USA National Phenology Network

Taking the Pulse of Our Planet

Phenology as an Indicator of a Changing Climate

LoriAnne Barnett
Education Coordinator, USA-NPN

Local Drought Impact Group

Take-Aways:

- Phenology
- Phenology indicates change
- Phenology & management
- *Nature's Notebook*
- Local applications

Photo credit: E. Alderson

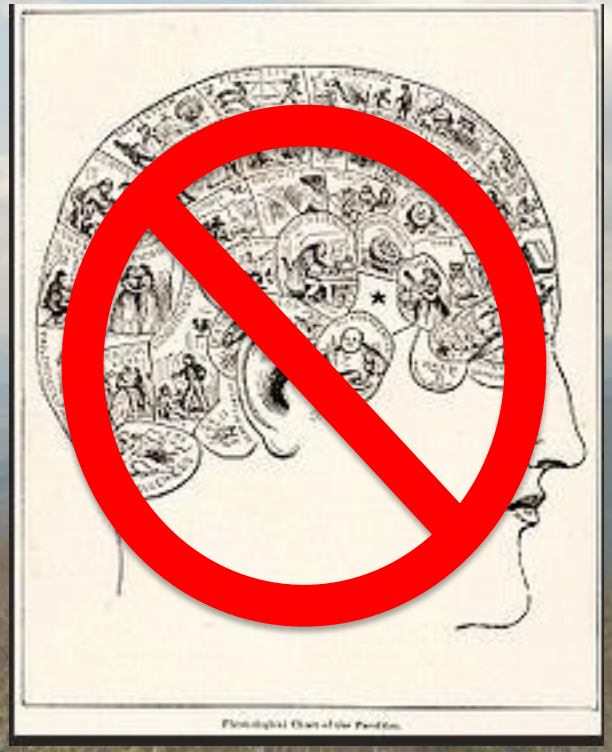
Photo credit: P. Warren

Photo credit: L. Barnett

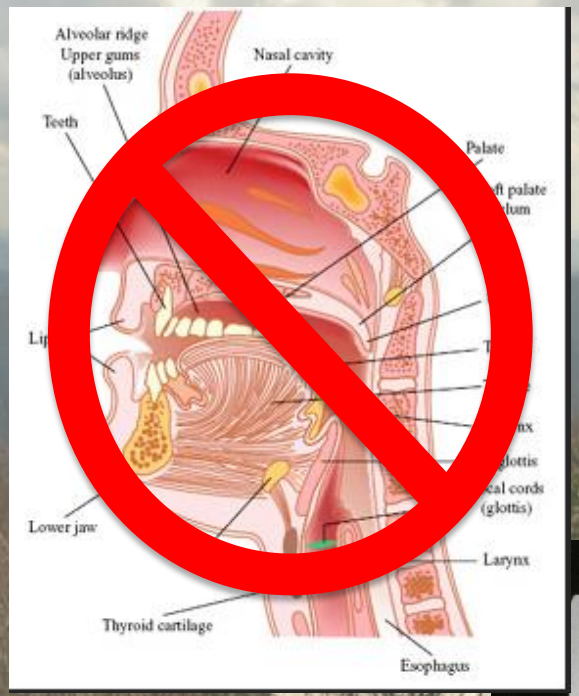
Photo credit: P. Warren

©W

Phenology

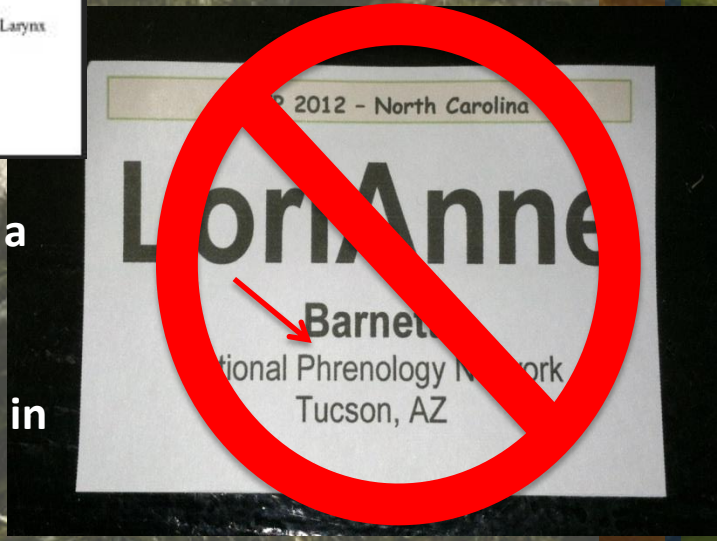


phRenology – a pseudoscience focused on measurements of the human skull and size of the brain



phOnology – a branch of linguistics concerned with the organization of sounds in

Just to be clear…



Phenology

…it is the study of recurring plant and animal life-cycle stages, or* phenophases*, and their relationship to environmental conditions.

What is phenology?

The science of the seasons

- Blooms and buds
- Hibernation, migration, emergence
- Easy to observe

Phenology

Who observes phenology?

- Scientists
- Gardeners/Agriculturists
- Land managers
- Educators
- Youth

Photo credit: P. Warren

Photo credit: C. Enquist

Photo credit: S. Schaffer

USA National Phenology Network

Primary goal

- Observe phenological events
- Understand how plants, animals & landscapes respond to climate change.
- ***Create a standardized dataset for use in multiple types of research.***

Mission

- Make phenology data, models and related information available to scientists, resource managers and the public.
- Encourage people of all ages and backgrounds to observe and record phenology.

A NATIONAL NETWORK OF INTEGRATED PHENOLOGICAL OBSERVATIONS ACROSS SPACE AND TIME.

usanpn.org

nature's notebook

A project of the USA-NPN

USA npn National Phenology Network Taking the Pulse of Our Planet

USGS science for a changing world

A Multi-taxa, National-scale

- Plant and animal phenology observation program
- ***Professional*** & **Citizen** science
- Core protocols for research

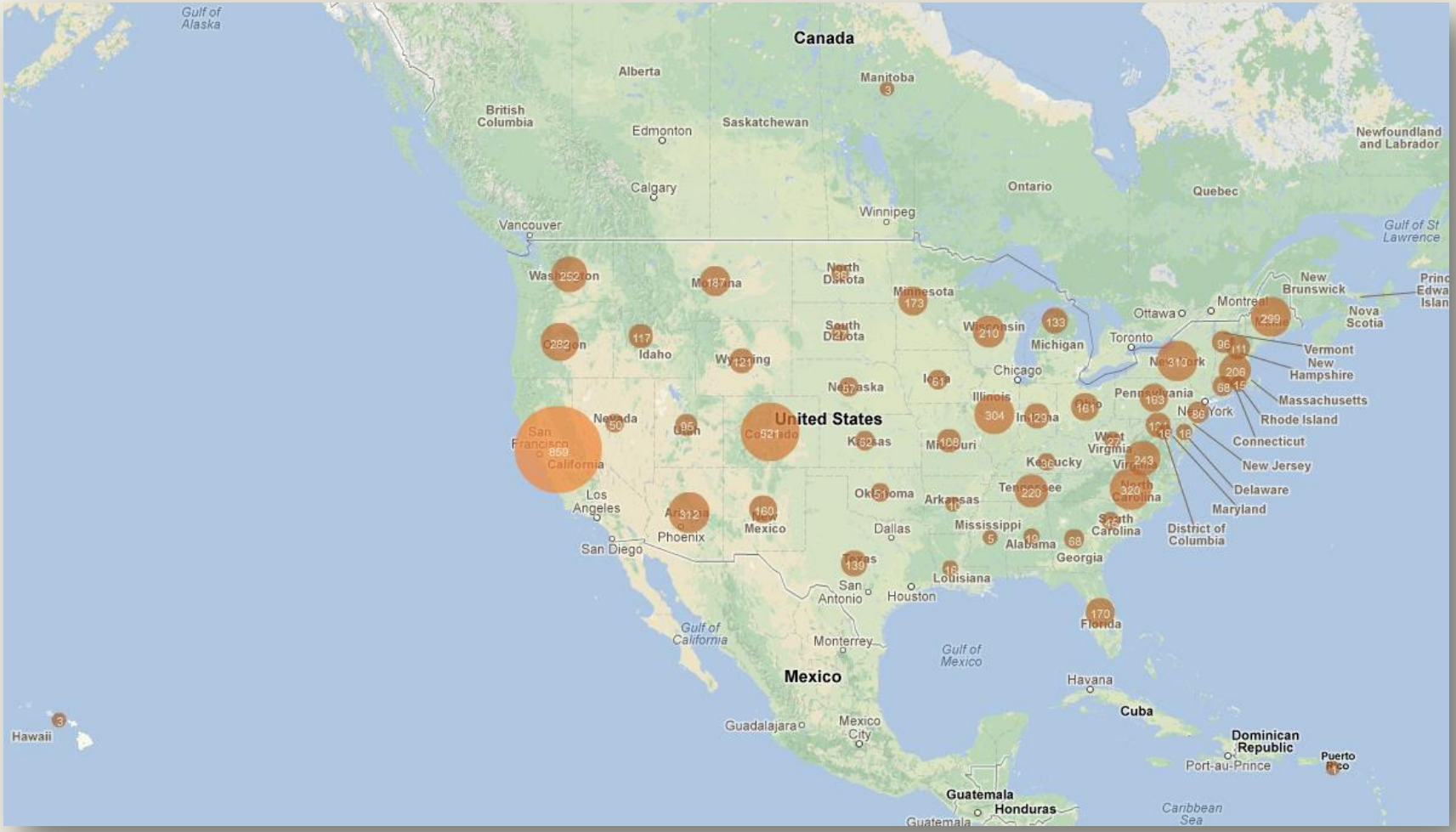
TRACKING Seasonal CHANGES IN PLANTS AND ANIMALS

Nature's Notebook is for scientists, naturalists, volunteers, land managers, park rangers, and YOU!

USA National Phenology Network

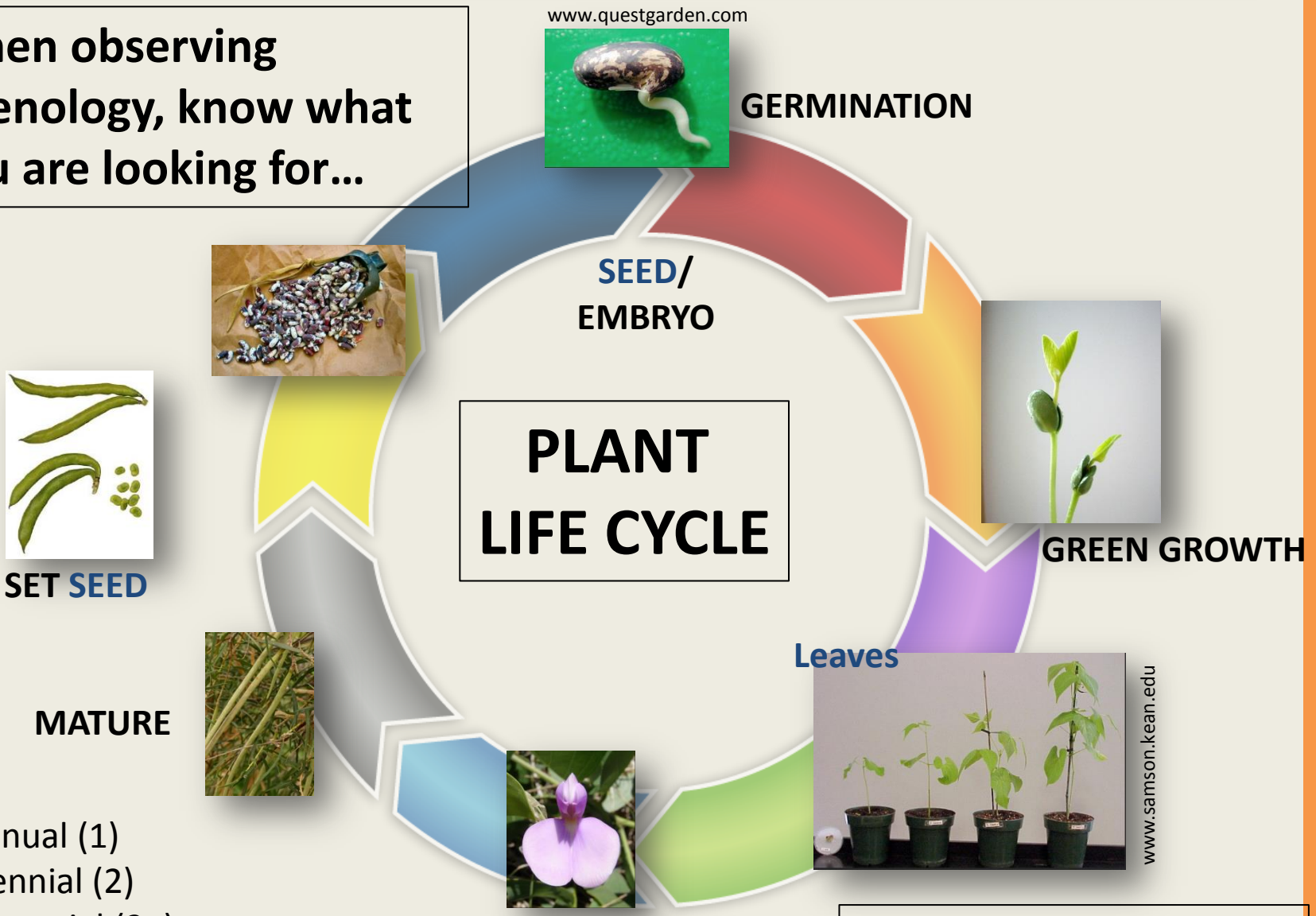
654 plant species and **243 animal species = ~900 total**

1815 observers reporting (6201 total) making **~250,000 observations**



Phenology

When observing phenology, know what you are looking for…



- Annual (1)
- Biennial (2)
- Perennial (2+)

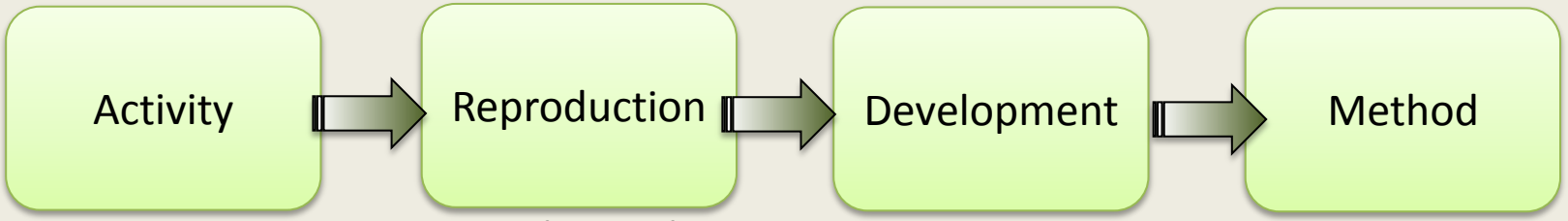
…and when it occurs

Phenology

Phenophases – Animals

Phenology

ANIMAL > Mammal, Bird, Snake



- Active individuals
- Feeding

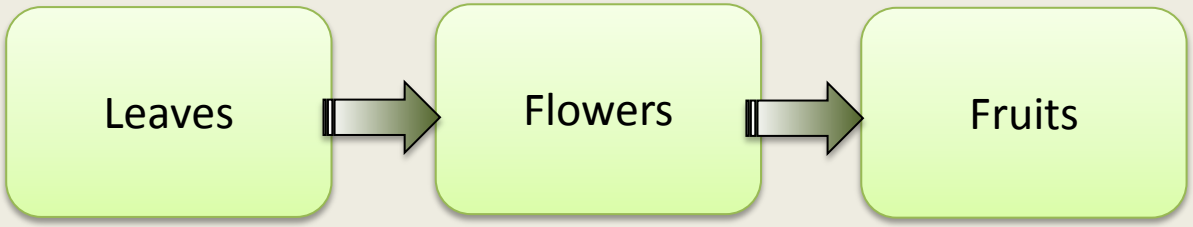
- Male combat
- Mating

- Young individuals
- Dead individuals

- Individuals at a feeding station

PHENOPHASES

PLANT



- Breaking leaf buds
- Leaves
- Colored leaves

- Buds
- Flowers or flower buds
- Pollen release

- Ripe fruits

Phenology

History and Phenology

Research, spring timing and range

Record keeping

- Journals, herbarium
- Crowd-sourced data, lilacs
- Spring Index

SPECIES AND ECOSYSTEMS ARE INFLUENCED BY GLOBAL ENVIRONMENTAL CHANGE

Local Drought Impact Group

Take-Aways:

- Phenology
- ***Phenology indicates change***
  - Phenology & management
  - *Nature's Notebook*
  - Local applications

Photo credit: E. Alderson

Photo credit: P. Warren

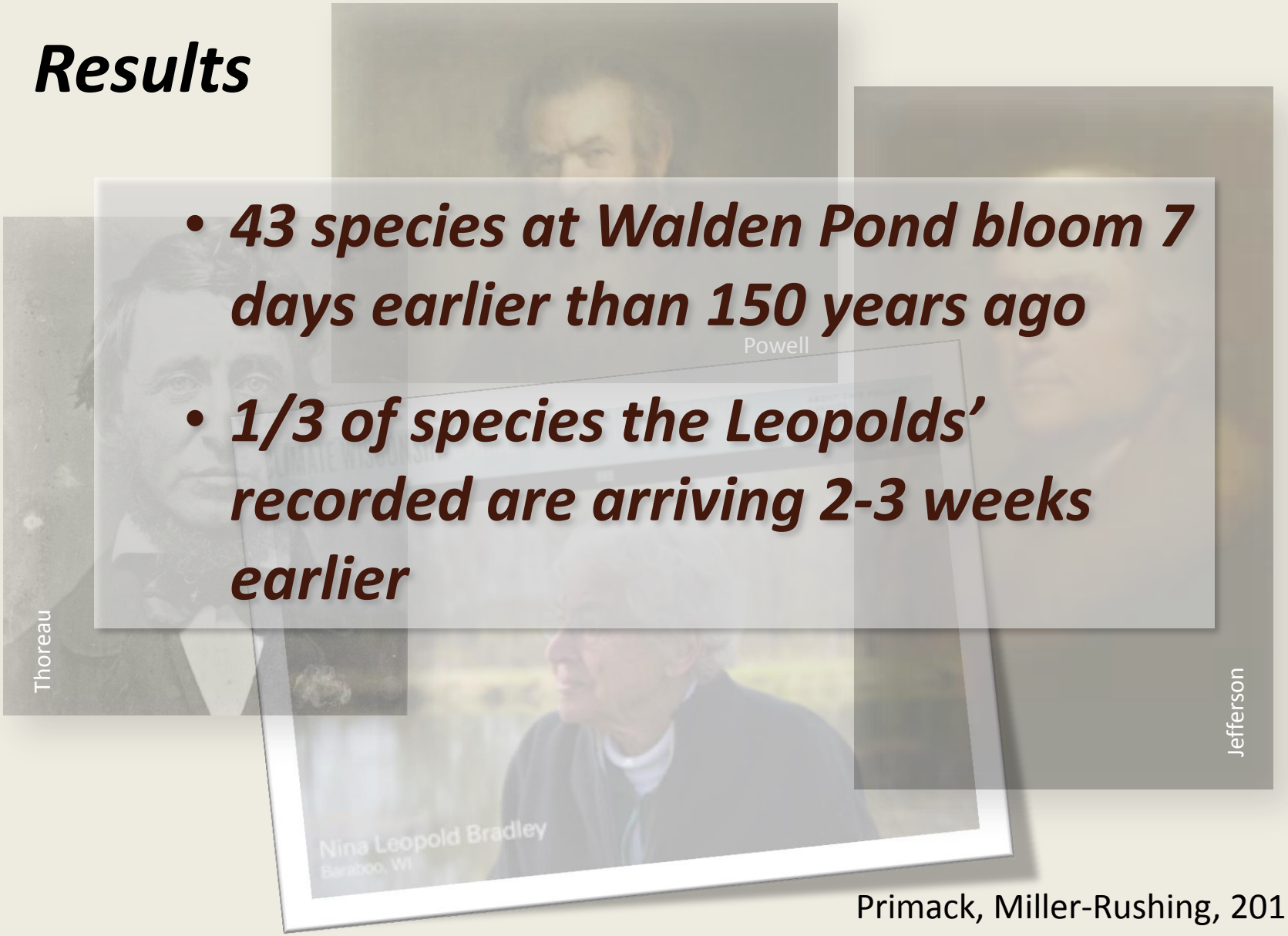
Photo credit: L. Barnett

Photo credit: P. Warren

©W

Phenology indicates change

Results



- ***43 species at Walden Pond bloom 7 days earlier than 150 years ago***
- ***1/3 of species the Leopolds' recorded are arriving 2-3 weeks earlier***

Primack, Miller-Rushing, 2011.

Phenology indicates change

English Oak

EARLIER

Phenology and Climate Change

Research, spring timing and range

A three-way mismatch

Winter Moth

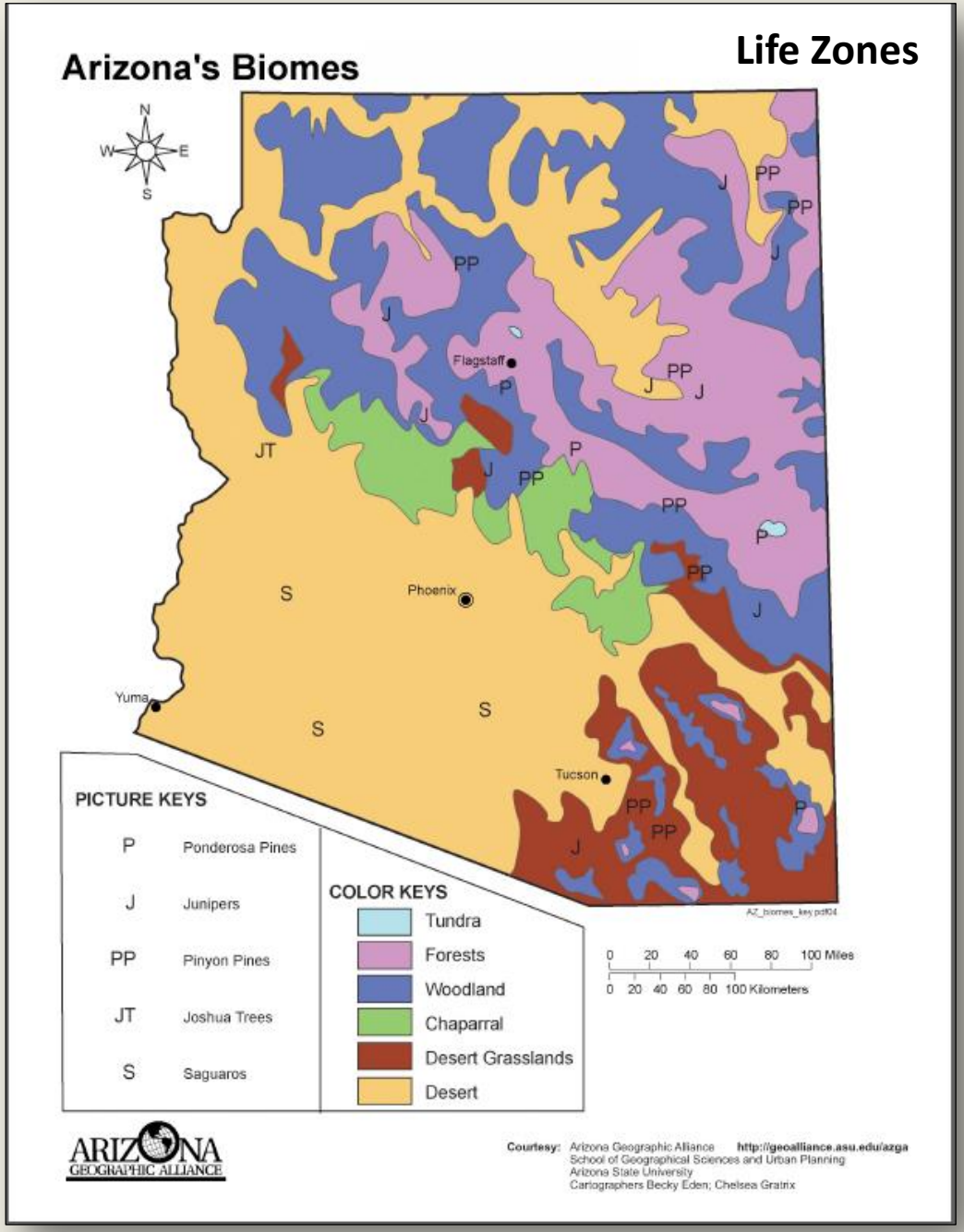
EARLIER

Pied Flycatcher

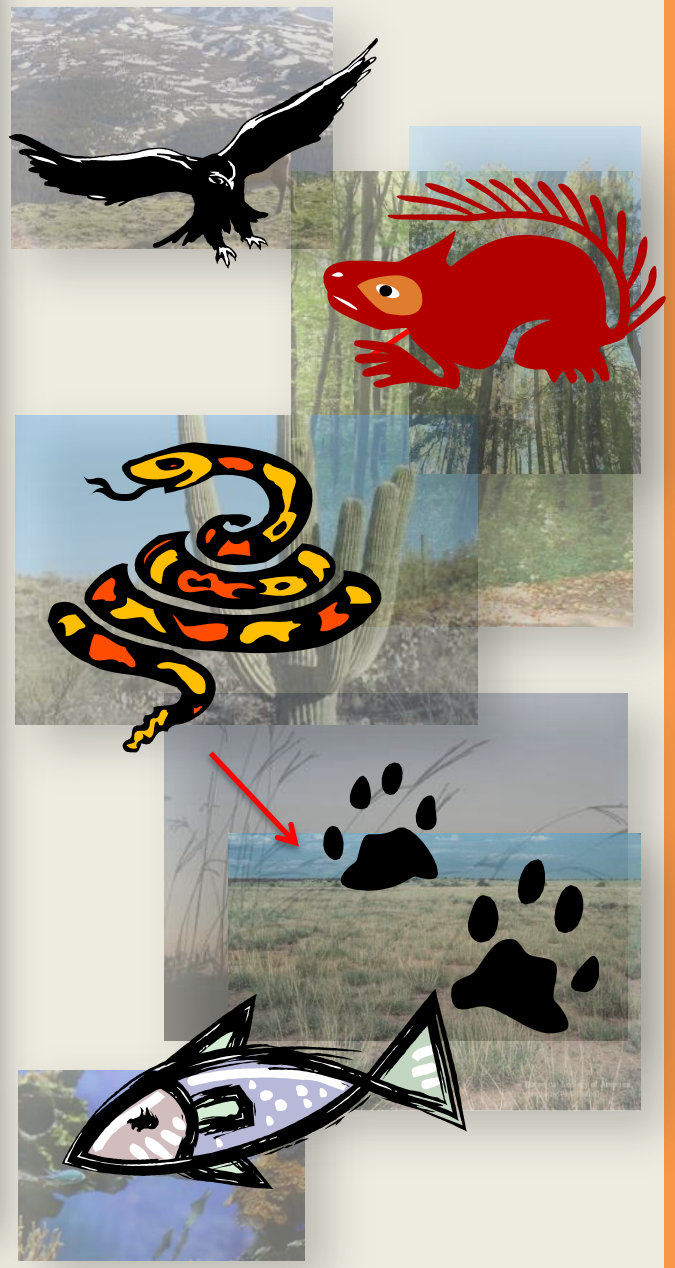
SAME TIME EACH YEAR

Both et al. 2006 Nature

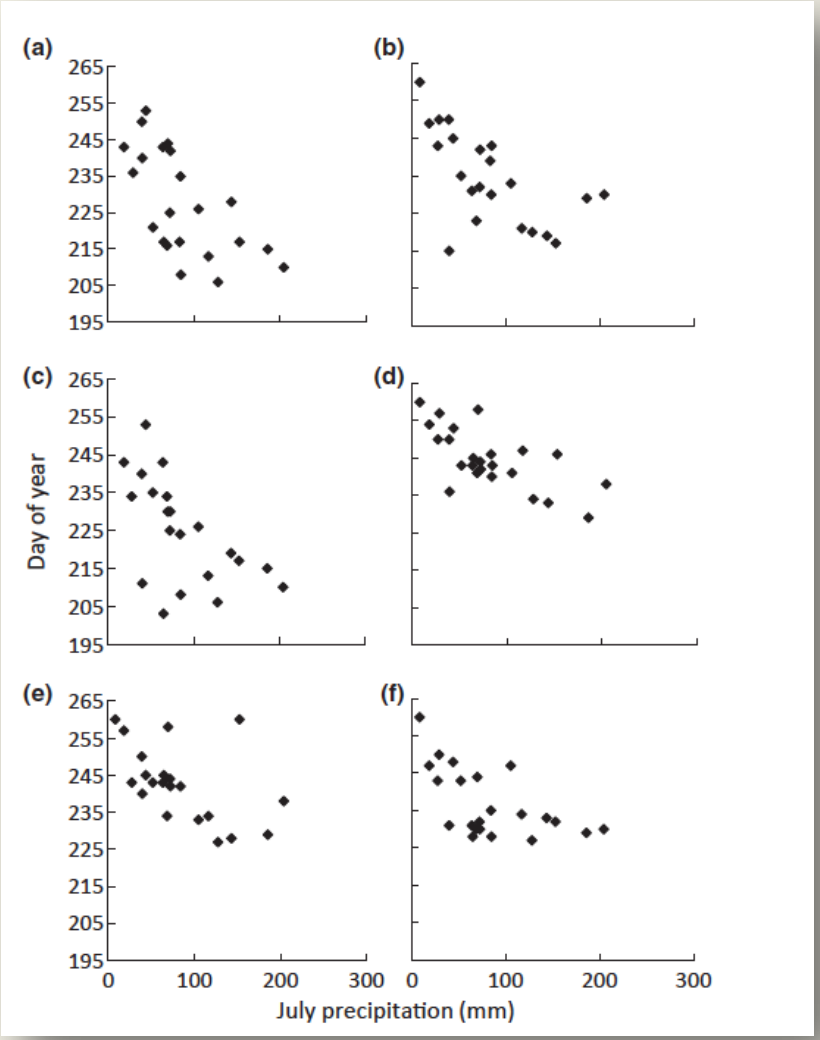
Life Zones



http://alliance.la.asu.edu/maps/AZ_biomes_web.pdf



Phenology indicates change



Onset of summer flowering in a 'Sky Island' is driven by monsoon moisture

Theresa M. Crimmins, Michael A. Crimmins, and C. David Bertelsen

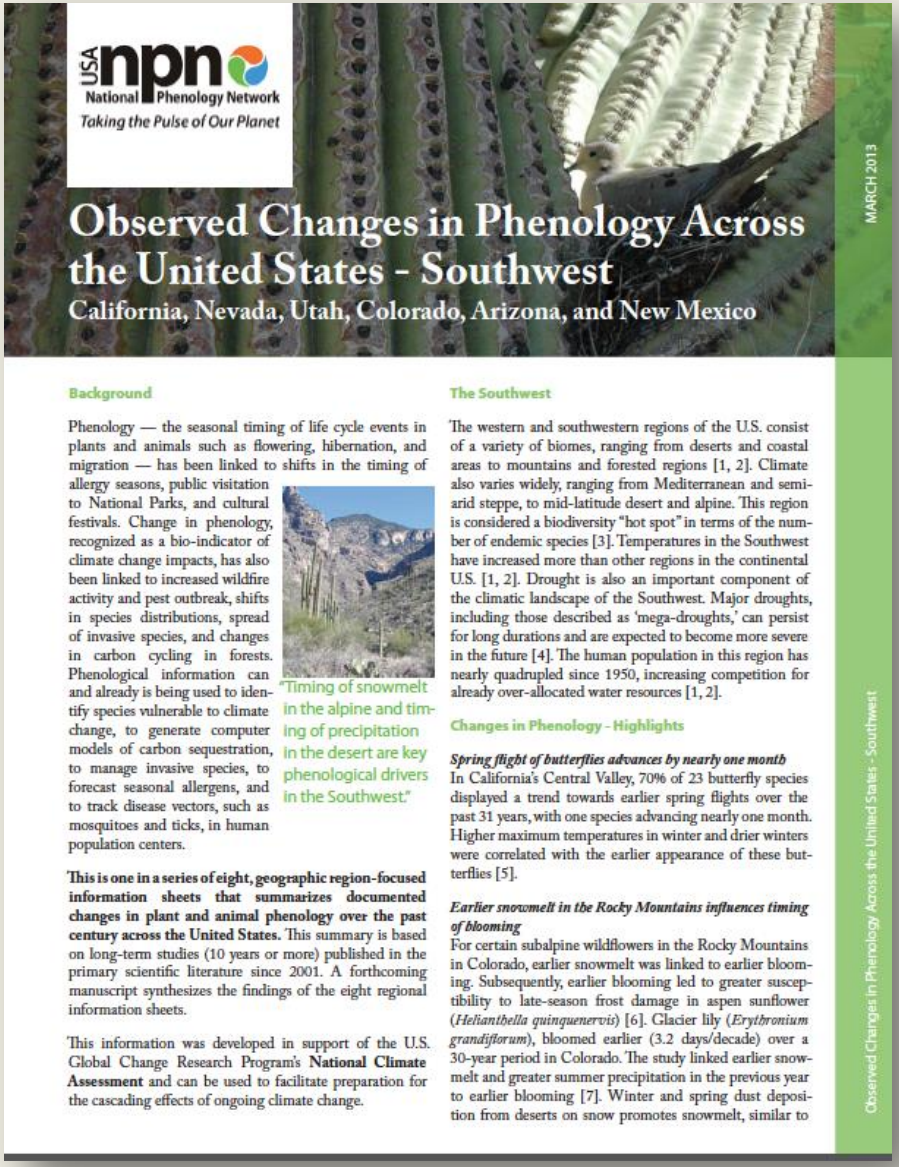
New Phytologist **(2011)** 191**: 468–479.**

Low elevation - monsoon precipitation

- More favorable conditions result in earlier flowering date
- The wetter the year, the earlier the flowers appear

Relationship between July precip and first flowering date for 6 species recorded along a route on Mt. Kimball, Santa Catalina Mountains, Tucson, AZ. 1984-2009

Phenology indicates change



USA npn National Phenology Network
Taking the Pulse of Our Planet

Observed Changes in Phenology Across the United States - Southwest

California, Nevada, Utah, Colorado, Arizona, and New Mexico

MARCH 2013

Background

Phenology — the seasonal timing of life cycle events in plants and animals such as flowering, hibernation, and migration — has been linked to shifts in the timing of allergy seasons, public visitation to National Parks, and cultural festivals. Change in phenology, recognized as a bio-indicator of climate change impacts, has also been linked to increased wildfire activity and pest outbreak, shifts in species distributions, spread of invasive species, and changes in carbon cycling in forests. Phenological information can and already is being used to identify species vulnerable to climate change, to generate computer models of carbon sequestration, to manage invasive species, to forecast seasonal allergens, and to track disease vectors, such as mosquitoes and ticks, in human population centers.

"Timing of snowmelt in the alpine and timing of precipitation in the desert are key phenological drivers in the Southwest."

This is one in a series of eight, geographic region-focused information sheets that summarizes documented changes in plant and animal phenology over the past century across the United States. This summary is based on long-term studies (10 years or more) published in the primary scientific literature since 2001. A forthcoming manuscript synthesizes the findings of the eight regional information sheets.

This information was developed in support of the U.S. Global Change Research Program's **National Climate Assessment** and can be used to facilitate preparation for the cascading effects of ongoing climate change.

The Southwest

The western and southwestern regions of the U.S. consist of a variety of biomes, ranging from deserts and coastal areas to mountains and forested regions [1, 2]. Climate also varies widely, ranging from Mediterranean and semi-arid steppe, to mid-latitude desert and alpine. This region is considered a biodiversity "hot spot" in terms of the number of endemic species [3]. Temperatures in the Southwest have increased more than other regions in the continental U.S. [1, 2]. Drought is also an important component of the climatic landscape of the Southwest. Major droughts, including those described as 'mega-droughts,' can persist for long durations and are expected to become more severe in the future [4]. The human population in this region has nearly quadrupled since 1950, increasing competition for already over-allocated water resources [1, 2].

Changes in Phenology - Highlights

Spring flight of butterflies advances by nearly one month

In California's Central Valley, 70% of 23 butterfly species displayed a trend towards earlier spring flights over the past 31 years, with one species advancing nearly one month. Higher maximum temperatures in winter and drier winters were correlated with the earlier appearance of these butterflies [5].

Earlier snowmelt in the Rocky Mountains influences timing of blooming

For certain subalpine wildflowers in the Rocky Mountains in Colorado, earlier snowmelt was linked to earlier blooming. Subsequently, earlier blooming led to greater susceptibility to late-season frost damage in aspen sunflower (*Helianthella quinquenervis*) [6]. Glacier lily (*Erythronium grandiflorum*), bloomed earlier (3.2 days/decade) over a 30-year period in Colorado. The study linked earlier snowmelt and greater summer precipitation in the previous year to earlier blooming [7]. Winter and spring dust deposition from deserts on snow promotes snowmelt, similar to

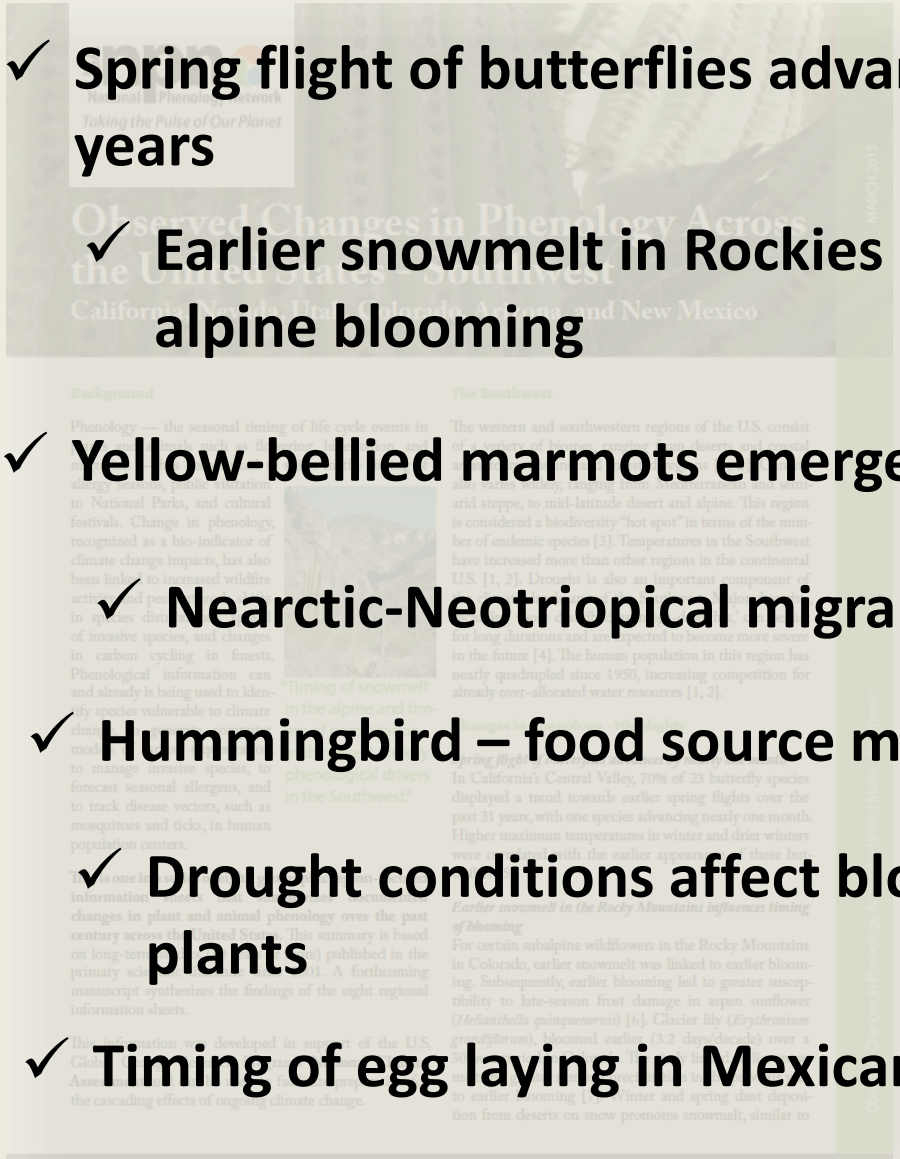
Observed Changes in Phenology Across the United States - Southwest

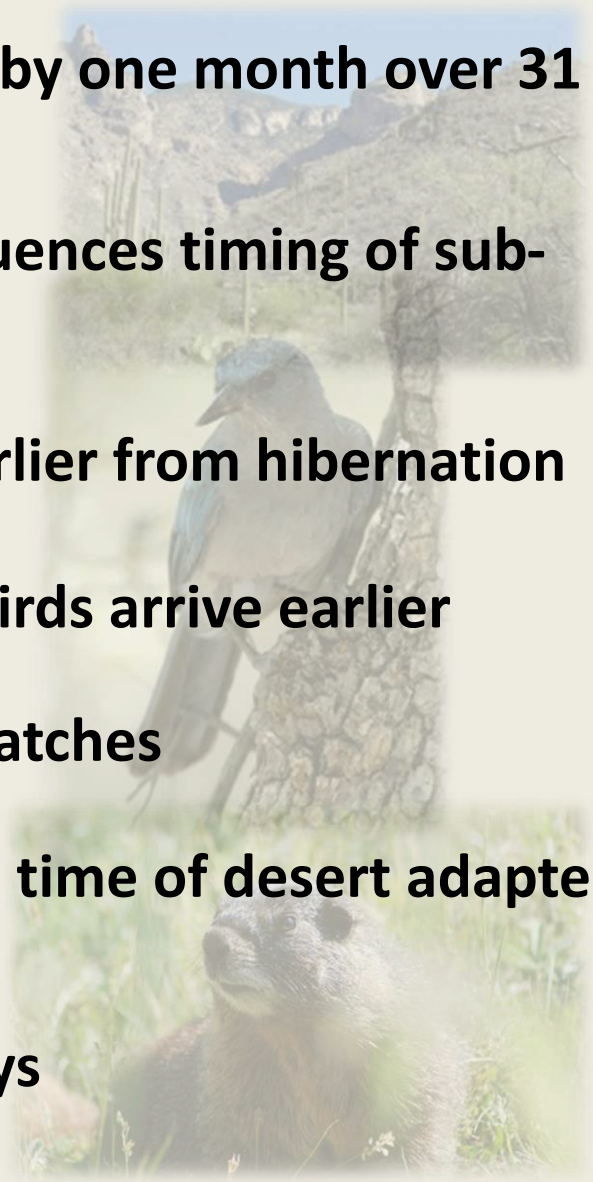
Documented changes in phenology across the United States

https://www.usanpn.org/pubs/reports

Phenology indicates change

- ✓ Spring flight of butterflies advance by one month over 31 years
- ✓ Earlier snowmelt in Rockies influences timing of sub-alpine blooming
- ✓ Yellow-bellied marmots emerge earlier from hibernation
- ✓ Nearctic-Neotriopical migrant birds arrive earlier
- ✓ Hummingbird – food source mismatches
- ✓ Drought conditions affect bloom time of desert adapted plants
- ✓ Timing of egg laying in Mexican Jays

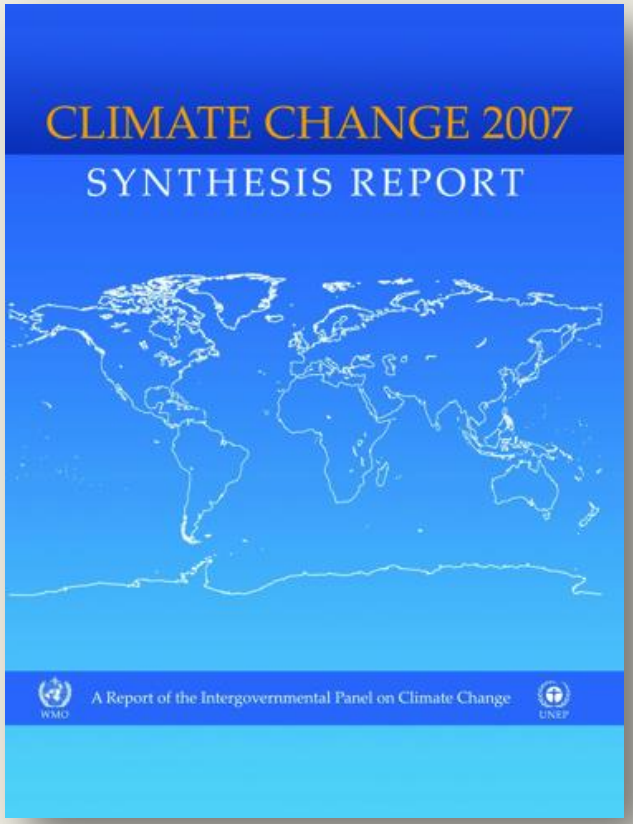




Phenological patterns are important, economically and biologically

… and sensitive to climate

… and sensitive to climate change.



***"Phenology…is perhaps the simplest process in which to track changes in the ecology of species in response to climate change."* (IPCC 2007)**

"Because of their close connection with climate, the timing of phenological events can be accurate indicators of climate change." (EPA 2010)

Local Drought Impact Group

Take-Aways:

- Phenology
- Phenology indicates change
- ***Phenology & management***
  - *Nature's Notebook*
  - Local applications

Photo credit: E. Alderson

Photo credit: P. Warren

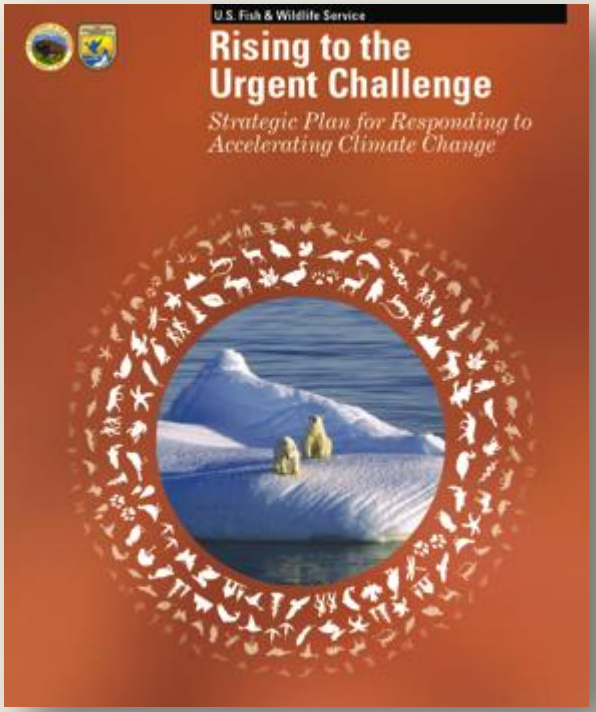
Photo credit: L. Barnett

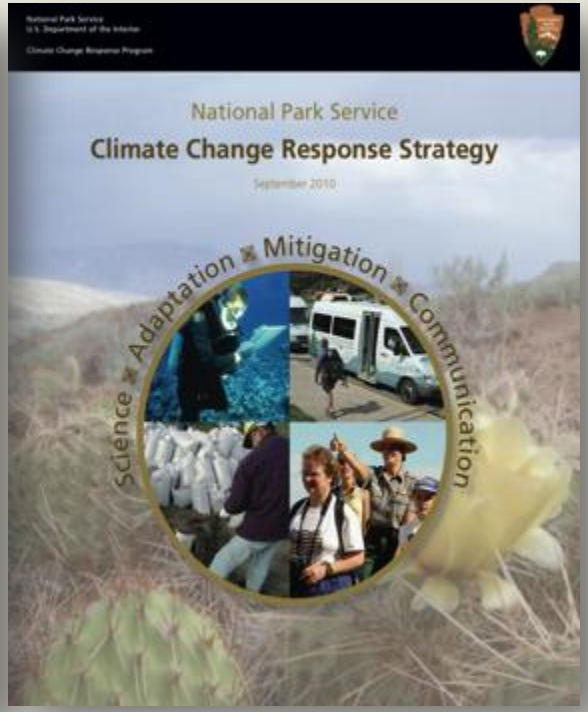
Photo credit: P. Warren

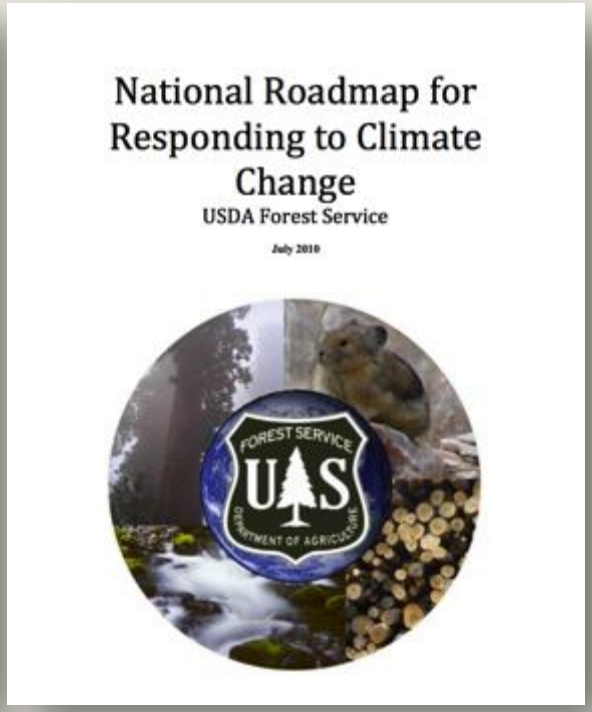
©W

Phenology & management

Climate-relevant information for Landscape Assessments

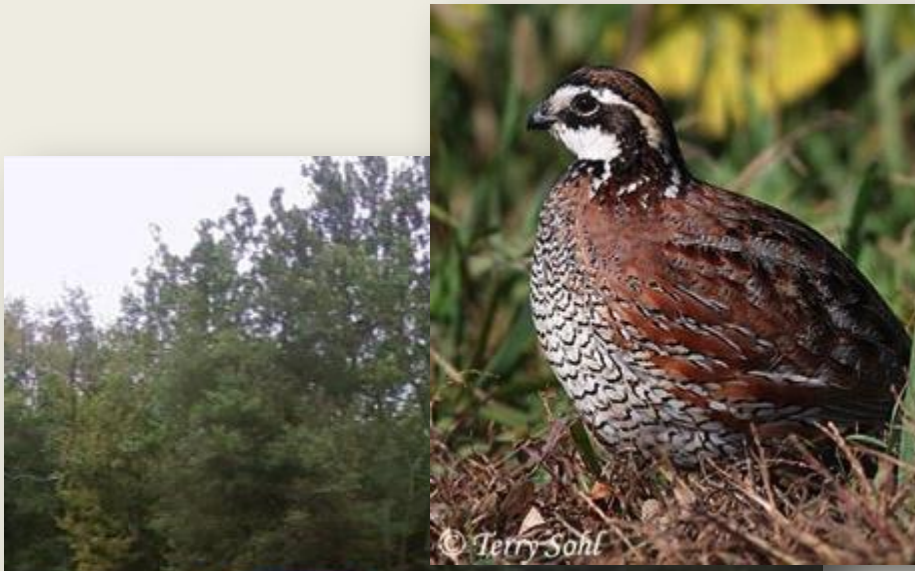




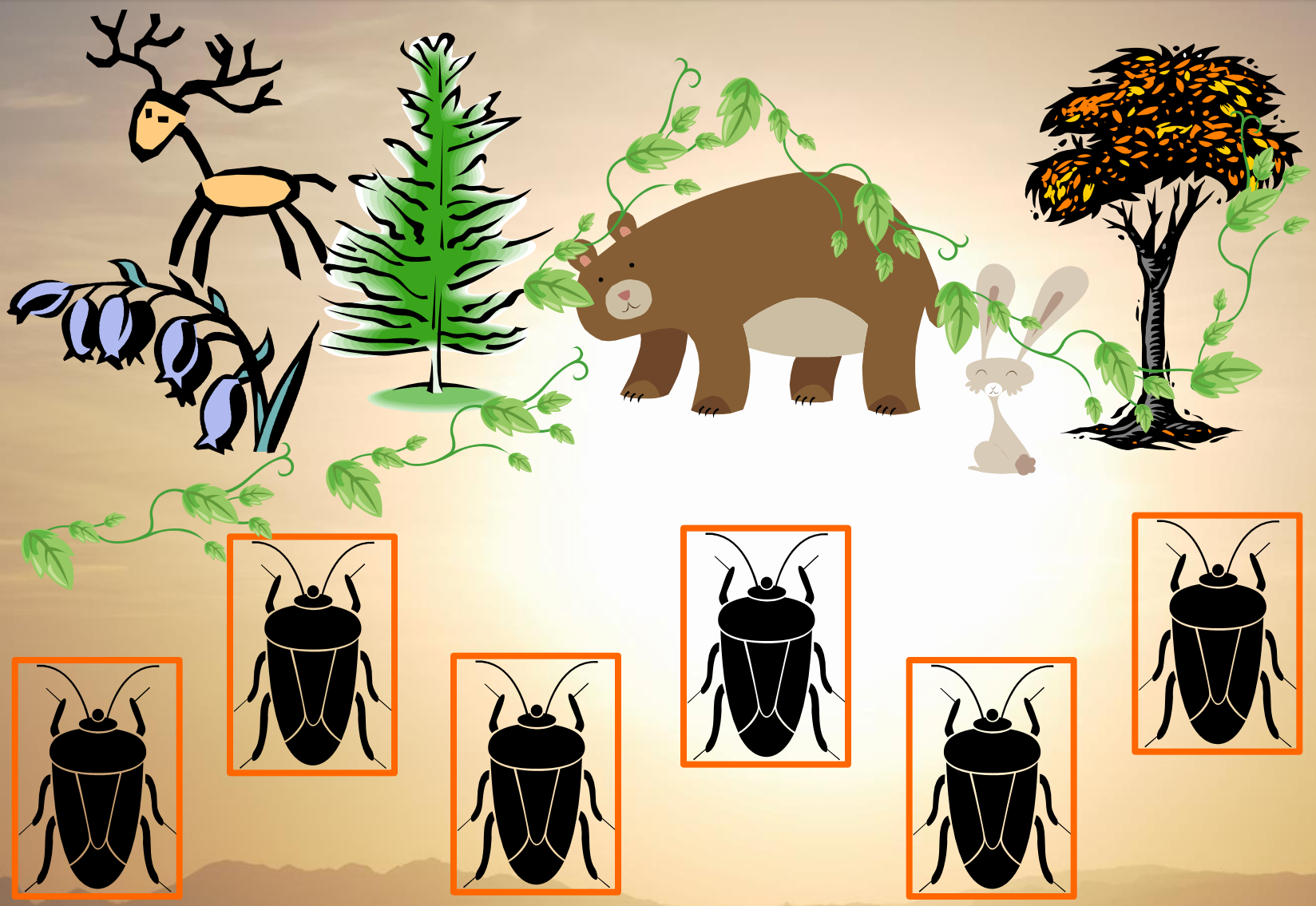


Phenology & management

Shifts in the Timing of Management Actions



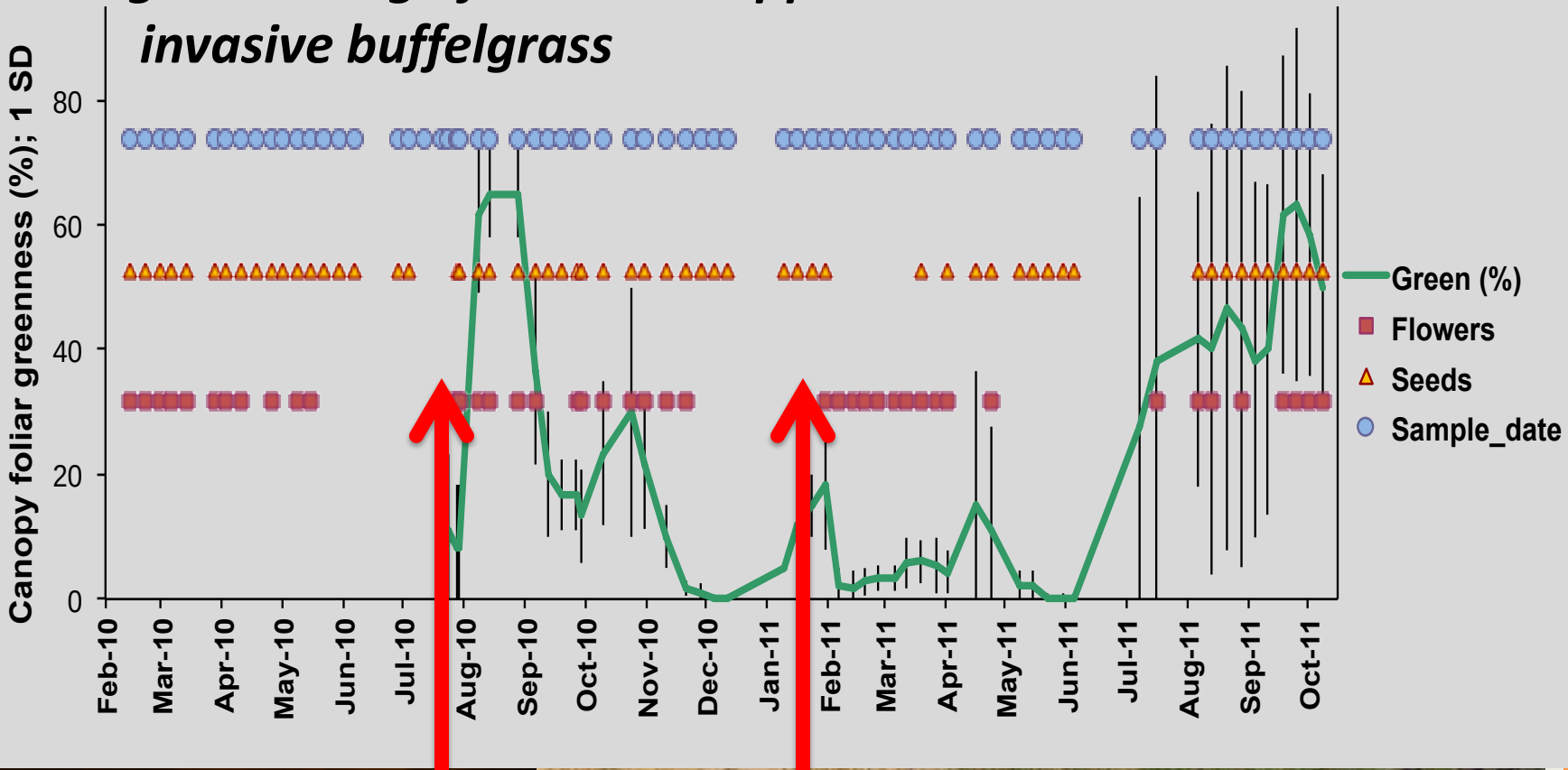
Phenology & Management



Phenology & management

Advising the timing of herbicide application to invasive buffelgrass

Advising the timing of herbicide application to invasive buffelgrass



Phenology & management

Drought

Longer dormancy

Fuel abundance

“The phenological status of vegetation represents the primary driver influencing fuel availability and moisture content.”

(2012, De Angelis, A. Bajocco, Ricotta, S.)

Local Drought Impact Group

Take-Aways:

- Phenology
- Phenology indicates change
- Phenology & management
- ***Nature's Notebook***
  - Local applications

Photo credit: E. Alderson

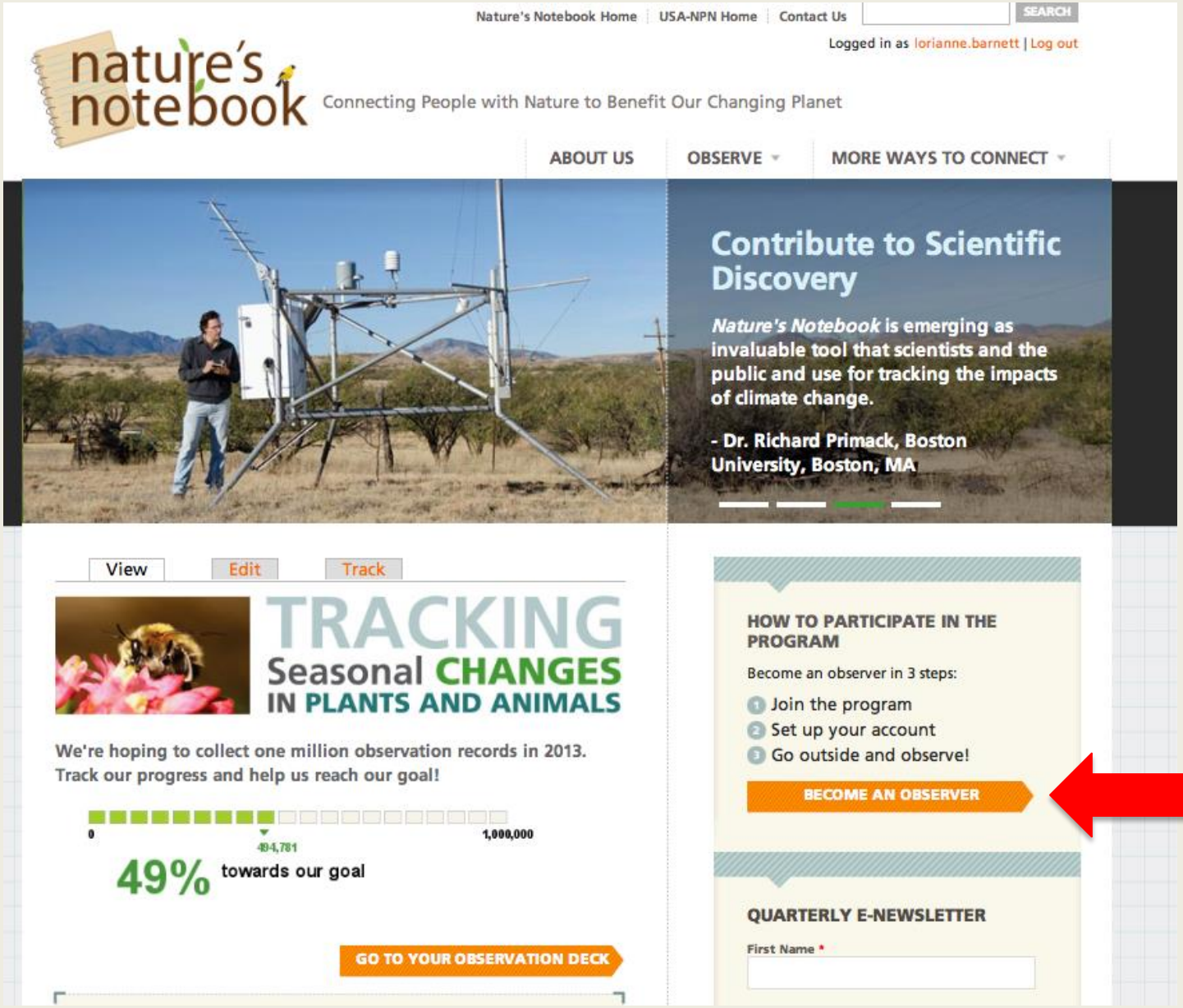
Photo credit: P. Warren

Photo credit: L. Barnett

Photo credit: P. Warren

©W

www.nn.usanpn.org



10 minutes to get set up

USA National Phenology Network

Observations

Enter your observations below or via smartphone. You can edit the sites, plants or animals you've seleted ar ne.

Sites

Pima County Extension

Green Valley Cooperative Exter
Pima Extension Office (P)
Santa Rita Experimental Range

Edit Site »
Add a New Site »
Add a Public Site »
Manager Users »

My Plants & Animals

PROVEL-1
PROVEL-2
CARGIG-1
FOUSPL-1
FOUSPL-2
LARTRI-1
LARTRI-2
SIMCHI-1
SIMCHI-2
DODVIS-1
DODVIS-2

Add or Edit Plants »
Add or Edit Animals »
Sort Plants & Animals »
Print Field Datasheets »

Details for this Organism

PROVEL-1
velvet mesquite (Prosopis velutina)
Patch? No
Wild? Unknown
Gender? Unknown

View Species Profile »
Print Field Datasheet »
Print Phenophase Definition Sheet »

Enter Observations

Enter Observation Data »
Download My Data (430) »

Nature's Notebook mobile apps for Android and iPhone.

FAQs | Terms of Use

Nature's Notebook is a project of the USA National Phenology Network.

USA National Phenology Network

Trees and Shrubs *Semi-deciduous*

nature's notebook

Nickname: _____
Species: ocotillo
Site: _____
Year: _____
Observer: _____

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:
Do you see...	Time:	Time:	Time:	Time:	Time:	Time:	Time:
Young leaves	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 ? _____
Flowers or flower buds	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 ? _____
Fruits	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 ? _____
Recent fruit or seed drop	y n ? _____	y n ? _____	y n ? _____	y n ? _____	y n ? _____	y n ? _____	y n ? _____
Check when data entered online:	☐	☐	☐	☐	☐	☐	☐
Comments:							

- **YES**
- **NO**
- **UNCERTAIN**
- **No record if you did not check**

USA National Phenology Network

Species: desert ironwood
Nickname: OLNtes01

Do you see...?	
Young leaves	y n ? ____
Leaves	y n ? ____
Colored leaves	y n ? ____
Flowers or flower buds	y n ? ____
Open flowers	y n ? ____
Fruits	y n ? ____
Ripe fruits	y n ? ____
Recent fruit or seed drop	y n ? ____
	y n ? ____
	y n ? ____
	y n ? ____
Check when data entered online:	☐

Leaves

Flowers

Fruits

https://www.usanpn.org/nn/guidelines

USA National Phenology Network

Species: ocotillo
Nickname: FOUSPL-1

Do you see...?		
Young leaves	y n ?	101 – 1,000
Leaves	y n ?	95% or more
Flowers or flower buds	y n ?	3 to 10
Open flowers	y n ?	
Fruits	y n ?	
Ripe fruits	y n ?	
Recent fruit or seed drop	y n ?	
	y n ?	
	y n ?	
	y n ?	
	y n ?	
	y n ?	
Check when data entered online:	☐ ✓	

USA National Phenology Network

Observations

Enter your observations below or via smartphone. You can edit the sites, plants or animals you've seleted anytime.

MY ACCOUNT

You are currently logged in as lorianne.barnett

MY ACCOUNT DETAILS

Sites

Pima County Extension

Green Valley Cooperative Exten
Pima Extension Office (P)

My Plants & Animals

PROVEL-1
PROVEL-2
CARGIG-1

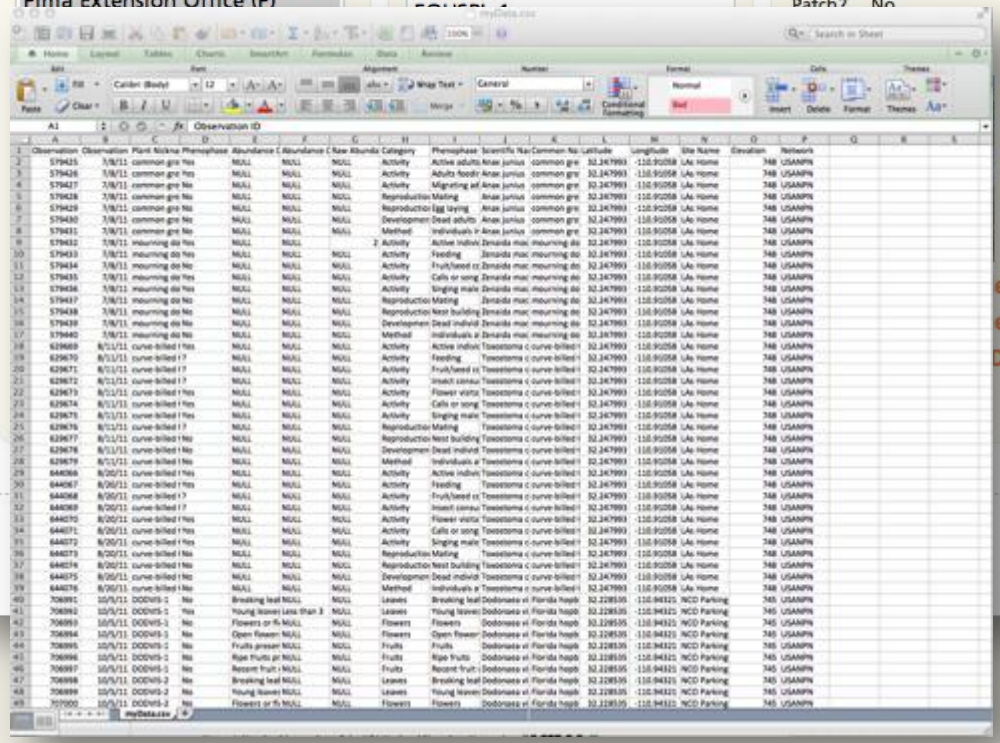
Details for this Organism

PROVEL-1
velvet mesquite (Prosopis velutina)

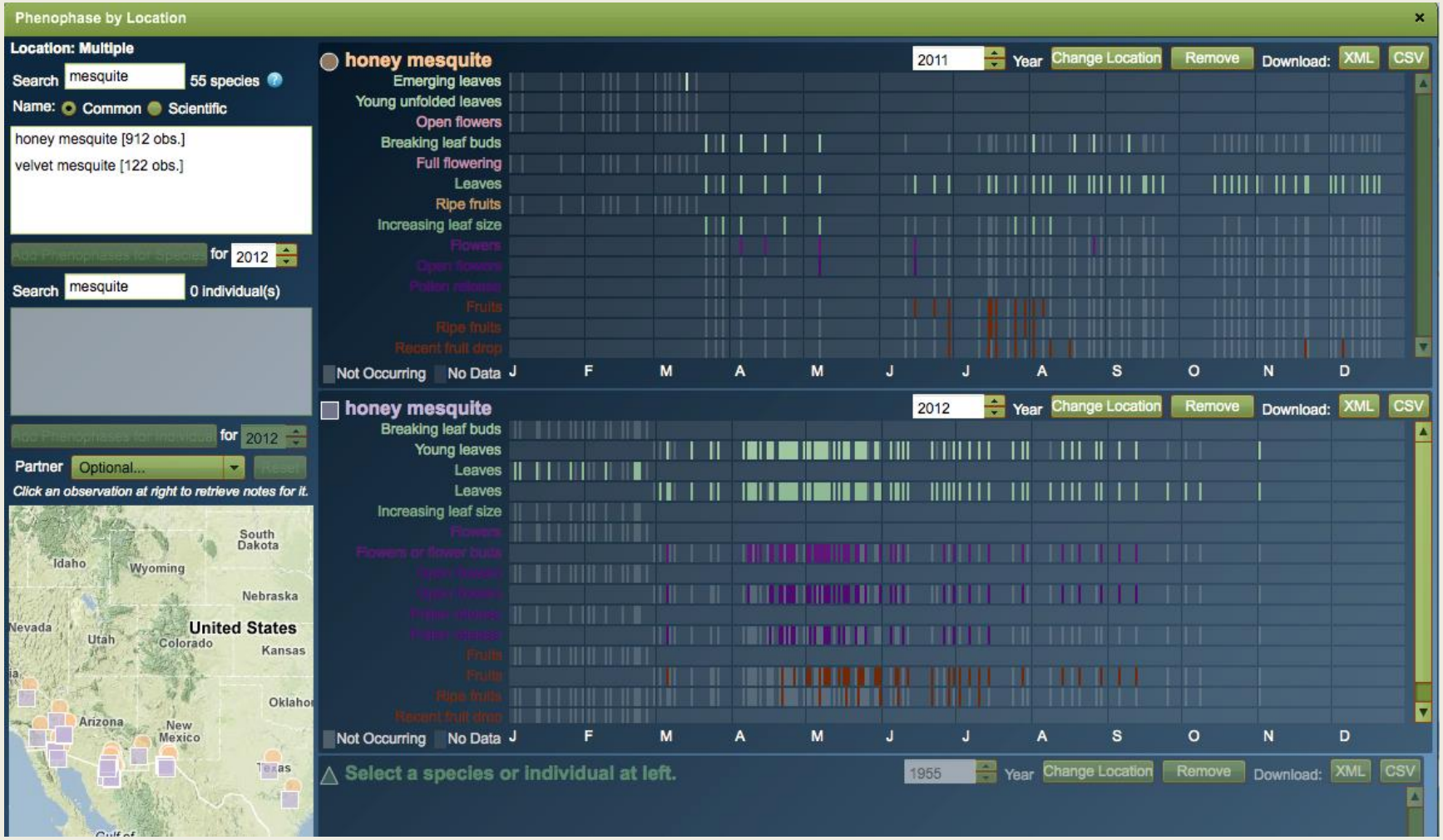
Enter Observations

Enter Observation Data »
Download My Data (430) »

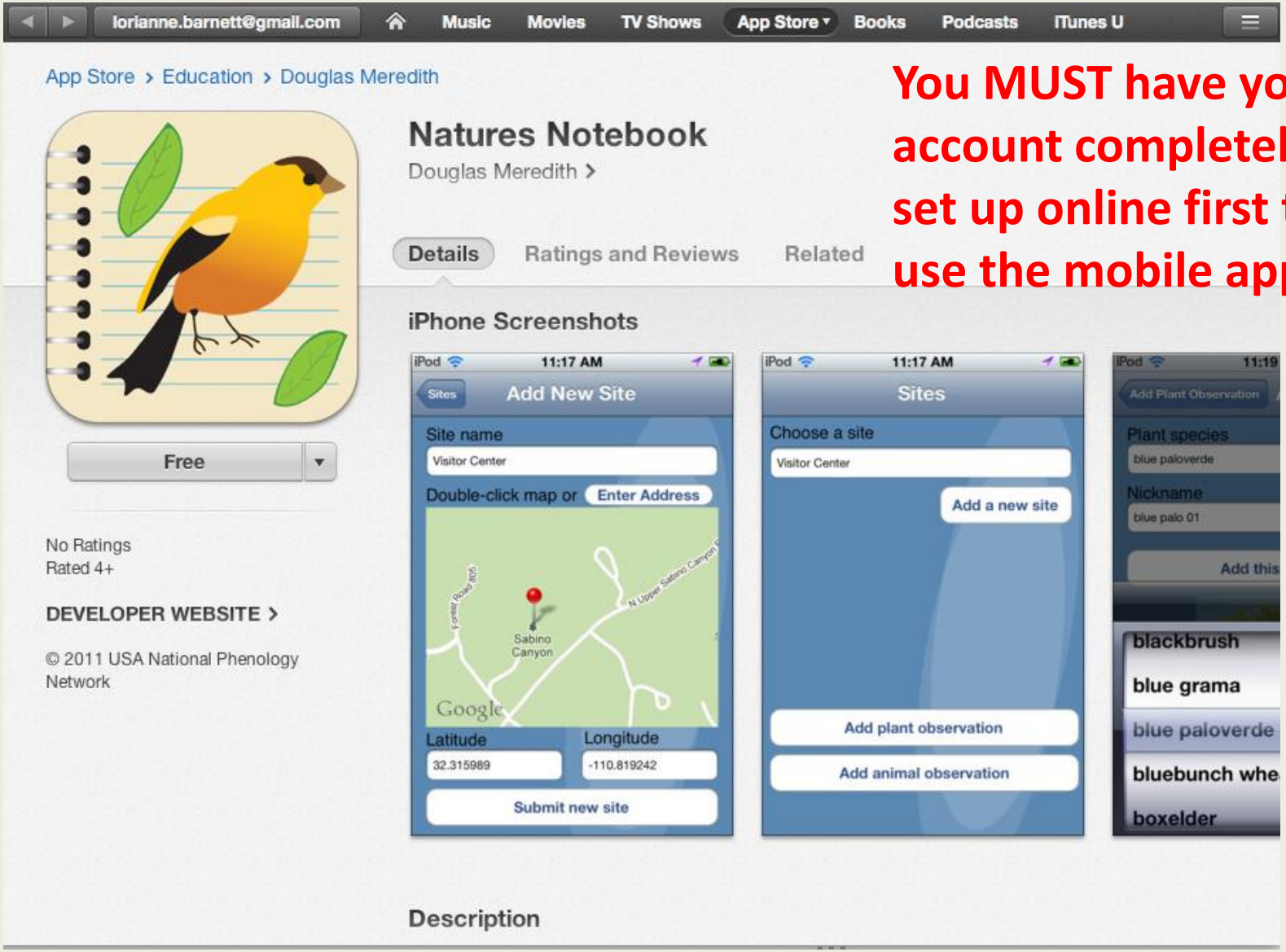
Nature's Notebook mobile apps for Android and iPhone.



USA National Phenology Network



USA National Phenology Network



You MUST have you account completely set up online first to use the mobile apps!

Local Drought Impact Group

Take-Aways:

- Phenology
- Phenology indicates change
- Phenology & management
- *Nature's Notebook*
- ***Local applications***

Photo credit: E. Alderson

Photo credit: P. Warren

Photo credit: L. Barnett

Photo credit: P. Warren

©W

Local applications

Buffelgrass

Photos credit: Wikimedia Commons (Starr)

Local applications

Common and cloned Lilac

Santa Rita Experimental Range

Local applications

What is a *Phenology Trail?*

A phenology trail is a network of *Nature's Notebook* observation sites. Each site has at least two plant and/or animal individuals tagged for data collection.

Observations help us remember what happened, and when.

Local applications

Tucson Phenology Trail

- Biosphere 2
- Tucson Audubon Mason Center
- UA Campus Arboretum
- Sam Hughes Neighborhood
- Pima Extension Offices (2)
- Rincon Heights Neighborhood
- SRER
- Borton Elementary School
- *Tumamoc Hill*
- *Arizona Sonora Desert Museum*

Total of 75 Miles, start to finish

3-10 species tagged at each

Local applications

Species being monitored

- Jojoba
- Velvet mesquite
- Yellow paloverde
- Blue paloverde
- Ocotillo
- Creosote
- Florida hopbush
- Saguaro
- Penstemon (parryi)
- Texas Ranger
- Desert Ironwood
- Buffelgrass

Whoever sees the land as a whole is likely to have an interest in it. –A. Leopold

Photo credit: L. Barnett

QUESTIONS?

Photo credit: L. Barnett

Thank you!

You're invited to connect with USA-NPN…

- Sign up for a phenology **e-newsletter** (quarterly)
- Join the *Nature's Notebook* community **and become an observer**: Contribute to science while having fun!
- Discover **new tools and resources** for work or play

usanpn.org

LoriAnne Barnett
lorianne@usanpn.org
@loriannebarnett