

Project BudBurst

Timing is everything!

A National Citizen Science Network



Caleb Slemmons & Sandra Henderson,
National Ecological Observatory Network

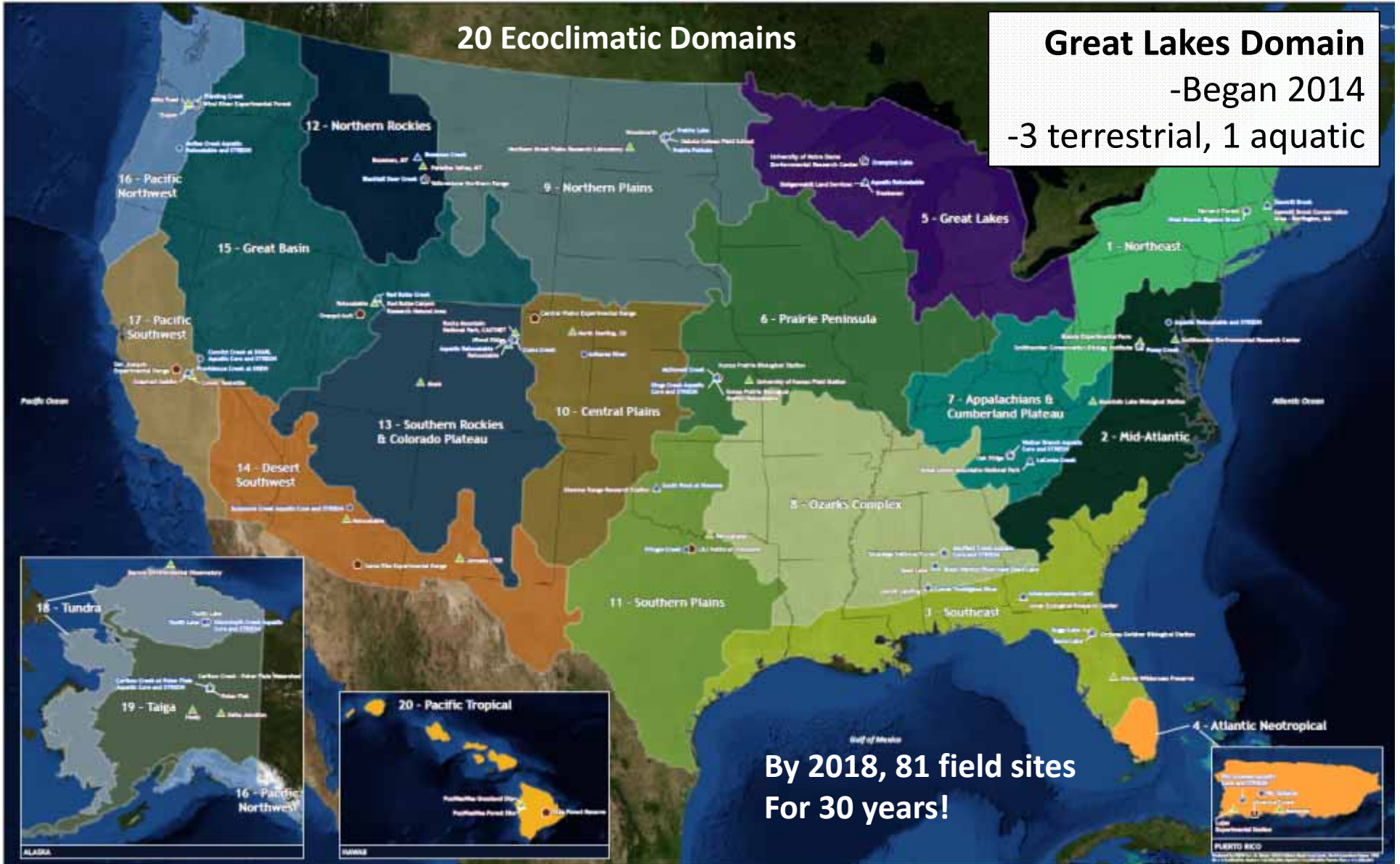


Overview

- **NEON Overview**
- **NEON Education & Outreach**
- **Project BudBurst**
- **Partnerships, Additional Resources & Season Spotter**

20 Ecoclimatic Domains

Great Lakes Domain
-Began 2014
-3 terrestrial, 1 aquatic



**By 2018, 81 field sites
For 30 years!**

Network of automated sensors



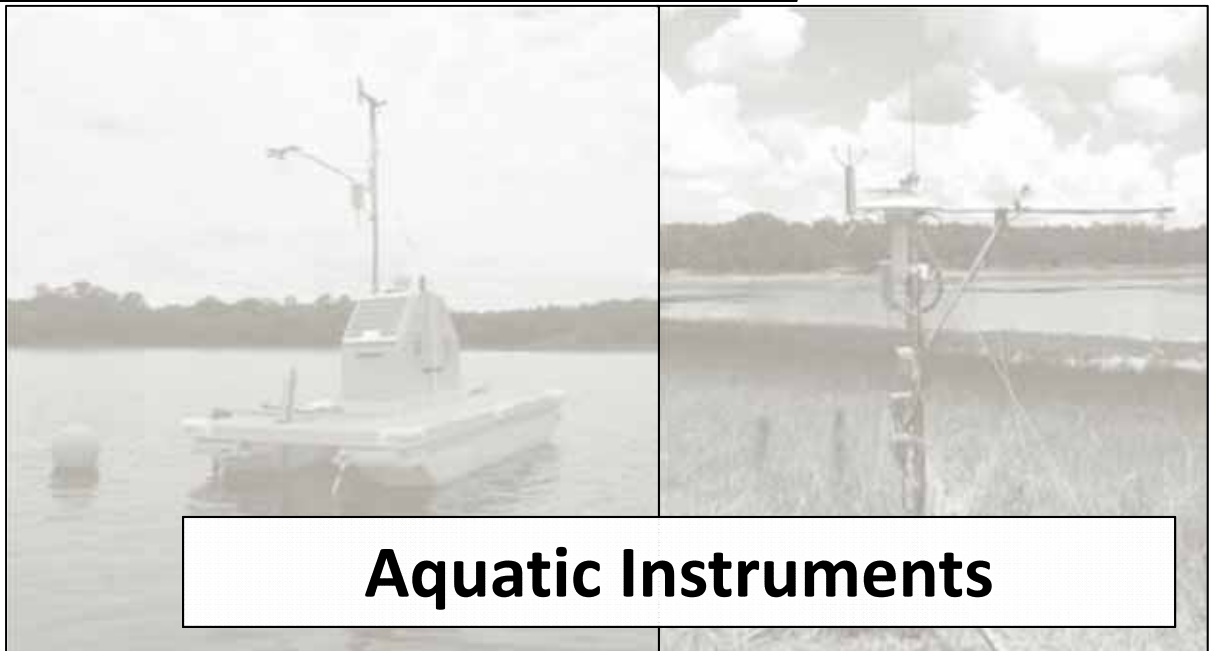
Terrestrial Instrument System



Airborne Observatory



**Instrumented
in 2014**



Aquatic Instruments

Network of automated sensors

Terrestrial Instrument System

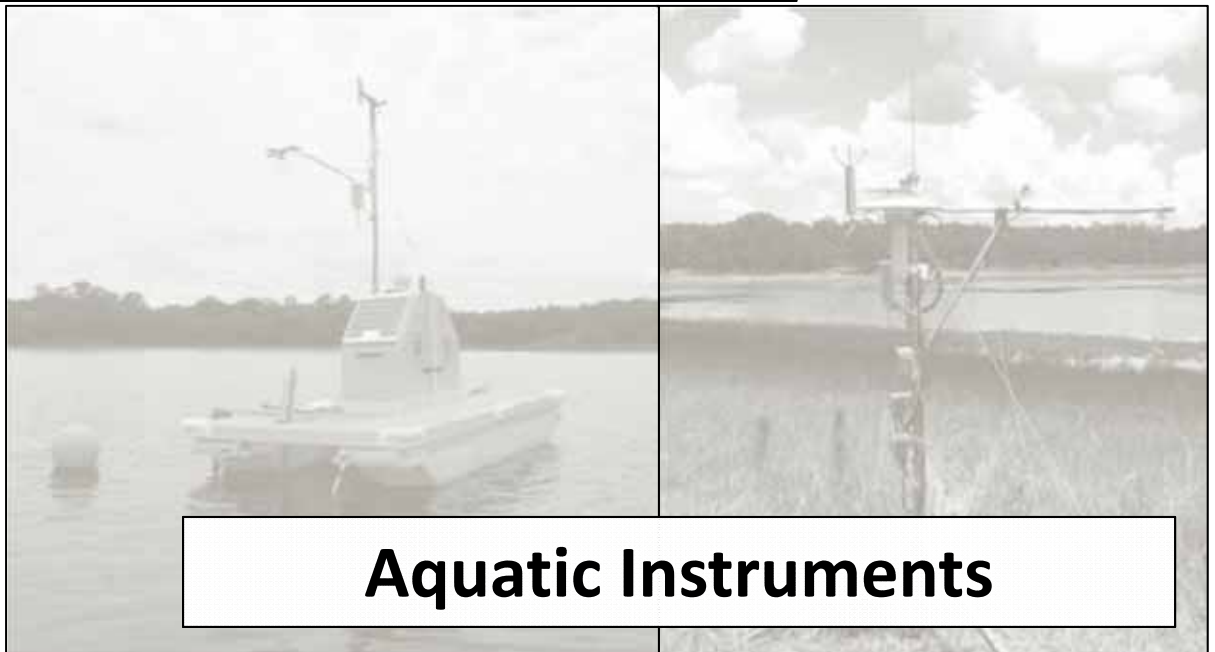


**Instrumented
in 2014**



Airborne Observatory

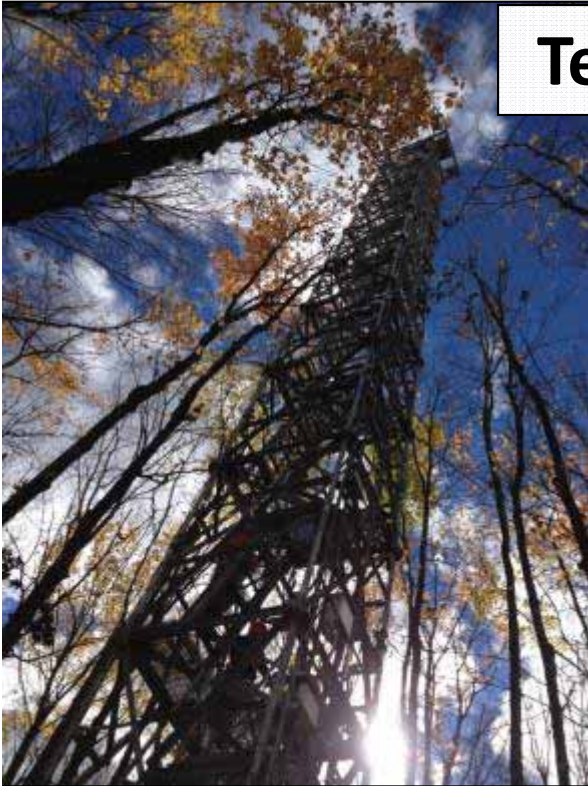
First GL Flight 2016!



Aquatic Instruments

Network of automated sensors

Terrestrial Instrument System



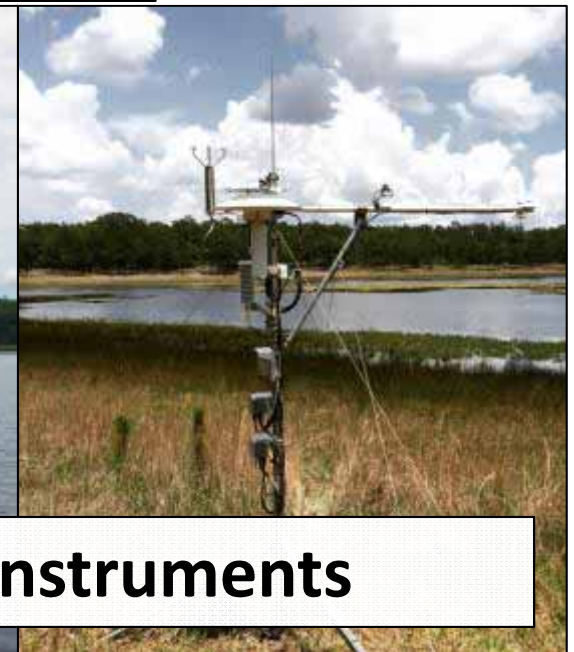
**Instrumented
in 2014**



Airborne Observatory

First GL Flight 2016!

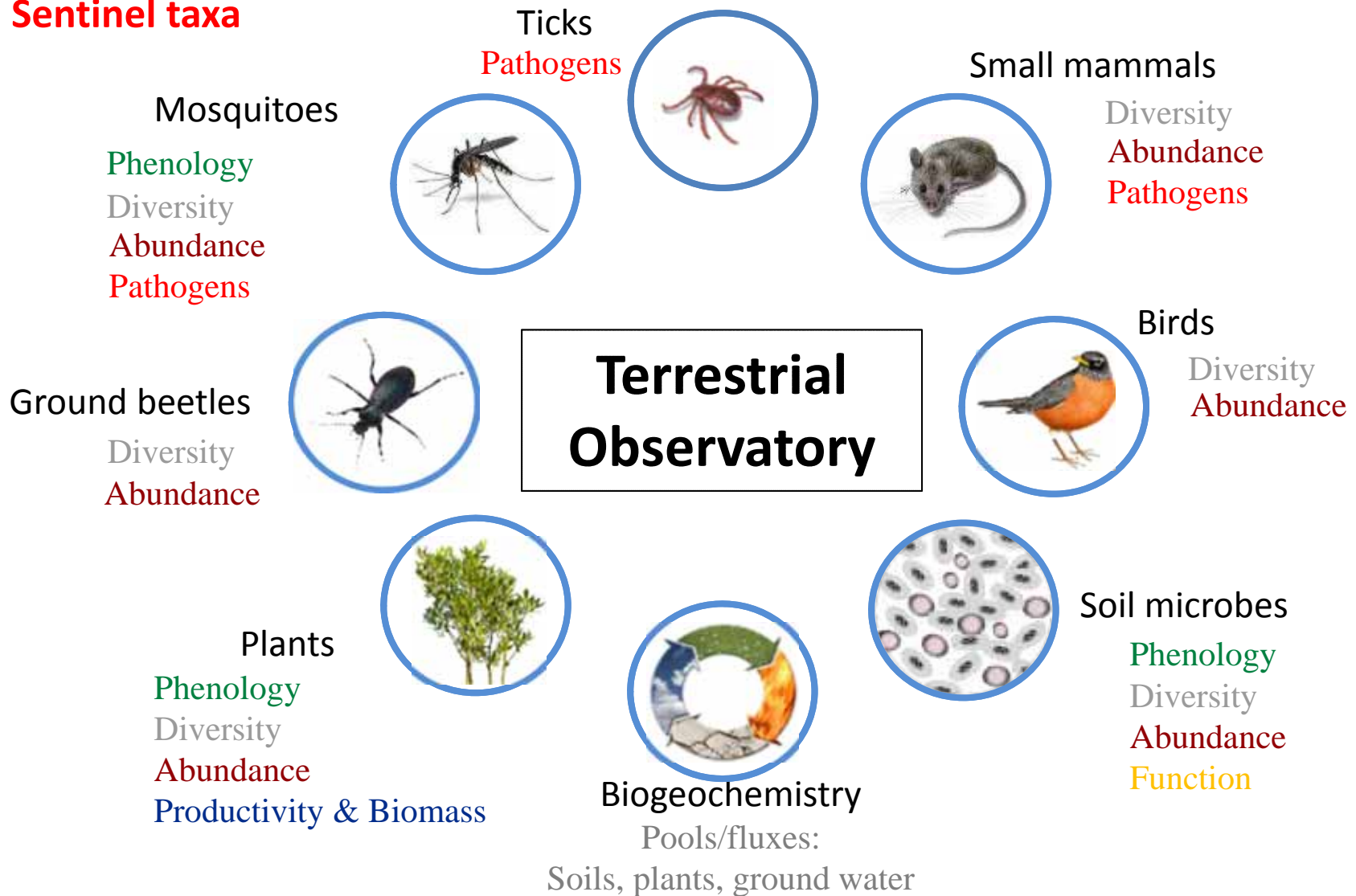
Planned for Fall, 2016



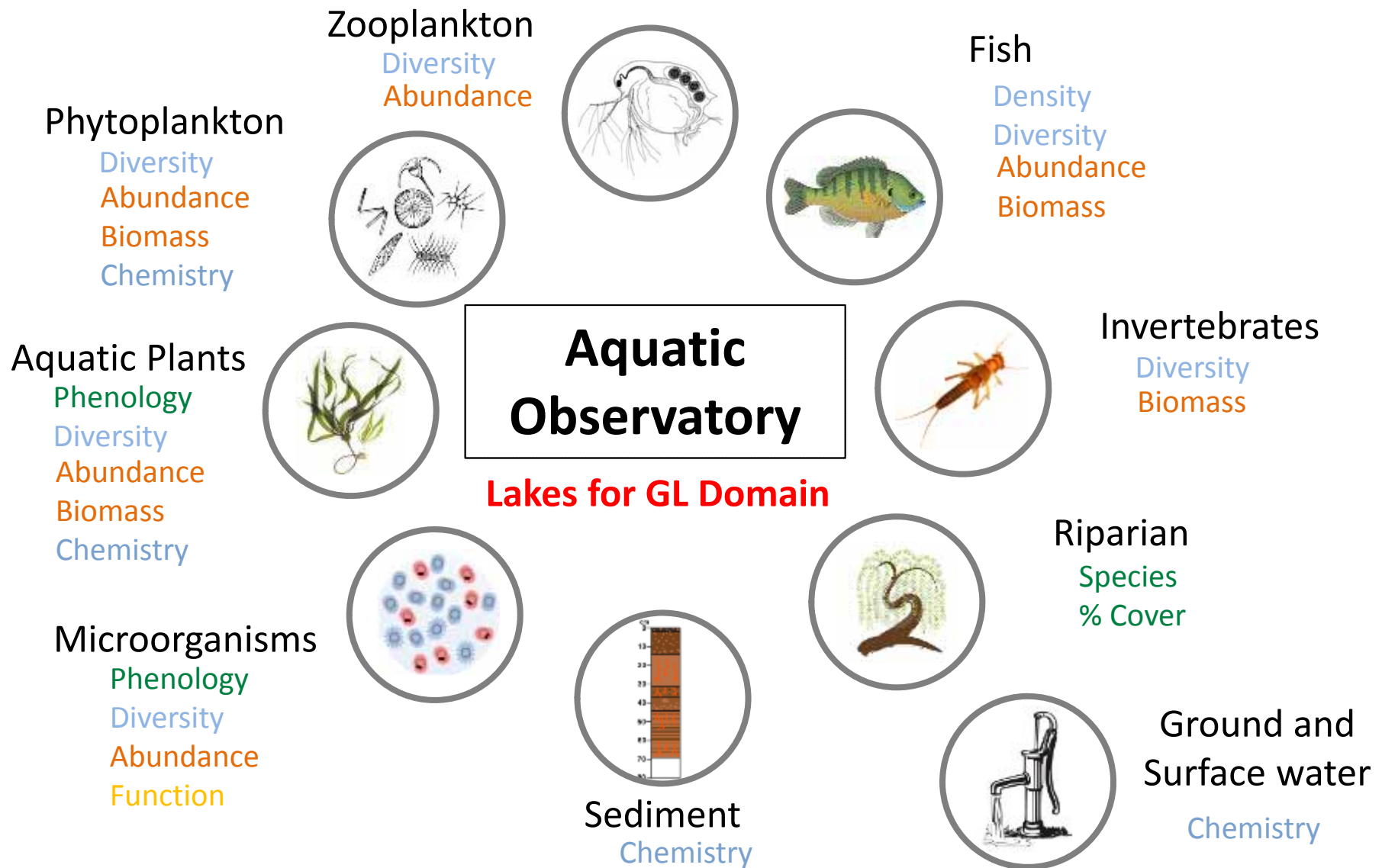
Aquatic Instruments

And on the ground sampling...

Sentinel taxa



And “on the water” sampling...



NEON as a resource...

NEON was designed to enable understanding and forecasting the effects of ***climate change, land use change, and invasive species*** on continental-scale ecology by providing:



- Physical Infrastructure
- Information Infrastructure
 - Data is free and will be publically available

AND

- **Educational resources:** Programs and tools for engaging communities in scientific discovery

Project BudBurst:

Project BudBurst
Timing is everything!

a plant phenology citizen science program



- ✔ Started in 2007
- ✔ Co-managed by NEON and Chicago Botanic Garden
- ✔ Individuals from all walks of life
- ✔ Participants from all 50 US states
- ✔ Easy to contribute, numerous partners (USFWS, NPS, gardens etc.)

What is phenology?

Phenology: science that measures timing of life cycle events (*phenophases*)

Scientists who study phenology are interested in the timing of biological events as they relate to changes in season and climate.

Aldo Leopold – tracked phenology from 1938-'48

Migration



First pollen



Nesting



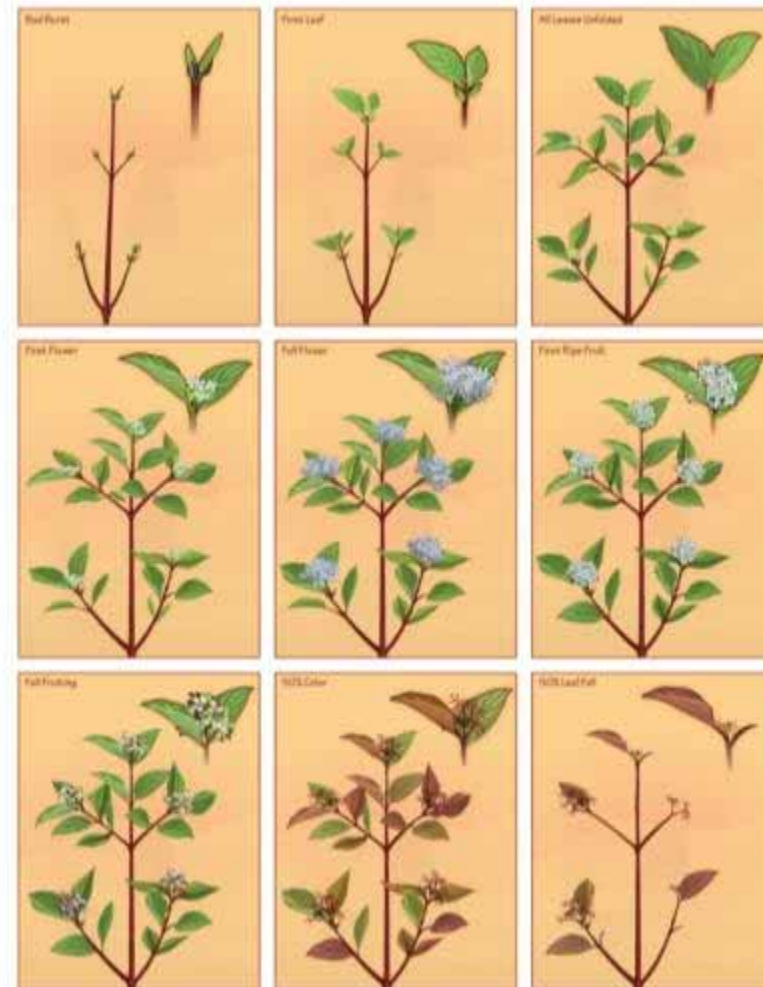
First leaf



Phenophase Example

Phenophases of Red osier dogwood through the seasons

- ✓ A **phenophase** is a distinct event in the life cycle of a plant or animal
- ✓ Each stage is an example of a phenophase



RED OSIER DOGWOOD
(*Cornus sericea*)

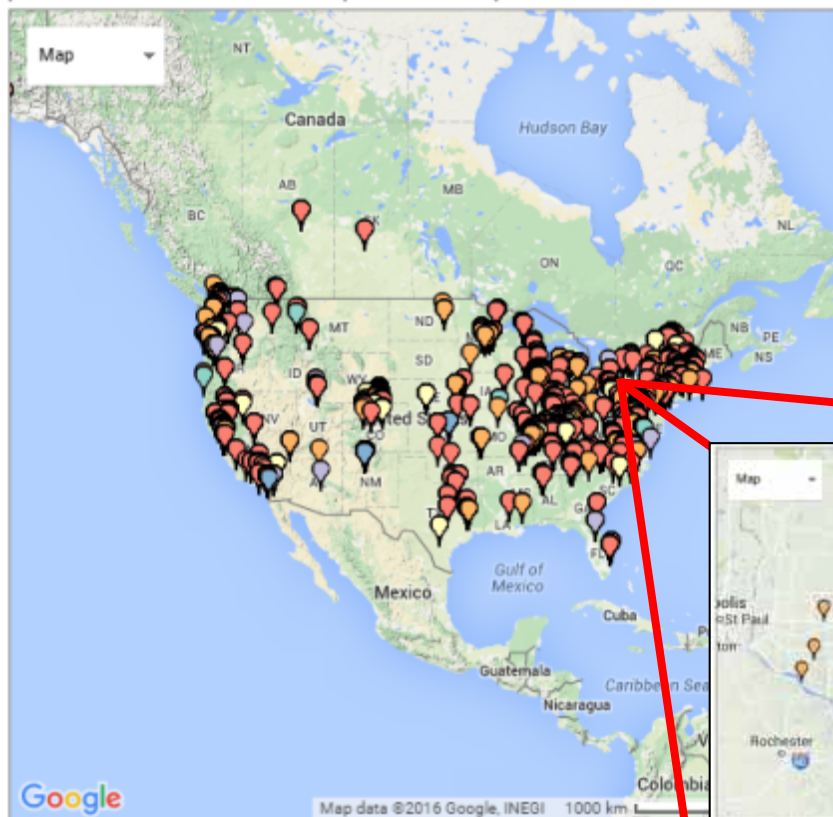
A National Network of Citizen Science:

Project BudBurst
Timing is everything!

Online and Mobile Access



📍 = Wildflowers and Herbs 📍 = Grasses 📍 = Deciduous Trees and Shrubs
📍 = Evergreen Trees and Shrubs 📍 = Conifers 📍 = Basic (Other)



Over 17K records for 2015
(417 from Wisconsin)



Observe

Observe a plant in your community.



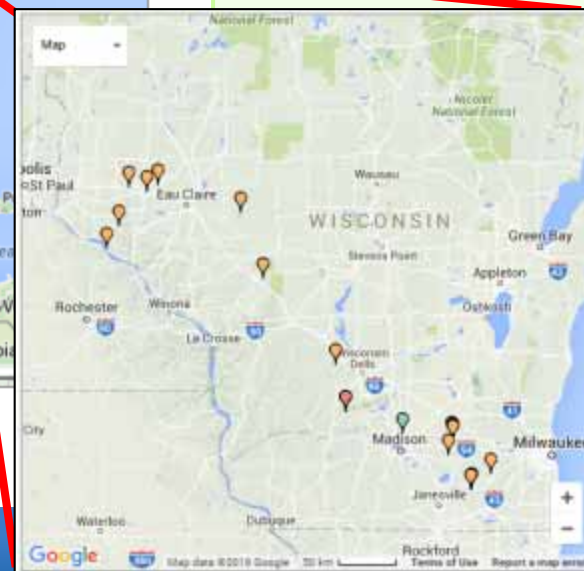
Record

Record your observation on a Single Report or Regular Report form.



Submit

Submit your observation on www.budburst.org



Register, then learn

Project BudBurst
Timing is everything!

neon Citizen Science | Sponsored by the National Science Foundation

Welcome Guest [Register/Login](#)

Project BudBurst

Timing is Everything!

People watching plants
Contributing to research
Join Project BudBurst

About Observing Plants Partners Education Science Data My BudBurst

BudBurst Home

Welcome to Project BudBurst!

Every plant tells a story about changing climates. We are a national network of citizen scientists monitoring plants as the seasons change. Join us!

- 1 Register Online**
Create a [My BudBurst account](#)
- 2 Learn How to Observe**
Find out [what to look for](#) when making observations.
- 3 Select a Plant**
Next, choose a [plant](#) to observe.
- 4 Go Outside and Observe**
Now the fun part! Print a report form, go outside, and observe your plant.
- 5 Report**
Sign in to your [My BudBurst account](#) to submit your observation. It's that easy!

Latest News

2015 Web Updates

Recent Reports

- Flowers (Early) on Jan 19
California poppy in Los Altos Hills, CA
Submitted on Jan 20
- 50% Leaf Fall on Oct 29
Forsythia in Denver, CO
Submitted by Denver Botanica on Jan 17
- 50% Color on Oct 29
Forsythia in Denver, CO
Submitted by Denver Botanica on Jan 17
- All Leaves Unfolded on Apr 25
Forsythia in Denver, CO
Submitted by Denver Botanica on Jan 17
- First Leaf on Apr 17
Forsythia in Denver, CO
Submitted by Denver Botanica on Jan 17
- 50% Leaf Fall on Oct 22
Red oiler dogwood in Denver, CO
Submitted by Denver Botanica on Jan 17

Newsletter Signup

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Project BudBurst

Timing is Everything!

Register your plants
Submit observations here
View My BudBurst

About Observing Plants Partners Education Science Data My BudBurst

Register

Welcome to the Project BudBurst Community!

By registering with us, you can save your observation location(s) and plant(s) that you are monitoring throughout the year and for coming years. This also allows you to report the phenological changes as they occur each week!

If you are under the age of 13, you must have your parent, guardian or teacher register for you. Please take our [privacy policy](#).

(* = required fields)

Project BudBurst Registration

*First Name:

*Last Name:

*City:

*State:

Zip Code:

*Email:

You will be asked to verify this email address by entering a verification code that will be sent to it.

I am at least 13 years of age:

I am an Educator: (Educator accounts allow formal and informal educators to register classroom sites and create student reporter accounts.)

You will see a sign and password if you choose to access your account.

2 Learn How to Observe

Find out [what to look for](#) when making observations.

Select a plant...make observations

The screenshot shows the Project BudBurst website. At the top, there is a navigation bar with links for About, Observing Plants, Partners, Education, Science, Data, and My BudBurst. Below this is a section titled "Plants to Observe" with a sub-header "Plants to Observe". It contains text explaining that there are over 250 plants on the master list and provides instructions on how to use the search and browse tools. There are three buttons: "Top 10 Plants", "Browse By State", and "Browse All Species". Below this is a section for "Browse Project BudBurst Plant Groups" with five categories: Woody plants and Herbs, Deciduous Trees & Shrubs, Evergreen Trees & Shrubs, Grasses, and Conifers. At the bottom is a search section titled "Search Project BudBurst Plants" with a search box and labels for Common Name, Scientific Name, and Plant Group.



The infographic compares "Regular Reports" and "Single Reports".

- Regular Reports:** Record specific dates throughout the year when your plant first has leaves, flowers and fruit. Time commitment: Many observations thru the seasons (represented by four pie charts).
- Single Reports:** Record observations of the leafing, flowering and fruiting stage(s) that best describes your plant at that moment. Time commitment: 15 minutes/one-time observation (represented by one pie chart).

Examples are provided for an Apple Tree:

- Regular Reports:** This year, I monitored an Apple Tree:
 - First leaf: Apr 14
 - First flower: May 1
 - First fruit: Jul 22
 - 50% Leaf color: Sep 10
- Single Reports:** Today, I observed that the Apple tree had:
 - May 20
 - ✓ Flowers

Regular or Single Reports

Apple

Bud Burst
Date when the protective scales coating it shed from the bud exposing tender new growth tissues of one or more flower buds or leaves.

Get your photo published!
Help us bring you a great photo of the phenomenon. Send your image to apple@budburst.org

First Leaf
Date when the first leaves are completely unfolded from the bud on at least 3 branches. Leaves need to be opened completely (flat) and the leaf stem or base must be visible (you might need to bend the leaf backwards to see this). Apple leaves can be quite small and round when they open up to first leaf, often within a few days of the buds opening.

All Leaves Unfolded
Date when at least 90% of the growing leaf buds have reached the first leaf stage.

First Flower
Date when the first flowers are fully open on at least 3 branches. When open, you will see the stamens among the unfilled petals.

Malus pumila

Full Flower
Date when half or more of the flowers are fully open on 3 or more branches. For apples, flowers usually develop from first flowers to full flowering, often within a few days, usually turning the whole tree a brilliant white color.

First Ripen Fruit
Date when the first fruits become fully ripe or ready drop naturally from the plant on 3 or more branches. Ripening is often indicated by a change to the mature color or by drying and splitting open. Typically this is a bright red color and with soft flesh, but may be yellow or other colors depending on the variety.

Full Fruiting
Date when half or more branches have fully ripe fruit on the woods and dropping naturally from the plant. If fruits are in clusters or stalks, then record when at least one fruit is ripe on at least half of the branches.

50% Color
Date when half or more of the unopened tree leaves which have started to change color.

50% Leaf Fall
Date when at least half of the leaves have fallen off the tree or shrub. Apple leaves tend to persist late. They often fall all at once in a strong fall storm.



Single Report

Deciduous Trees & Shrubs

Date

About your plant

Common Plant Name*

Scientific Name (if known)

Site Name (a unique name of your choosing)

Latitude*

Longitude*

City*

State* Zip

* Required fields

What is your plant doing now?

(Check the most applicable option in each category below.)

Leaves unfolding

No leaves

Early: Only a few leaves have unfolded from the buds (less than 5%)

Middle: Many leaves have unfolded from the buds

Late: Most leaves are fully unfolded (over 90%)

Leaves changing color

No leaves have changed color

Early: Only a few leaves have changed color (less than 5%)

Middle: Many leaves have changed color

Late: Most leaves have changed color (over 90%)

Leaves dropping

No leaves have dropped

Early: Only a few leaves have dropped (less than 5%)

Middle: Many leaves have dropped

Late: Most leaves have dropped (over 90%)

Flowers

No flowers or pollen

Early: Only a few flowers have emerged (less than 5%) or pollen is just starting to disperse

Middle: Many flowers have emerged or a lot of pollen is falling

Late: Most flowers have withered or fallen off (over 90%) or most pollen has fallen

Fruit

No ripe fruits

Early: Only a few ripe fruits are visible (less than 5%) are ripe

Middle: Many fruits are ripe

Late: Most fruits or seeds have been dispersed from plant (over 90%)

Participating in Project BudBurst

Observe: Observe a plant in your community.

Record: Record your observations on a Single Report form.

Submit: Submit your observations on www.budburst.org

Single Report forms are used to make observations of what one plant is doing on one specific day. Remember to report your data at www.budburst.org. Questions? Email us at budburst@neoncenter.org

Project BudBurst
Timing is everything!

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Report observations

Project BudBurst
Timing is Everything!

Register your plants
Submit observations here
Your MyBudBurst space

About Observing Plants Partners Education Science Data My BudBurst

BudBurst My BudBurst Submit Regular Reports Location

Enter Regular Reports - Register a Site

MyBudBurst Site - Where are you monitoring your plant(s)?

Site Location

Map Tool
Find your latitude and longitude by:

- entering the address of your site location into the search box below (i.e. 1655 36th St, Boulder, CO, 80301 or City Park, Denver, Colorado)
- OR-
- zooming in and clicking on the map to mark your location.

Search For: Search

Map Satellite

Describe Your Site
You can have more than one plant species at the same site.

*Site Name (A unique name of your choosing)

Use the map tool to determine latitude and longitude (measured at the center of your site).

*Latitude (decimal degrees, i.e. 40.01647)

*Longitude (decimal degrees, i.e. -105.24557)

*City:

*State:
Wisconsin

Zip code:

Describe the irrigation at this site
Select

Describe the shading at this site
Select

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Register your plants
Submit observations here
Your MyBudBurst space

About Observing Plants Partners Education Science Data My BudBurst

BudBurst My BudBurst Submit Regular Reports Observation

Enter Regular Report - Observation

MyBudBurst Site:
MyBudBurst Plant:
MyBudBurst Plant Group:

WHEN DO YOU OBSERVE?

Bud Burst:
First Leaf:
All Leaves Unfolded:
First Flower:



Then submit!

Partner Power!

Project BudBurst
Timing is everything!



- ✓ Trempealeau NWR,
- ✓ Community Partners – Mequon Nature Preserve & Riveredge Nature Center (Saukville, WI)



These observations matter!

Project BudBurst
Timing is everything!

At the interface of science and education, Citizen Science...



**All data available
through website
(2007-'15)**

**Over 23k
participants to date**

- Makes science real by providing authentic research experiences
- Advances scientific learning through hands-on learning
- Can promote a sense of 'ownership' of plants/data

Scientific Application

OPEN ACCESS Freely available online

PLoS ONE

Predicting the Timing of Cherry Blossoms in Washington, DC and Mid-Atlantic States in Response to Climate Change

Uran Chung^{1,2,3}, Liz Mack¹, Jin L. Yun², Soo-Hyung Kim^{1*}

1 Center for Urban Horticulture, School of Forest Resources, College of the Environment, University of Washington, Seattle, Washington, United States of America, **2** Department of Ecophysiology, Kyung Hee University, Yongin, Korea, **3** National Center for Agro-Meteorology, Seoul National University, Seoul, Korea

Abstract

Cherry blossoms, an icon of spring, are celebrated in many cultures of the temperate region. For its sensitivity to winter and early spring temperatures, the timing of cherry blossoms is an ideal indicator of the impacts of climate change on true phenology. Here, we applied a process-based phenology model for temperate deciduous trees to predict peak bloom dates (PBD) of flowering cherry trees (*Prunus yedoensis* 'Yoshino' and *Prunus serrulata* 'Nivara') in the Tidal Basin, Washington, DC and the surrounding Mid-Atlantic States in response to climate change. We parameterized the model with observed PBD data from 1961 to 2010. The calibrated model was tested against independent datasets of the past PBD data from 1951 to 1970 in the Tidal Basin and more recent PBD data from other locations (e.g., Seattle, WA). The model performance against these independent data was satisfactory (Frothing: $r^2=0.57$, RMSE = 6.9 days, bias = 0.9 days, and $r^2=0.76$, RMSE = 5.5 days, bias = -2.0 days). We then applied the model to forecast future PBD for the region using downscaled climate projections based on IPCC's A1B and A2 emissions scenarios. Our results indicate that PBD at the Tidal Basin are likely to be accelerated by an average of five days by 2050 s and 10 days by 2080 s for these cultivars under a mid-range (A1B) emissions scenario projected by ECHAM5 general circulation model. The acceleration is likely to be much greater (1.3 days for 2050 s and 29 days for 2080 s) under a higher (A2) emissions scenario projected by CGCM2 general circulation model. Our results demonstrate the potential impacts of climate change on the timing of cherry blossoms and illustrate the utility of a simple process-based phenology model for developing adaptation strategies to climate change in horticulture, conservation planning, restoration and other related disciplines.

Citation: Chung U, Mack L, Yun J, Kim SH (2011) Predicting the Timing of Cherry Blossoms in Washington, DC and Mid-Atlantic States in Response to Climate Change. PLoS ONE 6(11): e27426. doi:10.1371/journal.pone.0027426

Editor: Jeffrey A. Harvey, Netherlands Institute of Ecology

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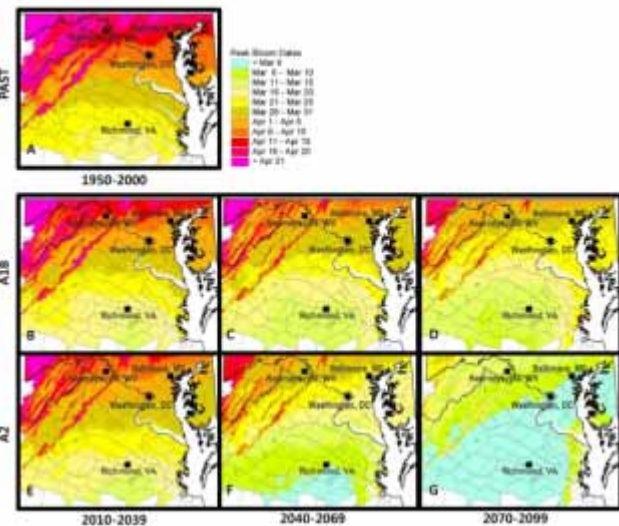
Funding: This work was supported by Cooperative Non-Development Administration, Republic of Korea. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

Introduction

Warming associated with climate change has altered ecosystem processes including phenology—organism development [1,2]. The phenology of plants and animals has been reported in regions; these shifts are likely to be a response to climate. For example, Mynel et al. [3] and Parmesan demonstrated that the growing season of trees has increased by 2.3 days in temperate tree species. In WA area, 89 of 100 plant species surveyed, including 9 trees, exhibited a significant advance of 8.5 days in over the 30 years from 1970 to 1999 [4]. It has been predicted that these trends will continue into the 21st century [7] changes in phenology will have a substantial reproduction, distribution and productivity of coincidence of ecosystem processes, such as flowering of pollinators, is disrupted [8]. Some species become less resistant to environmental challenges

PLoS ONE | www.plosone.org



REVIEWS REVIEWS REVIEWS

The phenology of plant invasions: a community ecology perspective

Elizabeth M. Welkovich¹ and Lisa E. Cleland²

Community ecologists have long recognized the importance of phenology (the timing of periodic life-history events) in structuring communities. Phenological differences between exotic and native species may contribute to the success of invaders, yet a general theory for how phenology may shape invasions has not been developed. Shifts toward longer growing seasons, tracked by plant and animal species worldwide, heighten the need for this analysis. The concurrent availability of extensive citizen-science and long-term datasets has created tremendous opportunities to test the relationship between phenology and invasion. Here, we (1) extend major theories within community and invasion biology to include phenology, (2) develop a predictive framework to test these theories, and (3) outline available data resources to test predictions. By creating an integrated framework, we show how new analyses of long-term datasets could advance the fields of community ecology and invasion biology while developing novel strategies for invasive species management. Although we focus here on terrestrial plants, our framework has clear extensions to animal communities and aquatic ecosystems as well.

From *Ecol Evol* 2011; 1(9): 287–294. doi:10.1002/ece.10013 published online 22 Sep 2011

The study of plant phenology—the timing of periodic events, such as leaf budburst and flowering—has increased attention and ecologists for centuries. In the 1830s, Henry David Thoreau kept diaries of notebook on the flowering of herbs and ferns in Concord, Massachusetts (Miller-Rushing and Primack 2008), whereas—during the early 1900s—John Muir described the phenology of pines in California's Yosemite Valley (Muir 1917). In the years since, research has shown that the timing of these events is adaptive (Vols 2007), limits species ranges (Chaine and Reboulet 2008), and plays a role in species coexistence (Fargione and Tilman 2005). Phenology has received increasing attention, because it is a major indicator of climate change (Fitter and Fitter 2002; Cleland et al. 2007; Sherry et al. 2007), promoting the development of new, geographically extensive databases (Moussier et al. 2005), in addition to previously available long-term records (Morat 2005).

Phenology may also play an important role in the success of invasive plant species, which may increase under projected climate change and disturbance regimes (Field et al. 2007). Many theories that attempt to explain how certain species are able to establish and spread suggest that exotic species possess unique characteristics—when compared with those of native species in their introduced community—that give them a competitive edge (Calkins and Lovett-Doust 2002). In particular, the phenology of a plant species may be tied to many characteristics important to plant competition, such as, leaf budburst and senescence strongly correlate with the beginning and end, respectively, of a plant's acquisition of soil and light resources and the time when these species are at greatest risk of herbivory. Likewise, the period of flowering determines when many species compete for pollinators.

Phenology may also be important to consider when and how new species invade. Here, we show native and exotic community ecology management strategies. We focus mainly on how phenology may change under climate change (under the species whose phenology is most sensitive to climate change). We focus mainly on how phenology may change under climate change (under the species whose phenology is most sensitive to climate change).

In a nutshell

Our study suggests that exotic species may have phenological timing of periodic events that is more distinct from those of native species, or are able to adjust their phenology to a new climate. Our major theories within community and invasion biology, including the resource-ratio model, and the role of niche overlap, plasticity in structuring communities framework for testing the role of phenology in species success, identifying potential invasion management strategies that exploit phenological differences.

For Ecological Analysis and Synthesis, Santa Barbara, California, and the University of California-San Diego, La Jolla, CA

*Correspondence

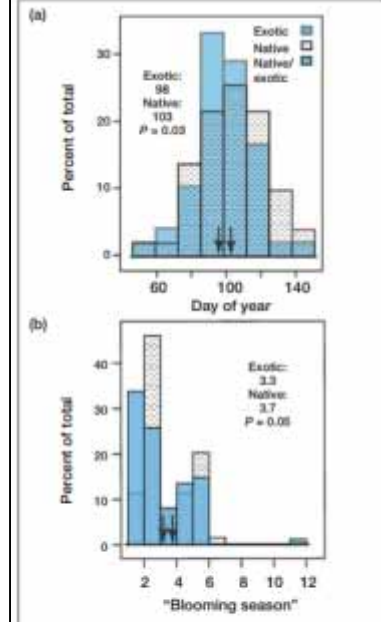


Figure 3. How citizen-science projects will provide nationwide estimates of species' phenology. Also, here, we show 308 native species in Project BudBurst, which encompasses a nationwide network of monitoring sites across the US.

Season Spotter



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Welcome clemmons! [Logout](#)

PhenoCam & Project BudBurst

What can be learned from Cameras on the landscape
Trees sharing seasons

About Observing Plants Partners Education Science Data My BudBurst

BudBurst Education PhenoCam

The PhenoCam Network and Season Spotter

What is PhenoCam?

Science Behind Seasons

Classify Images

The PhenoCam Network uses digital cameras to take continual pictures of different landscapes including forests, grasslands, and croplands

Your help is needed to classify images from the PhenoCam Network

A collaboration between Harvard University, NEON Inc., Boston University, Washington University, and University of New Hampshire



Willow Creek Tower Phenocam in Northern WI

SEASON SPOTTER IMAGE MARKING RESEARCH CLASSIFY FAQ TALK MORE INFO

BLOG ANSWER QUESTIONS

Draw a shape containing most of the leaves for a single tree. Do this for 3 trees. (You can do more trees if you want to.) If you can't identify individual trees, click Next.

Trees with BROAD leaves 0 drawn

Trees with NEEDLE leaves 1 drawn

Need some help with this task?

[Back](#) [Next](#)

A collaboration between Harvard University, NEON Inc., Boston University, Washington University, and University of New Hampshire

A phenocam network



- Uses Zooniverse platform for crowdsourcing
- Very simple, **no registration required** (though ~75% of classifications are from registered users)
- Minimal time commitment

US Phenocam Network

- 2 types, classifications & image marking
- Chat section to interact w/researchers
- “Need some help” tips and location for each image



Image classification for Bitter Root Valley, Montana

A phenocam network



- Over 105K classifications and ~7K participants (in 8 months!)
- Possible synergies with PBB, value added



Prince Albert National Park, Saskatchewan

Application

REVIEWS REVIEWS REVIEWS

04

Using phenocams to monitor our changing Earth: toward a global phenocam network

Tim B. Brown^{1*}, Kevin R. Hultine¹, Heidi Steltzer¹, Ellen G. Deem⁴, Michael W. Denslow¹, Joel Granados⁵, Sandra Henderson⁶, David Moore⁷, Shin Nagai⁸, Michael SanClements⁹, Arturo Sanchez-Azofeifa¹⁰, Oliver Sonnentag¹¹, David Tazik¹, and Andrew D. Richardson¹²

Rapid changes to the biosphere are altering ecological processes worldwide. Developing informed policies for mitigating the impacts of environmental change requires an exponential increase in the quantity, diversity, and resolution of field-collected data, which, in turn, necessitates greater reliance on innovative technologies to monitor ecological processes across local to global scales. Automated digital time-lapse cameras – “phenocams” – can monitor vegetation status and environmental changes over long periods of time. Phenocams are ideal for documenting changes in phenology, snow cover, fire frequency, and other disturbance events. However, effective monitoring of global environmental change with phenocams requires adoption of data standards. New continental-scale ecological research networks, such as the US National Ecological Observatory Network (NEON) and the European Union’s Integrated Carbon Observation System (ICOS), can serve as templates for developing rigorous data standards and extending the utility of phenocam data through standardized ground truthing. Open-source tools for analysis, visualization, and collaboration will make phenocam data more widely usable.

Front Ecol Environ 2016, 14(2): 84–93, doi:10.1002/fee.1222

Understanding and adapting to global environmental change is one of the major challenges of the 21st century. Among the most visible outcomes of alterations in environmental properties and processes are shifts in

phenology (the seasonal activity of plants and animals). Climate-driven changes in plant phenology, for instance, can have ecosystem-wide impacts, ranging from altered carbon budgets and productivity (Ciais et al. 2013) to effects on pollinators (Bellard et al. 2012) and crop yields (Lobell et al. 2011). However, quantifying such changes over large areas at appropriate timescales is challenging, even with satellite remote-sensing products.

Repeat photography has been used to detect and document changing landscapes since the earliest days of photography. Collections of photographs acquired from fixed locations have largely framed our understanding of global change processes, including desertification, glacial retreat, and alterations in land cover and land use (Webb 2010). Until recently, ground-based collection of time-series image data over long periods was expensive and technically challenging, but advancements in imaging and communication technologies are enabling continuous, widespread monitoring of the environment.

As high-quality, low-cost digital cameras have become more widely available, interest in applying these tools to ecological studies has expanded. “Near-surface remote sensing” utilizes data from automated ground-based sensors to augment conventional remote-sensing data, and to help bridge the gap between satellite monitoring and traditional

In a nutshell:

- Automated digital time-lapse cameras (phenocams) are powerful tools for recording and understanding ecological responses to global environmental change
- Documenting such changes in the environment is critical for informed decision making and to reduce or counteract negative outcomes
- Advances in digital imaging, computing, and networking technologies provide new opportunities for phenological monitoring, and the availability of low-cost, easy-to-use camera hardware brings the goal of developing a global environmental monitoring network within reach of most researchers
- Standardization of practices and metadata recording will improve the utility of phenocams and facilitate their integration with other monitoring methods

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To learn more about Project BudBurst Visit budburst.org

