Web-based Visualization of Phenology Data

Tom Auer, Alyssa Rosemartin, Doug Miller, Lee Marsh, and Stephen Crawford

Abstract— The National Coordinating Office (NCO) of the USA National Phenology Network (USA-NPN) contracted The Center for Environmental Informatics (CEI) at Penn State to design and develop a Flash-based visualization application for viewing, exploring, animating, and graphing phenology data collected through Nature's Notebook, a citizen science project studying the timing of plant and animal life cycle events (phenology). At the core of the application are two views of the data that focus on database-driven information visualization, a map animation and a stacked temporal graph, or "phenophase stack," both fully interactive and with user selection of parameters filtering the data. Developers at CEI designed and developed the application working closely with NCO staff. Two rounds of informal evaluation with usability experts and domain scientists gauged the success and utility of the application, as well as provided feedback for the development process. The work presented here details a case study in designing a web-based data-driven information visualization application with phenology data, a domain application that has seen little attention from the fields of web-mapping and visualization.

Index Terms— Map animation, graphing, phenology, Flash, web visualization, data-driven visualization.

1 Introduction

The USA National Phenology Network (USA-NPN) [1] "monitors the influence of climate on the phenology of plants, animals, and landscapes…by encouraging people to observe phenological events like leaf out, flowering, migrations, and egg laying, and by providing a place for people to enter, store, and share their observations." Phenology is the timing of plant and animal life cycle events, involving the relationship between phenological events and climate. A phenophase is a stage in a cycle unique to a species or group of species. Phenophases are grouped into categories based on similarity and temporal sequence. USA-NPN has been collecting and storing citizen-science observations of phenology through a data-entry portal called Nature's Notebook for five years, but has not made easily available a method for users to view, explore, map, and share their data. To respond to this need, a functional requirements document outlined what was to be developed, including the following: overlay of climate data for the lower forty-eight states of the US, a map window for viewing of data in animated form with user-selected phenophases, "phenophase stack" graphs that display phenophase occurrence over time for different species at user-configurable locations and years, and output in the form of downloading and URL sharing. This poster focuses on the challenge of designing and developing the map animation and phenophase stacks.

2 Problem Statement

Considering the functional requirements, we asked: how can an application be developed to facilitate novice and expert participants in interactively exploring patterns in phenology for multiple species across both seasons and years in map and graph forms, allowing comparison of those patterns with mapped climate averages?

We address this statement by designing and developing interactive spatiotemporal representations of user-selected data, in the forms of a map animation and graph-based "phenophase stacks." To evaluate success, user evaluation of the application was performed with both usability experts and domain scientists.

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3 Outcomes

Following is a discussion of design elements and implementations of the two relevant visualization forms, the map animation view and the "phenophase stack" view. To explore both, please visit (http://www.usanpn.org/results/visualizations).

3.1 Map View

The temporal progression of phenological events is relevant to the visual analysis of the data. Accordingly, USA-NPN sought to have a fully interactive map animation, to facilitate the analysis of the progression of phenophases changing across space and through time, as well as comparing phenophases at different spatial locations with underlying monthly climate data at four kilometer resolution (maximum temperature, minimum temperature and precipitation; both current month and 30-year normal are available).

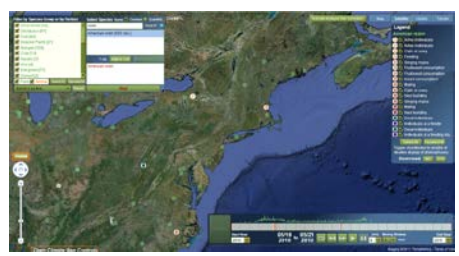

Fig. 2. Screenshot of the Map View.

Using the Google Maps for Flash API as a base-map service, observation locations returned from the USA-NPN database are mapped and coded by colored circle to represent up to three species. A scented [2] time-slider interface element allows the user to select the time frame (start and end years), animation rate (frames per second), and moving window as well as providing the user with standard VCR controls for temporal manipulation. The time-"scent" is a line graph placed above the slider bar, representing the total count of observations for each day, for each species. As the animation progresses, positive observations of phenophases for a species are represented by a symbol that fills and covers the background color of the existing placeholder circle. Color hue is used for phenophase category, while color value is used for single phenophases. Phenophases fall within a natural progression, or sequence, having an assigned value in the USA-NPN's database which is then used to define the sequence and map it to color value in the client.

3.2 Phenophase Stack View

Early "phenophase stack" prototypes from USA-NPN NCO sketched stacked horizontal bar graphs, with the x-axis representing linear time and the bars on the y-axis representing different phenophases. Drawing on these sketches, developers explored similar forms that allowed interactivity with a day-level granularity.

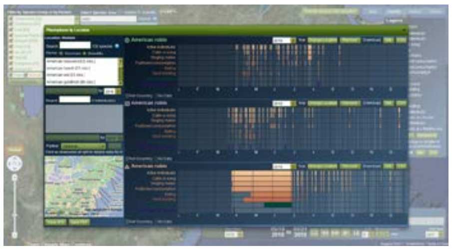

Fig. 2. Screenshot of the Phenophase Stack View.

A row for each phenophase is designed to hold a narrow rectangle for each day of the year. For each day, if the phenophase is positively reported it is colored with the corresponding phenophase color (consistent with the map animation). If it is negatively reported it receives a partially transparent pale gray fill and if there is data null record (representing uncertainty of the species or phenophase) it receives an almost completely transparent dark gray fill. When no data was reported only the black background of the graph appears, creating a visual hierarchy that allows users to easily see patterns of occurrence. Rows are stacked in the order of their phenophase sequence, as defined in the USA-NPN database. Each rectangle is interactive and on mouse-over, highlights its cell and the phenophase name label for the row, with a tool-tip showing the day and observation level. Clicking a rectangle renders any comments provided about the observation. Each stack can be defined by species or individual, year, and a set of locations.

4 Evaluation

The application went through an informal evaluative review with two different user groups. The first were USA-NPN affiliates and the second were graduate students and faculty at Penn State in the geography department with expertise in usability. Usability experts commented on the speed of the application, as well as the ease of map animation control use. However, they were critical of our initial legend designs and color coordination for species within the application, thinking that some users would get confused and find it difficult to read legends and mentally map symbols to species and phenophase types. Oddly, the usability experts had many critiques of our species selection mechanism, while domain scientists reported little difficulty in using it to map a species. Domain scientist input was especially helpful for symbol design, as a number of users had difficulty seeing and distinguishing colors used to represent phenophases and species, both in the map animation legend, as well as in the phenophase stacks. As the domain scientists were less adaptive to new software, they suggested that we should provide "help" cues along the way, to retrieve initial tooltips that guide users through the process of selecting and animating data or building a phenophase stack query.

The application is considered to have successfully achieved USA-NPN's goals, as both novice and science users have casually reported satisfaction, repeated use, and success in accomplishing visualization goals with the application. During the month following release, the application was USA-NPN's 11th most visited page.

5 Limitations & Implications

From a design perspective, we consider the final map animation symbolization to be cognitively challenging. Due to functional requirements that users be able to compare multiple species and phenophases (5-15 different phenophases per species), the complexity of the map animation quickly surpassed cognitive limits of that visualization form [3]. A more cognitively appropriate animation might help the user limit their selection to one species and up to three phenophases or up to three species and one phenophase.

In regards to the nature of the data, the map view suffers from overlapping symbols due to an underlying non-homogenous distribution, a result of uneven sampling. Our design does not address this issue by spatially aggregating the data [4] and by symbolizing locations that were un-sampled and had no positive observations differently [5]. Such a solution was not within the scope of the project nor NCO's currently available server-side resources.

One of the most important outcomes of this work was that it helped reveal the overall complexity of the dataset to science staff at the USA-NPN NCO, helping generate questions and ideas for future work and research related to phenology. Similarly, the complexity of the data helped developers at CEI understand the need for methods and tools to handle analysis of complex datasets for both novice and expert groups.

6 Conclusions

This case study describes the development of an information visualization application, with success being judged through informal evaluation with both domain scientists and usability experts, and through its overall, repeated use. We set out to iteratively develop a Flash-based application that allowed both novice and expert users to explore and visualization phenology data. In the process, NCO staff developed a better understanding of the complexity of their data and what is required to both analyze it and to manage it for similar uses. Developers show the difficulty in designing symbolization for complex map animations and the challenge that lies ahead in creating a more cognitively adequate map animation for USA-NPN data, as well as the need for better guidance on the topic. Finally, this case study helps provide a framework for others to use in designing visualizations for the specific application to phenology data, a domain previously little-explored in the field.

Acknowledgments

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