Butterfly Garden Phenology: A Pilot Year Study

Jug Bay Wetlands Sanctuary

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Abstract

Phenology is the study of the timing of the recurring life cycle stages, or phenophases, of plants and animals, and the study of phenology is particularly important as a 21st-century science because phenology records can help us understand ecological responses to climate change. Butterflies are one group of animals that have been found to be affected by climate change. A notable 2012 study explored changes in butterfly phenology using data from butterfly surveys conducted by amateur naturalists to estimate population trends, a project that could be conducted by volunteers at Jug Bay Wetlands Sanctuary and help to accomplish the Sanctuary's goals for public engagement in climate change research. Using the USA National Phenology Network's citizen science program Nature's Notebook as a starting point and guide, a plant and butterfly phenology data collection program was piloted at Jug Bay in the 2013 season. Although pilot-year results examining the relationship between weather and butterfly abundance were not significant, summary observations are presented in this report along with discussions of the limitations of the pilot-year data collection and suggestions for refining and continuing the program into future years with the support of Jug Bay staff and volunteers.

Introduction

Phenology is the study of the timing of the recurring life cycle stages, or phenophases, of plants and animals, such as leafing and flowering, maturation of agricultural plants, emergence of insects, and migration of birds. Historically, phenological events have been recorded by farmers, gardeners, and other communities dependent on seasonally recurring phenomena for their livelihoods and survival. However, the study of phenology is particularly important as a 21st-century science because phenology records can help us understand ecological responses to climate change.

Alterations in phenological events like flowering and bird migrations are among the most sensitive biological responses to climate change, and when the timing of events like flowering and migrations change, they perturb ecosystems and alter ecological interactions and processes like pollination and carbon cycling. Phenologists have noticed that across the world, many spring events are occurring earlier and fall events are happening later than they did in the past. Not all species are changing at the same rate, and some are not changing at all (USA National Phenology Network, 2013). Phenology data can help scientists identify which species are changing and how to better predict and manage the impact of these changes on natural systems.

Butterflies are one group of animals that have been found to be affected by climate change. A 2012 study by researchers at Harvard University of 100 butterfly species in Massachusetts revealed population expansions and declines near species' range limits and correlations between species declines and the life stage at which they overwinter (Breed et al., 2012). The results suggest that a major shift of North American butterflies is underway, with warm-adapted species shifting north and cold-adapted species retreating. What is particularly notable about this study, however, is that the researchers used data from butterfly surveys conducted by amateur naturalists to estimate population trends—something that could be done at public preserves such as Jug Bay.

Jug Bay's butterfly garden on the Glendening property, being easily accessible, succinct, and maintained with a high density of plants that are significant to multiple butterfly life stages, is an ideal observation site to conduct butterfly phenology research. Furthermore, because climate change is likely to become a unifying theme of all future research at Jug Bay, engaging the public with this research will become a priority to achieve the Sanctuary's missions. Citizen science programs are an ideal way to accomplish this goal of engagement, and Nature's Notebook, the USA National Phenology Network's citizen science program, provides a ready scientific framework and extensive resources for amateur observers.

Using Nature's Notebook as a starting point and guide, a plant and butterfly phenology data collection program was piloted at Jug Bay in the 2013 season. Summary observations are presented in this report for the baseline year of this study. However, the more significant results from the 2013 season are suggestions for refining and continuing the program into future years with the support of Jug Bay staff and volunteers, enriching the value of the phenology data and the insights that may be gained from it.

Methods

Overview of Nature's Notebook

Nature's Notebook was developed to gather information on plant and animal phenology across the United States to be used for decision making on local, national, and global scales (Nature's Notebook, 2013). The program is appropriate for both scientists and non-scientists, and it is being used by professional researchers, students, and citizens to collect phenology observations.

Nature's Notebook has several components:

- *A set of scientifically vetted observation protocols.* These protocols are outlined in their publication *How to Observe*, a phenology handbook that aims to standardize observation methods for the program.
- *Nature's Notebook website and Observation Deck.* A dynamic website that provides resources for observers, including a customized data entry interface, online data visualization tools, printable data sheets (Appendix A), phenophase guides for specific species (Appendix B), links to articles in primary literature that use Nature's Notebook data, and others.

The basic methodology for this study followed the Nature's Notebook observation protocol (USA National Phenology Network, 2010), and data were entered online to contribute to the national data collection effort for selected species.

Observation Site

The initial step in the study was to define an observation site, the approximately 300-m^2 butterfly garden adjacent to Plummer House on Jug Bay's Glendening Property (Figures 1 and 2). The butterfly garden contains species that are important to butterflies as caterpillar hosts or adult nectar sources (Appendix C), and they have been maintained by Jug Bay staff and volunteers since 2008. The garden was supplemented with Leafgro early in the season, minimally watered throughout the growing season, and weeded weekly to semi-weekly by volunteers and Jug Bay staff.

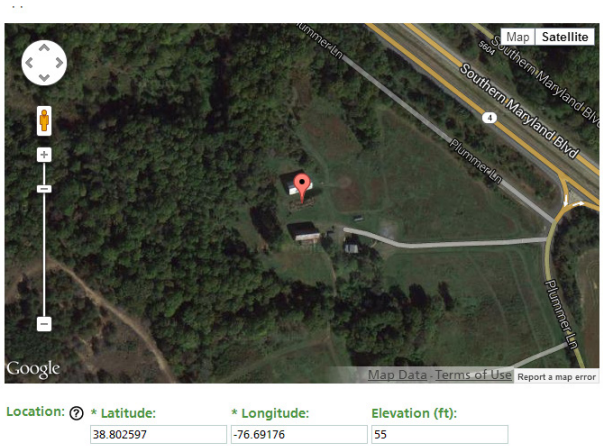

Figure 1. Satellite image of Jug Bay butterfly garden and surrounding area (from Nature's Notebook).

Figure 2. Satellite image of Jug Bay Wetlands Sanctuary showing location of butterfly garden in yellow circle.

Data Collected

Plants

From the list of known species that have been planted in the garden (~90 species), a subset of 18 species were chosen that 1) are of current interest to Nature's Notebook and 2) emerged in the garden in 2013 (Table 1). Plants or clusters of plants were identified and marked with flagging. A 2-m square transect was also used to grid the area and help in drawing up a map of the garden to aid in finding unfamiliar plants early in the season.

Table 1. Plant species surveyed in Jug Bay butterfly garden phenology study.

Scientific Name	Common Name
Aquilegia canadensis	Red columbine
Asclepias incarnata	Swamp milkweed
Asclepias syriaca	Common milkweed
Asclepias tuberosa	Butterfly milkweed
Aster novae-angliae	New England Aster
Cenoanthus americanus	New Jersey tea
Cephalanthus occidentalis	Common buttonbush
Echinacea purpurea	Eastern purple coneflower
Liatris spicata	Dense blazing star
Lindera benzoin	Northern spicebush
Monarda didyma	Scarlet beebalm
Monarda fistulosa	Wild bergamot
Panicum virgatum	Switchgrass
Passiflora incarnata	Purple passionflower
Salix discolor	Pussy willow
Solidago rugosa	Wrinkleleaf goldenrod
Spigela marilandica	Woodland pinkroot
Vernonia noveboracensis	New York ironweed

Butterflies

To develop a list of expected/possible butterflies to observe in the garden, a list of known species was compiled from existing records maintained by several Jug Bay volunteers. Phenology data were collected for all butterflies seen in the garden, but the subset of 12 species that are of current interest to Nature's Notebook are listed in Table 2.

Table 2. Nature's Notebook butterfly species surveyed in Jug Bay butterfly garden phenology study.

Scientific Name	Common Name
Battus philenor	Pipevine swallowtail
Celastrina ladon	Spring azure (complex)
Cercyonis pegala	Common wood-nymph
Colias eurytheme	Orange sulphur
Cupido comyntas	Eastern tailed-blue
Danaus plexippus	Monarch
Junonia coenia	Common buckeye
Nymphalis antiopa	Mourning cloak
Pholisora catullus	Common sootywing
Pieris rapae	Cabbage white
Speyeria cybele	Great spangled fritillary
Vanessa atalanta	Red admiral

Weather

Weather data, when examined over multiple years, can yield insight into climate trends. To this end, daily weather data from the Jug Bay weather station of the National Estuarine Research Reserve System Centralized Data Management Office Data Export System (http://cdmo.baruch.sc.edu/get/export.cfm) were downloaded into a Microsoft Access database. Parameters are given in Table 3.

Table 3. Weather data parameters collected for Jug Bay phenology study.

Weather Parameter	Units
Min, max, and average air temperature	C
Min, max, and average relative humidity	%
Min, max, and average barometric pressure	mb
Min, max, and average wind speed	m/s
Min, max, and average total photosynthetically active radiation (PAR)	milimoles/m^2
Sum and average of total precipitation	mm
Sum and average cumulative precipitation	mm

Data Collection Protocol

The data collection protocol and resources used are extensively described in the Nature's Notebook publication *How to Observe*, a link to which is given in the references. The following summary notes where protocols for this study differed from or expanded upon those of Nature's Notebook.

Plant survey

Phenophases of Nature's Notebook plants in the garden were surveyed two times a week from May 22 to September 19, 2013, or until the plant was no longer in the garden (due to accidental weeding or herbivory), with at least one day in between surveys. The survey method diverged slightly from that of Nature's Notebook in that Nature's Notebook generally allots each individual plant its own data sheet; for example, red columbine 1, red columbine 2, etc. For this survey, an average phenophase reading was taken of all the individual plants of a given species in the garden, because early in the growing season, it was noted that these averages generally fell within the same range as the individual plants that comprised them, i.e., most plants displayed the same phenophases at the same intensities.

Butterfly survey

Since the goals of the study were to observe as many butterfly species as possible on a given observation day and to record abundance of individuals of each observed species when possible, butterfly surveys were conducted during times of day and conditions when butterflies are expected to be most active, e.g., hot and sunny, especially afternoons. Butterfly phenophases were surveyed in the garden 3-4 days a week from June 4 to September 19, 2013. The Nature's Notebook area search method was used for surveys, namely, multiple passes through the site during an observation day.

Data was also collected on plant use by butterflies and caterpillars. Upon the first observation of an individual of a given butterfly species on a given day, plant on which the animal was observed was recorded on that species' data sheet (Appendix D). A four-letter code that corresponds (in most cases) to the first two letters of the genus and species of the plant was created for all known garden species (see Appendix C).

Results and Discussion

Since phenology is concerned with changes in the absolute and relative timing of phenomena over a series of seasons or other cycles, interpreting the results of a baseline-year study of butterfly garden phenology are somewhat premature. However, the following results from 2013 provide a snapshot of butterfly activity in the garden. Most significantly for this pilot year, in each of the following sections, limitations of the methodology and data are discussed, and suggestions are given for improving the quality of data in future years.

Summary of notable butterfly observations

Table 4 lists several notable butterfly observation details from the 2013 season. Forty-four butterfly species were observed in the Jug Bay butterfly garden in 2013 from June 4 to September 19, 2013 (Appendix E). All but one, southern broken dash, had been observed at Jug Bay before according to historical records (Figure 3).

Table 4. Notable butterfly observation details from 2013.

Parameter	Number
Number of species observed	44 (5 of these as both adults and caterpillars)
Highest count day	July 30, 2013 - 75 individuals
Highest species day	July 26, 2013 - 29 species
Longest observed flight period	107 days
Shortest observed flight period	1 day

Figure 3. Southern broken dash skipper, photographed in the Jug Bay butterfly garden in 2013.

The highest count day, July 30th, yielded 75 individual butterflies. July 30th was also one of the two peak days for observing eastern tiger swallowtails (the other being August 2nd), a species known to be experiencing an irruption year (Bay Weekly, 2013), with 19 individuals of that species observed. July 26th was the peak day for number of species observed, at 29, and that date included one of the species seen on only a single day, the silvery checkerspot.

Five butterfly species were seen over the entire observation period: cabbage white, eastern tailed-blue, eastern tiger swallowtail, orange sulphur, and silver-spotted skipper. Four species were observed on only one day of the season: northern cloudywing, question mark, silvery checkerspot, and viceroy.

Limitations and suggestions

For caterpillars, both identifying and recording abundance on a given day was easy and straightforward. For example, unrolling curled-up spicebush leaves during an area search of the garden often yielded several spicebush swallowtail caterpillars. Finding, identifying, and counting the other four species of caterpillar were similarly straightforward.

Identifying and estimating the abundance of flying adult butterflies, however, was more difficult because:

- Adult butterflies are often in motion.
- Many species are too small and/or similar to one another to be positively identified with the naked eye.
- Using identification tools such as binoculars or a camera limits the number of individuals that can be observed at one time.

To conservatively estimate the abundance of adult butterflies given these challenges, the highest number of a given species was recorded that could be confidently and simultaneously 1) observed and 2) identified from a single vantage point and in a single instance. The precision and confidence of counts varied from species to species. For example, it was relatively easy to identify a great spangled fritillary, a relatively large butterfly with unique field marks, with the naked eye, even at a distance of five feet or more. This combination of attributes permitted several great spangled fritillaries to be identified and counted at one time with a naked-eye scan of the garden from a single vantage point. Scans were repeated several times throughout the day, and the highest number seen at one time became the abundance number for that species for that day.

In contrast, identification and counting is much harder to do for a group of butterflies like the grass skippers, which are small, numerous, and very similar in appearance. In order to positively identify grass skippers, it is often necessary to look at them through binoculars, which limits the number of individuals that can be seen at a given time. As a result, abundance counts of grass skipper species are less precise than those of the larger butterfly species that are more unique in appearance.

Therefore, in estimating the abundance of individual butterfly species, a compromise must be struck between accurate identification and accurate counting. In 2013, a variety of tools and methods were used to aid in correctly identifying butterflies:

- Field guides
- Close-focusing binoculars

- Photography
- Jar capture and refrigeration

A good field guide is essential to learning to correctly identify butterfly species, but other tools, with their strengths and limitations (Table 5), must be used in conjunction with field guides.

Table 5. Strengths and limitations of butterfly identification tools (used in conjunction with field guides).

Identification Tool	Strengths	Limitations
Close-focusing binoculars	Allows close-up observation of field marks, binoculars' wide field of vision makes it easier to track moving animals	Identification must be made on the spot, no voucher for ID
Photography	Allows ID to be made later using photo viewing/editing software, photos serve as vouchers for species on a given date	Camera's narrow field of vision makes it difficult to track moving animals, skill is needed to take good photos that are in focus and show the relevant field marks
Jar capture and refrigeration	Allows close-up observation of field marks, manipulation of the immobilized animal, and photography for vouchers	Method is time consuming and can be difficult, animals may suffer damage in capture and enclosure

Butterfly flight periods

Figure 4 depicts the flight periods for each of the 44 adult butterfly species observed in the garden, with the left end of each bar representing the first date on which a species was observed, and the right end the last date. Some species were observed on only one day, whereas others were present during nearly the entire observation season.

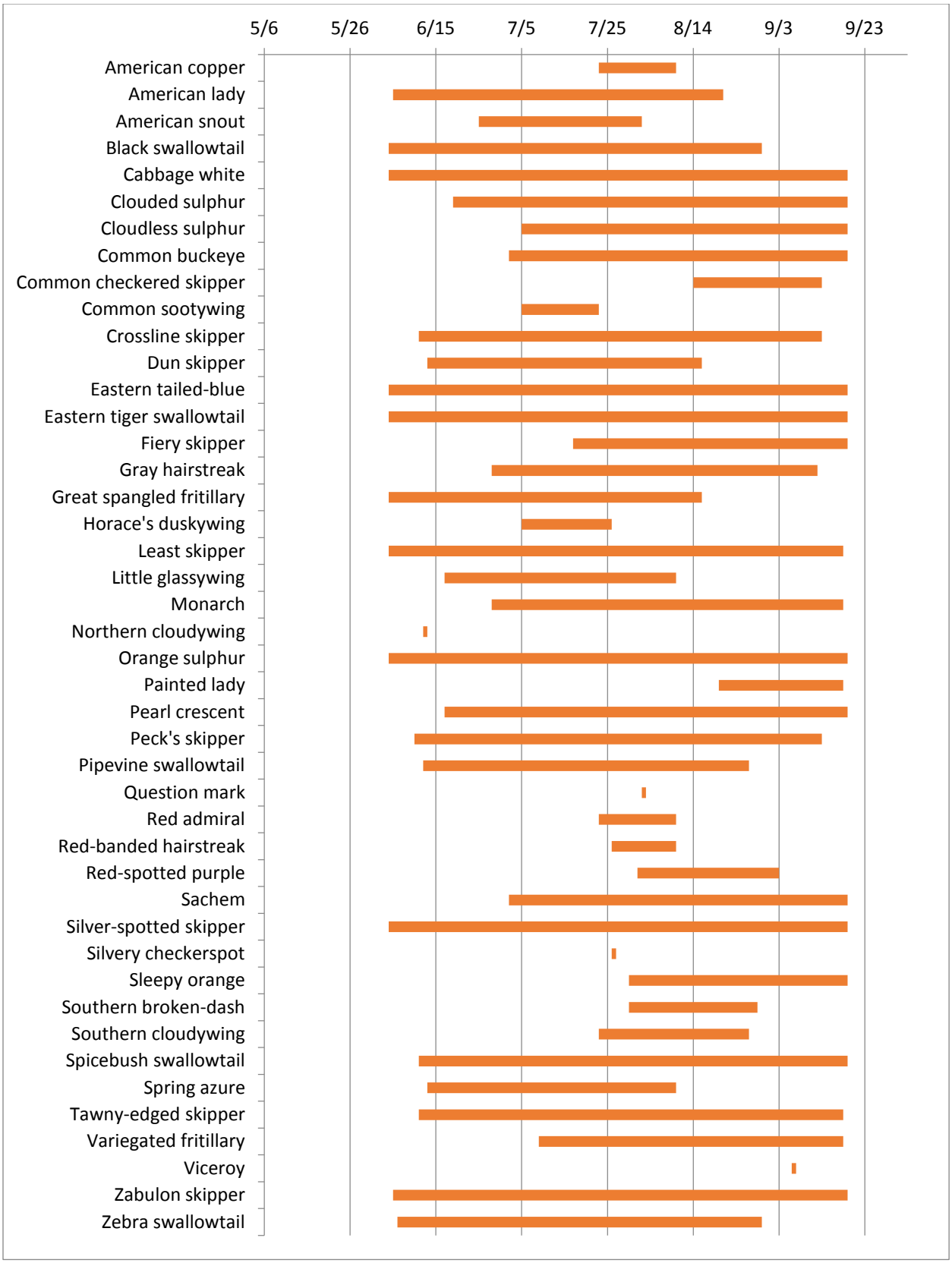

Figure 4. Observed flight periods for adult butterfly species in 2013.

Limitations and suggestions

Because the observation season of this study did not begin until late May and ended in mid-September, it is possible that flight seasons began earlier and/or ended later in 2013 than is reflected in the data. It is also possible that some early-spring-emerging species (e.g., mourning cloak, falcate orangetip) were missed altogether. In future years it is recommended that the study begin earlier in the spring and extend later into the fall to increase the confidence that the full flight periods of all species are being captured.

Examining abundance of individual butterfly species over a flight period may also yield insights into phenology, but estimating butterfly abundance is problematic, as noted in a previous section. More research is needed to find a methodology for estimating abundance that balances feasibility and reliability, especially for continuing the study with volunteer observers.

Caterpillar crawl periods

Five species of caterpillars were observed in the garden in 2013, as shown in Figure 5. Their "crawl periods" ranged from one week (American lady) to almost four months (black swallowtail).

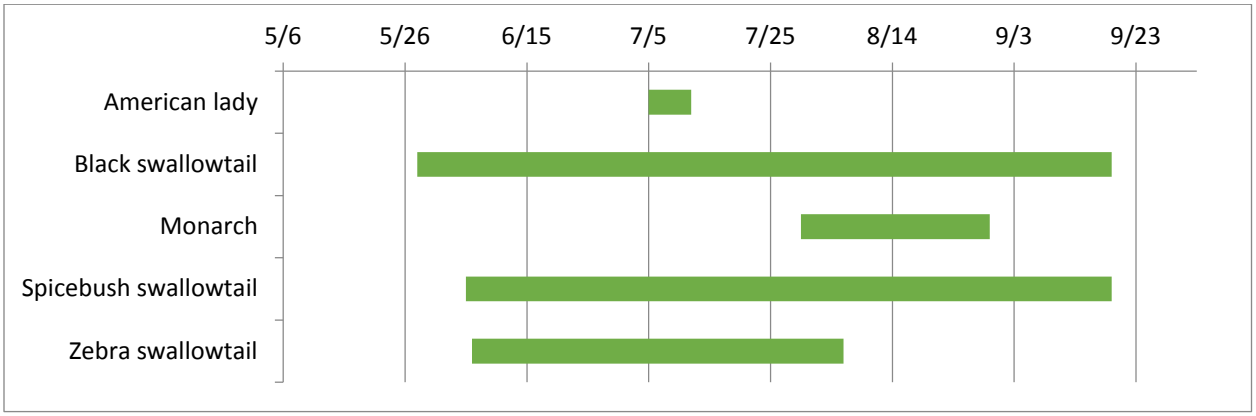

Figure 5. Observed crawl periods for caterpillar species in 2013.

Limitations and suggestions

It is likely that caterpillars were undercounted in the garden. Because many caterpillars are inconspicuous and camouflaged and their habits are generally more secretive than adult butterflies, they can be more challenging to observe. Furthermore, thorough caterpillar searches, especially of cryptic species in dense foliage, are time consuming and can be disruptive (e.g., shaking a host plant with enough force to knock its caterpillars to the ground). More advance training of observers in recognizing possible caterpillars and learning their host plants may increase the likelihood that more caterpillars of more species are found in subsequent years.

Although it is known that some species undergo multiple broods of caterpillars within a season, the beginning and end times of individual broods are not shown in Figure 5, only the beginning date of the first observed brood and the end date of the last observed brood. Examining abundance of caterpillars throughout the season may reveal recognizable brood cycles, which may be the more interesting phenological variable to compare with weather parameters.

Weather and butterfly abundance

Weather and climate differ by their measures of time: weather is concerned with atmospheric conditions over a short period of time, whereas climate is concerned with long-term averages in daily weather. It's often said that climate is what you expect—and weather is what you get (Gutro, 2005). Although weather may affect butterfly activity, climate likely has a greater influence on butterfly abundance and geographic range (Breed et al., 2012).

For this baseline year, an R^2 test was performed to examine the relationship between butterfly abundance and individual weather parameters, but relationships were insignificant in all cases.

Limitations and suggestions

There are many improvements that could be made to the study methodology to increase the usefulness of weather data in making phenological inferences in future years. First, growing degree days (GDD) may be a more significant parameter to examine in relation to butterfly (and caterpillar) abundance than average daily temperature. GDD is a measurement of the growth and development of plants and insects during the growing season (OARDC Extension, 2013), taking into account that development does not occur unless temperature is above a minimum threshold value (base temperature). Although a complex mix of factors influence the actual temperature experienced by an organism, a base temperature of 50°F (10°C) is considered acceptable for all plants and insects and is used in calculating GDD. More research is needed to determine the best way to measure and analyze GDD in the butterfly garden.

The second suggested improvement concerns the appropriateness of the weather data source to the objectives of the study. Although data from the NOAA CDMO are relatively easy to obtain, they may not be specific enough to the study site to be meaningful. Temperature, in particular, may need to be monitored at the actual site of the butterfly garden and at the exact time observations are made. Additional research into the most significant weather parameters and how to measure them effectively onsite is needed.

Summary of recommendations going forward

As anticipated, the most interesting discoveries in the baseline year of the butterfly garden phenology study were not in the results, but in the methodology and larger organizational context: these discoveries have to do with shaking out suggestions for refining the scope, improving the methods, and inspiring a team of supporters to continue, improve, and thereby enrich phenology data for the future. Recommendations are grouped into three categories: methodology and analysis, site maintenance, and volunteer recruitment and training.

Methodology and analysis

1. **For plants, follow the NN protocol exactly.** As the growing season progressed, it was observed that different plants of the same species progressed through their phenophases at different rates, making an "average" phenophase of all plants of that species less acceptable. In future study years, individual plants should be selected, numbered, marked, observed, and recorded on their own individual data sheets for the season to avoid this pitfall. Individual observers can still assign themselves as many individual plants (of the same or multiple species) as they want and can practically manage.

2. **For butterflies, redesign the data sheet to save paper, consolidate observations, and facilitate collecting accurate and usable data.** The pilot phenology season generated a great deal of paper, and locating species data sheets was sometimes inefficient. With a greater understanding of the pace of observation and the species and phenophases likely to be seen, a better data sheet can be designed.
3. **For butterflies, research and refine estimating abundance to find the best methodology.** Because abundance data may yield greater insights into phenology than presence/absence data alone for species, a robust protocol is needed for consistent data that can yield valid comparisons.
4. **Devise an experiment to discover an optimal daily observation period length.** It was observed, anecdotally, that if weather conditions were favorable for flight (i.e., sunny and warm), observing for about an hour generally yielded the same and same number of species as observing for a longer period of time. Formally testing this anecdotal perception would be a good follow-on project. If an optimal observation period can be obtained, then this would help to standardize data collection and impact statistical analysis.
5. **Research and refine the question(s) to be answered by recording plant visitation by butterflies and revise methodology accordingly.** Because following individual butterflies of all species around the garden to observe and record all the plants they land on is impractical and extremely time-consuming, plant visitation data were recorded for only the first individual of a given species-phenophase observed each day. However, recording plant visitation data for only the first instance of a species may be biased and irrelevant to the objective of the study.
6. **Prepare to collect data on degree-days instead of just temperature.** Growing degree days (GDD) are significant to the emergence and activity of invertebrates as well as the flowering of plants. Recording and analyzing degree-days may uncover a more significant relationship between emergence and abundance than temperature on individual days alone and be more significant to phenology.
7. **Compare flight and crawl periods at the Jug Bay butterfly garden with those of other Maryland/local sites if this data exists.** Comparing the phenology of species observed at Jug Bay with other local sites may yield insight into the specific habitat preferences of butterfly species and/or validate the thoroughness of the Jug Bay observation protocol.
8. **Expand the phenology studies beyond the boundaries of the garden.** There are many more species that are not found in the garden, especially spring emergents, that can be observed for NN or for the interest of Jug Bay. The same goes for certain species of butterflies (e.g., common wood-nymph, northern pearly eye, Appalachian brown) that are unlikely to be seen in the garden.

Garden site maintenance

1. **Make an attempt to mark the locations of plants in the garden before they die each fall/winter.** Some research on the best options for durable garden labels/signage is warranted. Ideally, stakes would be tall enough to be able to be located easily ensure that observers would not have to bend over to view them. In 2013, a detailed map was constructed of the locations of plants in the butterfly garden to aid in locating individual species at the beginning of the growing season, but permanent labels would take things even a step farther, increasing the likelihood

that observers can catch the "initial growth" phenophase in Nature's Notebook if they know where to look for each species.

2. **Add QR codes to the signage in the garden.** To expand the usability of the garden, QR codes can be added to signage to give visitors more information about plant species and their significance to butterflies and other pollinators. Links to Jug Bay's website and other resources for recruiting phenology observers could also be included in the codes. QR codes have an advantage over traditional signage in that they are more updateable---by linking to an external website that can be instantly updated, visitors can receive the most timely information about what they are observing and can explore it in greater detail than the space on a traditional sign allows. The design of the website to support the garden QR signage would be an ideal internship project.
3. **Add caterpillar host plant information to signage for applicable plants.** Stating on each plant's label whether it is a caterpillar host plant, and if so, for what species, will help observers come up to speed more quickly to prepare to search for caterpillars. Observers can look up a photo of the caterpillar using a smart phone or field guides and form a search image before they begin inspecting the plant.

Volunteer recruitment and training

1. **Schedule at least two orientation sessions at the beginning of the year.** Orientations could take the form of a slide presentation on Nature's Notebook techniques (1 hour, modeled after or even using a PowerPoint downloaded from the Nature's Notebook website) that would inspire volunteer observers to think about the organisms they want to observe, ask questions, and build excitement about the upcoming season. Scheduling an orientation for the wintertime helps to maintain a connection with visitors to the garden in the previous growing season. In addition, several known butterfly species at Jug Bay (mourning cloak, spring azure, falcate orangetip) fly very early in the spring, and volunteers must be prepared to observe them.
2. **Develop an online system that enables data entry, analysis, and long-term maintenance.** The change in protocol from a single observer to multiple observers within a season necessitates a more robust data storage and analysis system that supports access from multiple locations. A system could be developed and housed on a server maintained by a volunteer, similar to the frog population monitoring application developed by Dr. Jeffrey Campbell, a Jug Bay volunteer (J. Campbell, personal communication).

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Appendices

Appendix A: Sample Nature's Notebook data sheet (forb and butterfly)

Forbs

Directions: Fill in the date and time in the top rows and circle the appropriate letter in the column below.
y (phenophase is occurring); **n** (phenophase is not occurring); **?** (not certain if the phenophase is occurring).
Do not circle anything if you did not check for the phenophase. In the adjacent blank, write in the appropriate measure of intensity or abundance for this phenophase.

nature's notebook

Nickname: common milkweed-1
Species: common milkweed
Site: JB Butterfly Garden
Year: 2013
Observer: null null

	Date:	Date:	Date:	Date:	Date:	Date:	Date:	Date:
Do you see...	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:
Initial growth	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Leaves	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Flowers or flower buds	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Open flowers	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Fruits	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Ripe fruits	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Recent fruit or seed drop	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Check when data entered online:	☐	☐	☐	☐	☐	☐	☐	☐
Comments:								

	Date:	Date:	Date:	Date:	Date:	Date:	Date:	Date:
Do you see...	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:
Initial growth	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Leaves	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Flowers or flower buds	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Open flowers	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Fruits	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Ripe fruits	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Recent fruit or seed drop	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Check when data entered online:	☐	☐	☐	☐	☐	☐	☐	☐
Comments:								

Plant Phenophase Datasheet

Tracking the Pulse of Our Planet
Contact: nco@usanpn.org | More information: www.usanpn.org/how-observe

usa npn

Butterflies

nature's notebook

Species: spring azure
Site: JB Butterfly Garden
Year: 2013
Observer: null null

Directions: Fill in the date and time in the top rows and circle the appropriate letter in the column below.
y (phenophase is occurring); **n** (phenophase is not occurring); **?** (not certain if the phenophase is occurring).
Do not circle anything if you did not check for the phenophase. In the adjacent blank, write in the appropriate measure of intensity or abundance for this phenophase.

	Date:	Date:	Date:	Date:	Date:	Date:	Date:	Date:
Do you see/hear...	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:
Active adults	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Flower visitation	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Mating	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Active caterpillars	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Caterpillars feeding	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Dead caterpillars	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Dead adults	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Individuals at a feeding station	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Individuals in a net	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Check when data entered online:	☐	☐	☐	☐	☐	☐	☐	☐

Comments:

	Date:	Date:	Date:	Date:	Date:	Date:	Date:	Date:
Do you see/hear...	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:
Active adults	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Flower visitation	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Mating	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Active caterpillars	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Caterpillars feeding	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Dead caterpillars	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Dead adults	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Individuals at a feeding station	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Individuals in a net	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____	y n ? ____
Check when data entered online:	☐	☐	☐	☐	☐	☐	☐	☐

Comments:

Animal Phenophase Datasheet

Talking the Pulse of Our Planet

Contact: nco@usanpn.org | More information: www.usanpn.org/how-observe

Appendix B: Sample Nature's Notebook phenophase definition sheet (forb and butterfly)

Red Columbine

(Aquilegia canadensis)

Phenophase Definitions

Directions:
As you report on phenophase status (Y, N or ?) on the datasheets, refer to the definitions on this sheet to find out what you should look for, for each phenophase in each species. To report the intensity of the phenophase, choose the best answer to the question below the phenophase, if one is included. Feel free not to report on phenophases or intensity questions that seem too difficult or time-consuming.

Leaves

Initial growth
New growth of the plant is visible after a period of no growth (winter or drought), either from above-ground buds with green tips, or new green or white shoots breaking through the soil surface. Growth is considered "initial" on each bud or shoot until the first leaf has fully unfolded. For seedlings, "initial" growth includes the presence of the one or two small, round or elongated leaves (cotyledons) before the first true leaf has unfolded.

Leaves
One or more live, fully unfolded leaves are visible on the plant. For seedlings, consider only true leaves and do not count the one or two small, round or elongated leaves (cotyledons) that are found on the stem almost immediately after the seedling germinates. Do not include fully dried or dead leaves.

Flowers

Flowers or flower buds
One or more fresh open or unopened flowers or flower buds are visible on the plant. Include flower buds that are still developing, but do not include wilted or dried flowers.

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.

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.

Common Sootywing

(Pholisora catullus)

Phenophase Definitions

Directions:
As you report on phenophase status (Y, N or ?) on the datasheets, refer to the definitions on this sheet to find out what you should look for, for each phenophase in each species. For reporting animal abundance, if a specific question is included below the phenophase, choose the best answer to the question. If there is no specific question, enter the number of individual animals you observed in each phenophase. Feel free not to report on phenophases or abundances if they seem too difficult or time-consuming.

Activity

Active adults
One or more adults are seen moving about or at rest.

Flower visitation
One or more individuals are seen visiting flowers or flying from flower to flower. If possible, record the name of the plant or describe it in the comments field.

Reproduction

Mating
A male and female are seen coupled in a mating position, usually end to end. This can occur at rest or in flight.

Development

Active caterpillars
One or more caterpillars (larvae) are seen moving about or at rest. When seen on a plant, if possible, record the name of the plant or describe it in the comments field.

Caterpillars feeding
One or more caterpillars are seen feeding. If possible, record the name of the species or substance being eaten or describe it in the comments field.

Dead caterpillars
One or more dead caterpillars are seen, including those found on roads.

Dead adults
One or more dead adults are seen, including those found on roads.

Appendix C: List of butterfly garden plants in 2013, including four-letter codes

Abbrev.	Genus	Species	Common Name
AcFi	*Achillea*	*filipendulina*	Yarrow
AgFo	*Agastache*	*foeniculum*	Anise hyssop
AnMa	*Anaphalis*	*margaritacea*	Pearly everlasting
AnPa	*Antennaria*	*parlinii*	Parlin's pussytoes
AnPl	*Antennaria*	*plantaginfolia*	Plantain-leaf pussytoes
ArAr	*Aronia*	*arbutifolia*	Red chokeberry
AsCu	*Asclepias*	*curassavica*	Tropical milkweed
AsTr	*Asimina*	*triloba*	Pawpaw
AsLa	*Aster*	*laevis*	Smooth aster
AsNB	*Aster*	*novi-belgii*	New York aster
BaAu	*Baptisia*	*australis*	Wild indigo
BoCy	*Boehmeria*	*cylindrical*	False nettle
Bu	*Buddleia*	*sp.*	Butterfly bush
CaMa	*Cassis*	*marilandica*	Wild senna
ChLa	*Chasmanthium*	*latifolium*	River oats
ChGl	*Chelone*	*glabra*	White turtlehead
ClAl	*Clethra*	*alnifolia*	Sweet pepperbush
CoPe	*Comptonia*	*peregrine*	Sweet fern
CoCo	*Conoclinium*	*coelestinum*	Blue mist flower
ElCa	*Elymus*	*canadensis*	Canada wild rye grass
ErSp	*Eragrostis*	*spectabilis*	Purple lovegrass
EuDu	*Eupatorium*	*dubium*	Coastal plain Joe Pye weed
EuFi	*Eupatorium*	*fistulosum*	Joe Pye weed
EuMa	*Eupatorium*	*maculatum*	Spotted Joe Pye weed
EuPu	*Eupatorium*	*purpureum*	Joe Pye weed
FoVu	*Foeniculum*	*vulgare*	Bronze fennel
GoGl	*Gomphrena*	*globosa*	Globe amaranth
HeAu	*Helenium*	*autumnale*	Helen's flower
HeAn	*Helianthus*	*angustifolius*	Swamp sunflower
HiCo	*Hibiscus*	*coccineus*	Scarlet rose mallow
HiLa	*Hibiscus*	*laevis*	Halberdleaf rosemallow
HyDe	*Hypericum*	*densiflorum*	Busy St. Johnswort
ItVi	*Itea*	*virginica*	Virginia sweetspire
LaCa	*Lantana*	*camara*	Lantana
Le	*Leucanthemum*	*sp.*	Shasta daisy
LiMi	*Liatris*	*microcephalis*	Dwarf blazingstar

Abbrev.	Genus	Species	Common Name
LiPi	*Liatris*	*pilosa*	Shaggy blazingstar
LoSi	*Lobelia*	*siphilitica*	Great blue lobelia
LoSe	*Lonicera*	*sempervirens*	Coral honeysuckle
MiRi	*Mimulus*	*ringens*	Allegheny monkeyflower
PeDi	*Penstemon*	*digitalis*	Smooth beardtongue
PeHi	*Penstemon*	*hirsutus*	Hairy beardtongue
PeLa	*Penta*	*lanceolata*	Pentas
PhPa	*Phlox*	*paniculata*	Garden phlox
PyMu	*Pycnanthemum*	*muticum*	Short-toothed mountain mint
PyTe	*Pycnanthemum*	*tenuifolium*	Narrow-leaved mountain mint
RhCo	*Rhus*	*copallina*	Winged sumac
RuFu	*Rudbeckia*	*fulgida*	Black-eyed Susan/Orange coneflower
RuCa	*Ruellia*	*carolinensis*	Slender ruellia
SaEl	*Salvia*	*elegans*	Pineapple sage
SaLy	*Salvia*	*lyrata*	Lyre-leaved sage
SaNe	*Salvia*	*nemorosa*	Meadow sage
ScSc	*Schizachyrium*	*scoparium*	Little bluestem
SoNe	*Solidago*	*nemoralis*	Gray goldenrod
SoSp	*Solidago*	*sphacelata*	Dwarf goldenrod
SoNu	*Sorghastrum*	*nutans*	Indian grass
SpLa	*Spiraea*	*latifolia*	Meadowsweet
TrVi	*Tradescantia*	*virginiana*	Spiderwort
TrFl	*Tridens*	*flavus*	Purpletop grass
VaAn	*Vaccinium*	*angustifolium*	Lowbush blueberry
VaCo	*Vaccinium*	*corybosum*	Highbush blueberry
VeBo	*Verbena*	*bonariensis*	Brazilian verbena
VeHa	*Verbena*	*hastata*	Blue vervain
Ve	*Veronica*	*sp.*	Speedwell
VeVi	*Veronicastrum*	*virginicum*	Culver's root
ViAc	*Viburnum*	*acerifolium*	Maple leaf viburnum
Vi	*Viola*	*sp.*	Violets
ViLa	*Viola*	*labradorica*	Labrador violet
AqCa	*Aquilegia*	*canadensis*	Red columbine
AsIn	*Asclepias*	*incarnata*	Swamp milkweed
AsSy	*Asclepias*	*syriaca*	Common milkweed
AsTu	*Asclepias*	*tuberosa*	Butterfly weed
AsNA	*Aster*	*novae-angliae*	New England aster
CeAm	*Ceanothus*	*americanus*	New Jersey tea
CeOc	*Cephalanthus*	*occidentalis*	Buttonbush

Abbrev.	Genus	Species	Common Name
EcPu	*Echinacea*	*purpurea*	Purple coneflower
LiSp	*Liatris*	*spicata*	Blazingstar
LiBe	*Lindera*	*benzoin*	Spicebush
LoCa	*Lobelia*	*cardinalis*	Cardinal flower
MoDi	*Monarda*	*didyma*	Beebalm
MoFi	*Monarda*	*fistulosa*	Wild bergamot
PaVi	*Panicum*	*virgatum*	Switch grass
PaIn	*Passiflora*	*incarnata*	Passionflower
SaDi	*Salix*	*discolor*	Pussy willow
SoRu	*Solidago*	*rugosa*	Rough-leaved goldenrod
SpMa	*Spigelia*	*marilandica*	Indian pink
VeNo	*Vernonia*	*noveboracensis*	New York ironweed
Zi	*Zinnia*	*sp.*	Zinnia

Appendix D: Sample Jug Bay butterfly datasheet - 2013 design

Butterfly Species:		**Site: Jug Bay Butterfly Garden**		**Year:**		
	Date		**Date**		**Date**	
	Time	**Plant sp. visited**	**Time**	**Plant sp. visited**	**Time**	**Plant sp. visited**
Do you see:						
Active adults	y n ? _____		y n ? _____		y n ? _____	
Flower visitation	y n ? _____		y n ? _____		y n ? _____	
Mating	y n ? _____		y n ? _____		y n ? _____	
Active caterpillars	y n ? _____		y n ? _____		y n ? _____	
Caterpillars feeding	y n ? _____		y n ? _____		y n ? _____	
Dead caterpillars	y n ? _____		y n ? _____		y n ? _____	
Dead adults	y n ? _____		y n ? _____		y n ? _____	
Individuals at a feeding station	y n ? _____		y n ? _____		y n ? _____	
Individuals in a net	y n ? _____		y n ? _____		y n ? _____	
Check when data entered online	☐		☐		☐	
Comments:						
	Date		**Date**		**Date**	
	Time	**Plant sp. visited**	**Time**	**Plant sp. visited**	**Time**	**Plant sp. visited**
Do you see:						
Active adults	y n ? _____		y n ? _____		y n ? _____	
Flower visitation	y n ? _____		y n ? _____		y n ? _____	
Mating	y n ? _____		y n ? _____		y n ? _____	
Active caterpillars	y n ? _____		y n ? _____		y n ? _____	
Caterpillars feeding	y n ? _____		y n ? _____		y n ? _____	
Dead caterpillars	y n ? _____		y n ? _____		y n ? _____	
Dead adults	y n ? _____		y n ? _____		y n ? _____	
Individuals at a feeding station	y n ? _____		y n ? _____		y n ? _____	
Individuals in a net	y n ? _____		y n ? _____		y n ? _____	
Check when data entered online	☐		☐		☐	
Comments:						

Appendix E: List of butterflies observed in garden in 2013

Genus	Species	Common Name	Family
Ancyloxypha	*numitor*	Least skipper	Hesperiidae
Atalopedes	*campestris*	Sachem	Hesperiidae
Epargyreus	*clarus*	Silver-spotted skipper	Hesperiidae
Erynnis	*horatius*	Horace's duskywing	Hesperiidae
Euphytes	*vestris*	Dun skipper	Hesperiidae
Hylephila	*phyleus*	Fiery skipper	Hesperiidae
Poanes	*zabulon*	Zabulon skipper	Hesperiidae
Polites	*peckius*	Peck's skipper	Hesperiidae
Polites	*origenes*	Crossline skipper	Hesperiidae
Polites	*themistocles*	Tawny-edged skipper	Hesperiidae
Pompeius	*verna*	Little glassywing	Hesperiidae
Pyrgus	*communis*	Common checkered skipper	Hesperiidae
Thorybes	*bathyllus*	Southern cloudywing	Hesperiidae
Thorybes	*plyades*	Northern cloudywing	Hesperiidae
Wallengrenia	*otho*	Southern broken dash	Hesperiidae
Pholisora	*catullus*	Common sootywing	Hesperiidae
Calycopsis	*cecrops*	Red-banded hairstreak	Lycaenidae
Lycaena	*phlaeas*	American copper	Lycaenidae
Strymon	*melinus*	Gray hairstreak	Lycaenidae
Cupido	*comyntas*	Eastern tailed-blue	Lycaenidae
Celastrina	*ladon*	Spring azure	Lycaenidae
Chlosyne	*nycteis*	Silvery checkerspot	Nymphalidae
Euptoieta	*claudia*	Variegated fritillary	Nymphalidae
Libytheana	*carinenta*	American snout	Nymphalidae
Limenitis	*arthremis astyanax*	Red-spotted purple	Nymphalidae
Limenitis	*archippus*	Viceroy	Nymphalidae
Phyciodes	*tharos*	Pearl crescent	Nymphalidae
Polygonia	*interrogationis*	Question mark	Nymphalidae
Vanessa	*virginiensis*	American lady	Nymphalidae
Vanessa	*cardui*	Painted lady	Nymphalidae
Danaus	*plexippus*	Monarch	Nymphalidae
Junonia	*coenia*	Common buckeye	Nymphalidae
Speyeria	*cybele*	Great spangled fritillary	Nymphalidae
Vanessa	*atalanta*	Red admiral	Nymphalidae
Eurytides	*marcellus*	Zebra swallowtail	Papilionidae

Genus	Species	Common Name	Family
Papilio	*glaucus*	Eastern tiger swallowtail	Papilionidae
Papilio	*troilus*	Spicebush swallowtail	Papilionidae
Papilio	*polyxenes*	Black swallowtail	Papilionidae
Battus	*philenor*	Pipevine swallowtail	Papilionidae
Colias	*philodice*	Clouded sulphur	Pieridae
Eurema	*nicippe*	Sleepy orange	Pieridae
Phoebis	*sennae*	Cloudless sulphur	Pieridae
Colias	*eurytheme*	Orange sulphur	Pieridae
Pieris	*rapae*	Cabbage white	Pieridae