Recent UCSC graduate Alejandro Carbajal, who majored in Plant Sciences, writes on the important relationship between Phenology and understanding the changes in our climate. He discusses this relationship with Juliet Oshiro, who conducts the Phenology Walk Workshops at the UCSC Arboretum.

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The Changing Rhythms of Plants

*Blooms and buds are bursting earlier every year in Santa Cruz County.*
*Workshops at the UCSC Arboretum show how you can track these changes.*

by Alejandro Carbajal

Spring in Santa Cruz is looking more and more like summer. Each year, warming trends from climate change are causing plants to flower sooner—with real consequences for animals, agriculture, and the survival of the plants themselves. The study of these cyclic patterns has a name: phenology. And it’s easy to see it in action. Just go for a walk in nature.

On a cold cloudy mid-April morning, I went on such a trek behind Scotts Valley High School. I hiked around Cupcake Hill with Juliet Oshiro, a UC Santa Cruz graduate student in ecology who leads phenology tours at the UCSC Arboretum. Legendary local botanist Randall Morgan came to this spot month after month to record details every plant he observed. We were walking in Morgan’s footsteps, but were we seeing what he saw? Are plants behaving today the same way that they did 20 years ago?

The morning sun breaks through the clouds, lighting fields of Purple Needlegrass. Yellow, white and purple flowers are in bloom around us. Climate change is affecting all of it, Oshiro says. Today, we are seeing flowers emerge from some plants far earlier than Morgan did in his surveys from 1989 to 1998. Lately, these trends seem to be speeding up.

“This year has been really scary,” says Oshiro. “*Clarkia purpurea,* which has the common name ‘farewell to spring,’ bloomed in the middle of spring. I guess these are the effects of a really warm winter and spring.”

Research is beginning to show that while climate change may not eradicate many plants, higher temperatures do affect their life schedules. Plants bloom or grow their leaves with certain rhythms, and insects and other creatures depend on those
timely events. The effects of these changes ripple through ecosystems. Scientists like Oshiro are just now starting to chart this climate-caused asynchrony.

It might not seem to matter much if plants bloom beautiful bouquets of flowers a few weeks earlier. However, the seasoned hikers who come regularly to enjoy the region’s timely natural splendors, the winemakers who wonder if winter will affect their future grape harvests, and the farmers who depend on their strawberry crops to be pollinated would beg to differ.

Phenology, as applied to pollination, flowering cycles, and other plant-related events, is especially crucial for agriculture. Whether rhythms are in sync can lead to a profitable harvest or a poor one. The stakes are high. In 2013, the top three plant commodities in Santa Cruz County by market share and value were strawberries at 34% and $201 million, raspberries at 25% and $142 million, and nursery stock at 12% and $107 million.

Oshiro also collects temperature and precipitation data. According to local records it hasn’t really gotten hotter in the county, but it isn’t getting as cold as it used to. Lack of cold winters can increase pests that harm crops. Fluctuating temperatures can also harm crop growth and health.

“A lot of plants require a certain period of cold in the wintertime to allow them to produce more fruit or better tasting fruit,” especially wine grapes, notes UCSC environmental scientist Michael Loik.

Wine grapes only raked in $4.6 million in 2013, but Santa Cruz County vintages are gaining notice among wine enthusiasts. If there’s a bad year with a strong frost or an overly warm summer, the grapes will mature differently—with unpredictable impacts on how the wine tastes.

Oshiro graduated from UC Santa Barbara with a bachelor’s degree in ecology. “When I was in college, climate change was a new thing and really exciting,” she recalls. “It seemed like an unexplored field but a really, really important one.” After doing an honors paper on climate change, Oshiro decided she wanted to pursue research in the field. She found herself in Santa Cruz.

Studying climate change requires comparing consistent data from many years apart. Comparing historical datasets to modern ones allows scientists to create models, leading to forecasts of the future effects of global warming. Morgan’s detailed surveys give Oshiro the means to track how climate change is affecting habitats in our backyard—and to attach some firm numbers to her observations.

Randall Morgan, a Santa Cruz County native, already had his bird taxidermies on display in the Santa Cruz Museum of Natural History at age 12. He discovered
numerous plants and insects found nowhere else in the world but in this county. He is a particular authority on clovers and rein orchids. After his ten years of surveys, Morgan had collected more than 90,000 plant and insect specimens.

Soon after arriving in Santa Cruz, Oshiro began resurveying ten of the 39 sites surveyed by Morgan. She visited each site once a month for the next four years. She chose iconic settings: four spots in the county’s sand hills and six tracts of coastal grassland. “Both are understudied, but the sandhills are a rare habitat type,” Oshiro explains. “People are realizing the sandhills are rare and interesting, so they’re starting to study them.”

On our hike, the sun warms us as we cross the street from Scotts Valley High over to Glenwood Preserve, the second site of the day. We walk up a nearby hill and Oshiro explains the purpose of a small hillside plot with a few golden poppies.

These plots, just small sections of land marked with sticks, help Oshiro gather long-term data on different populations of plants in the same sites. She analyzes the phenophase of each plant—the stage of its seasonal cycle it displays—and their numbers, in this case golden poppies praising the sun.

We move further up the hill and do a general scan of the flowering hillside. Taking data requires familiarity. I keep getting one small cute purple flower—\textit{Erodium botrys}, an invasive species commonly known as Long Beaked Stork’s Bill for the shape of its fruit—mixed up with another tiny purple flower. This little purple star speckled every place we visited, revealing just how invasive it is.

The sun isn’t quite overhead, but the clouds from the morning are all but gone. We head down the hill, hike through some mud, climb another hill, and pass a lake where dozens of bullfrogs croak at us. We come upon another plot, but this time it’s grassy. We comb the grass spikelets—the inflorescences at the ends of the grass—to see whether their reproductive organs are exposed. The sex organs are minuscule; the male parts look like a pair of yellow or purple bananas at the end of tiny strings hanging from the spikelet, and the feathery female stigma is easy to miss. Their timeliness and sensitivity make grasses great plants to study.

“I contribute data to the NPN [National Phenology Network] database, using their citizen science data entry platform called Nature’s Notebook,” Oshiro tells me. “The data I take from these plots can be used by other researchers—the database is open access. I tell everyone who comes to my workshops at the Arboretum to collect data using Nature's Notebook for the NPN.”

The third site we visit is the Bonny Doon Reserve, a sand hill site burned in a fire in 2008. Dead trees like charred totem poles litter the landscape. We break for
lunch and I admire the unique vegetation. Peter Raven, a biodiversity expert, called the sand hills “the Galapagos Islands of Santa Cruz County.”

Gems strewn throughout the redwood forests, the sand hills of the Santa Cruz Mountains are fragile ecosystems. The poor soil makes it difficult for plants to thrive. Water drains quickly, growth is slow, and most plants barely reach shoulder height. Only the occasional patch of Silverleaf Manzanita bushes is taller than us; we’re both 5 foot 6 inches or so. Everything huddles close to the earth.

One Santa Cruz Manzanita bush marked for long-term observation has its final few rosy bell-shaped flowers outnumbered by immature green berries. We record estimates of how many meristemic buds we see—the tips of new growing shoots, flower buds, and flowers—and also immature and mature fruits.

The plants here are adapted to living in poor sandy soil. Over the course of millions of years, nature and evolution have shaped many plants to become specialized for life on the sand hills, like the Santa Cruz Wallflower—a delicate species whose population is shrinking. In the surrounding forests, monster redwoods screen out most sunlight; more voracious plants outcompete their sandhill counterparts. The sandhill plants are stuck on their islands of scarcity.

As climate change proceeds, scientists expect plants will adapt by shifting their ranges over generations to stay in a suitable set of temperatures. However, the species of the sand hills don’t have that luxury. They are confined to their islands of sand. Conservation efforts might sustain some species from going extinct. But in 2050, it’s likely the sand hills will look very different than they do today.

“I think it would take a lot to kill them off,” Oshiro says. “But if it does happen, sandhill-adapted species might be in trouble. They either need to adapt to new areas or. . . .” Oshiro doesn’t finish the statement. It’s impossible to predict how these habitats will respond without more research.

Not many people have studied these habitats. Indeed, Oshiro is one of the first to study phenology and climate change with a focus on the sand hills. By surveying a resource-poor area, she will be able to model other resource-poor habitats in central California, like the serpentine soils of Edgewood Park and Natural Reserve in Redwood City. These surveys and models will help scientists advise land-use planners on protecting these special environments for years to come.

Oshiro wants people to continue surveying the sites long after she moves on. To that end, the National Ecology Observation Network, or NEON, has created a citizen science program called Project Budburst. Citizen science is a way for people to learn how to take data like a naturalist and send it to someone who will
analyze it. Participants register online, take a quick course, and then go out in nature to observe and record what they see in a notebook or on their phone.

NEON is setting up long-term research plots across the country to collect such data. However, the dedicated scientists can only record so much by themselves. With help from the public participants, scientists can understand how a large range of plants may respond as our planet keeps getting warmer.

Grab a notebook and a pencil, take a walk outside and write about it. Notice the colors of the leaves on trees. Can you see any fruit or flower buds developing? Try to record details. What color is the flower, and how does it smell? Learn the names of the plants. Remember them like they are your best friends. Anyone can help scientists study phenology and understand the impacts of climate change.

Do the same thing on the same day in five years, and you may see a differently colored landscape than you do today. Your friends will still be there, but they may be a bit off schedule. The cherry blossoms may bloom in mid-March rather than in early April; the green leaves of the trees may last for a few more weeks into October. We’re used to seeing the seasons change, but now the seasons themselves are shifting around. It may take a while before they stop and we get used to them again.

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Alejandro Carbajal majored in plant sciences at UC Santa Cruz. He wrote this story for SCIC 160: Introduction to Science Writing.

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