



## USA National Phenology Network Review Implementation Plan 2016

A plan for implementing the recommendations in  
2015 report "*Review of the USA National Phenology  
Network*," USGS Circular 1411

**August 2016**

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# **USA National Phenology Network**

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“Review of the USA National Phenology Network,” USGS  
Circular 1411.

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## EXECUTIVE SUMMARY

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In January 2014, leadership from the U.S. Geological Survey (USGS) Ecosystems Mission Area commissioned a review of the USA National Phenology Network (USA-NPN) Program. A program review panel of nine representatives from the USGS, other Federal agencies, and academia was convened to provide advice and recommendations to USGS leadership.

The panel's findings are summarized in the report entitled Review of the USA National Phenology Network, USGS Circular 1411 (Glynn et al., 2015). Five overarching recommendations were highlighted in the report:

1. Commit to stable NPN funding and increase accountability.
2. Establish a Federal Steering Committee and a Scientific Phenology User Group.
3. Emphasize continental-scale phenology data and information.
4. Formalize volunteer engagement in phenology data collection.
5. Integrate phenology information into USGS Science.

These overarching recommendations each included a number of related actions items and suggestions from the review panel. Moreover, the panel recommended that the National Coordinating Office (NCO) of USA-NPN prepare an implementation plan to respond to the panel's suggestions. This Review Implementation Plan (RIP) organizes and explicitly addresses each of the panel's recommendations, and provides prioritized activities that will guide the USA-NPN over the next decade or more. When implemented, the RIP will increase USGS leadership and investment in the program, strengthen the USA-NPN community of stakeholders, and shift the operational focus of the NCO to development and delivery of high priority data products for a variety of stakeholders including researchers, resource managers and decision- and policy-makers.

## INTRODUCTION

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The USA National Phenology Network (USA-NPN), established in 2007 by the U.S. Geological Survey (USGS) in collaboration with other governmental and non-governmental organizations, is a national-scale science and monitoring initiative focused on phenology — the study of seasonal life-cycle events such as leafing, flowering, reproduction and migration — as a tool to better understand how plants, animals and landscapes respond to environmental variation and change. The USA-NPN seeks to enhance scientific understanding of phenology across a variety of spatial and temporal scales, improve decision-making using phenological data and information, support adaptive natural resource management, facilitate societal adaptation to environmental variation and change, and improve public understanding of climate change and the science of phenology. Stakeholders include researchers, resource managers, policy-makers, educators, communication specialists, and members of the public – from organizations including federal agencies, academia, non-governmental organizations, Tribes, and science networks – all of whom make decisions about resource management and societal adaptation to variable and changing climates and environments.

In January 2014, leadership from the USGS Ecosystems Mission Area commissioned a program review of the USA-NPN. A panel of nine representatives from the USGS, other Federal agencies, and academia was convened to provide advice and recommendations to USGS leadership as to the current and potential future value of the USA-NPN. Specifically, the panel was asked to assess the science utility of having a national phenology network; to consider USGS science mission and DOI management needs served by the USA-NPN; and to consider the utility of the USA-NPN to other Federal agency science missions or management needs, including the National Science Foundation (NSF) and university research funded by the NSF and other government agencies. The process used by the panel for the review, including the charge from USGS leadership to the panel, background information provided to the panel, and associated documentation of accomplishments and recommended activities is outlined in Glynn et al. (2015).

In their report, the review panel affirmed the value of the USA-NPN program and indicated that the USA-NPN is successfully meeting the needs of its stakeholders, including the USGS (Glynn et al., 2015). The panel provided five key recommendations:

1. Commit to stable NPN funding and increase accountability.

2. Establish a Federal Steering Committee and a Scientific Phenology User Group.
3. Emphasize continental-scale phenology data and information.
4. Formalize volunteer engagement in phenology data collection.
5. Integrate phenology information into USGS Science.

The panel also recommended that the National Coordinating Office (NCO) of the USA National Phenology Network prepare a plan that addresses and prioritizes the recommendations of the panel, and that outlines how the proposed activities will be implemented over time. This Review Implementation Plan (RIP) organizes and explicitly addresses each of the panel's recommendations, and provides prioritized activities that when implemented over the next five years will guide the USA-NPN over the next decade or more.

The NCO of USA-NPN receives major funding from USGS and is operated in cooperation with University of Arizona. Therefore, in this RIP the term "we" refers to the collective staff of the USA-NPN NCO -- including employees of USGS and University of Arizona -- who will be responsible for implementing the elements of this plan.

The program review report provided numerous suggestions or comments nested under each of the five main recommendations (Glynn et al. 2015). In some cases, these individual points were topically different from the main recommendation, and similar themes ran through multiple recommendations.

We identified the following key messages from the Review report:

- I. Sustain funding and increase accountability
- II. Modify external governance
- III. Place emphasis on generating carefully selected data products
- IV. Accumulate both contemporary and historical phenology data
- V. Place greater emphasis on advancing science; reduce emphasis on education and outreach

- VI. Explore alternatives for data collection, including automated systems
- VII. Purposefully and strategically engage partners
- VIII. Mindfully engage volunteers to maximize utility of resultant data and minimize related costs and efforts
- IX. Consider relationship with University cooperator
- X. Strengthen the relationship between USA-NPN and USGS

To provide a framework for (1) responding to review comments and (2) tracking implementation activities over time, we reordered the review comments into a hierarchical framework. The original recommendations are provided Appendix 1 of this report, with sequential identifiers added. In the text below, we respond to the themes presented in the recommendations and use the identifiers to track our responses to the recommendations of the panel. Table 1 summarizes each of the points from the panel, the location of our response in the text of this report, our assessment of the feasibility, effort and resources likely required to implement the recommendation, the relative priority of the implementation activity, an anticipated timeline, and a summary of activities anticipated or already underway.

## **RESPONSE TO RECOMMENDATIONS AND PLANS FOR IMPLEMENTATION**

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### **I. Sustain funding and increase accountability (Recommendation 1.0, see Table 1 and Appendix 1)**

In this recommendation, the review panel affirmed the value of the Network and the data, tools and products produced to date. The panel encouraged strengthening ties between USA-NPN and all Mission Areas of USGS, and the provision of long-term funding from these Mission Areas. However, they also suggested that a “champion” Mission Area provide stable funding for the USA-NPN.

We agree that both the USA-NPN and most Mission Areas within USGS stand to benefit by strengthening the ties between the organizations. As the report points out, data products produced by the USA-NPN will be of great value to the various Mission Areas; a commitment from these Mission Areas to support the development of these products would directly benefit the USA-NPN. In Fiscal Year 2016, USGS Ecosystems Mission Area committed to base-stable support for the USA-NPN at \$578,000. Thus, the report has already served as a valuable tool for demonstrating the value of the USA-NPN to USGS. We will continue to communicate with all relevant Mission Areas to find opportunities for collaboration on activities of mutual interest (Recommendation 1.0).

We also agree with the suggestion of the panel that the USA-NPN undergo periodic reviews to evaluate the program’s progress toward milestones and deliverables, as well as to assess and manage risk. In fact, this suggestion forms the cornerstone for future program evaluation and communication with not only USGS, but the broader suite of stakeholders involved in the Network proper. In short, we will plan for and conduct external program reviews, modeled on this review, at an interval of ~5-8 years.

### **II. Modify external governance (2.0, 2.1, 2.1.1, 2.2, 2.3, 2.4, 2.5)**

The review panel recommended that the current USA-NPN Advisory Committee be transformed into a Federal Steering Committee, with greater and more formalized authority over the NCO and the USA-NPN Executive Director. In addition, this recommendation suggests the establishment of a Scientific Phenology Users Group (SPUG), to share information on phenology science and applications with the broader phenology community.

Following these recommendations, the NCO disbanded the USA-NPN Advisory Committee in July, 2015. However, we do not plan to establish a Federal Steering Committee or other form of oversight group, primarily because the investment in the NCO is small relative to the continuing portfolio of the Ecosystems Mission Area. In other words, with a small staff, our ability to organize and properly engage such a group would require a disproportionate amount of our time and resources, and thus distract from the mission of the NCO. Instead, management of the activities of the NCO will rely on (1) strong leadership aligned with funding provided by USGS; (2) periodic external program reviews and associated review implementation plans; and (3) clear and regular communications between the NCO, USGS and the broader stakeholder community – both Federal and non-governmental – using a variety of communication tools and mechanisms.

Recommendation 2.0 also emphasizes the need for USGS to “take ownership” over the USA-NPN. In fact, USGS retains “ownership” over USA-NPN via majority financial support, which includes base-stable support for USA-NPN operations and leadership in the form of a Director of the Network, or more practically the NCO. Further, USGS operates USA-NPN “at will,” in that USGS can terminate or transfer authority and responsibility of USA-NPN at any time. However, in the spirit of this recommendation, we will work to improve collaborative relationships within USGS (e.g., Climate and Land-use Change Mission, Core Science Systems Mission, Water Mission), while retaining a broad community of collaborators and partners across a variety of federal and non-governmental organizations who stand to benefit from the activities of USA-NPN under the leadership of USGS.

We also agree with the review panel on the importance of engaging the broader phenology community. However, rather than creating a formally chartered Scientific Phenology User Group focused exclusively on data users (Recommendation 2.3), we are working to develop and sustain phenology Communities of Interest that collectively are broader, distributed and less-formal than a single formal user groups focused solely on science activities. Within the field of phenology, and as reflected in the current composition of the broader USA-NPN, there are three loosely-defined but clear Communities of Interest (COI): (1) Research, (2) Applications, and (3) Engagement (including recruiting and retaining volunteer participants and managing group dynamics). Individuals or organizations may be active in more than one of the Communities of Interest, and other Communities may evolve over time.

The relatively broad COI can include more formal or focused Communities of Practice, which are groups of people who share a common interest and who experience increased expertise around the topic as a function of interacting with the group. Currently, the NCO supports three active Communities of Practice (COP): a Local Phenology Leader COP, a Phenology Network Leaders COP, and a Phenology Researcher & Application COP. These COI and COP exist outside of the NCO, though we work to maintain ties to, and communication with, these groups through formal and informal activities, including workshops, symposia and presentations at professional conferences, engagement with professional societies or organizations, and audience-targeted contemporary communications (e.g., social media, newsletters) (Recommendation 2.4). Multi-channel communication is encouraged to elicit feedback and communication between the Communities and the NCO (Recommendation 2.5).

Working Groups are smaller, more clearly established groups of individuals that typically include participation by one or more NCO staff, that come together for a specific reason. Working Groups produce data or information products that, while concordant with the USA-NPN Strategic Plan and the priorities of the NCO, are of particular value to one or more COI (Recommendation 2.3). The Working Group model recognizes financial constraints on the capacity of the NCO coupled with the need to engage a broad variety of stakeholders who have particular – and not always overlapping – needs for phenological information, data and data products. This framework successfully meets the needs of the NCO while providing a mechanism to interact with various Communities of Interest. Example Working Groups already in place include a Data Product Working Group, a Phenology Network Coordinators Working Group, and several regional Working Groups focused on recruitment and retention of phenology observers for particular applications.

### **III. Place emphasis on generating carefully selected data products (3.0, 3.1, 3.1.1, 3.5, 3.5.1, 3.5.2)**

These panel recommendations echo a repeating theme that the NCO needs to emphasize (a) development of a small number of carefully chosen national-scale data products and (b) the collection of the data needed to produce them. To meet these recommendations, we have in the past year revised the USA-NPN Strategic

Plan; re-defined roles of staff to maximize capacity to produce high-quality, national-scale data; and – based in part on a workshop conducted in 2012 – created a framework for data product development and delivery.

First, we revised the USA-NPN Strategic Plan (USA-NPN 2016) to increase the emphasis on data product development and delivery in the Plan's Theme 1 and 2, *Advance Science* and *Inform Decisions*, respectively. We also converted Theme 3, *Educate and Communicate*, to a foundational approach of *Communicate and Engage* to support Themes 1 and 2 (Recommendation 3.1; see also Section V). We also redefined staff roles internally to focus on national collection of high-quality phenological data and the production and delivery of national-scale data products (Recommendations 3.0 and 3.1.1).

Second, consistent with recommendation 3.5.2, we hosted a workshop in 2012 to solicit input from the phenology research and applications communities as to their needs for phenological data and information, and to help prioritize USA-NPN data products ([USA-NPN 2012](#)). Results of the workshop informed the development of the [USA-NPN Data Product Development and Delivery Framework](#), or Data Product Catalog (DPC) (Gerst et al. 2015). The Data Product Catalog outlines the suite of products we plan to develop and deliver – including timelines, roles and responsibilities and external collaborations – over the course of the next five years (Recommendations 3.0 and 3.5).

As an example of how we will use the Data Product Catalog to improve our emphasis on development and delivery of national-scale data products, we can look to the *Green Wave* and *Spring Index* data products that were favorably highlighted by the review panel. We continue to support the development of these data products with focused regional to national data collection campaigns that are now in their fourth year. In 2016, we developed and released a suite of gridded Spring Index and Accumulated Growing Degree Day products leveraging daily temperature surfaces gridded at fine spatial resolution (2.5 km to 4 km), and make these products available through the USA-NPN Visualization Tool and via web services ([www.usanpn.org/data/phenology\\_maps](http://www.usanpn.org/data/phenology_maps)). In addition, lilac and honeysuckle data for the period 1956-2014, used to parameterize and validate the *Spring Index*, are now dynamically available from the USA-NPN website, and were fully documented and recently published in *Nature Scientific Data* (Rosemartin et al. 2015).

The USA-NPN has compiled nearly eight years of contemporary phenology observation data, i.e., collected through *Nature's Notebook* or other platforms since 2009 and integrated into the National Phenology Database (NPDb). The value of these data to national-scale phenological research were recently demonstrated by Yue et al. (2015), who used ~40,000 phenology records housed in the NPDb from ~1,000 sites to investigate 30-year trends in phenology of deciduous forest systems across the United States. To further maximize the value of current and potential future data in the NPDb, over the next several years we will host or participate in various workshops – in collaboration with the Research and Applications Communities of Interest (Figure 1) and with a focus on data interoperability, data integration, and model development – to define, prioritize and produce data products based on data held in the NPDb. These activities will inform a gap analysis of the NPDb (Recommendation 3.5.1), which in turn will be used to guide future efforts related to data collection or assimilation.

#### **IV. Accumulate both contemporary and historical phenology data (3.6, 3.6.1, 3.6.2, 3.7)**

In these comments, the review panel emphasized the importance of sustaining data collection for species with valuable historical records, pursuing data collection in support of certain gridded data products, and digitizing and integrating historical phenological records.

We continue to emphasize the importance of collecting observations on species that lead to the production of key data products (*Green Wave, Spring Indices*), including cloned and common lilacs, cloned and flowering dogwoods, and maple, oak and poplar species by hosting campaigns focused on these species ([www.usanpn.org/inn/campaigns](http://www.usanpn.org/inn/campaigns)) (Recommendations 3.6.1 and 3.6.2). We are also working with a growing number of researchers to encourage phenology data collection in support of their research questions ([www.usanpn.org/inn/campaigns](http://www.usanpn.org/inn/campaigns)). We plan to add or conclude campaigns as appropriate, based on the data needed to develop additional data products.

We have begun to discover and ingest legacy datasets to enhance the data resources housed within the NPDb (Recommendation 3.7). Two such legacy datasets have been integrated in the last year, as pilots of our integration and documentation systems. The NCO maintains a continually growing list of legacy datasets for potential ingestion into the NPDb. To facilitate the ingestion of

datasets collected following non-standard protocols, NCO staff are playing an active role in the development of a plant phenology ontology. In the absence of additional funding dedicated to supporting the ingestion of legacy datasets, we plan to integrate two to four legacy datasets each year. Datasets that have the greatest potential to contribute to key data products are given priority for integration, as are datasets with a long period of record, a broad geographic scope, or which fill key spatial or temporal gaps (Recommendation 3.6). In our prioritization strategy, we also consider factors such as funding, the feasibility of dataset integration, and the historical importance of the dataset.

**V. Place greater emphasis on advancing science; reduce emphasis on education and outreach (3.1, 3.1.1, 3.1.2, 3.1.4)**

These comments embody recommendations from the panel that the NCO place greater emphasis on data outputs – including “phenological data collection, quality assurance, archiving, and access” while reducing undue emphasis on activities – namely education and outreach – not directly aligned with these outputs. In response to these recommendations, we revised the USA-NPN Strategic Plan to reduce the emphasis on education, *per se*, and we re-defined the roles of staff to better focus on phenological data and information (as described in Section III).

To promote *Nature’s Notebook* as a program (i.e., a series of planned activities to achieve a specific result), to grow long-term participation in the program, and to sustain the activity of participants collecting and submitting high-quality observations to the NPDb, some outreach and education activities are necessary. For example, to ensure that phenology observations are of the highest possible quality, it is important to educate participants on topics such as species identification, phenophase identification, and use of the online data entry interface or smartphone (mobile) apps. Moreover, constructivist and experiential educational theories hold that meaningful participation yields more effective participant retention and long-term engagement. Experiential methods bolster individuals’ desire to take precise and accurate observations. Accordingly, we aim to meaningfully engage *Nature’s Notebook* participants to increase observation accuracy and to encourage longer-term participation.

In addition, outreach efforts – that is, the process of regular communication with participants and the demonstration to them that their efforts are valued and

appreciated – are also critical to sustain participation in the program. Since our desired output is frequent, careful observations collected by the same individuals at the same locations over a long period of time, we place strong emphasis on our observer retention efforts. These generally take the forms of regular email-based communications and webinars. As such, much of the effort that we’ve referred to as “education and outreach” has been in support of recruiting, training, and retaining participants, in service to developing data and data products.

However, in the spirit of the review panel recommendations, we have made several changes to how we both conduct and present our education, engagement, communication and outreach efforts. First, we revisited the *USA-NPN Strategic Plan* (USA-NPN, 2016), giving careful attention to what was formerly Theme 3, *Communicate and Educate*. In the newest iteration of the Plan, these activities are described as the *Communicate & Connect Foundational Strategy*, serving as the foundation for the two primary Themes, *Advance Science* and *Inform Decisions*. This more accurately reflects how our outreach activities support these key functions of the USA-NPN. The revised logic model for this Foundational Strategy (Appendix 1 in *USA-NPN Strategic Plan*) now clearly demonstrates how outreach activities operate in service to generating high-quality, sustained phenology observations and ultimately to producing key phenology data products (Recommendations 3.1.1, 3.1.4).

In addition, we reevaluated our staffing profile (Recommendation 3.1), and as of 2015 we are appropriately staffed to meet the Network’s primary goals of *Advance Science* and *Inform Decisions*. We now reflect a greater emphasis on data and data products (5 full-time equivalents, or FTEs) while maintaining a capacity to engage – and recruit, train and retain – our observers in service to data and data products (3 FTEs) (Recommendation 3.1.2).

## **VI. Explore alternatives for data collection, including automated systems (3.2)**

In this recommendation, the review panel encouraged us to consider emerging technologies for automating the collection of phenology data and information. In the next several years, we plan to place more emphasis on strengthening our relationship with the remote sensing and phenology camera (phenocam) communities (Recommendation 3.2). We plan to integrate in-situ phenology observations with both phenocam-generated data and remotely sensed phenology

data within the next five years (Gerst et al. 2015), and have already embarked on in-depth conversations with leads and staff of the Phenocam Network as to how best integrate our datastreams and web interfaces. However, because additional resources will be required, our effort will focus on developing collaborative relationships for information management and multi-scale research activities both within and outside USGS. For example, the NCO is part of a recently-funded NASA proposal, led by Dr. Josh Gray of North Carolina State University, which will support the enhancement of our existing online data visualization tool to display MODIS- and VIIRS-derived metrics of land surface phenology and climate change impacts. Integration with these national gridded observational products will be facilitated by the production and delivery via services of our gridded model products described above.

## **VII. Purposefully and strategically engage partners (3.8, 4.2)**

The concerns expressed in these points suggest that we are catering to many small-scale efforts that are generating localized datasets at the expense of engaging other partner organizations and networks that are believed to perform better at yielding the national-scale, long-term phenology observations needed to produce data products such as the *Green Wave* or *Spring Indices*.

Consistent with Recommendation 4.2, the USA-NPN has long had a strong focus on engaging both “extensive network” sites that can focus on data collection (e.g., National Parks, USFWS Fish and Wildlife Refuges) as well as “intensive network” sites that can focus on process-based phenological research (e.g., Long-Term Ecological Research Network and the National Ecological Observatory Network) (see Appendix 2 in Glynn et al. 2015). Progress toward engaging these networks in collecting phenology observations for the long-term has been slower than originally expected for several reasons.

First, we received feedback from potential partners that phenological data collection – with frequent, repeated observations of a phenomenon for an indefinite amount of time – is a significant request in a time of limited budgets and already busy schedules. We have learned over time to instead focus on understanding the needs of the potential partner, and on helping them understand the benefits of participation in the USA-NPN. This approach takes time, and occasionally the development of capacity (e.g., protocols, cyberinfrastructure) specific to the potential partner.

Our partnership with the National Ecological Observatory Network (NEON; [neoninc.org](http://neoninc.org)) represents one example of capacity development with a long build-out period. Based on the needs expressed by NEON when we first met with them in 2008, we focused on the development and publication of standardized phenological monitoring protocols for a diversity of taxa across the continent (Denny et al. 2014). As NEON continues construction of facilities and starts shifting to operations in 2016, they will implement plant phenological monitoring using USA-NPN protocols at 50 intensively monitored sites across the continent (Elmendorf et al. 2016). Phenological data are already available from the NEON data portal, and when the NEON cyberinfrastructure (including web-services, or APIs) is completed, these data will be seamlessly integrated into the NPDb. When built out, NEON will contribute about three-quarters of a million high-quality phenological records per year for over 100 ecologically and economically important plant species across the continent (Recommendation 3.8).

Second, many potential network partners – particularly those that are comprised of independent or quasi-independent units, such as the National Park Service, the Long-Term Ecological Research Network (LTER) and the USFWS National Wildlife Refuge System (NWRS) – are reasonably hesitant to make a sustained commitment to phenological monitoring without a tangible demonstration of the value to their organization. As such, we typically opt to invest deeply with one or several units within such networks to establish a demonstration “proof of concept.” At the same time, we engage national- and regional-level leadership, to generate support at these levels, enabling further adoption on the ground.

Establishing these pilot efforts takes time; however, we now have successful pilots within multiple networks, including NPS, NWRS and LTER, and more recently the Long-Term Agroecosystem Research (LTAR) Network, that can serve to demonstrate value to other network units as well as to national-level network staff. We will continue to grow our collaboration with these networks, while working to establish pilots within other networks where we haven’t yet made major inroads (e.g., Assessment, Inventory and Monitoring programs of the US Forest Service and the Bureau of Land Management). Our greatest successes seem to come when we can approach a network from two directions, both top-down – by engaging top-level administration – as well as bottom-up – through local pilot installations.

Finally, engaging national networks will be facilitated by our development of continental but scaleable phenological data and information products, as well as tools for data discovery, analysis, visualization and delivery (see also Section III), and the successful application of data and data products provided by USA-NPN. The production and delivery of national-scale data products is a new focus of the NCO (as described in Gerst et al. 2015). Ongoing improvements to the USA-NPN website, including recent improvements to (a) the data output tool that now enables users to discover and download QA/QC'd raw or summarized data, and (b) the data visualization and analysis tool including automated and customizable phenological calendars, should better demonstrate to potential partners the value added by participating in USA-NPN. The continued production of peer-reviewed publications that use contemporary or historical phenological data collected and held by USA-NPN will also demonstrate the value of the network to potential partners.

As noted by the review panel, we also engage many smaller organizations as partners; as of July 2016, nearly 300 local organizations, or "Local Phenology Projects," have submitted phenological data to *Nature's Notebook* ([www.usanpn.org/partner/current](http://www.usanpn.org/partner/current)). Though these organizations yield data at the local or regional scale, they make invaluable contributions to the national-scale data resource maintained in the NPDb. We strongly encourage these local projects to incorporate some or many of our high-priority campaign species, which enables the generation of USA-NPN signature data products such as the *Green Wave* and *Spring Indices*.

We understand the panel's concern that we are spending a large amount of time and resources in supporting local efforts. We are aware of the potential drain on resources that sustaining these efforts can be, and are working to find ways to ensure that these local efforts are as self-sustaining and self-supporting as possible. Time spent on developing infrastructure or resources to support either scale of organization can benefit the other; for example, protocols developed for NEON can be used by other networks, or by local projects, all of which can contribute to data used to create or validate national data products.

One way we are seeking to increase efficiency is by discovering and forging relationships with "phenology network coordinators" – enthusiastic individuals who recruit multiple institutions in tracking phenology using *Nature's Notebook*

within a region of the country ([www.usanpn.org/nn/groups/pnc](http://www.usanpn.org/nn/groups/pnc)). Several such individuals have voluntarily taken on this role, and by aligning ourselves with them, we have been able to dramatically increase our on-the-ground reach with minimal additional effort.

We periodically undertake formative evaluation of our outreach efforts to maximize efficiency. We plan to carefully evaluate the effort invested for organizations of various scales and the value of the resulting data, and to use this information to guide allocation of recruitment, training and retention efforts into the future.

### **VIII. Mindfully engage volunteers to maximize utility of resultant data and minimize related costs and efforts (4.0, 4.1, 4.1.1, 4.1.2)**

These recommendations underscore the review panel's interest that NCO efforts to engage volunteers in data collection be efficient and focused on generating data that are directly relevant to key data products. The panel suggested leveraging best practices from the citizen science field, considering the establishment of formal agreements with volunteer data collectors, and working more intensively with existing environmental networks such as LTER and NEON (also addressed in Section VII above).

About one third of the data in the NPDb are derived from participants who monitor phenology as part of their job (e.g., as part of networks described in Section VII above), whereas the balance of the data originate from volunteers, or citizen scientists, not necessarily affiliated with a formalized monitoring organization. Although we expect that the proportion of data provided by professionals, or by observers trained by professionals, will increase over time, volunteers will continue to be an important source of data to the Network. Accordingly, the NCO staff must follow best practices in the field of citizen science to ensure that observations submitted are of greatest value to producing high-priority phenology data products.

Several members of the NCO staff are active in the field of citizen science (e.g., Crimmins et al. 2014, Warren and Barnett 2014, McKinley et al. 2016). We have regular contact with the leaders and staff of several of the largest citizen science projects in the U.S.; we sit on advisory boards for other projects; and we are frequently called on as experts in the field. We constantly seek to improve our

existing strategies, and welcome input from other experts in the field. We are well-informed regarding “best practices” for recruitment and retention of participants, and regularly adapt our methods for engaging volunteers and for improving data quality and quantity. Key prevailing best practices for the field of citizen science include emphasizing volunteers’ contributions and thanking them regularly, communicating with them frequently, and demonstrating to them how their contributions are being used. We take these seriously and implement them rigorously (Recommendation 4.1, 4.1.2).

Though our individual volunteer observers collect data at a local scale, we work to ultimately maximize their contributions towards the development and production of national-scale data products. For example, we emphasize monitoring of species that support the development of key data products such as the *Green Wave* and *Spring Indices* by highlighting them in data collection campaigns ([www.usanpn.org/inn/campaigns](http://www.usanpn.org/inn/campaigns)). Volunteers are repeatedly reminded of the value of these species over the course of their participation: they are invited to monitor one or more campaign species when they sign up, they see these species highlighted in newsletter and webinar summaries, and they see these species highlighted throughout the website. If they sign up to track one or more of these species, they also receive campaign-specific messaging over the course of the year. Further, we are experimenting with prompting observers to collect observations when our phenology models predict that a transition in status is about to occur, as in our pilot Springcasting campaign in spring 2015. An encouraging pattern is that *Nature’s Notebook* participants who are collecting data as part of a formal campaign are more active over the course of a season than those that collect data for their own reasons (Crimmins et al. 2014).

Where possible, we partner with established volunteer organizations already collecting physical or biological observations (Recommendation 4.0). In fact, we have learned that participants in some of these networks, such as the Community Collaborative Rain, Hail, and Snow Network (CoCoRaHS) are among the most consistent participants in our program. We believe this is because they appreciate the importance of following established protocols, making repeated observations at their location, and submitting their data in a timely fashion; as such, they appear to apply the same rigor to phenological monitoring. We have also partnered with several state-level Audubon chapters, and Cooperative Extension in several states, and as described in Section VII above we have shifted to models that leverage on

local leadership (e.g., Local Phenology Leaders, Phenology Network Coordinators) who in turn facilitate training, technology transfer, and two-way communication (Recommendations 4.0, 4.1 and 4.1.2).

We have not created formal agreements for volunteer participants (as suggested in Recommendation 4.1.1), because there is little evidence in the citizen science literature for the effectiveness of this practice. The Great Sunflower Project experienced a higher return rate when participants were required to formally commit via an online checkbox (G. LeBuhn, pers comm). We will consider the addition of similar tools to create or codify agreements with observers based on further research and evaluation of pilot efforts. In the meantime, we are considering the development of a certification program for Local Phenology Leaders; however, we have little data within the field of citizen science to support the assumption that certification would encourage practices that lead to higher data quality, longer-term participation, and increased accuracy.

#### **IX. Consider relationship with University cooperator (3.3, 3.3.1, 3.4)**

In these comments, the review panel communicated the importance of thoughtfully choosing the administrative home for the NCO, while recognizing that there are pros and cons to moving the office to an alternative institution. These comments also recommended that we consider converting the NCO Assistant Director to an employee of USGS (as opposed to an employee of the University of Arizona).

Since its inception in 2007, the NCO has operated out of the University of Arizona (UA), and has been funded by a series of Cooperative Agreements with USGS, other federal bureaus and agencies, and grants from a variety of organizations including National Science Foundation. Throughout this time period, major funding has been provided by USGS. Currently, a four-year (2014-2017) Cooperative Agreement between the USGS and the UA provides office space and administrative support to the NCO with a 17.5% overhead rate. These are competitive terms within the context of an established agreement, so it might be imprudent to move the NCO to an alternate institution while this agreement is in place. However, at the end of this agreement, we will explore alternatives to ensure the best possible arrangement for all parties involved (Recommendation 3.3).

As the review report acknowledges, the co-location of the NCO at UA has fostered synergies between the two institutions. We believe that opportunities for collaboration will increase now that the USA-NPN is moving into a period of sustained data product development and delivery. We expect to collaborate more extensively with University researchers to develop these products, and collaboration will include increased efforts to pursue grant funding to support these creative endeavors (Recommendation 3.3.1).

Converting the NCO Assistant Director to a USGS employee has a number of benefits, particularly the sustainability of operations should the Director (who is the only USGS employee in the NCO) become indisposed (Recommendation 3.4). However, this option would likely increase costs, as an equivalent position at the USGS costs about 50% more than at the University. Further, many of the duties currently under the purview of the NCO Assistant Director, including supervising NCO employees and managing the USGS-UA Cooperative Agreement and associated budget, would still need to be conducted by a University employee at about the same level as the current Assistant Director. Nonetheless, the current USGS Director of USA-NPN is considering alternative options for leadership, budgets, location and operations of the NCO within the context of the federal landscape (Recommendation 3.3).

**X. Strengthen the relationship between USA-NPN and USGS (3.1.3, 3.5.3, 5.0, 5.1, 5.2, 5.2.1, 5.2.2)**

The gist of these review comments is improved integration of phenology – as an “integrative science that cuts across many traditional scientific disciplines” – into the “work or mission” of USGS. Specifically, the panel argued that USGS could benefit more directly from USA-NPN, e.g., utilizing the data, data products, infrastructure, services and capacity offered by the USA-NPN. The review team points out that phenology has relevance to six of the seven USGS Mission Areas – though a single Mission Area should be identified as a champion for phenological science – and that “USA-NPN has critical geospatial information needs that could best be met by “programmatic and infrastructure support from the...Core Science Systems [CSS] Mission Area.” Comments from Recommendation 3 that relate to USGS involvement in data infrastructure, data ownership, and attribution of USA-NPN generated protocols and tools are included here, because they represent an opportunity to improve data integration, infrastructure support, and resources for operations and research that benefit multiple science thrusts within USGS.

We agree that it would be optimal for USA-NPN to have one Mission Area within the USGS to serve as the champion for phenology science and the USA-NPN, and that all Mission Areas could offer interest, financial backing, and scientific resources (Recommendation 5.0). The current “champion” is Ecosystems Mission Area, which provides base-stable support of about \$578,000 annually; this indicates the tight concordance between the USA-NPN mission and the broader applied research thrusts – as well as recognized stakeholders – of Ecosystems. However, for the last several fiscal years, the Climate and Land-Use Change (CLU) Mission Area has provided up to one-third of the USA-NPN annual budget through the National Climate Change and Wildlife Science Center (NCCWSC), again because of a concordance of mission priorities.

The challenge to USA-NPN will be to maintain these relationships, and to ensure that Ecosystems and CLU see continuing value in their investment, while broadening the activities of the USA-NPN to improve concordance with other Mission Area priorities. This requires close two-way communication and a willingness to understand and support mission priorities across the Bureau. We foster relationships through steady and strategic communications (e.g., presentations within and outside USGS), identification of viable collaborations with programs, organizations and activities within USGS (e.g., collaboration on proposals with different USGS Science Centers, or co-supporting Mendenhall post-doctoral fellows with other Missions), and through demonstrations of the value of USA-NPN products across USGS (e.g., through production of branded data products for the US Global Change Research Program’s National Climate Indicators System).

As a recent example, we are working closely with two USGS Programs – Core Science Analytics, Synthesis and Libraries Program (within CSS) and the Status & Trends Program (within Ecosystems) – to support the development of a National Biogeographic Map that acquires biodiversity data from diverse sources for the purpose of integration and delivery of biodiversity data and information for novel reuse and applications. Because of the strong focus of the USA-NPN on all aspects of the data life cycle (Faundeen et al. 2013), and because of our strong focus on transparency, open data, documentation, sharing and machine readability, we will work to have USA-NPN serve as a model for other informatics activities within USGS. For example, a project recently funded by the CSS Community for Data Integration is focused on the development of a workflow for the delivery of dynamic biodiversity information while maintaining compliance with new open

data requirements established by the Administration. The goal is to produce and deliver national phenology data using 21<sup>st</sup> century tools (e.g., web services and on-line visualizations), and to document lessons learned that can be shared with other programs to improve discoverability and delivery of other biodiversity data across the Survey (e.g., Breeding Bird Survey).

We are also working to improve the branding and attribution to USGS of data, data products, content and outcomes of the USA-NPN (Recommendation 3.5.3). For example, all content is reviewed to ensure compliance with USGS visual identity rules, as appropriate. As an example of our efforts to be in compliance on these fronts, in 2015 the USA-NPN's *Nature's Notebook* Program received the USGS Eugene M. Shoemaker Communications Award (External Communications, Internet Product Category). Similarly, in 2016 the USA-NPN received the USGS Environmental Achievement Award in the category of "Climate Champion" for "outstanding work to increase the understanding of how plants and animals are responding to changing climate conditions, in addition to making data available to local and national decision makers." These awards demonstrate that USGS is aware of the value provided by the USA-NPN to the USGS mission; however, it will be important to maintain and expand excellent communication with all components of USGS, particularly as we move into the next Administration starting in 2017.

To make USA-NPN data and data products more discoverable and readily available to USGS Mission Areas, we have recently taken several steps to integrate data and data products curated by the USA-NPN into USGS systems (Recommendation 5.1), and have completed Recommendation 5.2 to make all USA-NPN data resources discoverable within USGS.

In 2016, we committed to full data life cycle compliance with USGS policies for information management. Thus far we have created a USGS-compliant data management plan, and included metadata for all of our data resources in [ecosystems.data.gov](http://ecosystems.data.gov) and ScienceBase to promote the discoverability of the data through federated search engines. We are currently engaged in Fundamental Science Practice (FSP) Review for all all datasets and data publications. The USA-NPN phenophase monitoring protocols (Denny et al. 2014, also available in ScienceBase), and the legacy lilac and honeysuckle data (Rosemartin et al 2015)

have undergone FSP review. Review is ongoing for the gridded product suite, and forthcoming for the contemporary data.

We have considered moving USA-NPN data infrastructure to USGS (Recommendations 3.1.3, 5.0 and 5.2). Such a shift would require significant resources; we estimate that this would require a dedicated systems administrator for two years as well as support to set up servers within the USGS and migrate the infrastructure. There would likely be additional policy constraints in terms of data distribution and internal security infrastructure that would require continuous additional resources for data and cyberinfrastructure maintenance and operations.

We are enthusiastic to work with the USGS Land Remote Sensing Program within the Climate and Land-Use Change (CLU) Mission Area, and more broadly, are looking to further develop our program in this direction over the next several years (Gerst et al. 2015). However, additional resources would be necessary to fully investigate the fusion of Landsat and USA-NPN products (Recommendation 5.2.1). We have initiated conversations about multi-scale, multi-platform integration of phenological data with various organizational components of CLU (including Earth Resources Observation Systems [EROS] Data Center, the Land Change Science Program, and the North Central Climate Science Center), and have formed a small ad-hoc working group of USGS scientists and program managers to focus on integrated phenology data products. However, it is likely that resource requirements to support a workshop and a post-doctoral scholar would be required to explore and develop integrated in-situ/satellite products.

While significant back-up and redundancy are currently in place for USA-NPN generated data, the NCO is developing a robust integrated server and data back-up system that will be fully implemented by 2017 (Recommendation 5.2.2).

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Table 1. Synopsis of implementation actions in response to recommendations by USA-NPN Program Review, with an abbreviated description of each recommendation, a hierarchical numbering system for the bulleted recommendations (see Appendix 1), section in the Review Implementation Plan where the recommendation is addressed in greater detail, estimated overall feasibility of implementing the recommendation, estimated staff effort and resources required to implement the recommendation, the proposed NCO action(s) for implementation, the priority or status of the action, and the timeline (calendar year) for that action.

<b>Report Recommendation (abbreviated)</b>	<b>Recommendation Number</b>	<b>Implementation Plan Section</b>	<b>Feasibility</b>	<b>Effort Required</b>	<b>Additional Resources Required</b>	<b>Proposed NCO Action</b>	<b>Priority</b>	<b>Timeline</b>
Commit to stable funding for USA-NPN and increase accountability	1.0	I	Feasible	Moderate	None	Base support at \$578K in FY16	Complete	2016
Establish a Federal Steering Committee (FSC)	2.0	II	Infeasible	High	Moderate	Direct oversight and leadership by USGS Ecosystems aligned with resources	Medium	2016
Establish clear roles and responsibilities for FSC members	2.1	II	Not Applicable (N/A)					
FSC members inform supervision of USA-NPN Executive Director	2.1.1	II	N/A					
FSC should have representation from several federal agencies	2.2	II	N/A					

<b>Report Recommendation (abbreviated)</b>	<b>Recommendation Number</b>	<b>Implementation Plan Section</b>	<b>Feasibility</b>	<b>Effort Required</b>	<b>Additional Resources Required</b>	<b>Proposed NCO Action</b>	<b>Priority</b>	<b>Timeline</b>
Establish a Scientific Phenology User Group (SPUG) with a formal charter	2.3	II	Feasible	Moderate	None	Establish and sustain phenology Communities of Interest, Communities of Practice, and Working Groups	Medium	2016 (ongoing)
Through the SPUG, engage the phenology community of practice	2.4	II	Feasible	Moderate	None	As above	Medium	2016 (ongoing)
Regularly convene meetings among FSC, SPUG, NCO, and USGS personnel	2.5	II	Feasible	Moderate	None	As above	Medium	2016 (ongoing)
Emphasize streamlined continental-scale but scalable phenology data and information	3.0	III	Feasible	High	None	Create Data Product Catalog (DPC); Revise Strategic Plan; Re-define staff roles; Working Groups	High	2015 (ongoing)
Realign NCO priorities and staffing	3.1	III, V	Feasible	Low	None	Revise Strategic Plan; Re-define staff roles	Complete	2015

Report Recommendation (abbreviated)	Recommendation Number	Implementation Plan Section	Feasibility	Effort Required	Additional Resources Required	Proposed NCO Action	Priority	Timeline
Place more emphasis on phenological data and information collection, quality assurance, archiving, access	3.1.1	III, V	Feasible	Moderate	None	Create Data Product Catalog (DPC); Revise Strategic Plan; Re-define staff roles	High	2015 (ongoing)
Invest in staff to support data informatics and information technology	3.1.2	V	Feasible	Low	None	Hire 2 <sup>nd</sup> programmer	Complete	2015
USGS should take ownership of data infrastructure for archive and access	3.1.3	X	Feasible	Moderate to High	Variable depending on scope	Database and metadata already archived through USGS repositories at no cost; moving CI to USGS will require considerable up-front investment and sustained M & O	Moderate	2016
Non-science activities should relate to the mission of USGS	3.1.4	V	Feasible	Low	None	Revise Strategic Plan; Re-define staff roles	Complete	2015

<b>Report Recommendation (abbreviated)</b>	<b>Recommendation Number</b>	<b>Implementation Plan Section</b>	<b>Feasibility</b>	<b>Effort Required</b>	<b>Additional Resources Required</b>	<b>Proposed NCO Action</b>	<b>Priority</b>	<b>Timeline</b>
Explore emerging best practices for automated data collection	3.2	VI	Resources required	High	Estimated \$100K/yr for 2-4 years	Create new collaborations; Proposal development	Low	2017
Periodically consider NCO agreement with U Arizona for re-competition, renegotiation, or relocation	3.3	IX	Feasible	Low - Moderate	None	USGS responsible for periodic reconsideration; current agreement through 2017	Low	2017
Maintain synergistic and mutually beneficial relationship between USGS, USA-NPN and U Arizona	3.3.1	IX	Feasible	Low	None	Maintain and enhance relationship via improved communication, coordination and collaboration	High	2015 (ongoing)
Consider having both Director and Assistant Director as USGS employees	3.4	IX	Resources required	Moderate	\$100K/yr	USGS to consider options for sustainability vs cost effectiveness	Low	2017

Report Recommendation (abbreviated)	Recommendation Number	Implementation Plan Section	Feasibility	Effort Required	Additional Resources Required	Proposed NCO Action	Priority	Timeline
Focus on delivering a limited number of data products	3.5	III	Feasible	Moderate	None	Create Data Product Catalog (DPC); Revise Strategic Plan; Re-define staff roles	Complete	2015 (ongoing)
Complete a gap analysis to guide data collection efforts	3.5.1	III	Feasible; resource needs depend on scope	Moderate	Variable	Consider alternatives which range from full statistical analysis (requires \$100k) to simple assessment of requirements to meet priority data products	Moderate	2016
Support workshop to identify data product needs of key agencies and stakeholders	3.5.2	III	Feasible	Low	None	A workshop in 2012 was used to set priorities in DPC; PCOI will evaluate progress and need for data products	Low	2016

Report Recommendation (abbreviated)	Recommendation Number	Implementation Plan Section	Feasibility	Effort Required	Additional Resources Required	Proposed NCO Action	Priority	Timeline
Increase USGS attribution of USA-NPN protocols and tools	3.5.3	X	Feasible	Low	None	Improve USGS branding and attribution for data, data products, content, and outcomes	High	2015 (ongoing)
Key products should include both legacy data and emerging data lines and approaches	3.6	IV	Feasible	High	None	Continue prioritized ingestion of legacy datasets; Co-develop APIs for data integration; Build collaborations for emerging approaches	Moderate	2015 (ongoing)
Expand sites observing cloned plants for model validation	3.6.1	IV	Feasible; resource needs depend on scope	Moderate	Variable depending on scope	Continue emphasis on increasing data from cloned plants; model development and validation will require resources	Moderate	2015 (ongoing)

Report Recommendation (abbreviated)	Recommendation Number	Implementation Plan Section	Feasibility	Effort Required	Additional Resources Required	Proposed NCO Action	Priority	Timeline
Enhance site-oriented and species-oriented datasets	3.6.2	IV	Feasible	Moderate	None	Continue data collection campaigns to support development of priority data products (in DPC)	Moderate	2015 (ongoing)
Discover and ingest legacy datasets to support modern observations	3.7	IV	Feasible; resource needs depend on scope	Moderate-High	~10K per dataset	Continue prioritized ingestion of legacy datasets; Collaborate to acquire funding for priority datasets; participate in the development of a plant phenology ontology	Low	2015 (ongoing)

<b>Report Recommendation (abbreviated)</b>	<b>Recommendation Number</b>	<b>Implementation Plan Section</b>	<b>Feasibility</b>	<b>Effort Required</b>	<b>Additional Resources Required</b>	<b>Proposed NCO Action</b>	<b>Priority</b>	<b>Timeline</b>
Consider utility of expected data inputs and products when engaging a partner organization	3.8	VII	Feasible	Low	None	Leverage established capacity to engage partners that help us best meet our data needs for key products	Moderate	2015 (ongoing)
Implement a more structured process for volunteer involvement	4.0	VIII	Feasible	Moderate	None	Target observers to fill gaps; Target partners to leverage on their capacity	Moderate	2015 (ongoing)
Leverage observer best practices	4.1	VIII	Feasible	Low	None	Gain and share "lessons learned" with other leaders in the citizen science community	High	2015 (ongoing)

Report Recommendation (abbreviated)	Recommendation Number	Implementation Plan Section	Feasibility	Effort Required	Additional Resources Required	Proposed NCO Action	Priority	Timeline
Establish formal agreements with volunteer participants	4.1.1	VIII	Feasible; cost-effective?	Moderate	Some staff effort to implement and track	Little evidence this would be effective or cost-efficient; will explore this possibility using evidence-based approaches	Low	2017
Minimize costs by leveraging observer best practices	4.1.2	VIII	Feasible	Low	None	Gain and share "lessons learned" with other leaders in the citizen science community	High	2015 (ongoing)
Target existing scientific observation networks for expanded observations	4.2	VII	Feasible	Moderate	Variable, depending on scope and need for co-funding	Focus of effort is on developing channels of communication, showing value of participation to partner network	High	2015 (ongoing)

Report Recommendation (abbreviated)	Recommendation Number	Implementation Plan Section	Feasibility	Effort Required	Additional Resources Required	Proposed NCO Action	Priority	Timeline
Cultivate financial, technical, scientific support from five mission areas within USGS. Core Science Systems could provide additional programmatic and infrastructure support.	5.0	X	Feasible	Moderate	Variable if co-funding is required	Focus of effort is on developing channels of communication, showing value of data through publications and applications	Moderate	2015 (ongoing)
USGS should proactively integrate phenology information into applications consistent with USGS mission areas.	5.1	X	Feasible	Moderate	Variable if co-funding is required	Focus of effort is on developing channels of communication, showing value of data through publications; developing pilots.	Moderate	2015 (ongoing)

Report Recommendation (abbreviated)	Recommendation Number	Implementation Plan Section	Feasibility	Effort Required	Additional Resources Required	Proposed NCO Action	Priority	Timeline
USGS should offer IT solutions for preservation and accessibility USA-NPN information	5.2	X	Feasible	Moderate	Variable if co-funding is required	Some data already integrated into USGS IT systems, additional efforts and communication with Core Science Systems planned	High	2015 (ongoing)
Work with USGS Land Remote Sensing Program to fuse Landsat and Spring Indices	5.2.1	X	Feasible, resources required	Moderate	\$100K/yr for 2 years	Develop channels of communication; develop pilot	Low	2015 (ongoing)
Readily back data up using cloud technologies	5.2.2	X	Feasible	Moderate	Variable; cost of cloud storage or equivalent	Current back-up system will be improved; Scoping cloud and other off-site options	High	2016

## **APPENDIX A: REVIEW PANEL RECOMMENDATIONS (EXTRACTED FROM GLYNN ET AL. 2015)**

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### **1. Commit to stable NPN funding and increase accountability:**

**USGS should commit to stable NPN funding** of at least \$535,000 per year for 5 years and consider a single organizational champion (e.g. Ecosystems Mission Area) for longer-term sustainment. Other USGS Mission Areas and programs that benefit scientifically from the USA-NPN should be recruited to provide additional funding. The USA-NPN National Coordinating Office (NCO) should be held accountable for demonstrating results from this funding through regular program reviews that address schedule, milestones and deliverables, and risk management. Program reviews should include progress toward science directions and milestones identified by a USGS-led Federal Steering Committee (see below).

### **2. Establish a Federal Steering Committee led by the USGS and a separate Scientific Phenology User Group:**

The NPN Advisory Committee needs to be transformed into a **Federal Steering Committee (FSC) led by the USGS**. We recommend that the Department of the Interior Solicitor's Office be consulted before this change is implemented. The new committee would provide USGS with an opportunity to *take ownership* of the USA-NPN and to promote its value across USGS Mission Areas and other Federal agencies. The Committee would have formal authority to advise and guide the NCO and the Executive Director. The current configuration of an external Advisory Committee has lacked the authority to guide the NCO's implementation of the NPN. The new Federal Steering Committee would enable the USGS to *directly guide future development* of the USA-NPN and to promote its value across USGS Mission Areas and other Federal agencies.

*2.1 Clear roles and responsibilities:* The FSC Chair should be a USGS manager, and the supervisor (or someone in the supervisory chain) to the NCO

Executive Director should also serve as an ex-officio member on the FSC, as USGS resources and priorities allow. The Chair and the ex-officio USGS members of the Federal Steering Committee should be different individuals from two different USGS Mission Areas (e.g. Climate and Land Use Change, Water).

*2.1.1* The supervision of the NCO Executive Director, although within the USGS management chain, should be informed by the advice of FSC members.

*2.2 Representation from other Federal agencies:* The science provided by the USA-NPN is important to many Federal agencies, as discussed previously. The FSC should be created through a Memorandum of Understanding that invites Federal agency partners to participate. Agencies invited to be represented on the FSC should include ARS (USDA), the Office of Science (Department of Energy), NASA, the NIAID (National Institutes of Health [NIH]), NOAA (Department of Commerce), NPS (DOI), NSF, USFS (USDA), and USFWS (DOI). Additionally, the FSC should consider extending invitations to the CDC and to NIFA (USDA), and also possibly to NIEHS (NIH), BOEM (DOI), BLM (DOI), and other agencies if the need and mutual interest arise. Each agency represented on the FSC should nominate one representative and one alternate.

USGS, through its Federal Steering Committee, should also facilitate the **development of a Scientific Phenology User Group (SPUG) that includes key science and data partners for the USA-NPN**. The primary role of the SPUG is to share information with the greater phenology community (including those contributing to the USA-NPN) on phenology science and applications.

*2.3 Formalize groups:* The SPUG should be formally chartered with established, staggered terms of service to ensure rotation and continuity. The charter should address interactions with the FSC and the NCO. The [Distributed Active Archive Center](#) (DAAC) for Biogeochemical

Dynamics, which is funded by NASA and located at Oak Ridge National Laboratory, has a User Working Group that might serve as a good model for the SPUG (cf. <http://daac.ornl.gov/UWG/publicuwg.shtml>).

*2.4 Align existing communities of practice:* The SPUG should provide for the organization of technical user groups for a phenology-based “community of practice.” In any interactions with the SPUG, the FSC should take care not to undermine the existing strength of USA-NPN as a community effort with broad investment across organizations and sectors.

*2.5 Regular information sharing:* Members of the FSC, the SPUG, and key members of the NCO, as well as USGS personnel from Mission Areas with interests in the USA-NPN, should be encouraged to share information frequently and should strive to meet in person at least once a year to share information on the latest scientific developments in phenology science and accomplishments of the USA-NPN. Such a meeting could be organized within the context of a large national or international meeting such as the fall meeting of the American Geophysical Union.

### **3. Emphasize continental-scale phenology data and information:**

The NPN NCO needs to shift its focus to the **creation of high-quality, continental-scale data and information**, with USGS responsibility for data infrastructure. Although natural resource management relies on regional or even local-scale information, the ability to scale up phenological information is vital to addressing an array of environmental change science questions. Continental-scale products can take the form of weather-based algorithms for plant and animal developmental stages developed and validated with actual phenological observations and can then be mapped and assessed at regional to national scales using weather and climate reanalysis data. Related scalable products include data-fusion modeling efforts that synergistically exploit phenological ground observations and remote sensing data. Data fusion is particularly well suited for

exploiting long-running USGS Landsat and other remote sensing of land surface phenology.

*3.1 Realigned NCO priorities and staffing:* USGS should reevaluate the NCO staffing profile, their functions, and the overall coverage of USA-NPN and NCO needs. Recent NCO personnel changes, and the recommendations offered by the current report, make this reevaluation particularly appropriate in the near future.

*3.1.1* The NCO's current weighting of priorities (50 percent for Advance Science, 20 percent for Inform Decisions, and 30 percent for Communicate and Educate) needs to be revised to emphasize a predominant focus on phenological data and information collection, quality assurance, archiving, and access.

*3.1.2* Staff investment in data informatics and information technology is critical.

*3.1.3* USGS needs to take ownership of the data infrastructure associated with archive and access.

*3.1.4* All nonscience activities should directly relate to the USGS' national-scale resource information mission, given the predominant science (versus outreach/educational focus) of the USGS.

*3.2 Best practices for data collection:* Emerging data-collection options, including automated approaches, should be explored, based upon best practices for data management and data product development. These practices should reflect up-to-date standards and be consistent with international collaborations.

*3.3 NCO competition:* The NCO should be periodically reviewed for prospective recompetition, renegotiation, or relocation by the USGS. Such reviews should consider possible pros (additional resources, space, and staff) and cons (instability of operation) of moving the office.

3.3.1 The co-location of the NCO with the University of Arizona's School of Natural Resources and the Environment has fostered synergies between the two organizations. The research foci of the school have been beneficial to the NCO, offering opportunities for collaborative research and staff augmentation.

3.4 *USGS supervision of the NCO:* The USGS should consider the possibility of having both the Executive Director and the Assistant Director of the NCO as USGS employees. This would enhance USGS supervision of the NCO.

3.5 The NCO should also focus on **delivering a limited number of specific product lines** that leverage its phenology holdings.

*Analysis of data coverage and collection needs:* The NCO and the newly-constituted FSC should commit to

3.5.1 complete a comprehensive gap analysis to determine data coverage and collection needs for a coherent national-scale phenological database;

3.5.2 support a workshop to determine a finite suite of product lines that address key constituent needs within the USGS, DOI, and other agencies (with a particular focus on collaboration with Climate Science Centers and elsewhere in the USGS).

3.5.3 Attribution of protocols and tools to USGS needs to be strengthened.

3.6 *Current and emerging product lines:* Key products should include both legacy (e.g., lilac clones) and emerging (e.g., blended satellite and in situ grids) lines.

3.6.1 Densification and extension of lilac/dogwood/etc., clone observation sites should be considered to improve significantly validation of the Spring Indices and other continental-scale, weather-based algorithms for seasonal plant development.

3.6.2 These products should enhance both site-oriented and species-oriented databases using standard protocols and data capture tools to improve access and filtering capabilities.

3.7 *Extension of accessible historical phenological records:* The NPN should discover and ingest existing legacy data to shore up modern observations around legacy sites. Such work would help strengthen historical baselines for ongoing and future changes in seasonal timing.

3.8 *Decision tree:* The NCO should prepare and follow a decision tree that tests its involvement and efforts in partnerships and outreach (current and potential) against the usefulness of their scientific data and product lines. The primary goal of the USA-NPN should be to advance science at **national and long-term** scales in coordination with other DOI bureaus, for example by providing and adding to Green Wave and Spring Index products and to already extensive legacy datasets rather than by focusing on products of only limited, local need.

#### 4. **Formalize volunteer engagement in phenology data collection:**

The USA-NPN should review and implement a **more structured, proactive, and directive process for volunteer involvement** that contributes to *nationally scaled* phenology data and products. The involvement should draw on participation from other existing environmental networks.

4.1 *Leverage observer best practices:* The process should be based on the best practices from other government programs (e.g., USGS Breeding Bird Survey, NOAA/NWS/Cooperative Observer Program, Volunteer Watershed Monitoring groups) in conjunction with Citizen-Science groups and professional observers that are already making physical and biological observations as part of a larger network.

4.1.1 For example, greater efficiency in volunteer recruitment and especially retention might be improved by establishing formal

agreements and more direct cooperation with other existing environmental networks. Volunteer agreements should draw on existing networks of professional observers (e.g., LTER, NEON).

4.1.2 Further efforts by the NCO to leverage best practices for Citizen Science should help minimize related costs and efforts.

4.2 *Target existing observer networks for expanded phenological observations:* Despite many efforts (discussed in Appendix 4), the NCO has so far had limited success in recruiting existing environmental (biological or physical) networks (e.g., NWS Cooperative Observer Program, LTER, Organization of Biological Field Stations, USDA Agricultural Stations, FLUXNET sites) to make additional phenological observations that would strengthen the scientific utility and scope of the USA-NPN. The NCO (and the USA-NPN) has opportunities to build on its recent success engaging NEON and should strive to recruit other scientific observation networks. The goal should be to bring in data on a select and limited number of species that form a national core of observations and serve compelling long-term and continental-scale objectives.

### ***5. Integrate phenology information into USGS science:***

Phenology is an integrative science that cuts across many traditional scientific disciplines and that has relevance to six of the seven USGS Mission Areas. One Mission Area in the USGS should be identified to be the champion for phenology science and for the USA-NPN. However, active interest, financial participation, and leveraging of scientific resources should be strongly encouraged from the five other relevant Mission Areas (cf. discussion in the “Background” section). In addition, the USA-NPN has critical geospatial information needs that could best be met by **programmatic and infrastructure support from the USGS Core Science Systems Mission Area.**

*5.1 Proactive data integration:* The USGS should proactively integrate phenology information, including applications in ecosystems, climate and land-use change, natural hazards (fire and drought), and environmental health.

*5.2 Infrastructure support:* The USGS should offer relevant Information Technology solutions for preservation and accessibility of USA-NPN information.

*5.2.1* For example, work with the USGS Land Remote Sensing (LRS) Program fusing Landsat and Spring Index work.

*5.2.2* Data should readily be backed up using cloud technologies.