Ijams Nature Center
Local Phenology Program

A Citizen Science Project
A Partnership with the National Phenology Network

Report covering Activities – 2016 to 2019

Photo by Dean Turley
Ijams Nature Center Local Phenology Program: A Citizen Science Project

Introduction

Phenology refers to the study of recurring plant and animal life cycle stages, such as leafing and flowering, the maturation of agricultural plants, the emergence of insects, and the migration of birds. It also involves understanding the relationship of these life cycle stages to weather and, in the long term, climate.

The USA National Phenology Network (USA_NPN, https://www.usanpn.org/home) was established in 2007 to collect, store, and share phenology data and information. Phenology observations using the USA_NPN protocols were started at Ijams Nature Center in the fall of 2016. The USA_NPN observation protocols involve the regular collection (weekly) data on the status of leaves, flowers, and fruit of canopy and sub-canopy trees, and shrubs. The Ijams phenology observations are made by a team of volunteers that are trained to collect accurate data using the specified protocols. Data collected by these volunteers are uploaded to the USA_NPN database where they are immediately available to the public.

The USA-NPN brings together citizen scientists, government agencies, non-profit groups, educators and students of all ages to monitor the impacts of climate change on plants and animals in the United States. There are over 2,300 active sites in the USA_NPN network across the United States that provide over 400,000 observations annually. Scientists use observational data in the National Phenology Database along with models to understand how responsive species and phenological phases are to changes in climate across time and space and result in over a hundred scientific publications every year. Ijams phenology observations are already an important contribution to this scientific enterprise.

Our phenology information also provides information on the response of Ijams Nature Center ecosystems to changes in environmental and biological conditions. Most importantly, these regular observations provide new information on the biology of many tree species at Ijams. This includes impact of invasive species, response to management for enhancing the recovery of disturbed ecosystems, and monitoring the impact of changing climate on growth and reproduction of the forests at Ijams. Participation in phenology monitoring engages a wide variety of community volunteers and provides useful information on sustainability of Ijams forests, and help guide management decisions. This citizen science program also provides a wealth of information that can be used in hands-on placed-based learning opportunities (e.g. school field trips, service projects) and training (e.g. Tennessee Naturalists) programs.
Ijams Nature Center Phenology Program

In early fall of 2016 we established the first 2 tree plots that include 15 trees with 11 different tree species. In January 2018, 2 additional plots, called Shady Invader plots, were added to better understand the phenology and ecology of 3 species of invasive shrubs compared to 2 species of native understory woody plants. In October 2019 three additional plots were established on the Meads Quarry side of Island Home Ave. Two were established in the Subaru Preserve – one in the riparian zone of Toll Creek, the second in an upland location. The third plot is located in a mature oak-hickory stand on the Hickory trail.

The 7 phenology plots cover a wide variety of Ijams forest ecosystems enduring various types and stages of disturbance. Data from these plots provide important primary information on Ijams ecosystems that can be used to more deeply understand the present status and provide information for understanding future response of trees and shrubs to management, recovery processes, and changing environmental conditions at Ijams. The 3 relatively mature forest tree plots (Secret Pond Trail, River Trail, and Hickory Trail) provide information on 22 tree species. The two Subaru Preserve plots provide monitoring information that may be useful for the restoration of these damaged ecosystems. The 2 Shady Invader plots are a resource for understanding the establishment and expansion of invasive shrubs and may provide information for management to reduce their impact on Ijams ecosystems. Each Shady Invader plot includes individuals of 2 native species and 3 invasive species.

Methods

Monitoring Locations

Ijams Phenology currently has 7 plots – three are tree plots for long term observation and contribute to NPN's goals of understanding climate change impacts. This information is also relevant for Ijams science and education programs. One is located on the Secret Pond Trail, another is at the junction of the North Cove and River Trails, and the third is in the middle of the Hickory Trail property on the south side of Island Home Ave. The Secret Pond plot has 7 trees, the River Trail Plot has 8 trees, and the Hickory Trail has 7 trees. There are 20 different tree species over these three plots.

There are 2 plots that contribute to the understanding of the current and future impact of invasive shrubs. These Shady Invader Plots monitor 5 understory plants – 3 invasive (Amur honeysuckle, privet, multiflora rose) and 2 native (Northern spicebush, flowering dogwood). Both of these are located on the River Trail.
Figure 1. Location of the Ijams Phenology plots north of Island Home Ave. Dark blue dots indicate the 2 tree plots. Light blue dots are the locations for the 2 Shady Invader plots.

Two additional plots are located in the Subaru Preserve and are intended for monitoring potential changes in phenology resulting from restoration management.
Figure 2. Location of Ijams Phenology plots south of Island Home Ave. These plots were established in September of 2019.

Data Collection Procedure

Information packets (one for each plot) describing the location of the plots and positions and photographs of the trees and shrubs in each plot are located in the Hub Room just outside the Lead Naturalists office. These packets contain information on each tree/shrub that aid the volunteers in making observations using the USA_NPN protocols. The data is entered using the Natures Notebook application on smartphones or tablets carried to the locations. Data is automatically uploaded to the USA_NPN database.

The phenology lead volunteer keeps volunteers engaged by communicating with volunteers on a monthly basis with observing tips, data results of interest, scientific results that involve currently collected data. There is a schedule for plot visitation maintained as a Google Drive doc. It also contains contact information for all the volunteers, which allow them to contact each other if they need assistance in visiting plots on schedule. Recruiting and training volunteers is currently done on an ad hoc basis when needed.
The lead volunteer does on-going maintenance and up-keep. Tree and shrub tags can become weathered or vandalized and need periodic checking on heir condition. The information packets for each plot are maintained and are especially for orientation of new volunteers.

Observation Quantity Summaries

Observation quantity information was prepared using the Local Phenology Project Dashboards page (www.usanpn.org/nn/groups/dashboard). There have been a total of 22,878 observations added to the USA_NPN database to date from Ijams Nature Center phenology plots. Table 1 provides details.

Table 1. Quantity of phenology records by plot and year.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Trail Plot</td>
<td>395</td>
<td>2,040</td>
<td>2,614</td>
<td>1,419</td>
<td>6,468</td>
</tr>
<tr>
<td>Secret Pond Trail Plot</td>
<td>640</td>
<td>2,438</td>
<td>2,846</td>
<td>1,927</td>
<td>7,851</td>
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<tr>
<td>Shady Invader 1 Plot</td>
<td>--</td>
<td>--</td>
<td>1,941</td>
<td>1,862</td>
<td>3,803</td>
</tr>
<tr>
<td>Shady Invader 2 Plot</td>
<td>--</td>
<td>--</td>
<td>1,919</td>
<td>1,854</td>
<td>3,773</td>
</tr>
<tr>
<td>Subaru Preserve Creek Plot</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>385</td>
<td>385</td>
</tr>
<tr>
<td>Subaru Preserve Upper Plot</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>370</td>
<td>370</td>
</tr>
<tr>
<td>Hickory Trail Plot</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>228</td>
<td>228</td>
</tr>
<tr>
<td>Totals by Year</td>
<td>1,035</td>
<td>4,478</td>
<td>9,320</td>
<td>8,045</td>
<td>22,878</td>
</tr>
</tbody>
</table>

The following pie charts give a snapshot of the number of phenology records per species and phenophase for 2019. Approximately one-half of the observations are related to the presence and status of leaves. Another one-third of the observations are related to the presence and status of fruits. The remainder of the observations are concerned with flowers. This proportion is largely the same for every year.
Figure 3. Summary for 2019 of the quantity of phenology observation for all of the Ijams plots by phenophase category, and species. Phenophase categories are composites of a larger number of phenophases actually recorded. Leaves includes Breaking leaf buds, Leaves, Increasing leaf size, Colored leaves, and Falling leaves. Flowers include Flowers or flower buds, Open flowers, and Pollen release. Fruit includes Fruits, Ripe fruits, and Recent fruit or seed drop.

Results and Discussion

We used the USA_NPN’s Visualization Tool (https://www.usanpn.org/nn/connect/visualizations) to prepare graphs of various phenophase observations from Ijams data in the USA_NPN database. Below are calendar plots for the leaf of tree and shrub species observed at Ijams in 2018. The colored bars indicate dates on which the phenophase was observed. The gray bars indicate dates where observations were made but the phenophase was not present. This plot gives a graphical representation of the frequency of visits to plots. In spring and fall visits are weekly. During summer and winter changes in phenophases are low and so visits during these seasons are less frequent.
Figure 4a. Calendar plots for the leaf of tree and shrub species observed at Ijams in 2018. Plots like these are readily prepared using the USA_NPN Visualization Tool.

Figure 4b. Calendar plots for the leaf of tree and shrub species observed at Ijams in 2018. Plots like these are readily prepared using the USA_NPN Visualization Tool.
Figure 4c. Calendar plots for the leaf of tree and shrub species observed at Ijams in 2018. Plots like these are readily prepared using the USA_NPN Visualization Tool.

It will take several more years of observations for this data to reveal phenological patterns specific to Ijams Nature Center. This data, however, already contributes to several USA-NPN campaigns including Green Wave, and Tracking the Status of Spring as well as contributing to peer-reviewed publications (see https://www.usanpn.org/publications).

**Shady Invaders campaign**

The USA-NPN started the Shady Invaders campaign at the request of Penn State PhD student Erynn Maynard to help her collect data for her study of extended leaf phenology on invasive shrubs in the eastern US. We added 2 plots in 2018 to contribute data to this campaign. This data also contributes to quantitative information about the interaction between native and invasive shrubs at Ijams that may be useful for management.

The data from Ijams (see Figure 5) clearly indicates that invasive shrubs (Amur honeysuckle, Multiflora rose, and Privet) leaf out earlier than native shrubs (Flowering dogwood, Northern spicebush), by as much a 3 to 4 weeks. They also retain their leaves longer in the fall. This phenomenon is called Extended Leaf Phenology.
Using data from over 100 additional sites that contributed data to this campaign, researcher Erynn Maynard also analyzed what environmental factors contribute to this difference.

She found that invasive shrubs leaf out earlier than native shrubs, but this effect diminishes at northern latitudes. This is likely because at the most northern latitudes, cold spring temperatures end up limiting both native and invasive plants. Invasive shrubs are better able to take advantage of warmer spring temperatures that occur at lower latitudes like ours.

Maynard also looked at which environmental variables have the most impact on shrubs, and found that both native and invasive shrubs have an earlier onset of leaves with warmer average spring temperatures. Invasive shrubs also respond to warmer bud chilling days, greater spring precipitation, and higher elevation. For additional information about this campaign see
https://www.usanpn.org/nn/ShadyInvaders,
https://www.usanpn.org/nn/ShadyInvaders#Results.

Observer Activity

Volunteers are the key to the success of the phenology program. Their activity is easily monitored using the Nature Notebook Observer Activity dashboard. Table 2 indicates the number of volunteer visits to each of the phenology plots.
Table 2. Number of visits by volunteers by plot and year.

<table>
<thead>
<tr>
<th>Site Name</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Trail Plot</td>
<td>5</td>
<td>24</td>
<td>32</td>
<td>16</td>
<td>77</td>
</tr>
<tr>
<td>Secret Pond Trail Plot</td>
<td>5</td>
<td>25</td>
<td>39</td>
<td>27</td>
<td>96</td>
</tr>
<tr>
<td>Shady Invader 1 Plot</td>
<td>--</td>
<td>--</td>
<td>38</td>
<td>36</td>
<td>74</td>
</tr>
<tr>
<td>Shady Invader 2 Plot</td>
<td>--</td>
<td>--</td>
<td>37</td>
<td>36</td>
<td>73</td>
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<tr>
<td>Subaru Preserve Creek Plot</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Subaru Preserve Upper Plot</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Hickory Trail Plot</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Totals by Year</td>
<td>10</td>
<td>49</td>
<td>146</td>
<td>130</td>
<td>335</td>
</tr>
</tbody>
</table>

There are many reasons people volunteer to make phenology observations. These include having fun outdoors, deepening connections with nature, learning about phenology, and contributing to scientific discovery. We are fortunate to have 5 dedicated volunteers that have been committed to this project for over 2 years. We are starting a relationship with the University of Tennessee Student Naturalist Club sponsored by the Department of Ecology and Evolutionary Biology. They helped in establishing the 3 new plots in 2019 in the Subaru Preserve and Hickory Trail and will be making observations at these plots.

Lessons Learned

Our lessons learned mainly revolve around how best to recruit and schedule volunteers, how to split them up amongst our plots, establishing criteria for setting up new plots, and how to report our data to the Ijams Nature Center staff at large. Our solutions to these issues are continuing to evolve.

Education and Outreach Activities

There are several opportunities to use phenology citizen science to provide educational activities to youth and adults. Engaging people in phenology observations offers placed-based, hands-on learning opportunities about the process of science and the use of science observations in understanding natural processes. These require identification and development. Current phenology volunteers could be a resource in the development of these education and outreach opportunities.

Programs with adults could provide information about the importance of phenology and how the Ijams phenology program is contributing to scientific data and information. In particular, information on how phenology is contributing to understanding how Ijams ecosystems respond to disturbances from invasive species, past and current land management, and climate change could be the focus of short field trips.
We have already had several field trips with middle school age students that focused on Citizen Science. One of the activities in the rotation is phenology. The students got a brief orientation about phenology and how phenological events can be divided into phenophases and quantified. The students were then given individual sheets from the plot packet to locate the tree and make the observations using a simplified data sheet with the protocol questions. This was well received by the students and teachers. However curriculum needs to be developed in order to meet the quality standards of an Ijams field trip opportunity. See the short-term objective 3 in the following section on Next Steps.

Trail signage at one or more of the phenology plots could inform the visiting public that Ijams Nature Center is participating in science activities. See short-term objective 1 in the following section on Next Steps.

**Summary and Next Steps**

The Ijams phenology program has completed over 3 years of data from the original 2 plots and since has established an additional 5 plots. Observations have engaged adults, many graduates of the Tennessee Naturalist Program, and college students. Data collected so far when combined with observations from the larger USA_NPN network have informed several science investigations.

This project would benefit from development of long-term and short-term objectives. The following draft objectives should be considered for continued development of this project.

**Objectives**

**Long-term Objectives:** Inform the public about the scientific significance of Ijams Nature Center resources for contributing to scientific research and understanding; provide science based educational opportunities for school field trip programs, adult programs, and service projects; and provide data from phenology studies for resource understanding and management by Ijams staff.

**Short-term Objectives:**
1: Develop and install interpretive trail sign by Shady Invaders Plot 1.
   - Responsible Person(s): Mac Post for layout, Jen Roder for final approval, funds, construction, and installation.
   - See Appendix for a draft suggestion.

2: Develop a phenology annual report.
   - Responsible Person(s): Mac Post, volunteer observers, Jeremy Clothier (Ijams Public Program Coordinator)
• Barriers and Challenges: Use NN visualization tool to create graphics using Ijams Phenology data. Compose message about goals and objectives achieved and plans for future for inclusion in Nature Center’s annual report.
• Required Resources: NN Visualization Tool

3 : Develop education materials for use with middle school field trips.
• Responsible Person(s): Mac Post, Tyler Edmondson, Ijams Lead Naturalist
• Offer placed-based, hands-on learning opportunities, provide a collaborative platform for site-based educators, and promote cross-subject engagement while addressing standards of learning.
• Barriers and Challenges: Become familiar with science standards for 6, 7, and 8 grade students, design a 2 hour program that provides hands-on learning incorporating pertinent standards, get feedback from local teachers
• Required Resources: Documentation of state science standards
• Completion Date: March 1, 2020
• Interim Updates: Draft materials for review early January 2020

4 : Provide an opportunity for Tennessee Naturalist Program graduates with service opportunities.
• Responsible Person(s): Mac Post, appropriate Ijams Staff
• Barrier and Challenges: Develop a learning module compatible with the TN Naturalist Curriculum and train the teaching staff to use the module.
• Required Resources: Considerable information for module development exists on the USA_NPN website and can be modified appropriate to introduce phenology and citizen science to student.
• Completion Date: September 1, 2020

Location of Project Components

All data is entered online via Nature’s Notebook usually using their smartphone application, and sometimes by their web portal, and is stored in the USA-NPN National Phenology Database, available for download at www.usanpn.org/results/data.

Using the administrator login and going to the “My Observation Deck” link, many management activities can be performed including managing users (assigning administrators, data technicians, users), adding sites, adding or editing plants, downloading site data.

Information packets for use by volunteers are available in the Hub Room.
**Appendix:** Concept draft of Shady Invaders interpretive sign.

This draft of a Shady Invaders interpretive sign for potential placement by Shady Invaders Plot 2 on River Trail is a concept for short-term objective 1 (see above). It was completed as a requirement for Local Phenology Leader certification by Mac Post in April 2019.