Moderator: We are happy to start off our semester with Dr. Liz Matthews, here from University of California, Santa Barbara. She came all the way up here from beautiful Santa Barbara, she brought the good weather with her. So thank you for coming.

Dr. Liz Matthews: Thank you.

Moderator: She's going to be talking today about her work with the California Phenology Project involving citizens in science and, you know, assumed to collect more data than any one scientist can collect alone. Liz is a postdoc at UCSB and she was at North Carolina where she got her degree in Plant Ecology. Right?

Dr. Liz Matthews: Correct.

Moderator: And just to let you know, next week we have a local seminar speaker, Dr. Michael Ennis from the Department of Psychology. Kind of a different topic from today, but I hope you all can make it then as well. So thank you for coming.

Dr. Liz Matthews: Great. Thanks for the introduction. [Applause] And it's really great to be here. I just wanted to thank you all for the invitation, particularly Jim for getting me up here and it's been wonderful chatting with a lot of you today. It sounds like Chico is primed for some Phenology monitoring and I hope that when I leave there will be a legacy left here, a seed planted in all of your minds and hopefully the CPP
can expand up here to the North Valley area.

So I will be talking about the California Phenology Project, which I will often refer to as the CPP today. So if I start falling into CPP language, that’s what I'm talking about. And this is a project that is focused on engaging citizen scientists in ecological monitoring, particularly focused on Phenology.
Before I jump into the presentation and the content, I do want to point out that this is a really collaborative project. There have been 10 to 15 employees of the National Park Service, the National Phenology Network, UC Santa Barbara, Nature Bridge, and Environmental Education Organization, among others, who are contributing a lot of time, money, and energy to this project. So everything I talk about today is not something that I've done alone, but I've done in partnership with many individuals, some of whom are up here. And I won't go through all of their names, but you can visit our website and see all of the collaborators who are working with us on this project.
So the brief overview, I just wanted to let you all know what I will be talking about this afternoon. I'll start with an introduction to phenology, a little bit of background information about the project, and then I'll talk specifically about what the California Phenology Project has been up to over the last two years towards building a Regional Phenological Monitoring Network. I will then talk a little bit about our relationship with the national organization. That's the USA National Phenology Network, which I will often refer to as the NPN. So if you hear that acronym, that's what I am referencing. And then finally, very briefly and kind of depending upon time, I'll mention a little bit about what we are hoping to do over the next two to five years as part of the CPP effort.
And so I’d like to start with pointing out or describing what is phenology. I already was asked that right before the seminar. And the most succinct definition I can come up with for phenology is the study of recurring plant and animal life-cycle stages. And the term that we use for these life-cycle stages is phenophases and you’re probably all very familiar with a few phenophases, including the flowering of plants, fall foliage color change, or animal migration. And often the study of phenology is linked to the environmental or biological drivers of these phenological events. So we’re interested in when they occur, sometimes the duration of these phases, so how long is wildflower flowering, and then why is it -- why did it begin at a certain and why does it extend for a certain duration.
I also like to point out that phenology is interesting biologically, but it is also very interesting economically, particularly in this project since we are working with the National Parks and with a lot of public. It's always to answer the question why are you doing this right at the beginning. And just as a few examples, we have many slides describing why phenology is economically important, but a few that might be close to home here.

Wildfires in California are very tightly connected to phenological events. So the dry down of vegetation in the late summer is a big driver for our wildfires, particularly in the Mediterranean zone and often influences the intensity of those fires.

Another example would be allergens, which many people are unfortunately very familiar with, so the production of certain pollen or the production of pollen by certain species can be a real driver of allergic reactions.

One that was in the news a lot last year, so you may be familiar with, is the DC Cherry Blossom Festival. This is a yearly festival that is scheduled around the cherry blossom flowering events around the Mall in DC. And last year there was a particularly warm winter and warm spring and the cherry blossoms came three weeks before the festival. That's a big letdown for the festival organizers and for tourists who are coming from far away, particularly international tourists, since the cherry trees were donated from the Department -- or from Japan, there is often a big international component to that festival.
Another great example that's come up in the scientific literature recently is biological invasions. So it seems that many successful plant invaders that there's a phenological component to their success. Either they're able to capitalize on resources at a different time period than native species and this is buffelgrass in the southwestern US.

And then finally, agriculture is a pretty obvious one. So the ripening of fruits and the period of harvesting.
I also like to point out that phenology is important biologically. So it's not just economics we're interested in here. And I should probably come out and say right now that my bias is plants. As you already heard, my degree is in plant biology, plant ecology, and the California Phenology Project to date is focused exclusively on plants. We do hope to extend into animal monitoring, but almost all of the examples I give today will be focused on plants.

When we think about plant phenology, it's really useful to break that down into vegetative phenology and reproductive phenology. In thinking about vegetative phenology, there are all sorts of ways that the timing of leaf production and the intensity of leaf production is important on a local scale and I'll mention that a little bit later in the talk. But the production of leaves is also very important for global biogeochemical cycles. And we're probably all familiar with this figure on the bottom right here where we see atmospheric carbon dioxide measured in parts per million at Mauna Loa in Hawaii. And that's on the Y-axis. On the X-axis here we have the last five years, a little bit more than that, of data. And most of us are familiar with this black line, which shows the long-term average increase in atmospheric carbon dioxide. But there's also this intra-annual variation where there's an increase in atmospheric carbon dioxide during the winter period. So when there is not as much photosynthesis happening in the northern hemisphere. And then as the summer and leaves come out, photosynthetic rates increase and we've got a draw down of atmospheric carbon dioxide.
In addition, just to point out the importance of reproductive phenology, the timing of flower — flowers opening and the attraction of pollinators is very important for the success of plant reproduction rates. So many flowers, many species need to attract pollinators in order to pollinate their flowers, such that there can be fertilization and the production of fruit. Without this correct phenological match in the production of flowers and pollinator activity, we have an issue with plant reproduction, right? So there may not be successful reproduction. In addition, plants rely on dispersers. So dispersers need to be active at the period when fruits are ripe and available.
So that's just a quick overview of why we might be interested in studying phenology, both from an economic perspective and from a biological perspective. And I'm happy to come back to that a little bit later in the talk, but I'm going to jump into phenological monitoring and the history of phenological monitoring in the US. So given the importance of phenology, there have been many efforts over the last maybe five to six decades to develop phenological monitoring programs, both in the US and in Europe.

And probably the most successful program that was ever developed in the US was a program focused on monitoring common lilacs. This was developed by Professor Joe Caprio who was an agricultural ecologist at Montana State and he distributed lilacs across the US, asked people to plant them in their backyards, and then monitor phenophases. So when do you see the first flower? When do you see the first fruit? When do you see the appearance of the first leaf? And as an example, these are vegetative phenophases of the common lilac. So here we have a bud that's protected over the winter by these bud scales. In early spring, as temperatures begin to warm, the bud scales open up to reveal these growing and developing young leaves. We can now see most of the leaf tip here. And eventually, we see a fully developed leaf later in the spring.

Since about 1960, Joe Caprio collected postcards of people sending in saying the day that he -- that they witnessed each of these events. And then the data that he collected was passed on to some contemporary researchers who have used these data in a variety of ways.
One example is the Spring Index that was developed by Mark Schwartz at the University of Wisconsin in Milwaukee, where he used observations to develop an index of when we might expect spring to arrive at different locations across the US. So what we're looking at here is a map where each of the blue dots represents one of these lilacs that was monitored in the backyard of -- someone's backyard and the red lines are contour lines that indicate similar behavior. The value on the red lines is the day of year when you would expect the first leaf out of -- emerging out of one of these over-wintering buds.

So as we might expect, this is probably not surprising, on day 60 in the southern regions we see the first leaf, whereas in the northern regions, we have to wait an additional few months, an additional, you know, 60 days before we see the first leaves in the northern US. This is one of the biggest examples, most geographic widespread examples, of connecting plant phenology with elevation -- with latitudinal gradients. And there is also an obvious relationship here with elevation, where you have later onset of phenological events at higher elevation. It is important to point out, of course, that latitude and elevation aren't actually driving the biological phenomenon, its temperature and precipitation that vary with these geographic descriptors.
So this is many individuals tracked over a really large area, but what about monitoring a single plant over a long period of time.
In the northeast region, many of the lilacs that were monitored over this 40-plus-year period, this is a lilac that was monitored for 50 years, we see this pattern where many phenological events have advanced -- have begun earlier and earlier in the year, as climates have warmed in those regions. So here, this is a figure that we'll see something very similar a few times, so again, I'll point out the axes here. On the Y-axis here we have days after January 1, so the day that a phenological event occurred and on the X-axis we have year. And while there is a lot of inter-annual variation in the day that we see the first leaf or the day that we see the first flower, over time there's a trend towards earlier leafing out and earlier flowering.
And in this area, in particular in the northeast, there's also been well-documented increases in temperature over this same period.
So one of the concerns about changes in phenological patterns over time, particularly for some of these plant species that are advancing their phenology earlier and earlier in the year, some of the interacting species may not adjust to changes in temperature and precipitation at the same rate that plants are. And there have been a few examples of this in the last decade or so. This one is probably one of the most frequently cited and this was a study in Europe looking at the documented phenological mismatch. And there are three players in this relationship. The English Oak over recent decades has been leafing out earlier and earlier, as temperatures warm, particularly winter temperatures. And one of the caterpillars that utilizes this flesh of leaf resources is the winter moth and luckily, the winter moth has been keeping track with the advancing phenology of the English Oak. So English Oak is leafing out earlier and earlier. The winter moth is emerging earlier and earlier. But there is a species of fly catchers that over winters in Africa and it's arriving in Europe at the same time. Does that mean it's arriving too early or too late for its primary resource, which is the winter moth?

**Audience member:** Too late.

**Dr. Liz Matthews:** Too late. Right.
So now it's beginning to miss the peak of its resource and in places where the fly catcher is arriving particularly late, the populations have decreased by up to 90 percent.
So these phenological mismatches are a real concern and they've only been documented in a few places to date, but this is mostly because we don't have the data to know whether or not phenological mismatches are occurring more frequently in North America or Europe.
And with that in mind, I’m going to transition and talk a little bit about the California Phenology Project. So given the interest economically and biologically in phenology and given the concern of ecological effects of shifting phenologies, the potential for phenological mismatches in particular, there’s a lot of interest in the western states, particularly in some land management agencies, in developing a widespread phenological monitoring network to get an idea of what’s happening.

There's been a long bias in the US of monitoring plant phenology on the East Coast in deciduous ecosystems. And in 2009, the National Park Service Climate Change Response Program put out a call for a climate-change focused research programs that might guide management. A few different park networks put in proposals suggesting that they wanted to develop regional phenology-monitoring programs. And the California program was funded, particularly because there -- it -- there hasn't been a history of monitoring phenology in California and in western states. And they hoped that by funding a project in California, the tools and products that were developed here could be used more broadly across the west.

One of the other real benefits of developing a program like this in California is that we have a very diverse state. And so we can develop protocols for high-elevation systems. We can develop protocols for arid systems. And then we've got a lot of variation along our coast from Mediterranean climates to very wet climates in the northern part of the state.
So in 2010, the National Park Service Climate Change Response Program funded a two-and-a-half-year project that would be focused on seven pilot National Parks and these parks were selected to represent a variety of local communities. So urban areas, very rural areas, and they were selected to represent the variety of ecosystems that are present in California. The goal again, was to develop monitoring tools and infrastructure that could be more broadly implemented outside of the parks after an initial period of testing in these seven focal parks.
The overarching goal of the project has been to establish a widespread geographic -- geographically widespread monitoring program, such that sites are picked to represent important environmental gradients. So we know that precipitation is important. We know that temperature is important. So we've selected sites that represent different temperature regimes, represent different precipitation regimes. And similar to the lilac-monitoring program, if we monitor across a wide geographic area, we can figure out how phenology varies across space.
The more -- the three more specific goals and outcomes of this shorter pilot period were to address scientific questions that I'll talk a little bit more about in a moment. To guide or hopefully develop some steps towards guiding resource management in the large land-managing agencies in California, the National Park Service, US Forest Service, and BLM. And finally, to engage the public in monitoring in a way to -- as one tool to educate the public about their local ecosystems and about climate-change research.

And this is a really important point to make right now. That everything that's been done over the last two years as part of this effort, really is a balancing act. We do have a lot of scientific goals, but we -- one of our equally important goals is to engage the public and to get as many citizen scientists involved in the effort as possible. So depending upon the location, sometimes our focus is more on science. Sometimes our focus is just getting a fifth grader to look at a plant and record a phenological observation. Sometimes those data don't even end up in our database, but we still feel like that is an accomplishment.
So that background, I'm going to talk more specifically about what the CPP has been up to over this two-year pilot period. So we really got started in January 2011. We're about two years into the project right now and we're really focused on -- focused on wrapping up what we've done over these first two years at this point.
I'm going to break up this part of the talk as well into a few different sections, talking about some of our main projects. And I'll talk about each one of these in sequence.
The very first thing that we did as a group was to identify scientific questions and a scientific framework for everything that we would do in the field.
And in November 2010, about two months before we really got out on the ground, we convened a scientific advisory panel that involved agency scientists, academic scientists, conservation biologists, and really anyone who felt like they wanted a hand in developing this project. And this panel was asked to identify scientific questions that they thought were important, that they thought we could address with two to five years of monitoring in California, and that they thought might guide resource-management issues in the long term. This panel also developed guidelines for selecting our focal species, but I'll talk about that a little bit more in a moment.
Just to give an example of some of the questions that came out of this meeting, most of these were really broad questions, but again, as I mentioned early on, we really don't know a lot about phenology in the western US, particularly in Mediterranean and arid regions. So some of these are very basic questions. So how do iconic and widespread species respond to environmental variation over the short term and climate change over the long term? Are there particular taxa or functional groups that are particularly sensitive that we might need to be paying attention to for management reasons? Are there communities or habitats that also differ in their responses to environmental and climate change? And again, that's an important one for resource management. And then, are there relationships between plant and animal mutualists that may be disrupted by climate change? And this is where we're looking for these phenological mismatches that may be developing.
With these questions in mind, we then set out to select some species to monitor and, as I mentioned earlier, the CPP is only focused on plant species right now, which does limit what we're doing on some levels. It's a little -- it's hard to figure out if a plant animal mismatch is occurring if you're not monitoring the animal as well, but those are questions and protocols we hope to add to the network's effort over the next few years.
And with the scientific questions in mind, we then convened a whole other set of working groups that represented agencies, academic institutions and asked them to identify species that occur in California that might be used to address the questions we came up with. We also asked them to identify species that fulfilled a suite of criteria we thought were important for this project.
And these ranged from identifying some dominant species for common habitat types, species that were widely distributed across the state so that we can replicate monitoring at many National Parks and other institutions or public lands. A pretty obvious one is choosing species of management concern. That was one of the Park Services' big interests. Because this is a citizen-science-driven project, we wanted the public to be actively involved. We also wanted to choose species that were relatively easy to identify on the fly. So most of these are very iconic, well-known taxa.
And because we are stretched pretty thin and we are relying on citizen science field monitors, we tried to select species that occur near other monitoring efforts and that way we can link the data that we're collecting as part of this project with population level information for example or information related to interacting species. We tried to find taxa for which there were legacy data available. I'll talk a little more about that in a moment. We really didn't find any accessible legacy data, so that ended up dropping out as a criterion. And then, as I mentioned earlier, a really important one was the ability to engage citizen scientists.
So with all of these selection criteria in mind, with our scientific questions in mind, we set about whittling down the flora of California, over 5,000 plant species, to what we thought would be a manageable group to monitor. And that was no easy task, and over time we moved from a group of 5,000 plus species to about 75 high-priority species for monitoring.

And I wouldn't say that these high-priority species are the species to monitor. It's possible that there's some good ones that didn't make it on the list. We also have people asking us, "Why isn't this species there?" And it's often for no good reason. It just didn't make it in the end. And with this list of 100 high-priority species in hand, we then went out to the field and tried to find monitoring locations, engage the public. We very quickly realized that many of these species are not present and abundant in locations where we could have public visitation in National Parks. And because of that, we were able to move from a list of 75 species to a list of 30 species that are now monitored across the state of California and I'll mention a few of those throughout the talk.

This will come up a few times and I've already alluded to it once, but there's often a trade off between the scientific questions we hope to answer and the citizen-science component of this project. So some of our working group members really wanted us to monitor a few rare species, but again, they're in locations that aren't accessible to citizen scientists, aren't accessible to National Park visitors, so they're not the focus of this project, although it's possible that partners could develop more focal -- more focused monitoring efforts.
If you're interested, after the talk -- I'm not going to go through the list of 30 species, but those are listed on the CPP website. Now blue doesn't show up very well, but if you Google California Phenology Project, you will be directed to the website. There's a tab that says Meet the Species and there's a list of the 30 taxa that we're actively monitoring. In addition to these 30 species, there are many more that are focal species for the National Phenology Network. So we do like to remind people that even if you're not interested in setting up a program that links in very closely with what the CPP is doing, a lot of the national target species are present in California and they're a great potential focus for monitoring efforts because you can compare patterns seen here in California to patterns observed in Washington State, for example.
As a quick example of one of the species that was identified for monitoring, Joshua tree was one that very quickly made it to the list of 30 species. It's an iconic desert species, widespread throughout southern California in the arid regions. There are a variety of scientific and management issues related to this species. It's one that its climate envelope is expected to move into a region where it probably won't be able to migrate. So there's some issues related to climate change. Because it's so iconic, it's really a great one for getting citizen scientists to monitors. The only phenophases that are monitored on Joshua trees are flowers, open flowers, and fruits, so it's pretty simple in that way. It's a very small set of metrics to record. There are many ongoing monitoring efforts to focus on Joshua trees in Joshua Tree National Park and Death Valley. And it's an indicator species for many Mojave Desert plant communities.
I’m not going to talk too much about *Mimulus guttatus*, but just as an example, this is one that we really thought would be a wonderful choice for monitoring for a variety of reasons, but the first four parks we visited, while it is present, it involves back-country hiking to find populations and we realized very quickly it really wasn’t a viable candidate for a citizen-science program.
So next I'm going to talk briefly, very briefly, about developing phenophase descriptions. So again, phenophases are the life history stages that we're monitoring. So is a plant in flower? Is a plant producing ripe fruits?
And, as I mentioned earlier, there has been a long bias towards monitoring phenology in temperate deciduous systems.
And the lilac is a perfect example of one of these Eastern deciduous species that has very discrete phenophases that are pretty easy to identify. So we've got the over-wintering bud here. The bud break is very obvious. The release of the developing leaves from the bud scales.
And we quickly learned that our California plants do not conform to this pattern. These are two of the species that we're monitoring in Southern California, Chamise and Eriogonum fasciculatum or buckwheat -- California buckwheat. Many of our Mediterranean and arid species don't put on over-wintering obvious buds and it's really hard to distinguish young leaves from last year's leaves, particularly given that in sporadic precipitation events, a lot of these species will put on just a few new leaves, which then stop growing when it dries down again. So you get all these really teeny leaves and size isn't a great indicator for age. And so we spent a lot of time developing tools to help observers identify and distinguish between young and old leaves. We like to remind people now that color is a great indicator of young leaves. They tend to be a brighter green. Their texture is a great indicator often. Whether or not they're fuzzy, have pubescents on them is a good indicator for the age of the leaf. And I'll talk a little bit about the tools that we developed to help guide observers in addressing these difficult phenophases.
We also spent a good bit of time in the first year trying to identify historical data sets. If we have historical records of plant phenology it makes our contemporary observations that much more powerful. With only two years of observation, we can then compare what the pattern is like today with older observations.
This has been done frequently on the East Coast again, where there are many naturalist journals, some regional phenological monitoring networks, historical photographs, like this one here from a cemetery in Boston showing photograph in 1868, May 30 and then 2005, same day of the year, very different phenological status for the majority of the deciduous trees around here.
Unfortunately, we weren't able to come up with very many accessible long-term records. We heard here and there people mentioning old naturalist journals, but we weren't able to get our hands on any of them, which is a little bit disappointing, but we decided to redirect our efforts a little bit. And Susan Mazer and I, my advisor at UC Santa Barbara, developed a complementary project where we've trained 15 UCSB undergrads to examine herbarium specimens, so preserved plant specimens to build phenological data sets that represent historic periods.
Just as one taxon that we're focusing on, Trillium ovatum is monitored at Redwood National Park, but also across the Pacific Northwest at other NPN sites. And it's a really easy one to identify its flowering period, based on herbarium specimens. The flower is big. There's only a single flower.
And it's well represented in herbaria, both in California and in the Pacific Northwest. This is a graph -- or this is a map of the collection location of specimens that our undergrads have examined over the last few months. So they've already looked at 314 individuals. The red dots are collection locations for which the resolution is very poor, so we don't have a good idea of what their elevation was. So we are actually not using those in analyses to date, but the collections represent a really long period.
So we have specimens all the way back from 1880 or from the 1880s. And so we're able to reconstruct this long-term phenological pattern.
We’re just beginning to analyze some of these data and for a few of the species, we’ve actually seen the opposite trend from what we might expect, where again, we’ve got the day of year of flowering, collection year, and we seem to see a delay in flowering for some of the plant taxa that we’re looking at in California.
So finally, with all of this in mind, with our protocols ready to go, with our species lists ready to go, we then had to set up monitoring sites in the National Parks.
And what we've done is tag individual plants for repeated monitoring. So if we remember that figure of the lilac monitored in Vermont over a 60-year period, we can track long-term changes in the timing of its phenophases. We've done very similar things where each balloon here represents an individual plant that's been tagged for monitoring.
These are what the tags look like. They have unique identifiers and so the data sheets are matched to the plant, based on these identifiers.
We've created maps for citizen scientists who go out at the parks to find the plants. The maps are produced at a variety of scales, so this is a monitoring location in the Presidio, downtown San Francisco.
And if you were interested in finding individual plants at site number four at this monitoring location, there are maps that are at a different spatial resolution, such that you could figure out the relationship of individual plants to each other.
We created Google maps that are all available on our website. Again, these are interactive and you can zoom in and get an idea of how the plants are arranged across the site.
We’ve also had a variety of interns working on the projects who have developed and tested different tools for finding the tagged plants. A lot of the interns worked on these first-person perspective guides, so there are photos of each location with the plants annotated and this site is monitored by middle school students now.
We also produced these species guides for each of the 30 species that we’re focused on. I am providing -- which provided a little bit of additional information about each phenophase. So information that goes above and beyond what the National Phenology Network provides and then photos of each phenophase to help identification in the field.
And these are just close ups of some of the photos showing leaf buds breaking, emerging and growing leaves, colored leaves, flower buds, and open flowers, open flowers and ripe fruit for a California Buckeye.
And then finally, with the monitoring site set up, it was time to lead training workshops to recruit citizen scientists at each of the parks.
And over the last two years, the UCSB group and our NPN collaborators have traveled to all the National Parks two or more times to lead training events for park staff and for volunteers.
We have developed partnerships with educational groups, like Nature Bridge, which now takes students out at many of the sites in the National Parks.
And we've led over 30 workshops, which have been attended by -- this number's probably a little out of date -- something like 700 participants, 80 of which now subscribe to the list, serve, and actively contribute data. And all of their data are contributed to the National Phenology Network's database. So they're accessible to anyone who wants to download them.
And, I'm going to transition and talk a little bit more about where the data go as part of this project. One of the big benefits in partnering with the National Phenology Network is that this data outcome, all of these data that have come out of this project, go straight into their database. They have IT people that are managing that database.
They're available for anyone to download and we don't have to deal with that part of the project. [Laughter] Which is really wonderful. So the National Phenology Network is a nationwide -- is an organization that's focused on nationwide level phenological monitoring. They're based in Tucson, Arizona and they're funded by the US Geological Survey. So it's a federal government-funded agency. They're not going anywhere anytime soon, which we like to remind people, so they're database will always be available. They're protocols will always be available.
And it is a consortium that works with many different agencies. They work with school groups. They work with academic institutions. They have close partnerships with the National Park Service, with the US Fish and Wildlife Service, among others.
These are their active monitoring sites as of last summer actually. And so you can see there are many locations across the US that submitting phenological observations to their database.
And all of those data are entered via an online entry tool called Nature's Notebook.
The NPN does not accept information for any taxon. They focus monitoring on a subset and so many of the species that we selected for monitoring were actually added to their list after we selected them. We had an agreement with them that they would add California taxa to the list. And at this point, there are over 300 plant species that are on their website, over 160 animal species that have protocols developed for monitoring.
As an example, I'm going to real quickly show what the monitoring protocols look like, but I'm not going to spend too much time talking about that.
This is probably a busier data sheet. Not all of them have this many phenophases that are monitored, but we do use the NPN's data sheets. We use their protocols. The basic set up is that when you approach an individual plant for monitoring, you answer a series of questions. So do you see breaking leaf buds on this individual? Yes, no, or I don't know. That would be the question mark here. And then do you see leaves? Do you see increasing leaves? Do you see flowers? Do you see open flowers? So it's relatively simple. Not always this simple in practice.
But the set up of the data sheets is straightforward and there's a list of phenophase -- very detailed phenophase definitions if you're uncertain of what a leaf is, what's an increasing leaf.
So using these protocols, as I mentioned, we've observed over 30 species that represent a variety of life forms. They're monitored at many parks. Some of those species are replicated across parks. We've tagged almost 1,000 individual plants for repeated monitoring. And in the last two years we've submitted over a quarter of a million observations to the USA National Phenology Network's database. In 2011, they haven't summarized the 2012 data yet, but the CPP data accounted for 22 percent of all observations submitted to the National Phenology Network's database, which we were really excited about.
Real briefly, I'm just going to show what the data look like. And I would say this is an area of NPN that's rapidly developing. They're constantly developing visualization tools and ways to download observations, so that observers who are participating in any of these efforts can see their data immediately, can download those data, and can analyze them. The visualization tool that they have on their website allows you to summarize phenological observations for a species at a general location. So this is what the visualization would look like for a California Buckeye that's monitored at Sequoia National Park. It's a little hard to see.
I don’t think the colors are great, so what I actually did was just overlay boxes where you can see when a yes observation was recorded for each phenophase. And along the bottom here, we have months. And we’ll see the sequence of different phenophases appearing. So in early February, we have breaking leaf buds in the foothills area of Sequoia National Park. And again, these are for California Buckeyes. Just a few days after, they started observing leaves, so full-size leaves. A few months later, in the early summer, they started seeing colored leaves. So Buckeye is one of those plants that responds very strongly to the summer dry-down period. The leaves drop off long before the fruits are ripe. We see the first observation of flowers in early April. The first observation of open flowers in May, followed a month later by fruits and then ripe fruits a few months later. The data are all available for download as well, so you can manipulate them however you like. And there’s a link up here that’ll allow you to download observations in any format or in a variety of formats.
And we have explored a few different ways to display the data that have been collected by CPP observers. Here we have observations of Coyote Brush at Golden Gate National Recreation Area, where we've lumped observations in 15-day periods. And on the y-axis we have the proportion of those observations that reported seeing a flower. So what proportion said they saw a flower on this 15-day period, what proportion saw a flower the next 15-day period? And we can see that there was a big peak in flowering in September and October and then a few smaller peaks in the winter and spring.
One thing that we thought was quite interesting is when we overlaid big rain events for Coyote Brush in this area, we saw that any rain event larger than 2 centimeters resulted in one of these little peaks in flowering. So we're just beginning to explore how to link our observations with climate data. And we hope both the CPP and the NPN to provide this climate data eventually for an easier linking of observations -- phenological observations with climate observations.
So that is my transition to talk a moment about what our future directions are. This was a project that was funded as a pilot, so again, we're ending the two-year pilot period, pursuing funding to expand the network. We feel like over this period we've really ironed out a lot of the issues with phenophases, describing California plants. We've developed a pretty good data set -- baseline data set -- for these 30 taxa, which makes it really exciting to add new monitoring sites. So even with one year of monitoring and a new location, you can compare phenological patterns in this -- the current growing season to patterns that were observed last year at a different location in the state.
Over the next two months, we're finalizing all of the protocols that we've developed in partnership with the National Park Service. Those, as all of our tools, will be posted on our website and they're all available for download by anyone. We're moving into a data analysis period where we hope to summarize all the observations collected over the pilot period. And then, we're pursuing additional funding to extend the network, to bring in new partnerships, to develop new tools, and maybe to extend monitoring to a few additional focal species that have come up a few times. And I think that's about it.
I'll put up our website again. It's usanpn.org/cpp, but if you Google California Phenology Project, you'll be directed to that website. And my email's up there, as is a general email that gets sent to all the UCSB collaborators. If you have any questions, I always recommend sending it there because you have the higher likelihood of hearing from someone quicker. I'll take any questions.

[ Applause ]

**Dr. Liz Matthews:** Chris.

**Chris:** I have two questions actually. One is I heard that there's an Iphone app for Nature's Network. I was wondering if that's true and if it you could comment on it. The second questions is sort of what about data quality?

**Dr. Liz Matthews:** Yep.

**Chris:** Is there -- is there, you know, any kind of training process or something required before citizen scientists are allowed to upload data into the database?

**Dr. Liz Matthews:** I'll start with question one because it's really easy. Yes there is an Iphone app. It's -- as with many of the tools that the NPN provides, it's constantly in development. And so it's ready to go, but it's not -- it doesn't work offline. So if you're
in a remote location and you don't have internet connectivity, you can't use it, but they expect to solve that problem over the next month. But it does work great if you're monitoring plants in the Presidio of San Francisco. The data quality issue is one that comes up a lot as well. The only filter in -- in Nature's Notebook where you enter observations is that you have to create an account and you self-report your level of training and your expertise. So the data are linked to what your level of training is and theoretically, you could filter data based upon the observer who entered those data.

That said, there are always issues in big citizen-science databases where you want to have different ways to filter data and you might, you know, want to add layers of complexity that weed out some of the quality issues. The NPN is still developing additional filters, which are not available now. And I think the long-term goal is that with enough data and with enough options of filtering, that won't be a problem. It remains to be seen. [Laughter]

**Audience Member:** Can you go into a little more detail on how you chose the high-priority of local plants?

**Dr. Liz Matthews:** Yeah. So we came up with that list of -- the list of science questions we wanted to address and then the list of criteria that we thought were important given the goals of this project. We then did -- we combined the floras for each of the National Parks and for each of the UC Natural Reserves and looked at -- identified the
top 200 species in each region that were most frequent across public lands. So we wanted to find species that would be -- we could replicate across sites. And then we sent out that list of 200 species -- common species in each region to the working group, which was anywhere from 20 to 30 individuals, and we asked them to rank those species, given all of the criteria and explain why they thought they were good candidates.

We then used these ranked lists -- we also allowed them to add species that weren't on the list if we looked over something. We then had held a series of webinars where we reviewed the top-ranked species and cut them out if there were issues for one reason or another. And kind of -- it was an iterative process, going back and forth, i.e., we'd create another ranked list, send it back out, hold another webinar, and slowly we arrived at a list of about 100 species that again, I wouldn't say is the list. There were some really great candidates that didn't make it onto that list. And then the final filter was simply finding those species in a location that was accessible and a place where they were abundant. Did that answer it? It was a very long and tedious process.

**Audience member:** Is the California Plant Society involved with the project?

**Dr. Liz Matthews:** Yeah. Yeah -- yes they are, but not in a very formal way. We've given a few presentations to chapter meetings. We've gone down to the LA Society meeting twice. We've done a field training for them at some of the UC Natural
Reserves and we've had a lot of expressed interest, but there hasn't been a real formalized interaction with the Society. We -- there are a few volunteers at the parks that are CMPS members, but there's, you know, the -- the Sacramento Group, you know, hasn't bought in and decided that they want to make this a real aim of the State Group. Though we're always looking for an in, so if you have connections. [Laughter]

**Audience member:** So as you notice this [inaudible] plant life, which is great, but as you're moving forward are you thinking about bringing in other species? If so, what target might you have? And does that -- can you -- can you borrow other protocols or do you have to start off developing one specific protocol?

**Dr. Liz Matthews:** So are you asking specifically about plants? Is that what you said? No.

**Audience member:** No moving beyond plants and doing insects, birds --

**Dr. Liz Matthews:** Right, okay. So the NPN does have protocols developed for many animal species. I would caution that all of the NPN protocols are somewhat general. And they're general because it's an organization that's focused on monitoring in a very large spatial scale. So they want the behavior that you would observe or patterns and descriptions that you might see or might work in California need to also work if you're monitoring the same species in Oregon. And so any of the protocols that you
pick up and use from the NPN I think really need a year of field testing at a specific site and maybe developing additional tools that help monitor. So they’ve got protocols ready to go for animals, they just haven’t been as well tested here. And so it might involve, you know, choosing a few that are on their lists, trying it out for a year, and then making some additional tools that could be used by observers, but they are ready to go and I think they’re pretty well developed and have been used, particularly on the East Coast, to monitor birds and maybe a few insects. Any other questions?

Great. Thank you.