Successes and Challenges on a Spectrum of Stakeholder Engagement

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Abstract-- *The USA National Phenology Network (USA-NPN) is a federally-funded, national-scale science and monitoring initiative focused on phenology, the study of seasonal life cycle events, as an approach to understanding how plants, animals, and landscapes respond to environmental variation and change. Through the collection and curation of professional and citizen scientist-derived datasets, a primary aim of the Network is to inform decisions across a diversity of realms, from natural resource management and conservation to public health and human well-being. The Network does this by developing and delivering quality-controlled data and products designed to improve decision-making at local to regional to continental scales. These include heat accumulation and pest forecast maps, visualizations of phenology activity and customizable dashboards for partner organizations, and accessible descriptions of how the timing of spring is shifting across the National Park system. Furthermore, we facilitate informed decision-making by enabling partners and stakeholders to build their own data collection programs and engaging them early in the product development process. In this paper, we share challenges and lessons learned from our experiences over our initial 10 years. In particular, we examine a series of case studies through the lens of stakeholder engagement and collaboration. We found that one size doesn't fit all, but instead, successful engagement is context-specific and scale-dependent. As the Network looks to the future, we identify next steps for achieving "actionable" science through implementing robust evaluation methods and fostering enduring partner collaborations.*

INTRODUCTION

There has been an emerging recognition that using a co-production approach to knowledge creation -- in which scientists, decision-makers, and stakeholders work together as equal partners to develop research and tools to address a problem -- holds immense value to all parties involved. A number of useful frameworks and case studies have been described to guide and evaluate the efficacy and implementation of these processes, particularly in the context of climate adaptation projects and natural resource management (e.g. Dilling and Lemos 2011, Hegger et al. 2012, Kirchoff et al. 2013; Meadow et al. 2015, Reed et al. 2014, Wamsler 2017). Some basic principles that have been identified as best practices in conducting such work in order to increase the likelihood of success include collaboration, engagement, commitment, buy-in, communication, and decision-relevant outcomes (Enquist et al. 2017, Schlesinger 2010). Ideally, these approaches can solidify collective knowledge from individuals and organizations that have successfully demonstrated how research can be most effective and actionable.

The USA National Phenology Network (USA-NPN; www.usanpn.org) is a federally-funded, national-scale science and monitoring initiative focused on phenology, the study of the seasonal activity of plants and animals, as an approach to understanding how communities and landscapes respond to environmental variation and change. The Network consists of volunteers, scientists, natural resource managers, educators, students, and policy makers who collect, share, and use phenological data and information. Ultimately, the Network aspires to advance science and inform decisions across a variety of realms and disciplines. We achieve these goals by communicating and connecting with stakeholders and engaging diverse communities of practice across science, education, and management. The Network was established 10 years ago with an initial goal of collecting, storing and sharing phenological data and information. However, as we have become more sophisticated in data delivery and the volume of data we collect and share, we have expanded our focus in recent years to facilitate the use of the data in decision making. Our stakeholders often need phenological information to control invasive species, assess vulnerability in sensitive species, monitor keystone species, communicate with park visitors about the timing of wildflowers or leaf color change, assess health risks due to peaks in pollen production or activity of disease vectors, and a variety of other applications (Enquist et al. 2015). We wish to offer data products, tools, and resources that directly address these needs.

Thousands of professional and citizen scientists have volunteered their time over the past decade to contribute data using standardized protocols through the *Nature's Notebook* (www.naturesnotebook.org) platform (Denny et al. 2014; Rosemartin et al. 2013). This effort has resulted in a continually growing dataset of over 13 million observation records describing the seasonal activity of plants and animals across the United States. The Network offers these raw observations as well as derived, value-added products and datasets to more directly meet data users' needs. Data and products have been used for applications across a broad range of disciplines, from validating land surface phenology (Peng et al. 2017, 2018), understanding climatic drivers in water-limited ecosystems (Gerst et al. 2016; Mazer et al. 2015), and predicting activity in invasive species (Chapman et al. 2014, Wallace et al. 2016).

The USA-NPN: A Boundary Organization

The USA-NPN is uniquely situated to co-produce and deliver actionable science as we look forward to our next decade. As a boundary organization and a network with a diverse membership, we have the capacity to bring together scientists and land managers or other practitioners to shape phenology products to be highly credible and to be packaged for robust and deliberate decision making. From early in its history, the USA-NPN has recognized the need to build and sustain relationships with partners to create tools and products that meet the needs of practitioners on the ground (Kirchoff et al. 2013; Wall et al. 2017a); however, it has taken time to build the infrastructure and products to support deep collaborations (Schwartz et al. 2012; USA-NPN 2011, 2012). The National Coordinating Office (NCO) of the USA-NPN, which organizes the efforts of the USA-NPN, applies broad scientific knowledge and connections in the researcher communities to keep a pulse on advancements in the field and knowledge gaps while simultaneously identifying stakeholder needs through workshops, conferences, and relationship building within management agencies and individuals.

In recent years, the USA-NPN has engaged in a range of collaborative endeavors that ranged from limited initial stakeholder input to the cultivation of deep relationships; these collaborations have varied in their efficacy, longevity, and buy-in. Here, we assess USA-NPN projects using existing co-production frameworks and best practices. The goal of this paper is to reflect on lessons learned of engaging in a spectrum of engagement approaches by highlighting projects or tools where the USA-NPN strived to address stakeholder needs.

We chose to evaluate the pros and cons of six case studies projects by applying the four approaches to stakeholder engagement presented in Meadow et al. (2015): Contractual, Consultative, Collaborative, and Collegial. We chose this framework for this retrospective analysis because we recognized that the USA-NPN has delivered products that fit appropriately along this spectrum of co-production in terms of the origin of the research question or need, the nature of the relationship with researchers, and the involvement of stakeholders. Table 1 summarizes our experience with the four modes; below we describe the case studies in detail.

USA-NPN CASE STUDIES: TOWARD EFFECTIVE STAKEHOLDER ENGAGEMENT TO SUPPORT DECISION-MAKING

Maps of heat accumulation

Project details: In 2016, the USA-NPN began producing daily maps of the accumulation of heat across the country (Figure 1A; Crimmins et al. 2017). The Accumulated Growing Degree Day maps (AGDD; www.usanpn.org/data/aggd_maps) were developed because temperature is known to be a driver of phenology in many species. Many organisms respond to the accumulation of heat in the spring by transitioning into a phenophase, such as leafing or flowering, once the necessary amount of warmth has occurred (Panchen et al. 2014). The USA-NPN opted to offer these daily maps to "test applicability of new technology" (Meadow et al. 2015) and to demonstrate our capacity to deliver gridded maps of variables that drive phenology.

Engagement mode: While the USA-NPN effectively communicated about these maps to key audiences and received positive feedback, overall, stakeholders played a limited role in the scoping and development of the product. This

contractual mode of engagement was characterized by a unidirectional flow of information from the USA-NPN to potential end users.

Figures 1A & 1B

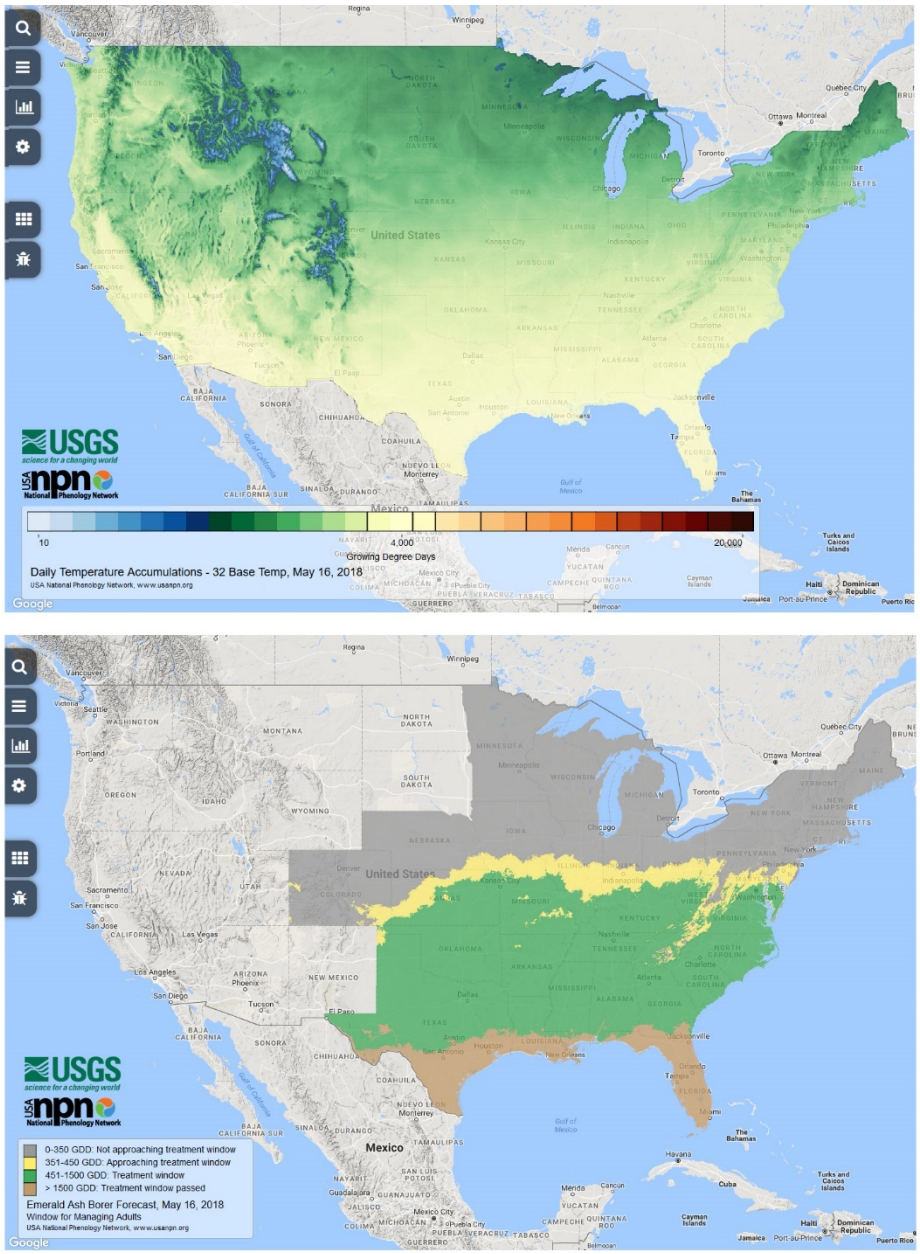

Figure 1A-- Daily Heat Accumulation maps produced by the USA-NPN.

Figure 1B-- Emerald Ash Borer pheno forecast map based on AGDD maps show the timing of predicted management windows up to 6 days in advance. Maps created on May 16, 2018.

Table 1-- Pros and cons of different modes of collaboration employed by the USA-NPN.

Mode of Collaboration	Tool or Project	Pros	Cons
Contractual	● Heat Accumulation maps	● Can generate products with relatively quick turn-around based on internal expertise ● Can prioritize internally without lengthy process to scope	● Unclear if or how products are being used by target audiences ● Less likely to get important parameters right for all audiences
Consultative	● Activity curve phenology visualization ● Pest Pheno Forecasts	● Products have use cases in mind during scoping process and are designed for broad appeal ● Input from target users on how to deliver information and at what scale	● Difficult to assess and evaluate use of information and products in decision-making context
Collaborative	● Custom U.S. Fish & Wildlife Service data dashboard ● Timing of Spring in National Parks research study	● Buy-in and engagement from partners ● Increased likelihood to use tool or information in decision-making	● Products are specialized to target agency partners and information not necessarily transferable ● Timeline/budget dependent on partner
Collegial	● Local Phenology Leader project planning process	● Sustained participation in *Nature's Notebook* is self-motivated and goal-oriented ● Can evaluate progress at site or local scale	● Return on investment may be on the timescale of years and difficult to quantify ● Loss of ability to track outcomes for participants that use resources independently

Outcomes and lessons learned: A benefit of this approach is that we could quickly generate a suite of map products that are both relevant and useful to society and also demonstrate the capacity offered by the USA-NPN to generate,

maintain, and deliver data products relevant to science and management applications. A drawback of taking this approach is that it can be difficult to assess the impact of this approach.

2. Pest management forecasts

Project details: When combined with documented heat accumulation thresholds, gridded AGDD layers can be transformed into maps that indicate when specific events are likely to occur. In 2017, the USA-NPN began generating predictive maps of phenological transitions based on the AGDD maps and published thresholds, thereby offering products that are more relevant for decision-makers. We opted to focus on species of concern to managers, particularly insect pests with known thresholds associated with stages when management action can be taken.

Engagement mode: In this effort, we undertook using a consultative mode of collaboration, characterized by researchers consulting with stakeholders to recognize the problem and brainstorm a solution. We reached out to dozens of managers, foresters, researchers, arborists and extension agents to learn about their needs for maps, existing information gaps, and species of interest in order to synthesize their experience and knowledge. This process largely involved discussions with stakeholders to understand both their needs and to get feedback on various iterations of the product prior to release.

Outcomes and lessons learned: This effort led to a pilot suite of daily pheno forecast maps that show, for five insect pests, up to 6 days into the future, *when* and *where* the vulnerable stage of the insect will occur in order to take management action (www.usanpn.org/data/forecasts; Figure 1B). We used existing scientific knowledge to solve an applied problem by presenting information in a digestible and accessible way. Largely this has been a successful effort in that it has shown a broader array of stakeholders our capacity so that future products can be shaped to be delivered and developed in a more involved co-production framework. In the future, these maps will be used to engage new stakeholder communities to expand phenological forecasts into broader applications, including human health and disease vectors. This will require nimbleness, as we have learned that what suits one community may be very different than another in terms of format, messaging, and timelines of product delivery.

Phenology visualizations

Project details: Data are collected through the *Nature's Notebook* observation program using "status" protocols; observers are asked to record positive observations of phenophases and their intensity as well as when phenophases are absent. This has enabled the USA-NPN to create an interactive, customizable feature called *Activity Curves* in the Visualization Tool (www.usanpn.org/data/visualizations). This visualization emerged from in-depth discussions with partners, including the Audubon Society (Figure 2). Activity curves allow users to display the seasonal magnitude and shape of observations through time across sites to explore how the timing and intensity of phenological stages compare between years, regions, species and phenophases. Managers can use this tool to watch for asynchrony between interacting species; for example, one can investigate potential mismatch between flowering and pollinators, or fruit availability and arrival of migratory birds.

Engagement mode: As in the case of developing the pheno forecast maps described above, this process was consultative, with iterative feedback from engaged audiences through the development process but lacking a research question driven by stakeholders.

Outcomes and lessons learned: We were limited in assessing the impact of this new tool in meeting the needs of the community, and there is the potential for the tool to not be broadly applicable. However, we maintain ongoing discussions with the targeted user community to learn if and how they are using the tool, and how to improve the tool in future iterations.

Custom interactive dashboards

Project details: The USA-NPN builds strong, trust-based relationships within land management agencies such as the U.S. Fish and Wildlife Service. One of the products that emerged from this collaboration is an online Dashboard that

allows individual refuges to customize summarized data from the USA-NPN database for both their own internal and external audiences (www.fws.usanpn.org/phenology-refuges). Refuge managers control the presentation and delivery

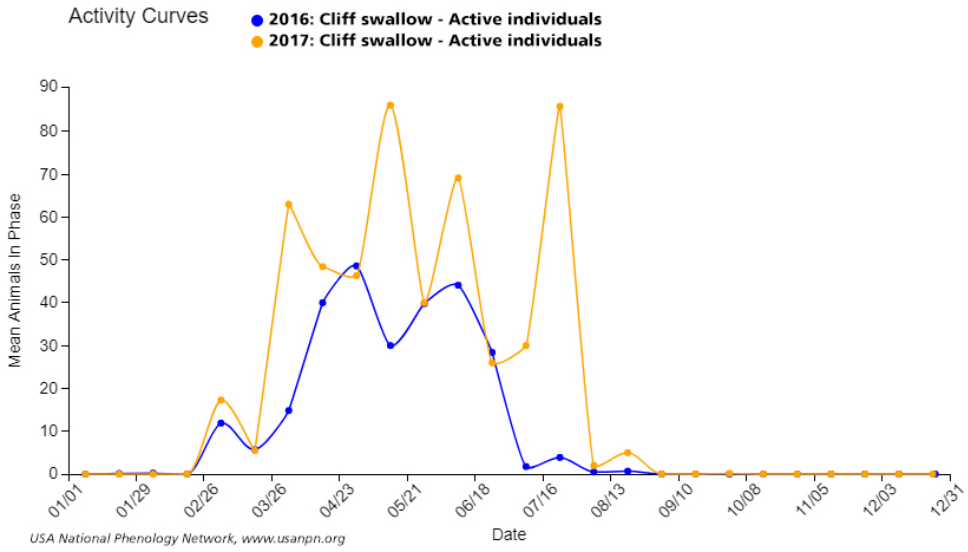

Figure 2-- Phenology Activity Curve visualization showing the timing and the magnitude of active birds in 2016 and 2017. This graphic shows cliff swallow data from BirdSeasons California (Audubon group).

of information for their refuge by customizing the design of a series of widgets, which include custom calendars and activity curves, that display select patterns on species of interest to the individual refuge in a meaningful timeframe and context (Figure 3).

Engagement mode: The approach to this partnership is largely within the **collaborative** mode of stakeholder engagement, characterized by stakeholders and researchers being equal partners throughout the process of the project, from conception to delivery. Here, partners guided the ultimate product and communication messages to their own stakeholders and staff and have ownership to build a refuge-specific dashboard that fits their needs while leveraging on the tools developed by the USA-NPN.

Outcomes and lessons learned: The Dashboards are used by refuge staff to plan management activities, inform visitors about active wildlife or plant life cycle events of interest, and effectively time monitoring. This has led to greater buy-in across the organization and provided an additional incentive for refuges to use the *Nature's Notebook* platform for phenology data collection. While these Dashboards were time intensive to develop and unique to the needs of this partner, certain aspects of the tool are transferable to other partners and projects.

5. Spring Index models serve a National-scale collaboration: Providing historical phenological status and trends of Spring for the National Park Service

Project details: The USA-NPN delivers historical and contemporary maps that show the onset of spring (Ault et al. 2015; Schwartz et al. 2006; www.usanpn.org/data/spring_indices). These models have been designated as national Climate Indicator by the Environmental Protection Agency, the National Climate Assessment, and the USGS Global Change Program and can be used to track how the timing of spring has changed over space and time.

Engagement mode: In 2014 the USA-NPN and the National Park Service launched a collaborative project to understand historical changes in the timing of spring for each park unit (Monahan et al. 2016). We approached the NPS Climate Change Response Program with our historical Spring Index maps, suggesting that they might be useful context for park management. NPS staff agreed, but clarified that results needed to be provided at the park unit level and backed

by a peer-reviewed publication. The study was jointly framed by USA-NPN and NPS staff, analyses were conducted by NPS staff, and academic researchers were engaged to ensure that the models were described and applied appropriately.

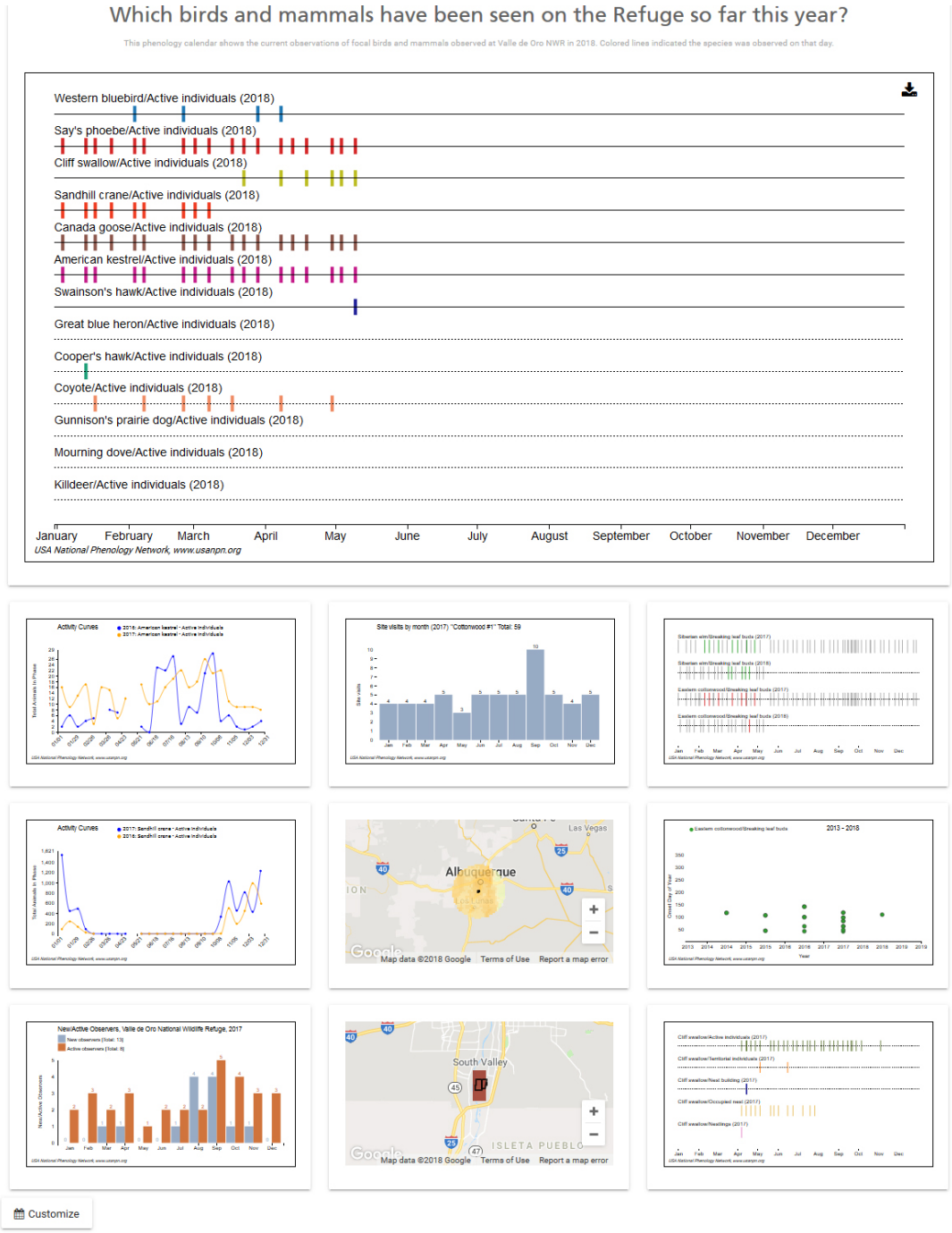

Figure 3--Refuge Dashboard for Valle de Oro National Wildlife Refuge. Custom-selected, dynamically-updated visualizations show phenological activity of focal plants and animals, status of spring onset and accumulated temperature at the Refuge, and metrics on observer recruitment and retention. Users of this tool can customize their calendars by location, year, species and phenophase of interest, to have a better understanding of when they might expect to find various phenological stages in an area.

Outcomes and lessons learned: This project revealed that, for 3 out of every 4 natural resource parks, spring has advanced in recent years relative to historic averages. Half of the parks are experiencing extremely early springs that exceed 95% of historical conditions. Results were disseminated by the NPS via a national event with a press release, a website (https://www.nps.gov/subjects/climatechange/springonset.htm), a resource brief and a national webinar. NPS staff use project results as part of the background information that parks review as they develop new resource stewardship strategies. This project provided relevant, contextual information to many parks to aid in planning. Although this kind of collaboration is time-intensive, the payoffs can substantial with proper communication and buy-in. However, we have learned that to properly scale results from a large-scale study down to a decision-making context is a challenge that must be addressed in a more local scale; this can be a limitation for the USA-NPN given the national-focus and small staff.

6. Cultivating a new generation of local phenology leaders: empowering partners through individualized program development training

Project details: The USA-NPN has recently begun investing heavily in providing partners with resources and support to identify questions, develop their own program, and evaluate successes. To create a site in *Nature's Notebook* for a group or organization where many people will be contributing data (e.g. at a nature preserve, school, botanical garden, or refuge), a local phenology leader must carry out a needs assessment to identify their goals and timelines. In addition, leaders have the opportunity to enroll in an 80-hour online course to receive advanced training and a certificate in the development of a successful phenology monitoring program, including identifying achievable outcomes and measurable success.

Engagement mode: This program planning process is facilitated by the USA-NPN and fits into a collegial mode of stakeholder engagement. This mode of engagement is characterized by researchers supporting and encouraging local project development and capacity. The course and program include a community of practice element with peer-to-peer learning. This helps new leaders learn from others who have experience coordinating a program and enhances new leaders' experiences.

Outcomes and lessons learned: We have seen a shift in the driving motivation of partners from a desire to contribute to a broader effort, to a desire to answer their own local research and management questions. This shift has resulted in greater retention and buy-in from groups that have received training and work closely with NCO staff to develop their own robust and self-sustaining program. In addition, this approach allows for greater tracking of progress of individual partners towards informing decisions and evaluating their success. While partners are asked to complete annual surveys describing their impacts and progress towards their goals, the nature of this mode of collaboration allows partners to independently move through the program planning and evaluation progress without reporting back to the USA-NPN.

CHALLENGES AND OPPORTUNITIES

The USA-NPN is a national organization with a relatively small staff; it can be challenging or even impossible to meet the needs of diverse communities across regions by engaging in deeply collaborative processes in all circumstances. As such, we strive to create tools and resources that can be readily adjusted and customized for a variety of applications, with the understanding that no one size fits all (Lemos and Morehouse 2005). We aim to balance a desire for short-term, rapid results and outcomes with the need for long-term datasets and vetted, high-quality science to ensure that decisions are informed with the best possible information; this requires a diverse set of approaches to the development of products and level of stakeholder input. We have learned in some circumstances our partners are best served by a streamlined production of generic, highly vetted scientific products, such as the continental-scale heat accumulation and Spring Index maps that can then be customized with a specific audience using a co-production approach. For example, our analyses investigating the timing of spring in National Parks and the delivery of pest forecast maps both build upon the more all-purpose Phenology maps that were generated with less stakeholder input. In essence, this allows us to help bridge the usability gap between ready-to-go research and information and the needs of different communities of users (Lemos et al. 2012).

Our experiences reveal that investing in highly collaborative or collegial modes of engagement such as the Local Phenology Leader course results in greater buy-in, stronger relationships, and higher likelihood of success. However, it has been challenging to quantify the return on investment of such relationship building in an era of shifting resources and priorities. This may be remedied by implementing a robust evaluation program in conjunction with training leaders to develop customized programs. Additionally, even if these activities do not directly result in immediate actionable science that is measurable, they lay the groundwork to ensure that the science and data collection being conducted are decision-relevant (Enquist et al. 2017).

CONCLUSIONS

The USA-NPN's focus has progressed over the past 10 years from creating platforms for data collection and resources to supporting researchers in accessing data, to applying these tools and data in management or applied contexts, to actively collaborating and listening to needs and letting this drive our actions and priorities. In the next decade, the USA-NPN will embark on a coordinated effort to seek input from new stakeholder audiences and cultivating relationships to co-development projects by connecting people early and often. We will also pursue opportunities to work with social scientists with expertise in collaborative decision-making. In doing so, we hope to better facilitate linkages between the needs of our communities, gaps in the production and availability of knowledge, communication between stakeholders and scientists, and the evaluation of successful progress towards broad strategic goals and project-specific outcomes. We recognize that, for our organization, one of the missing pieces is the need to set, track, and evaluate our programmatic goals related to knowledge co-production with stakeholders to ensure that our products and tools are useful to science and society, and to evaluate the process by which we can facilitate decision-making in a quantifiable framework (e.g. Wall et al. 2017b).

By investing in our future through engagement and collaboration with interdisciplinary teams, the USA-NPN aims to create and share a new generation of tools to allow phenological information to be more easily integrated into decision-making. We are becoming increasingly agile in our ability to effectively build and nurture such relationships and maintain societal and scientific relevance in a changing world. Future outcomes from these efforts will likely include the dissemination of forecasts to help determine when and where to anticipate phenological activity based on known relationships between climate, weather, and phenological transitions to inform short-term decisions and to support adaptation to climate change.

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REFERENCES

Ault, T.R.; Schwartz, M.D.; Zurita-Milla, R.; [et al.] 2015. Trends and Natural Variability of Spring Onset in the Coterminous United States as Evaluated by a New Gridded Dataset of Spring Indices. Journal of Climate 28:8363-8378.

Chapman, D.S.; Haynes, T.; Beal, S.; [et al.] 2014. Phenology predicts the native and invasive range limits of common ragweed. Global Change Biology 20:192-202.

Crimmins T.M.; Crimmins M.A; Gerst K.L.; [et al] 2017. USA National Phenology Network's volunteer-contributed observations yield predictive models of phenological transitions. PLoS ONE 12(8): e0182919. https://doi.org/10.1371/journal.pone.0182919

Denny, E.G.; Gerst, K.L.; Miller-Rushing, A.J.; [et al.] 2014. Standardized phenology monitoring methods to track plant and animal activity for science and resource management applications. International Journal of Biometeorology 58:591-601.

Dilling L.; Lemos, M.C. 2011. Creating usable science: Opportunities and constraints for climate knowledge use and their implications for science policy. Global Environmental Change 21(2): 680-689.

Enquist, C.A.; Jackson, S.T.; Garfin, G.M.; [et al] 2017. Foundations of translational ecology. Frontiers in Ecology and the Environment 15:541-550.

Hegger, D.; Lamers, M.; Van Zeijl-Rozema, A.; [et al.] 2012. Conceptualising joint knowledge production in regional climate change adaptation projects: success conditions and levers for action. Environmental Science & Policy, 18: 52-65.

Gerst, K.L., Rossington, N.L.; Mazer, S.J. 2017. Phenological responsiveness to climate differs among four species of Quercus in North America. Journal of Ecology. 105: 1610-1622. doi:10.1111/1365-2745.12774

Kirchhoff C.J.; Lemos, C.M.; Dessai, S. 2013. Actionable knowledge for environmental decision-making: broadening the usability of climate science. Annual Review of Environment and Resources 38: 393-414.

Lemos M.C; Morehouse, B.J. 2005. The co-production of science and policy in integrated climate assessments. Global environmental change 15(1): 57-68.

Lemos, M.C.; Kirchhoff, C.J.; Ramprasad, V. 2012. Narrowing the climate information usability gap. Nature climate change 2(11):789.

Mazer, S.J.; Gerst, K.L.; Matthews, E.R.; [et al.] 2015. Species-specific phenological responses to winter temperature and precipitation in a water-limited ecosystem. Ecosphere 6(6):98. http://dx.doi.org/10.1890/ES14-00433.1

Meadow, A.M.; Ferguson, D.B.; Guido, Z.; [et al.] 2015. Moving toward the Deliberate Coproduction of Climate Science Knowledge. Weather, Climate, and Society 7:179-191.

Monahan, W.B.; Rosemartin, A.; Gerst, K.L.; [et al.] 2016. Climate change is advancing spring onset across the U.S. national park system. Ecosphere 7:e01465.

Panchen Z.A.; Primack R.B.; Nordt, B.; [et al.] 2014. Leaf out times of temperate woody plants are related to phylogeny, deciduousness, growth habit and wood anatomy. New Phytologist 203(4):1208-19.

Peng, D.; Zhang, X.; Wu, C.; [et al] 2017. Intercomparison and evaluation of spring phenology products using National Phenology Network and AmeriFlux observations in the contiguous United States. Agricultural and Forest Meteorology 242:33-46.

Peng, D.; Wu, C.; Zhang, X.; [et al.] 2018. Scaling up spring phenology derived from remote sensing images. Agricultural and Forest Meteorology 256-257:207-219.

Reed M.S.; Stringer, L.C.; Fazey, I.; [et al.] 2014. Five principles for the practice of knowledge exchange in environmental management. Journal of Environmental Management 146: 337-345.

Rosemartin, A.H.; Crimmins, T.M.; Enquist, C.E.; [et al.] 2014. Organizing Phenological Data Resources to Inform Natural Resource Conservation. Biological Conservation. 173: 90-97.

Schlesinger, W.H. 2010. Translational Ecology. Science 329:609-609.

Schwartz, M.D.; Ahas, R.; Aasa, A. 2006. Onset of spring starting earlier across the Northern Hemisphere. Global Change Biology 12:343-351.

Schwartz, M.D.; Betancourt, J.L.; Weltzin, J.F. 2012. From Caprio's lilacs to the USA National Phenology Network. Frontiers in Ecology and the Environment, 10: 324-327. doi:10.1890/110281

USA-NPN National Coordinating Office. 2011. USA National Phenology Network Agency Information and Listening Session Report. USA-NPN Programmatic Series 2011-002. www.usanpn.org.

USA-NPN National Coordinating Office. 2012. Identifying and prioritizing data products and tools for use in science, management, and decision making. Research Coordination Network workshop report. USA-NPN Programmatic Series 2012-002. www.usanpn.org.

Wall, T.U.; McNie, E. Garfin, G.M. 2017a. Use-inspired science: making science usable by and useful to decision makers. Frontiers in Ecology and the Environment 15:551-559.

Wall, T.U.; Meadow, A.M.; Horganic, A. 2017b. Developing Evaluation Indicators to Improve the Process of Coproducing Usable Climate Science. Weather, Climate, and Society, 9(1): 95-107. doi:10.1175/wcas-d-16-0008.1

Wallace, C.; Walker, J; Skirvin, S.; [et al.] 2016. Mapping Presence and Predicting Phenological Status of Invasive Buffelgrass in Southern Arizona Using MODIS, Climate and Citizen Science Observation Data. Remote Sensing 8:524.

Wamsler, C. 2017. Stakeholder involvement in strategic adaptation planning: Transdisciplinarity and co-production at stake? Environmental Science & Policy 75:148-57.