Timing is Everything: *Phenology as a Tool for City Foresters*

by Theresa Crimmins, USA National Phenology Network; theresa@usanpn.org; @TheresaCrimmins and
by Dudley Hartel, Urban Forestry South, USDA Forest Service; dhartel@fs.fed.us; @treeobs

Given your education, experience, frequent contact with trees, and honed observational skills, you as municipal foresters are well suited for tracking recurring seasonal events such as leafing, flowering, and fruiting. The study of these phenomena is known as phenology. Adding this activity to your weekly routine has a lot to offer; this simple measurement can help you choose the best time to perform management activities, serve as an early warning indicator of trouble brewing among your trees, offer education and engagement opportunities, and support research. And, it's fun!

Schedule management activities

Tracking phenological events such as leaf-out and leaf drop can be very informative for planning. For example, knowing when leaves are falling from different dominant tree species can help public works crews schedule street sweeping operations for maximum efficiency. The Twin Cities of Minneapolis-St. Paul, Minnesota are using residents' observations of when different tree species are dropping their leaves to schedule street sweeping activities. Such well-timed removal keeps leaves out of storm drains, which improves water quality in city lakes and impoundments.

Knowing when to expect leaf drop for each of the species can help establish the beginning and end of leaf pickup services. When coupled with tree inventory data on species distribution and tree size, a manager can predict the date range of leaf fall and estimate expected leaf volume.

Another management area for which phenology information is helpful is invasive species control. Knowing when troublesome invasives are green—and whether valuable native species are also green during the same windows—can inform scheduling of removal as well as the potential decision to use broad-spectrum herbicides vs. selective ones.

Identify problems in the early stages

Tracking phenology entails making frequent visits to the same individual plants. Ideally, these observations take place weekly or more frequently, in order to accurately pinpoint the onset of flowering, the appearance and opening of leaf buds, or the end of leaf drop. Such frequent and careful observations offer the benefit of additional information on plant status and health. If you choose to track the phenology of just one representa-

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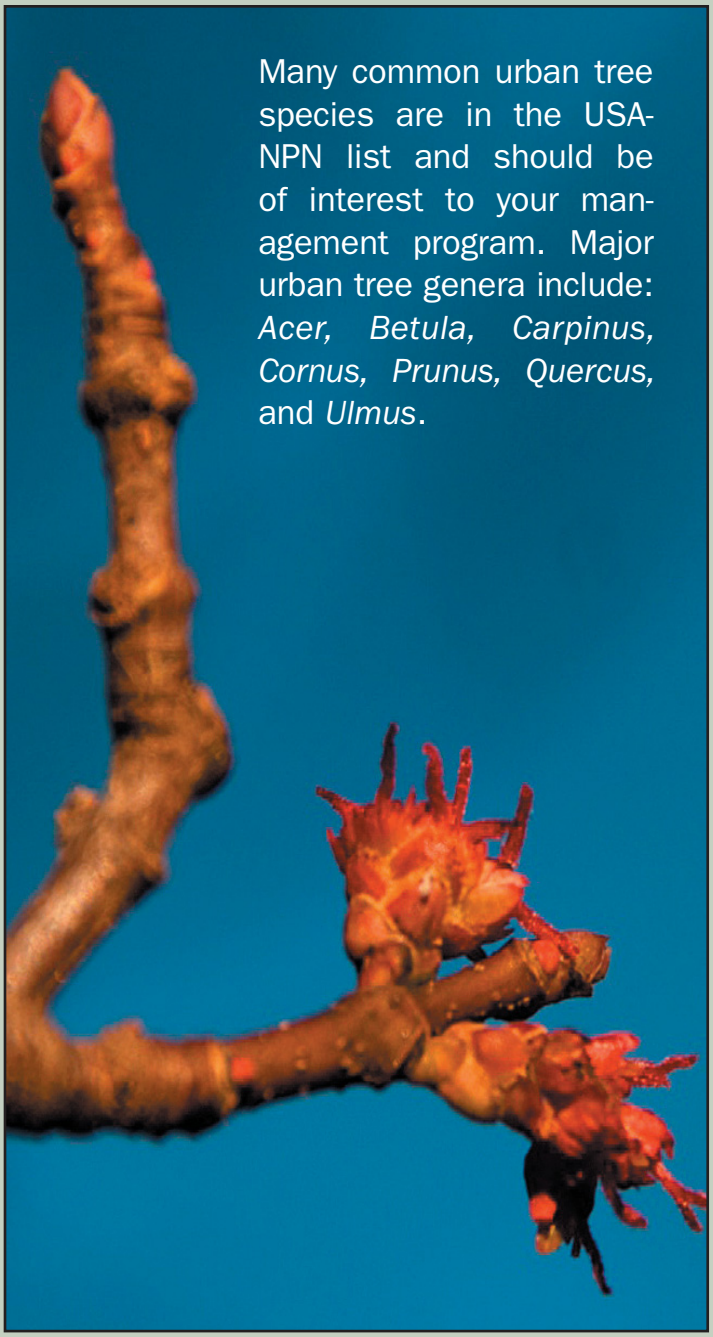

Coauthor Dudley Hartel found his red maple (*Acer rubrum*) blooming before Christmas in both 2012 and 2013. Photo by Dudley R. Hartel 2014

Phenology trackers have entered nearly three million records into *Nature's Notebook*. Photo by Brian F. Powell

tive individual in a stand of trees, you are likely to note early on if this individual shows signs of disease or pest infestation. This one carefully tracked individual may serve as an "early warning" indicator for the entire stand, tipping the observer off to signs of trouble at a stage where it may be possible to control or treat.

Increase local knowledge of phenology and much more

Carefully tracking phenology yields a wealth of site-specific information, with much greater temporal resolution than planting guides can offer. An awareness of when various species undergo leaf, flower, and fruit stages in a particular location can inform plant selection and encourage a more diverse palette. For instance, phenology tracking can help you select plants to maximize flower displays during a particular month, minimize messy fruit drop, or concentrate leaf drop during a short window.

Making repeated observations of phenology can lead to improved observation skills, increased awareness of basic tree biology, and a greater appreciation for the amazing things that happen under our noses every day. I (Theresa) have been carefully tracking a desert willow (*Chilopsis linearis*) in my backyard in Tucson, Arizona for over two years. During this time, I have documented the onset and end of flowering, budburst, and leaf fall, and noted major differences in these events in the two years I've been watching. It's been fun to anticipate these events, and interesting to ponder why I saw fruits

The USA National Phenology Network is partnering with dozens of organizations to promote phenology monitoring at a local level. If tracking phenology seems like a good fit for you, please let me (Theresa) know and we can discuss how to make it make your needs best. We have ample training and support materials to offer and can offer customizations to our system to meet your program's specific needs.

Support research

Key life cycle events such as leafing, flowering, and fruiting are triggered by environmental conditions such as temperature and moisture status. However, for the vast majority of plant species, what the specific conditions are that cue phenological events are unknown. As climate changes, the timing of these life cycle events also changes for many species. However, not all species are exhibiting changes, and the changes that are occurring are not all in the same direction or of the same magnitude. The implications for this are wide-ranging and not yet completely realized, but include mismatches in the timing of open flowers and the arrival of pollinators depending on the flower food sources, spread of invasive species, and changes in species ranges. Local observations of phenology can provide critical data for scientists studying the effects of changing phenology.

So, how do I track phenology?

Phenology observations, if collected in a standardized way across the country and maintained in one giant database, make up a great resource for managers, scientists, and decision makers. To meet these needs, the USA National Phenology Network (USA-NPN) was created. USA-NPN is a consortium of individuals and organizations that collect, share, and use phenology data, models, and related information. The USA National Phenology Network serves science and society by promoting broad understanding of plant and animal phenology and its relationship with environmental change.

Nature's Notebook (www.nn.usanpn.org) is the plant and animal phenology observation program offered by USA-NPN. It offers standardized observation protocols for 673 plants and 268 animal species, field data forms, an online data entry interface, smartphone apps for data entry, long-term data management, support staff, training and outreach materials, and online data visualization and download tools.

Thousands of individuals are actively tracking phenology using this user-friendly system, and to date, nearly three million records of phenology status have been submitted to the online database (more than one million in 2013 alone!) All data are readily available for exploration and download.

To get started, we recommend that you select a few representative individual trees (or other plants) from the list of species (www.usanpn.org/nn/species_search) that you can easily observe regularly. Start small, and ensure that your trees are convenient. Choose one that you can see when you look out your office window, or one that you park under regularly. That way, making your observations will be something that can be done very quickly, rather than being "one more thing" that you have on your already too-long to-do list.

Each time you make an observation, you will report on the leaf, flower, and fruit status of the tree, following the protocols specific to the species. The protocols consist of a series of questions intended to be answered with a "yes" or a "no"—for example, "Do you see open flowers?" Each of the questions is followed with an explicit description of what constitutes a "yes" answer. You may also answer optional questions about the intensity or abundance of a phenophase—for example, "What percentage of all fresh flowers on the plant are open?" These questions are multiple-choice (e.g., Less than 5%; 5-24%; 25-49%; 50-74%; 75-94%; 95% or more).

To get started, follow the instructions at www.nn.usanpn.org. If you have any questions, don't hesitate to contact me (Theresa: theresa@usanpn.org) or another member of our staff. We're here to help!