay NWR/NERR and Mississippi Sandhill Crane NWR, manage savannah habitats which include prescribed fires and mechanical clearing. At the Mississippi Sandhill Crane NWR's Visitor Center Trail, two prescribed burns on April 3, 2019 and May 9, 2019 impacted almost half of the observed plants. After five months the plants resprouted; wax myrtle, yaupon holly, and red bay were reported as sprouting from the roots when observations were made on October 17, 2019. They were retagged and monitored again. 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 30. Left - Purple Martin gourds, *Photo © G. Bishop,* Right - Purple Martins, *Photo © author unknown*

Currently our data do not present a clear picture for answering this question about Purple Martins. However, based on the graph (Fig. 31) Purple Martins were recorded in mid-February in 2017, 2018, and 2019. Of the past three years, the longest duration of Purple Martin activity was recorded in 2018. Purple Martins are observed only at the Grand Bay NWR/NERR where a pole with gourds is located. We either will record more data on this species in subsequent years or decide whether we should remove this question from our list.

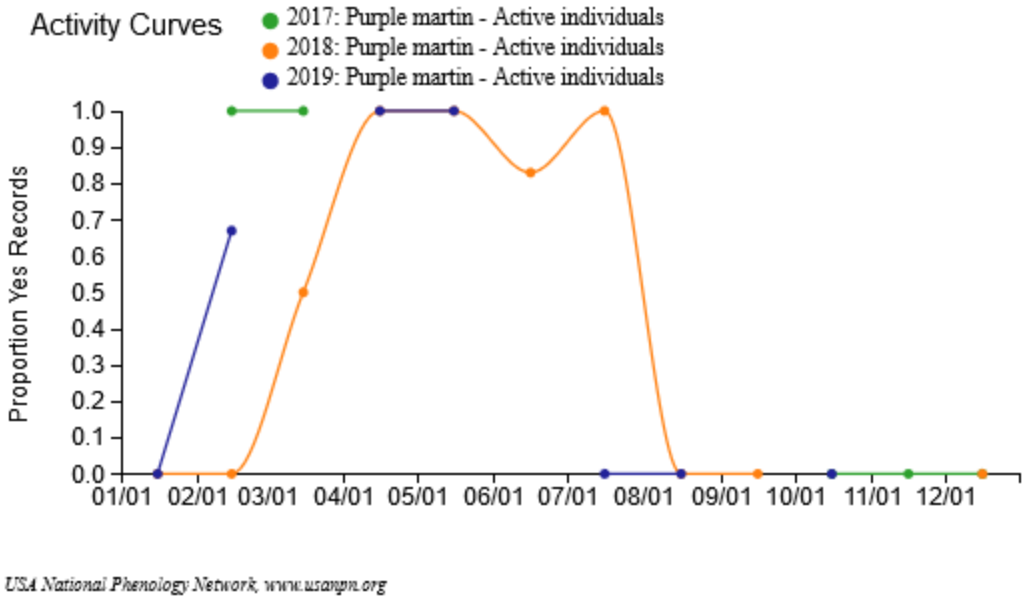


Figure 31. Activity curve for Purple Martin Active Individuals from 2017-2019.

Weather Data Summary

New Orleans, Louisiana

In 2019, eleven months out of twelve were warmer in New Orleans than the 30-year normal (1981-2010). Across months, the average temperature was 2.5 degrees higher. Although half the months were wetter and the half were dryer, the average rainfall for New Orleans was 0.08 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 2019. Departure from 30-year normal is based on years 1981-2010 (NOAA 2020).

Month 2019	Average Temperature (F)	30yr Normal Temperature (F) (red indicates warmer than 30Yr Normal)
January	54.5	53.4 (+1.1)
February	65.1	56.7 (+8.4)
March	63.2	62.6 (+.6)
April	70.0	69.1 (+.9)
May	79.6	76.1 (3.5)
June	84.1	81.5 (+3.6)
July	84.3	83.3 (+1.0)
August	85.5	83.3(+2.2)
September	85.3	79.7 (+5.6)
October	75.5	71.3 (+4.2)
November	60.6	62.7 (-2.1)
December	59.6	55.6 (+4.0)
Annual Mean	72.3	69.7 (+2.5)

Table 4. Precipitation summary table for New Orleans, Lou. Weather Station in 2019. Departure from 30-year normal is based on years 1981-2010 (NOAA 2020).

Month 2019	Total Precipitation (in.)	30yr Normal Temperature (F) (red indicates warmer than 30Yr Normal)
January	4.40	5.15 (-.75)
February	6.11	5.30 (+.81)
March	1.67	4.55 (-2.88)
April	6.81	4.61 (+2.88)
May	8.04	4.63 (+3.41)
June	4.32	8.01 (-3.69)
July	11.52	5.93 (+5.59)
August	3.89	5.98 (-2.09)
September	0.19	4.97 (-4.78)
October	12.46	3.54 (+8.92)
November	0.29	4.49 (-4.20)
December	2.83	5.24 (-2.41)
Annual Mean	62.53	62.45 (+.08)

Gulfport, Mississippi

In 2019, eleven months out of twelve were warmer in Gulfport than the 30-year normal (1981-2010). Across months, the average temperature was 2.0 degrees warmer. Although April, August and October were wetter than the 30-year normal rainfall average in the Gulfport, Mississippi recording location. it was dryer in 2019 by 15.49 inches (Table 5 and 6).

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).

Month 2019	Average Temperature (F)	30yr Normal Temperature (F) (red indicates warmer than 30Yr Normal)
January	51.3	50.8 (+.5)
February	62.1	53.8 (+8.3)
March	60.1	50.1 (10.)
April	66.5	57.4 (+9.1)
May	77.5	74.3 (+3.2)
June	82.4	80.3 (+2.1)
July	83.2	82.4 (+.8)
August	83.3	82.4 (+.9)
September	83.2	78.2 (+5.)
October	73.0	69.2 (+3.8)
November	56.5	60.3 (-3.8)
December	55.9	53.1 (+2.8)
Annual Mean	69.6	67.6(+2.0)

Table 6. Precipitation summary table for Gulfport, Miss. Weather Station in 2019. Departure from 30-year normal is based on years 1981-2010 (NOAA 2020).

Month 2019	Total Precipitation (in.)	30yr Total Precipitation (in.). Red indicates higher than Normal
January	4.43	5.19 (-.76)
February	3.31	5.23 (-1.92)
March	1.34	5.99 (-4.65)
April	6.62	4.56 (+2.06)
May	4.09	5.11 (-2.02)
June	3.02	6.39 (-3.37)
July	6.17	7.21 (-1.04)
August	7.27	6.28 (+.99)
September	0.69	5.63 (-4.84)
October	9.50	3.55 (+5.95)
November	0.68	4.64 (-3.96)
December	2.07	4.90 (-2.83)
Annual Total	49.19	64.68 (-15.49)

Mobile, Alabama

In 2019, eleven months out of twelve were warmer in Mobile than the 30-year normal (1981-2010). Across months, the average temperature was 2.4 degrees higher. Perception was wetter than normal for six months and dryer than normal for six months. Overall the average precipitation amount was 1.45 less 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 2019	Average Temperature (F)	30yr Normal Temperature (F) (red indicates warmer than 30Yr Normal)
January	51.6	50.4 (+1.2)
February	62.9	53.8 (+9.1)
March	60.3	60.2 (+.1)
April	66.7	66.4 (+.3)
May	77.3	74.1 (+3.2)
June	81.6	79.8 (+1.8)
July	83.1	81.8 (+1.3)
August	83.4	81.6 (+1.8)
September	83.2	77.5 (+5.7)
October	72.7	68.4 (+4.3)
November	57.3	59.6 (-2.3)
December	55.4	52.4 (+3.0)
Annual Mean	69.6	67.2 (+2.4)

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 2019	Total Precipitation (in.)	30yr Total Precipitation (in.). Red indicates higher than Normal
January	4.27	5.65 (-1.38)
February	5.22	5.12 (+0.10)
March	1.62	6.14 (-4.52)
April	6.31	4.79 (+1.52)
May	3.86	5.14 (-1.28)
June	6.66	6.11 (0.55)
July	6.24	7.25 (-1.01)
August	10.68	6.96 (+3.72)
September	1.57	5.11 (-3.54)
October	11.13	3.69 (+7.44)
November	1.27	5.13 (-3.86)
December	5.87	5.06 (+0.81)
Annual Total	64.70	66.15 (-1.45)

Education and Outreach

Figure 32. Left - National Phenology Local Phenology Leaders Workshop, Right - Mississippi Sandhill Crane Refuge "Crane Fest" Festival *Photo © J. Buchannan*.

In 2019, we focused on education, local recruitment and training, and participated in community events in multiple locations. Three additional partners were added to the Trail including University of Southern Mississippi Long Beach Campus in Harrison County, Miss.; McLeod Park in Hancock County, Miss.; and New Orleans City Park in Orleans Parish, Lousiana. There are now 12 partners on the Trail.

We met with student leaders and staff at the University of Southern Mississippi Long Beach Campus to discuss establishing a phenology trail. Trail Coordinator Gail Bishop met the faculty advisor, Dr. Michael Carney, for the Pine Restoration Trail at the Mississippi Gulf Coast Community College Gautier Campus and talked to his students about *Nature's Notebook*. A student continued to participate in making observations as she did in 2018. Approximately 30 Ocean Springs Middle School science students made spring observations with trained adult observers at the Fontainbleu Trail at the Mississippi Sandhill Crane NWR.

Local recruitment was informal in 2019 and new observers were trained by the Trail Coordinator or the Science Advisor Dr. Sue Wilder. Observers from partner sites in Mississippi visited the Barataria National Preserve and joined observers there for a field trip. It gave the volunteers opportunities to ask questions and see another phenology trail location.

The first Local Phenology Leaders Workshop and Clinic was held at the Grand Bay NWR/NERR and the Mississippi Sandhill Crane NWR in Jackson County, Mississippi in October. About 20 leaders from across the United States were represented for the 3-day workshop led by Lorianne Barnett, Education Coordinator for the USA National Phenology Network and *Nature's Notebook*. Assistance was provided by Refuge Ranger Melissa Perez from the Mississippi Sandhill Crane NWR and Assistant Director Margo Postem from the Grand Bay NWR/NERR.

The Trail Coordinator presented a *Nature's Notebook* PowerPoint for the Pinewoods Audubon Chapter in Hattiesburg, Mississippi for 20 people. Although that chapter is located out of our coastal region, members were interested in learning about the ways they could participate as citizen scientists at home. In addition to that Audbon Chapter, the Trail Coordinator and Science Advisor attended a "Climate Watch" program led by the Coastal Audubon Stewardship Program to learn if the Trail observers could assist the National Audubon with gathering data

on bluebirds or brown nutches. Informal talks on *Nature's Notebook* were presented at a political "Meet and Mingle on Citizen Science," Mississippi Native Plant Society, and at an Audubon luncheon. Participation in special events were held at the "Swamp Science Festival"at the Barataria Preserve in Barataria, Louisiana: "Estuarine Day" at the Grand Bay NWR/NERR in Moss Point, Mississippi; "Sandhill Crane Festival" at the Mississippi Sandhill Crane Festival, in Gautier, Mississippi; and "Wild Things Festival" at the Southeastern Lousiana Refuges in LaCombe, Lousiana.

Dr. Sue Wilder, science advisor, presented an online session about our work for the United States Fish and Wildlife Refuge National Conservation Training Center's Citizen Science Course in August, 2019. We communicated with Dr. Joydeep Bhattacharjee at the University of Louisiana-Monroe about the Trail and suggested ways her department could set up observations sites to monitor.

Lessons Learned 2019

1. After three years of data collection, we revisited our focal species and created an updated list based on the needs of natural resource managers such as National Wildlife Refuge staff:
   - Trees: red maple
   - Shrubs: red bay, wax myrtle, yaupon holly, eastern baccharis
   - Herbs: purple passionflower- *Passiflora incarnata*, pitcher plants - *Sarracenia alata, Sarracenia psittacina*
   - Invasive plants: Chinese tallow
   - Animals: Purple Martins, monarchs, Gulf frittilaries
2. We added new partners to the Trail in 2019, some of which had their own priorities species for phenology observations. For those species that are not priority species of the Trail and therefore not included in this report, we recommend that Local Phenology Leaders for those partners use the USA National Phenology Networks online tools to download, visualize, and summarize their data.
3. Workshops and/or field trips should continue for current volunteer observers. These activities provide opportunities to network and maintain engagement in the program.
4. At savannah sites, selected species for observation are occasionally impacted by managed prescribed fires and/or mechanical clearing or brushing. Tags and flagging are often chopped or destroyed making finding the plants difficult for future observations. Most plants do experience basal sprouting and can be observed again, with a comment about the damage added to *Nature's Notebook*. Accurate GPS coordinates can assist the observer when trying to relocate the plants.
5. Ideally, making observations early in the morning will make it easier for observers to view animal activity.
6. Retaining volunteers is an issue regardless of the volunteer activity. Making the volunteer activity relevant to individuals is key. Explaining the natural health benefits of being outdoors is another way to maintain engagement.
7. Our observations of monarch butterfly and eastern baccharis over the past two years suggest that there may be a mismatch. This information has led to additional questions about other species that migrate and are dependent on specific plants for nourishment.

Suggestions from Trail members:

1. Instead of using just the NOAA weather station data available at NOAA.gov, consider also using available weather data from local weather stations at Barataria Preserve and Grand Bay NWR/NERR (https://cdmo.baruch.sc.edu/aqs/index.cfm).
2. Engage the partners more by asking about what kind of phenology information they need for their work.
3. Look for additional funding sources and partners to answer questions such as the *Does the phenology of native plant pollinators match native plant phenology over time under a changing climate?*

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 that began 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 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

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Appendix A. Partner and Observation Sites 2019

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. 2019 Plant Inventory Number of Species

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

Species	BARP	BS	BBM	CR	GB	MP	MSC	MGCCC	NOLA-CP	PRAC	USM-LB	USM-MEC	TOTAL
American beautyberry	1		3				2		1			2	9
American Elm		2											2
American sycamore									2				2
Bald cypress	4	3							2				9
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					1						7
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
Possumhaw	4												4
Red buckeye										3			3
Red maple	4	7	9	3	7	3	7	3	1	2	1	3	50
Redbay		3		4	5		6	3	2	2		4	29
Southern magnolia			3						1				4
Sugarberry	1												1
Sweetbay						1	1				3		5
Sweetgum	5	2							1				8
Trumpet creeper	4												4
Water tupelo	2												2
Wax myrtle	4		5	4	4	3	10	2		4		3	39
Virginia crownbeard	1												1
Yaupon holly			4	3	4	4	8	2		4		4	44
TOTAL	48	28	29	23	23	13	43	12	12	15	11	16	

Appendix C. 2019 Animal Inventory

BARP -Barataria Preserve (Jean LaFitte NPP)
BS-Bayou Sauvage
BBM-Big Branch
MSC-Miss.Sandhill
PRAC Pascagoula River Audubon Center

Species	BARP	BS	BBM	MSC	PRAC	TOTAL Sites
Birds						
American Robin		x		x		2
Bald Eagle	x					1
Blue Jay				x		2
Carolina Wren	x					1
Chimney Swift					x	1
Eastern Bluebird				x	x	2
Hooded Warbler						1
Northern Mockingbird				x		1
Northern Parulla	x					1
Osprey				x		1
Purple Martin					x	1
Ruby-crowned Kinglet					x	1
Ruby-throated Hummingbird					x	1
Sandhill Crane				x		1
Tufted Titmouse				x		1
Yellow Rumped Warbler		x			x	2
Insects						
Gulf fritillary		x				1
Monarch		x	x			2
TOTAL Species	3	4	1	7	6	

Appendix D. 2019 Gulf Coast Phenology Trail Site Visits