USA National Phonology Network






2009 Data Summary

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USA National Phenology Network

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TABLE OF CONTENTS

ABSTRACT

The USA National Phenology Network (USA-NPN) seeks to engage volunteer observers to collect phenology observations of plants and animals using consistent standards and to contribute to the USA-NPN National Phenology Database. In March 2009, the USA-NPN National Coordinating Office staff implemented an online monitoring program for 213 plant species.

In this pilot year of the program, 547 observers reported phenology observations on one or more plants via the online interface. There was a substantial national interest in participating in this program, focused only on plants and with minimal advertising or marketing, which resulted in a thousand new registrants, a thousand new sites, and tens of thousands of observations on 133 plant species across the nation in less than a year.

Participants tended to stay involved, reporting most phenophases for an average of nine unique dates over almost two months during the year. This suggests a sustained interest in participation, and that the online interface and status monitoring are both conducive to engaging the public and keeping them involved in the project and engaged in participatory monitoring and outdoor activities.

The data collected by participants show interesting patterns of plant phenology on regional to national scales that are commensurate with our understanding of climatological gradients associated with latitude, longitude, elevation, and degree of continentality. As such, these data should be useful to a variety of stakeholders interested in the spatial and temporal patterns of plant activity on a national scale; through time, these data should also empower scientists, resource managers, and the public in decision-making and adapting to variable and changing climates and environments.

INTRODUCTION

The USA-National Phenology Network (USA-NPN) seeks to engage volunteer observers to collect phenological observations of plants and animals using consistent standards and to contribute their observations to a national data repository. To guide the effort, the USA-NPN National Coordinating Office, based in Tucson, Arizona, has developed phenology monitoring protocols and an information management system that houses a data repository, the National Phenology Database. In March 2009, the National Coordinating Office staff implemented an online monitoring program for 213 plant species. This report summarizes the results of the 2009 monitoring season.

What is phenology?

Phenology refers to recurring plant and animal life cycle stages, such as leafing and flowering, maturation of agricultural plants, emergence of insects, and migration of birds. It is also the study of these recurring plant and animal life cycle stages, especially their timing and relationships with weather and climate. The Intergovernmental Panel on Climate Change report (2007) notes that plants and animals respond to changes beyond their tolerances by shifting the timing of life-cycle events, shifting range boundaries, changing morphology, or becoming extirpated or extinct. The report states that "phenology ……is perhaps the simplest process in which to track changes in the ecology of species in response to climate change." Understanding the phenology of a species includes understanding the influence of seasonal and interannual variation in climate on the life-cycle events and activities of the species.

People have observed and responded to phenological events long before written history as part of their day-to-day activities, yet in the contemporary era people are often unaware of or overlook the importance of phenology in their everyday lives. Current understanding of phenology is important for society to identify how species are responding to climate change and to plan for how these changes might affect activities such as resource management, public health planning, agriculture and range management, and recreational/tourism marketing.

The USA National Phenology Network

The USA National Phenology Network monitors the influence of climate on the phenology of plants, animals, and landscapes. We do this by encouraging people to observe phenological events and by providing a place for people to enter, store, and share their observations. We also work with researchers to develop tools and techniques to use these observations to support a wide range of decisions made routinely by citizens, managers, scientists and others, including decisions related to allergies, wildfires, water, and conservation.

The USA-NPN is comprised of many partners including federal, state and local agencies, universities, colleges and schools, non-governmental organizations, citizen volunteers, and many others. Our participants range from individual observers making observations in their backyards to professional scientists monitoring long-term plots.

PARTICIPATION SUMMARY

The first fully functional version of the USA-NPN online user interface to facilitate standardized monitoring of plant phenology was released on March 2, 2009 and was named "MyNPN." Through MyNPN, phenology observers could 1) register as an observer with the USA-NPN; 2) register one or more sites where they are observing plant phenology; 3) register one or more individual plants under observation; and 4) enter phenology observations.

Individuals participating in the USA-NPN plant phenology observing program follow species-specific protocols consisting of a suite of **phenophases**, or observable stages or phases in the annual life cycle of the plant that can be defined by a start and end point. Each organism has a suite of potential phenophases that can be observed at each sample date. USA-NPN phenology protocols employ phenological "status" monitoring, rather than "event" monitoring. Instead of events, we recommend that people monitor phenological status. This approach has a number of advantages over event monitoring (e.g., calculation of error, estimation of effort, "negative" or "absence" data, capture of multiple events and duration, flexibility of definitions for phenological metrics, adaptability for animal monitoring).

On each visit to an individual plant, the observer indicates 'yes' if the phenophases is occurring and 'no' if it is not. Monitoring protocols, phenophases, and general plant descriptions are provided via species profile pages on the USA-NPN website. Details of this system and monitoring protocols implemented for the 2009 growing season are provided in *The National Phenology Monitoring System, v0.1* (www.usanpn.org/results/reports).

***Status** versus **event** monitoring*

Phenological **event** monitoring involves precisely documenting defined points in the annual life cycles of plants or animals, such as first and last flowering, and first and last arrival of migratory animals. In contrast, **status** monitoring involves noting the phenological status (e.g., the presence of leaves, flowers, or fruits; singing or mating) of plants and animals during a series of repeated observations.

USA-NPN protocols are based on **status** monitoring.

Because the MyNPN interface and USA-NPN observation protocols were still undergoing many changes in 2009, this year was treated as a "beta" data collection year. Accordingly, the National Coordinating Office chose to limit advertisement of the program. A press release announcing the program was distributed in early March; however, no further large-scale engagement efforts were undertaken in 2009.

From January to December 31, 2009, **2,154 individuals registered** as observers with the USA-NPN plant phenology program via MyNPN. This number includes nearly 700 observers in an historic lilac observation program (www.usanpn.org/lilac) who were incorporated into the National Phenology Database (NPDb) in January (Figure 1). Registration was also strongly influenced by a March press release and the appearance of the USA-NPN Executive Director on NPR's *Science Friday*. Otherwise, the number of individuals submitting phenology observations shows a distinct seasonal pattern, with peaks occurring in April and October. We are unaware of a particular reason for the small peak in new registrants occurring in October, though this may be related to the opportunity to track fall foliage color, or increases in fall flowering commensurate with cooler autumn temperatures.

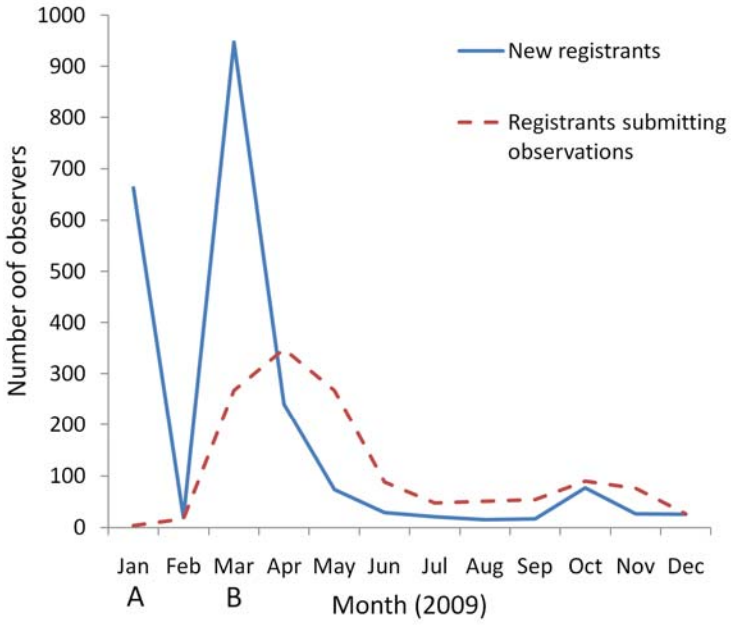

Figure 1. Observers registering and submitting plant phenology observations via MyNPN to the USA-NPN National Phenology Database (NPDb). (A) Historic lilac network observers added to the NPDb. (B) Launch of new USA-NPN website with press release; USA-NPN Executive Director hosted on *Science Friday.*

In total, **1,504 individuals not associated with the lilac network registered** with MyNPN in 2009. The states with the greatest number of registrants (e.g., the northeastern U.S. and California) are generally states where regionally-focused phenology observation programs are under development or have been established (Figure 2). Other states showing large numbers of registrants (e.g., Colorado, North Carolina) reflect use of the USA-NPN plant phenology monitoring program by middle and high school or college classes as part of class projects. In total, **1,000 observation sites** were registered with the USA-NPN via MyNPN in 2009 (Figure 3). States reflecting the highest numbers of sites registered reflect active regional activities (e.g., California and New York).

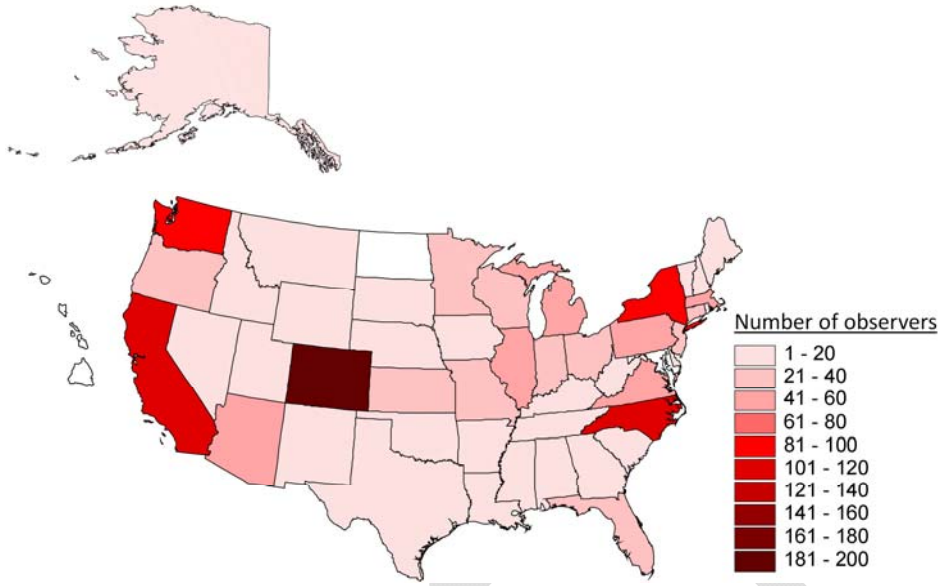

Figure 2. Observers registering with the USA-NPN plant phenology observation program by state in 2009.

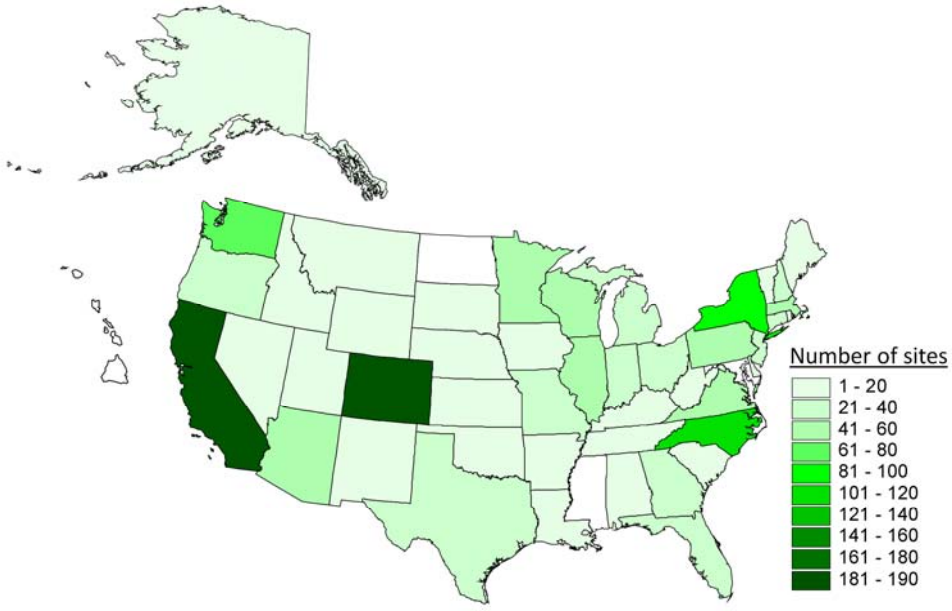

Figure 3. Phenology observation sites registered with the USA-NPN plant phenology observation program by state in 2009.

In 2009, 662 historic lilac observers were added to the NPDb (Figure 4). There were 657 associated historic lilac observation **sites** that were also added to the NPDb in 2009 (Figure 5).

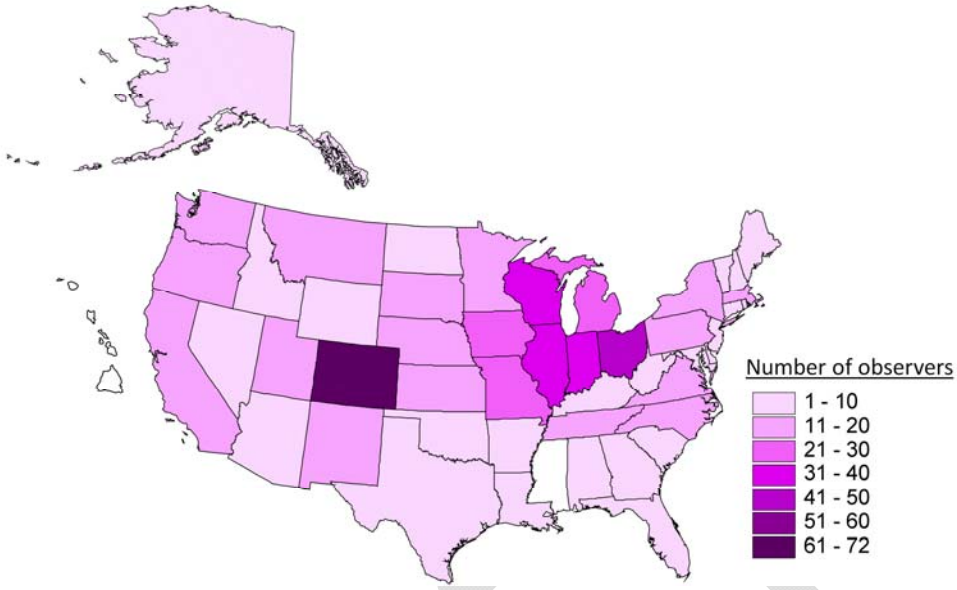

Figure 4. Historic lilac observers added to the National Phenology Database in 2009.

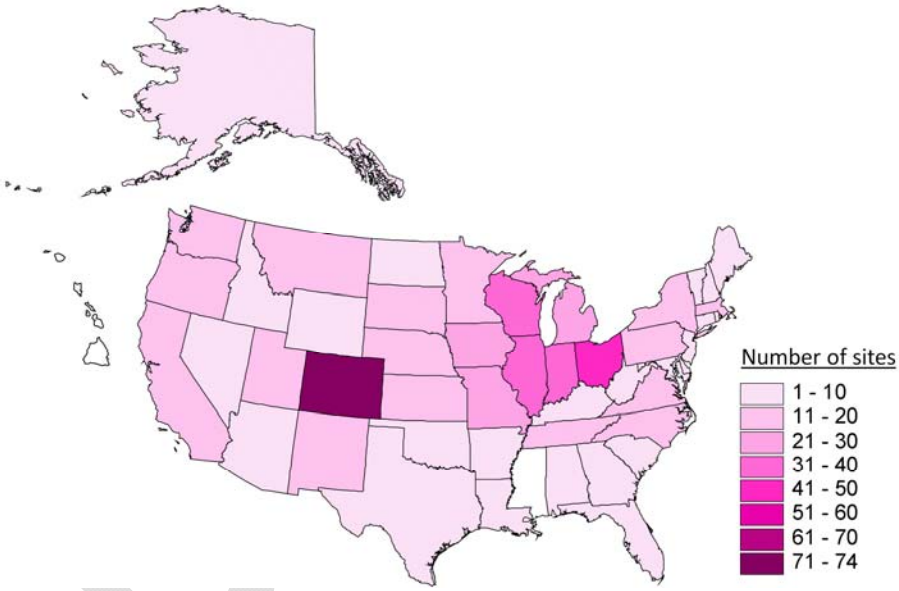

Figure 5. Historic lilac observation sites added to the National Phenology Database in 2009.

In 2009, **547 observers reported phenology observations** for one or more plants. Twenty-six percent of all registered observers reported information on at least one individual plant. Observations were reported for **133 species of plants** (Appendix A). The species for which observations were most commonly submitted were common lilac (*Syringa vulgaris*; 164 observers tracking 230 individual plants; Appendix A), Red Rothomagensis lilac (*Syringa chinensis*; 79 observers tracking 175 individual plants), common dandelion (*Taraxacum officinale*; 103 observers tracking 115 individual plants), red maple (*Acer rubrum*; 73 observers tracking 101 individual plants), red osier dogwood (*Cornus sericea*; 91 observers tracking 98 individual plants), and forsythia (*Forsythia* spp.; 88 observers tracking 98 individual plants).

On average, each individual participant reported phenology observations for nine unique dates in 2009. In total, USA-NPN observers submitted **17,700 plant observations** (an observation is a report of a suite of phenophases for an individual plant on a given day and includes from 3 to 10 phenophase status records, depending on the species), resulting in **151,709 phenophase status records** in the NPDb (Appendix A).

Participants are asked to report on a suite of between 3 and 10 phenophases each time they make an observation (e.g., emerging leaves, unfolded leaves, ≥75% of full leaf size, ≥50% of leaves colored, all leaves colored, ≥50% of leaves fallen, all leaves fallen, open flowers, full flowering, ripe fruits). On average, **participants reported on 79% of the possible phenophases** on each site visit in 2009. There was no difference in the number of phenophases reported across plant part categories (leaves, flowers, fruits); i.e., observers did not tend to report more frequently about one plant part or another.

Total observations reported by day are presented in Figure 6. A bimodal seasonal pattern reflects observer activity represented in Figure 1. In general, participants reported many observations in spring (late April through early June). A second peak is apparent in the fall (mid-October to mid-November). The day-to-day variation in observations is unexplained; this variation does not follow any pattern regarding day of the week.

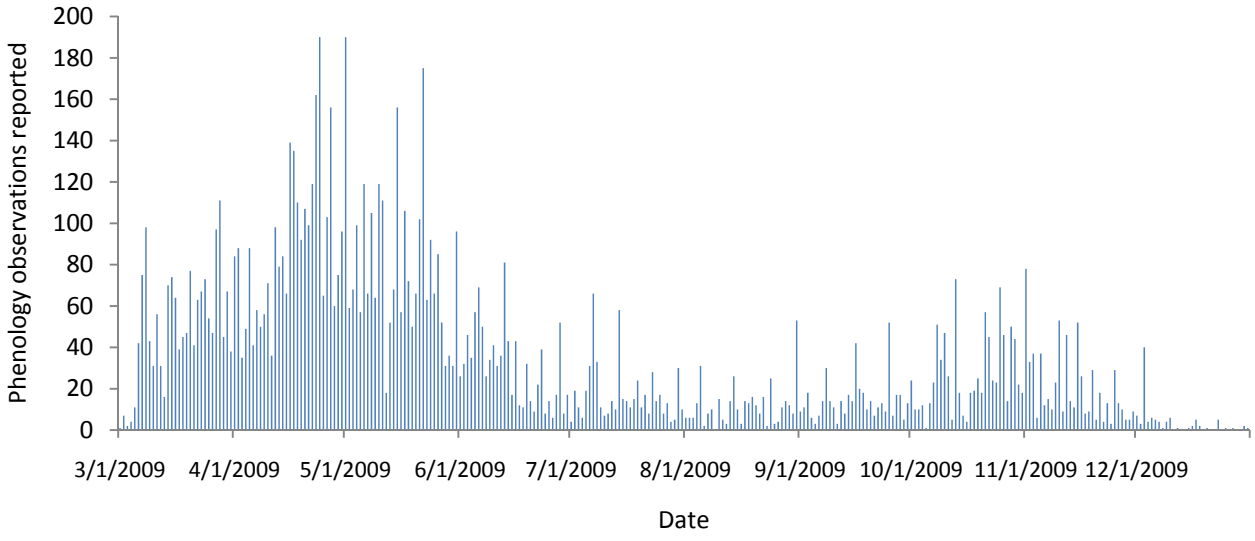

Figure 6. Plant phenology observations reported via the USA-NPN online interface, MyNPN, in 2009.

Participants logged into MyNPN and reported phenology observations for an average of nine days per year (Figure 7). Most (55%) participants reported data for five or fewer dates, and of these, about half reported observations for only one date. However, ten participants reported observations taken for 50 or more days, and a single participant reported observations for 130 days.

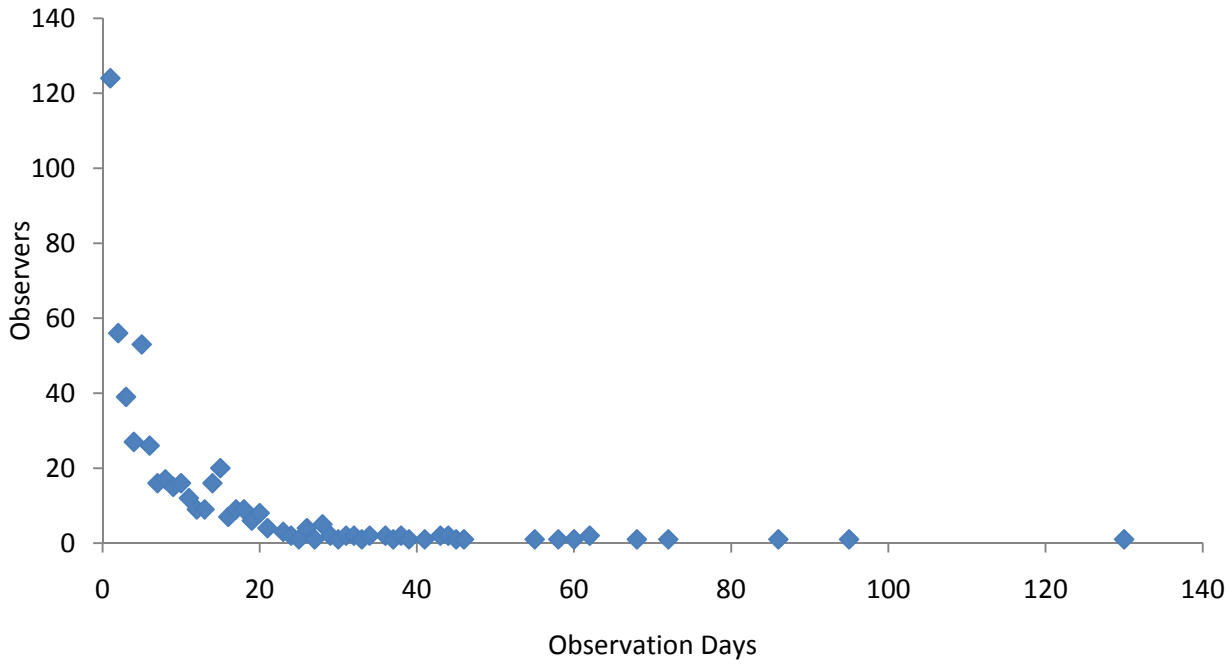

Figure 7. Frequency of phenology observations made by participants in the USA-NPN plant phenology observation program in 2009.

On average, participants remained active in the program for 55 days. Active participation was calculated as the number of days between an observer's first and last reported observation. Many observers remained active for less than 50 days, but some reported observations over a duration of greater than 250 days (Figure 8).

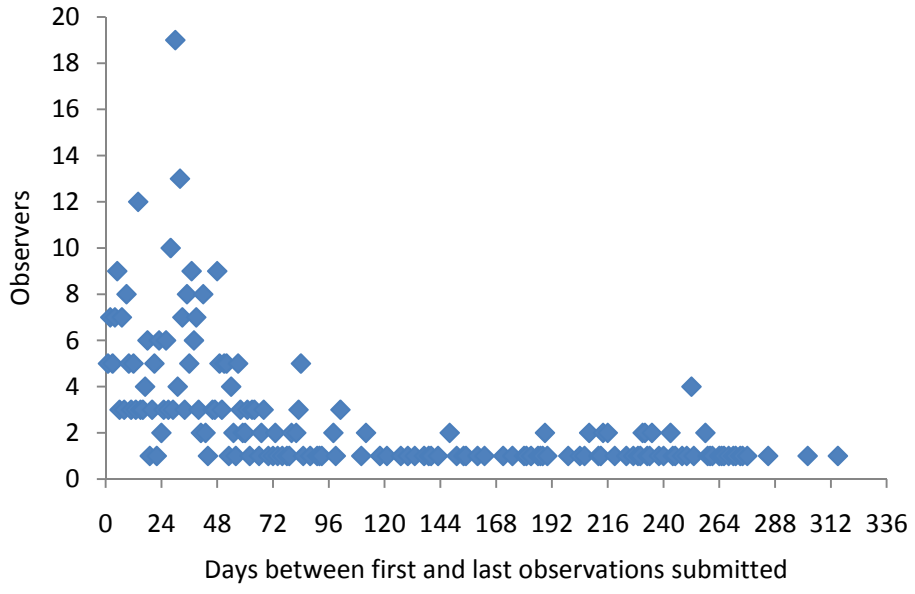

Figure 8. Duration over which participants remained active in the USA-NPN plant phenology observing program, calculated as the duration of time between an observer's first and last reported observation.

Partner organizations

When participants register with the USA-NPN phenology observation program, they are given the opportunity to self-identify with some of the organizations with which the USA-NPN has an established relationship. In 2009, the USA-NPN allowed users to self-identify with the Great Sunflower Project, HoneyBeeNet, and Monarch Watch.

Twenty-five individuals submitting plant phenology observations in 2009 noted their affiliation with the Great Sunflower Project (GSP). An additional 365 GSP participants submitted phenology observations directly through the GSP website; these data were subsequently added to the USA-NPN National Phenology Database. Fourteen USA-NPN plant phenology program participants indicated that they were affiliated with Monarch Watch, and two participants were a part of HoneyBeeNet.

EXAMPLE RESULTS

Data reported in 2009 showed patterns based on latitude and elevation. For example, open *Forsythia* spp. flowers were first reported in March in Kansas, Kentucky, Virginia, and Georgia, and in April and May in northeastern states (Figure 9). Interestingly, the few observations from the Pacific Northwest appear to reflect the gradient between maritime and continental climates, with early flowering near the coast and later flowering in the interior. A similar pattern was apparent for open dogwood (*Cornus florida*) flowers (Figure 10) and emerging red maple (*Acer rubrum*) leaves (Figure 11). These and similar data are now freely available to scientists, resource managers, and the public for use in decision-making and adapting to variable and changing climates and environments.

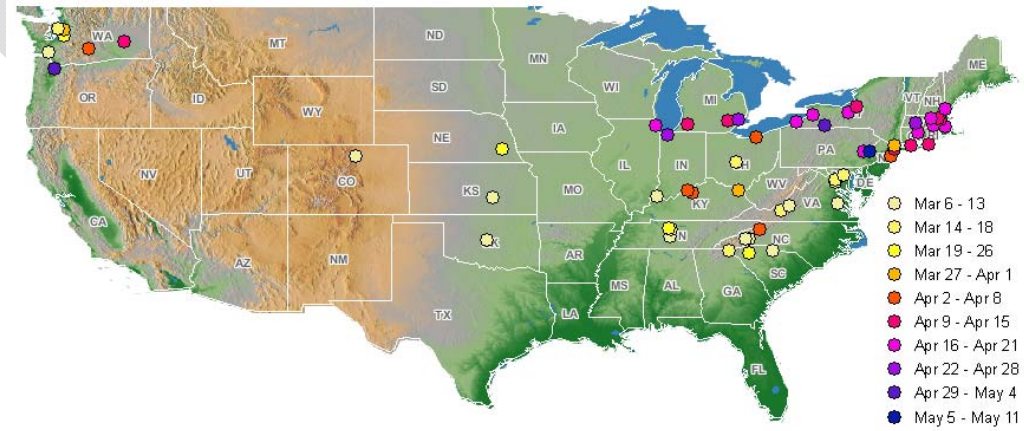

Figure 9. First recorded date of open flowers, *Forsythia*, spp. Reporting period: March 2 – August 20, 2009.

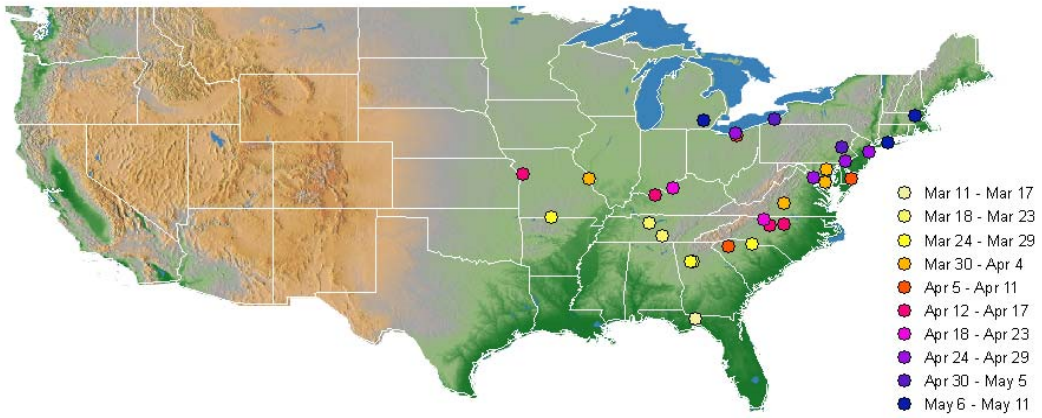

Figure 10. First recorded date of open flowers, flowering dogwood (*Cornus florida*). Reporting period: March 2 – August 20, 2009.

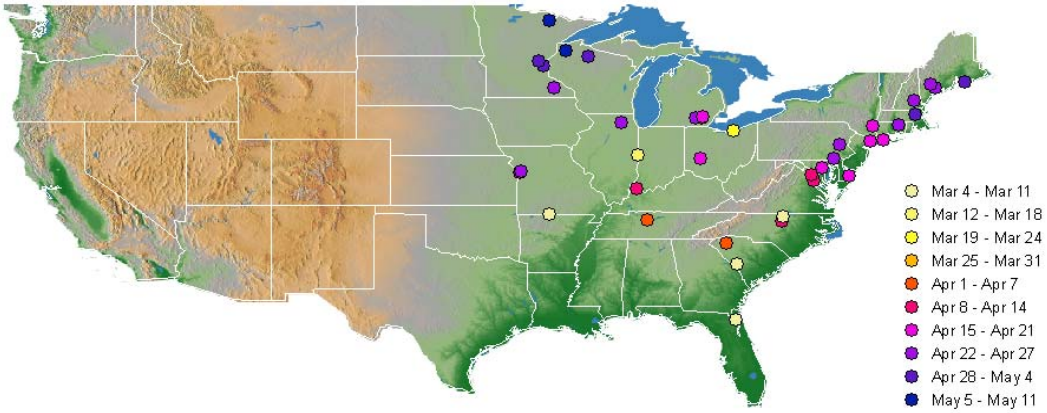

Figure 11. First recorded date of emerging leaves, red maple (*Acer rubrum*). Reporting period: March 2 – August 20, 2009.

CONCLUSIONS

We were able to integrate historic observers, sites and data into our contemporary, internet-based phenology monitoring system. There was a substantial national interest in participating in this program, focused only on plants and with minimal advertising or marketing, which resulted in a thousand new observers, a thousand new sites, and tens of thousands of observations on over 100 plant species across the nation in less than a year.

Participants tended to stay involved, reporting most phenophases for an average of nine unique dates over almost two months during the year. This suggests a sustained interest in participation, and that the online interface and status monitoring are both conducive to engaging the public and keeping them involved in the project and engaged in participatory monitoring and outdoor activities.

As mentioned in the *USA-NPN Strategic Plan* (www.usanpn.org/results/reports), partnerships are essential to the long-term success of the USA National Phenology Network, in part because these partner organizations can provide participants in the USA-NPN monitoring program while also meeting their own strategic goals (e.g., engagement of public in science activities, contributing information to facilitate understanding and adaptation to climate change). Collaboration with partner organizations in 2009 resulted in relatively few observations in the National Phenology Database. However, these partnerships were essentially pilots, and the development of more explicit and active partnerships as well as the development of training and outreach materials and tools (e.g., web services, mobile applications) should greatly increase the number of people participating as part of partner organizations.

Finally, the data collected by participants show interesting patterns of plant phenology on regional to national scales that are commensurate with our understanding of climatological gradients associated with latitude, longitude, elevation and degree of continentality. As such, these data should be useful to a variety of stakeholders interested in the spatial and temporal patterns of plant activity on a national scale; through time, these data should also empower scientists, resource managers, and the public in decision-making and adapting to variable and changing climates and environments.

CONTRIBUTIONS & ACKNOWLEDGMENTS

TMC performed data analysis and drafted the text. AHR envisioned data queries and output. KAT envisioned and performed initial data queries. RLM performed data queries. EGD reviewed drafts and contributed to framing questions. JFW provided revisions to the structure of the document.

We gratefully acknowledge participants in the USA-NPN plant phenology observing program. We also recognize Bruce Wilson (Oak Ridge National Laboratory) for his key role in the development of the National Phenology Database data model.

APPENDIX A. 2009 DATA SUMMARY

Number of observers, individual plants registered, observations, and phenophases status records in the National Phenology Database (NPDb) by species. Observers and registered plants with no reported observations are not included in the tally. An observation is a report of a suite of phenophases for an individual plant on a given day and includes from 3 to 10 phenophases status records, depending on the species.*

Common_Name	Scientific name	Number of observers	Individual plants registered	Observations	Phenophase status records
common lilac	*Syringa vulgaris*	164	230	1446	7318
Red Rothomagensis lilac	*Syringa chinensis*	79	175	1309	6605
red maple	*Acer rubrum*	73	101	970	11687
red osier dogwood	*Cornus sericea*	91	98	919	9300
forsythia	*Forsythia spp.*	88	98	793	6359
common dandelion	*Taraxacum officinale*	103	115	713	3620
quaking aspen	*Populus tremuloides*	54	76	691	6940
black cherry	*Prunus serotina*	12	28	491	6600
chokecherry	*Prunus virginiana*	27	39	439	4410
flowering dogwood	*Cornus florida*	57	65	413	4180
kinnikinnick	*Arctostaphylos uva-ursi*	5	23	404	1620
tuliptree	*Liriodendron tulipifera*	24	34	399	6033
American basswood	*Tilia americana*	46	48	387	3910
northern red oak	*Quercus rubra*	17	28	379	5710
sweetgum	*Liquidambar styraciflua*	19	30	373	5818
American beech	*Fagus grandifolia*	19	32	341	5320
paper birch	*Betula papyrifera*	18	29	337	3440
eastern purple coneflower	*Echinacea purpurea*	25	36	333	1670
eastern redbud	*Cercis canadensis*	41	50	332	3340
Virginia strawberry	*Fragaria virginiana*	24	33	301	1505
Tatarian honeysuckle	*Lonicera tatarica*	7	16	283	1471
Canadian serviceberry	*Amelanchier canadensis*	11	15	254	2540
white ash	*Fraxinus americana*	3	7	235	4170
sugar maple	*Acer saccharum*	16	25	231	2340
pignut hickory	*Carya glabra*	3	5	212	3830
big bluestem	*Andropogon gerardii*	10	13	183	920
black walnut	*Juglans nigra*	19	22	170	1700
common milkweed	*Asclepias syriaca*	15	29	134	675
bur oak	*Quercus macrocarpa*	4	5	134	1360
switchgrass	*Panicum virgatum*	7	11	130	660
tamarack	*Larix laricina*	1	5	129	1161
butterfly milkweed	*Asclepias tuberosa*	13	14	115	575
paradise apple	*Malus pumila*	17	22	115	1142
Virginia bluebells	*Mertensia virginica*	9	11	113	565

American plum	*Prunus americana*	13	17	111	1120
jack in the pulpit	*Arisaema triphyllum*	14	16	110	440
eastern white pine	*Pinus strobus*	4	8	110	555
bunchberry dogwood	*Cornus canadensis*	4	6	106	424
boxelder	*Acer negundo*	7	13	100	1010
white oak	*Quercus alba*	16	17	99	997
yellow marsh marigold	*Caltha palustris*	8	11	96	480
gray alder	*Alnus incana*	2	8	90	900
common snowberry	*Symphoricarpos albus*	4	5	90	900
bluebead	*Clintonia borealis*	1	4	88	440
common yarrow	*Achillea millefolium*	3	6	78	390
white trillium	*Trillium grandiflorum*	10	13	72	360
eastern redcedar	*Juniperus virginiana*	5	19	71	231
Canada thistle	*Cirsium arvense*	17	18	69	365
black elderberry	*Sambucus nigra*	9	20	69	690
bluebunch wheatgrass	*Pseudoroegneria spicata*	2	5	68	360
green ash	*Fraxinus pennsylvanica*	6	8	65	670
spotted knapweed	*Centaurea biebersteinii*	6	6	65	325
Canada mayflower	*Maianthemum canadense*	5	8	64	320
red columbine	*Aquilegia canadensis*	8	10	63	315
dogtooth violet	*Erythronium americanum*	9	12	59	295
common sunflower	*Helianthus annuus*	8	8	58	290
swamp milkweed	*Asclepias incarnata*	5	8	56	280
Pacific dogwood	*Cornus nuttallii*	5	7	56	560
creeping barberry	*Mahonia repens*	5	5	54	275
black spruce	*Picea mariana*	1	3	51	255
American witchhazel	*Hamamelis virginiana*	6	8	51	510
balsam fir	*Abies balsamea*	4	4	50	260
creosote bush	*Larrea tridentata*	5	10	49	256
Virginia springbeauty	*Claytonia virginica*	5	7	49	245
yellow birch	*Betula alleghaniensis*	2	10	47	470
highbush blueberry	*Vaccinium corymbosum*	9	11	45	450
peach	*Prunus persica*	13	14	43	430
black locust	*Robinia pseudoacacia*	4	4	41	430
annual ragweed	*Ambrosia artemisiifolia*	9	10	40	200
big sagebrush	*Artemisia tridentata*	5	5	38	190
snowbrush ceanothus	*Ceanothus velutinus*	2	2	37	185
cheatgrass	*Bromus tectorum*	6	6	36	180
ponderosa pine	*Pinus ponderosa*	8	8	34	170
blue grama	*Bouteloua gracilis*	3	3	34	185
honey mesquite	*Prosopis glandulosa*	4	5	31	155
red trillium	*Trillium erectum*	7	7	31	155
common buckthorn	*Rhamnus cathartica*	4	4	30	300
beaked hazelnut	*Corylus cornuta*	4	5	30	300
saguaro	*Carnegia gigantea*	3	5	30	96
ocotillo	*Fouquieria splendens*	2	4	29	87

tall blazing star	*Liatris aspera*	3	3	29	145
antelope bitterbrush	*Purshia tridentata*	4	4	28	140
sideoats grama	*Bouteloua curtipendula*	2	2	28	140
shagbark hickory	*Carya ovata*	4	4	28	280
striped maple	*Acer pensylvanicum*	2	4	27	270
alfalfa	*Medicago sativa*	5	5	26	130
loblolly pine	*Pinus taeda*	6	6	25	125
curl-leaf mountain mahogany	*Cercocarpus ledifolius*	3	3	23	115
common buttonbush	*Cephalanthus occidentalis*	2	2	22	220
Lewis' mock orange	*Philadelphus lewisii*	1	1	20	200
Saskatoon serviceberry	*Amelanchier alnifolia*	1	1	20	200
common cowparsnip	*Heracleum maximum*	2	2	20	100
Rocky Mountain maple	*Acer glabrum*	1	1	20	200
Woods' rose	*Rosa woodsii*	2	2	20	200
sundial lupine	*Lupinus perennis*	2	3	20	100
western wheatgrass	*Pascopyrum smithii*	3	3	19	95
yellow paloverde	*Parkinsonia microphylla*	2	5	19	105
Douglas-fir	*Pseudotsuga menziesii*	1	1	19	95
needle and thread	*Hesperostipa comata*	1	1	19	95
buffalograss	*Buchloe dactyloides*	4	4	18	90
mesquite	*Prosopis juliflora*	5	5	17	85
mayapple	*Podophyllum peltatum*	1	1	15	75
red alder	*Alnus rubra*	2	2	15	150
cuman ragweed	*Ambrosia psilostachya*	1	1	14	75
wine grape	*Vitis vinifera*	6	6	13	130
American hazelnut	*Corylus americana*	1	1	13	130
blue paloverde	*Parkinsonia florida*	3	3	13	69
bigleaf maple	*Acer macrophyllum*	4	4	12	120
jewelweed	*Impatiens capensis*	4	5	12	60
desert ironwood	*Olneya tesota*	2	5	11	55
scarlet globemallow	*Sphaeralcea coccinea*	2	2	10	50
citrus	*Citrus spp.*	1	2	10	65
Utah serviceberry	*Amelanchier utahensis*	2	2	10	100
American mountain ash	*Sorbus americana*	2	2	10	100
western columbine	*Aquilegia formosa*	2	2	9	45
white crownbeard	*Verbesina virginica*	1	8	8	40
scarlet gilia	*Ipomopsis aggregata*	1	1	7	35
bitter root	*Lewisia rediviva*	1	1	7	35
prairie ironweed	*Vernonia fasciculata*	1	1	6	30
common reed	*Phragmites australis*	1	2	5	25
tamarisk	*Tamarix spp.*	2	4	5	25
pride of Ohio	*Dodecatheon meadia*	1	1	4	20
soybean	*Glycine max*	2	2	4	25
white fawnlily	*Erythronium albidum*	1	1	4	20

Colorado blue columbine	*Aquilegia caerulea*	1	1	3	15
Yoshino cherry	*Prunus yedoensis*	2	2	2	20
kudzu	*Pueraria montana*	2	2	2	20
stiff goldenrod	*Oligoneuron rigidum*	1	1	1	5
bitter cherry	*Prunus emarginata*	1	1	1	10
wheat	*Triticum spp.*	1	1	1	5
buffelgrass	*Pennisetum ciliare*	1	1	1	5
twoneedle pinyon	*Pinus edulis*	1	1	1	5
common evening primrose	*Oenothera biennis*	1	1	1	5
purple loosestrife	*Lythrum salicaria*	1	1	1	5
greyleaf willow	*Salix glauca*	1	1	1	10
Totals			**2,095**	**17,700**	**151,709**

* For some species in this table, the number of phenophase status records is not an even multiple of 3 to 10 times the number of observations. This is because some observers reported multiple observations for the same plant on a given day in 2009. It is no longer possible to report more that one observation per plant per day through Nature's Notebook.