Arcane Research With Global Implications

Geography professor uses the phenology of lilacs to show that spring is arriving earlier

By Peter Hansen

Alan Magayne-Roshak

Using lilac observations and weather data, Mark Schwartz has helped elevate the rather arcane field of vegetation phenology into an important indicator of global climate change.

As a young geography doctoral student seeking a research topic in the early '80s at the University of Kansas, Mark Schwartz was told by his adviser that phenology might become an important field of study.

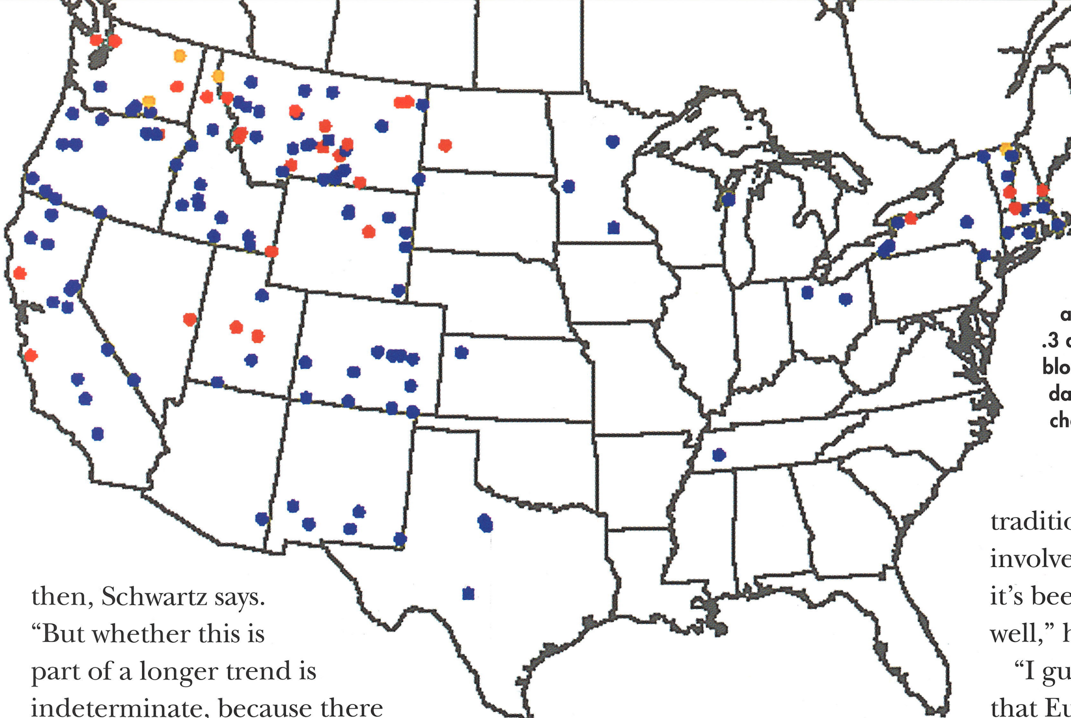
"What's *that*?" he remembers asking.

Schwartz, now an associate professor of geography at UWM, overcame his uninformed initial inquiry into phenology—the study of how living organisms respond to seasonal and climatic changes to their environment—and has gained wide recognition for his pioneering efforts in vegetation phenology, which focuses on plants.

Vegetation phenology has traditionally been of interest primarily to farmers looking to schedule crop planting and harvesting or botanists observing spring flowering, but Schwartz has helped elevate this rather arcane field into an important indicator of global climate change.

Studying the phenological data of select lilac species collected since 1961—specifically, the dates of first spring leafing and blooming—as well as other historical records since 1900, Schwartz has concluded that the onset of spring, or "green-up" as he often calls it, started an average of 5-6 days earlier across North America in the 35-year period from 1959 to 1993.

The trend has continued since



Dots represent observation stations with at least 20 continuous years of lilac phenological data during the period 1959–1993. At sites marked by red dots, lilac bloom advanced an average of more than .3 days/year. At yellow-dot sites, bloom advanced an average 0 to .3 days/year. There was no significant change at blue-dot sites.

then, Schwartz says. "But whether this is part of a longer trend is indeterminate, because there didn't seem to be any trend before the '50s. Things have been changing since '59. It's not possible to definitively tie this to this century-long process of global warming. However, I think that what we're seeing in this last 35-year period is definitely related to warmer spring temperatures. There's no doubt about that."

"I'm expecting temperatures to continue to warm because I accept the basic hypothesis that global warming is occurring—I think most climatologists accept that—and I go a bit farther," Schwartz continues. "I think that human activities—the additional gases that are in the atmosphere—are what is causing this. So my expectation is that these things are going to continue to get earlier. But one has to be careful when you're just looking at a statistical fact study because there's nothing in my data in and of itself that sheds any light onto whether things will continue."

While spring temperatures have increased in all parts of the continent during this period, Schwartz found that the springtime months of greatest change have varied from region to region. In the West, March was the month of greatest increase, while the East warmed more during April.

Innovative modeling

Phenological observations are generally done with lilacs and honeysuckles because they are adaptable to a large number of regions, and they have phenological events that are easy to observe, Schwartz says. "I've been working more with lilacs because honeysuckle plants are an invasive species. I'm not actively promoting using honeysuckle plants."

In collecting data on the timing of springtime lilac events, Schwartz has had to overcome several obstacles. While advances in satellite technology since the 1970s have provided valuable information about the spring green-up, frequent cloud cover has prevented consistent collection of data.

And unlike in Europe, where there are well-established networks of phenological observers, Schwartz has found that records of phenological events in the United States are scattered and inconsistently kept. "I suspect that (in Europe) there's more of a tradition of individuals being involved and interested in this, and it's been fostered and managed well," he says.

"I guess it's a bit embarrassing that Europe has such a good network and we do not have a very good network here, other than these one or two species, and we don't have as many stations and as wide a network as I'd like."

But in poring over huge amounts of historical data, Schwartz has found that daily weather records are available consistently in North America dating from the late '40s. He has used that data, in an innovative way, to create a model that can reconstruct past and predict future green-ups.

To predict the timing of lilac events (first leaf, blooming, etc.),

"One has to be careful when you're just looking at a statistical fact study because there's nothing in my data in and of itself that sheds any light onto whether things will continue."

Photos Courtesy Peter Dunn

Peter Dunn (inset) and swallow nesting sites at the UWM Field Station in Saukville, about 30 miles north of Milwaukee. While swallows have flourished in earlier springs, Dunn says some species have suffered.

conventional models add up *degree days.* A plant species will not experience growth below a specific base temperature, which for lilacs is 33°F. Degree days are calculated for each day by subtracting lilacs' base temperature from the average daily temperature. For example, if the average temperature for a day is 50°F, then the number of degree days accumulated is 17; if the average temperature is below 40°F, degree day accumulation is 0.

Schwartz says conventional-model calculations were "like filling a bucket." "Once you reached a certain number of degree days, then the plant event was supposed to happen at that time." But Schwartz has found more success with what he calls a "synoptic-based model."

"You change one thing—when the primary food product is appearing—and it has all these other potential impacts on the rest of the system."

"What's important is not all the energy, but high-energy events: Times when you have a big surge and a lot of warmth and moisture, typically with a low pressure area coming in—a storm system bringing in a big surge of moisture."

In addition to these periodic high-energy events, Schwartz noticed that the weather patterns leading to the spring green-up would normally end with two warm, low-pressure events. The first of these two "capstones," as he calls them, occurs about a week before the green-up and the second comes at the time of the green-up.

"So it was counting these high-energy events and then looking for these capstones at the end, he says. "That was the strategy of constructing the model."

"It resulted in a model prediction that was a half-day to a day better, which doesn't sound like a lot, but it made a difference and it gave a better, consistent result."

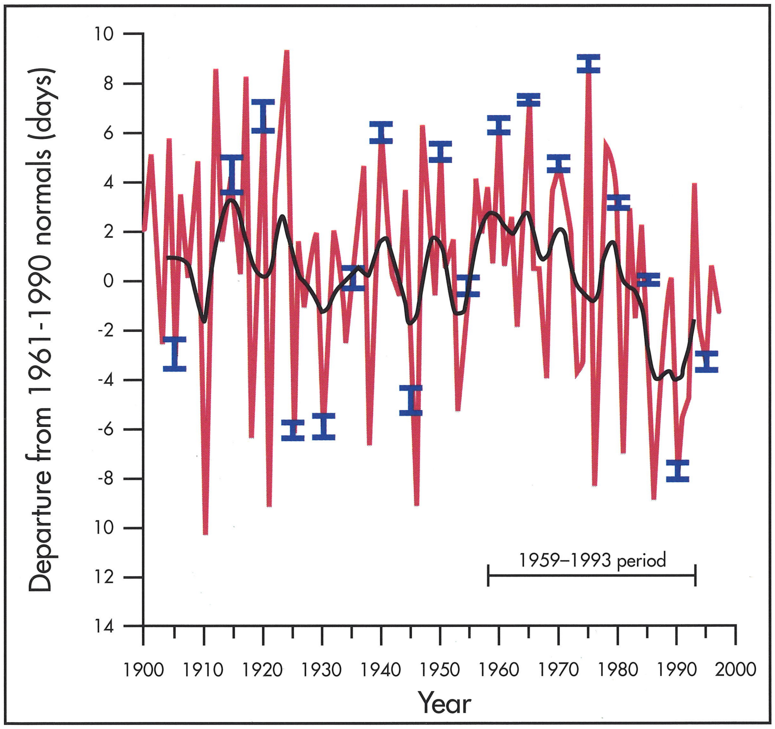
Schwartz says he has had to be a "data minimalist" in constructing his model. "Most of the time we only have daily max./min. temperature data to work with, so I've tried to develop models that can work with that. If you have more data you can do more."

Ultimately, Schwartz sees his model not as a tool by itself, but a way to help verify the observations of satellites.

"By having my model, by having the ability to simulate this, it does give an ability to make a first-cut assessment of how well the satellite is doing. My contribution is more in the lines of providing an actual mechanism to begin doing some of the assessment over the large area, and go back into the past when you don't have satellite data."

"We aren't going to have the luxury of having as many ground stations as we have with weather stations, but we'll be able to establish some, make the connections with the satellite data, and establish a global network to monitor biological, basically plant, activity."

To increase the number of lilac observers, Schwartz plans to enlist the help of elementary and high school students involved in the worldwide GLOBE Program. The program, short for Global Learning and Observations to Benefit the Environment, was launched in 1994 with the dual goals of gathering environmental data using the Internet and cultivating young people's interest in science. GLOBE is managed in the U.S. by a partnership that includes the National Oceanic and Atmospheric Administration, NASA, the National Science Foundation, the Environmental Protection Agency, and the Departments of State and Education. Since the program began, students from over 85 countries have recorded over 4 million observations in the areas of atmosphere and climate, hydrology, land cover, and soils.



North American departures from the mean of spring index first leaf date, 1900–1997, with ±1 standard error bars, and smoothed trend produced by a 9-year, moving average normal curve filter (heavy black line). The black line shows that while the onset of spring has fluctuated throughout the 1900s, a marked trend toward earlier springs began in the late '50s. Map (p.7) and graph reproduced with permission from "Changes in North American Spring," by Mark Schwartz and Bernard Reiter in the *International Journal of Climatology*. © John Wiley & Sons Limited.

Schwartz has also begun collaborating with researchers in China, trying to determine if there have been changes in the onset of spring there. Preliminary indications are that while spring is not getting earlier in China, the last frost of the year is happening considerably sooner in many areas of the country. "It's a different signal than what we're seeing in North America and Europe."

Possible domino effect of earlier spring

Of particular concern to Schwartz and many other scientists is the implications earlier spring onset may have on other plant and animal species.

"Essentially, it starts to change the strategies of other plants, perhaps, in terms of competition, but also animals," he explains. "If the plants are blooming and blossoming at different times, that means that insects are going to have to become active at different times. Either they're going to adapt or they're not, and then birds that are eating the insects are going to have to change their behaviors. They may have to be nesting earlier, and that may affect the survival of their young. You change one thing—when the primary food product is appearing—and it has all these other potential impacts on the rest of the system."

In a study of tree swallows across

the northern United States and Canada, Peter Dunn, an associate professor in UWM's Biological Sciences Department, has found evidence of this domino effect.

From 1959 to 1991, Dunn found, the average date at which the tree swallows nested in the spring advanced nine days. In a study, published in the *Proceedings of the Royal Society*, Dunn and David W. Winkler from Cornell University credit warmer spring temperatures for the advance. The swallows have thrived in the earlier laying season, largely because the warmer temperatures have also hastened the emergence of flying insects and arachnids, tree swallows' primary food source during their laying season.

But not all species appear to benefit, Dunn says, citing the "intricate relationship" that exists between birds and their food supply. "Some birds are mistiming their reproduction." Dunn points to studies in Europe involving chickadee-like birds called great tits (*Parus major*).

"Recent evidence has suggested that warmer spring temperatures can lead to a mismatch in the timing of egg laying relative to the availability of food for nestlings," Dunn wrote in the *Proceedings of the Royal Society*." As a result, later-laying females may produce fewer surviving young."

Greater recognition

As noteworthy as Schwartz's findings is the success of his research methods. His vision of creating a phenological model on a continental scale represented a new way of thinking. "People thought of surface phenology as an agriculture model," he says. "When I first did my dissertation work, the idea was, 'You can't build a model over a large area. They just won't work.' Well, fool that I was, I said, 'Let's give it a shot, and try it out."

Thanks in large part to Schwartz's efforts, his doctoral adviser's prediction that phenology would become an important area of research is coming true.

And his work hasn't gone unnoticed. Bruce Hayden, professor in the Department of Environmental Sciences at the University of Virginia, writes of Schwartz, "It is not often, in these days, that the work of an individual scientist changes the direction that science takes." Hayden was writing to support Schwartz's nomination for a Graduate School/UWM Foundation Research Award, which he received last year. Schwartz's work has appeared in such prominent journals as *Nature* and the *Annals of the Association of American Geographers*, and he is a co-editor of *Phenology of Seasonal Climates*, a widely acclaimed professional textbook.

"I was 'that funny guy that works with the lilacs' for quite a while. The work was respected, but it was like, 'We're not sure how all of this fits in.'"

Schwartz says recognition of his work was not immediate. "It's only been the last five or six years that the research has been getting a lot more attention," he says.

"I was 'that funny guy that works with the lilacs' for quite a while. The work was respected, but it was like, 'We're not sure how all of this fits in.'"

More recently, Schwartz has seen more references to his work in the writings of others. In the journal *Climate*, he says, "There have been five or six articles in the last year or so that were using my research in one way or another. It's kind of gratifying."

The annual spring onset "has been realized as an appropriate thing to look at, a very sensitive thing to look at in terms of whether (long-term) changes are taking place," he says.

"What we're seeing more recently is a more profound change—potentially over the next 50 years or so, the most profound changes that there have been in quite some time. It has implications for human activities."

While Schwartz says it's important for people to be aware of the potential impact of environmental change, he's wary of what he describes as extreme views: complacency with how things are now or predictions of apocalyptic tragedy.

"There is a pretty likely middle ground, where there are going to be (environmental) changes that take place, and it's prudent to evaluate the options and look at the risks," he says. "I think of it as similar to buying insurance: You have that not because you want bad things to happen, but it's a step you take to mitigate the damage in case something bad unexpectedly happens. Right now the policy seems to be more along the lines of, "Do nothing and hope that nothing bad happens." ■