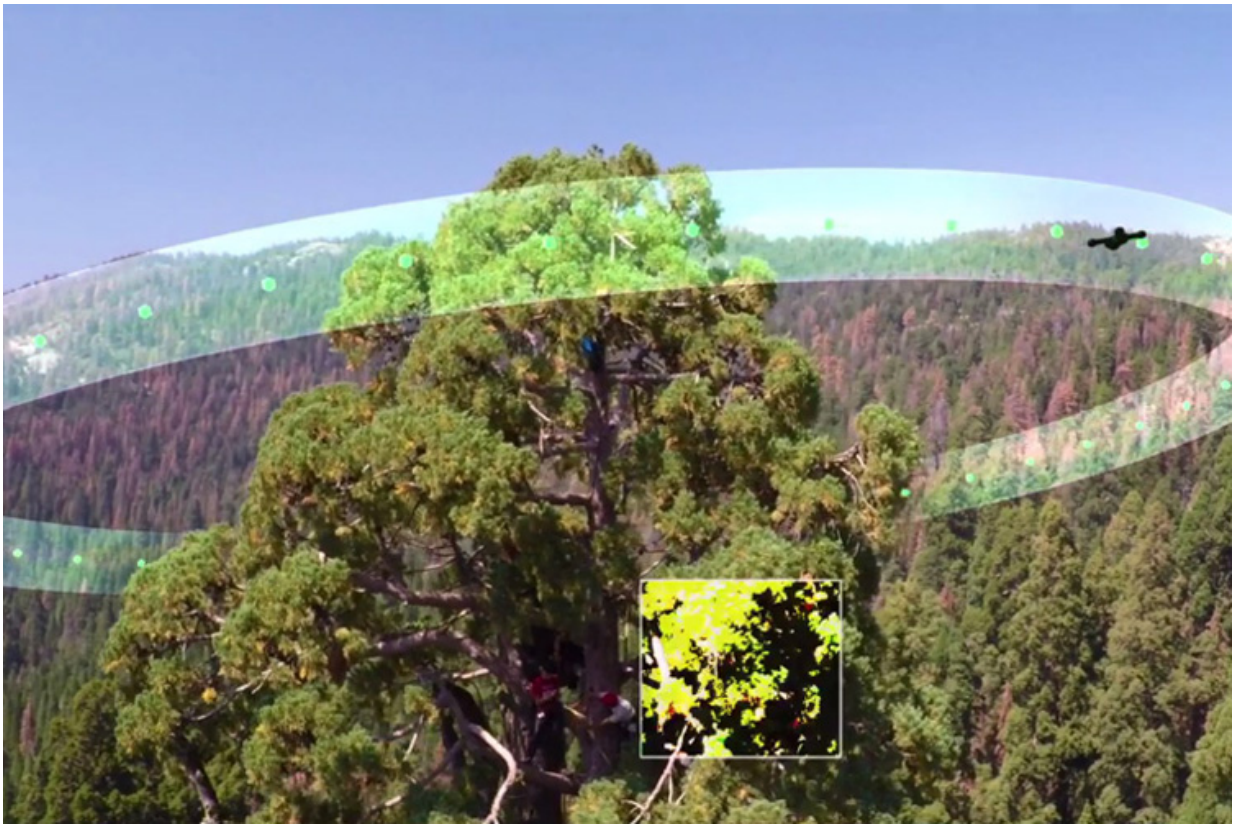
Drones help monitor health of giant sequoias

December 8 2016, by Robert Sanders



A camera-equipped drone can scan the same tree multiple times a day to produce digital maps of the leaves and branches (inset) as they change their respiration and photosynthesis throughout the day. Credit: University of California - Berkeley

Todd Dawson's field equipment always includes ropes and ascenders, which he and his team use to climb hundreds of feet into the canopies of

the world's largest trees, California's redwoods.

It's laborious work, but he'll soon be getting a little help. From drones.

Dawson, a professor of integrative biology and environmental science, policy and management at UC Berkeley has teamed up with Parrot to test the company's drone-based research tools as a way to monitor the Sierra Nevada's giant sequoias more intensively, helping him find out how they utilize water and sunlight and predict how they will deal with a warmer Earth and changes in water supply.

The need is urgent, Dawson said. Since 2010, more than 102 million trees, mostly pines and firs, have died in California because of drought, 62 million in 2016 alone. Why are pines and firs succumbing, but the thousand-year-old sequoias surviving, and will that continue into the future?

In August, he and Gregory Crutsinger, a plant ecologist and head of scientific programs at Parrot, performed the first test of a drone, a quadcopter, equipped with a state-of-the-art multispectral camera that takes photos in red, green and two infrared bands. Called the Sequoia, the camera works like more expensive satellite and airborne sensors, measuring the sunlight reflected by vegetation in order to assess physiological activity or plant health.

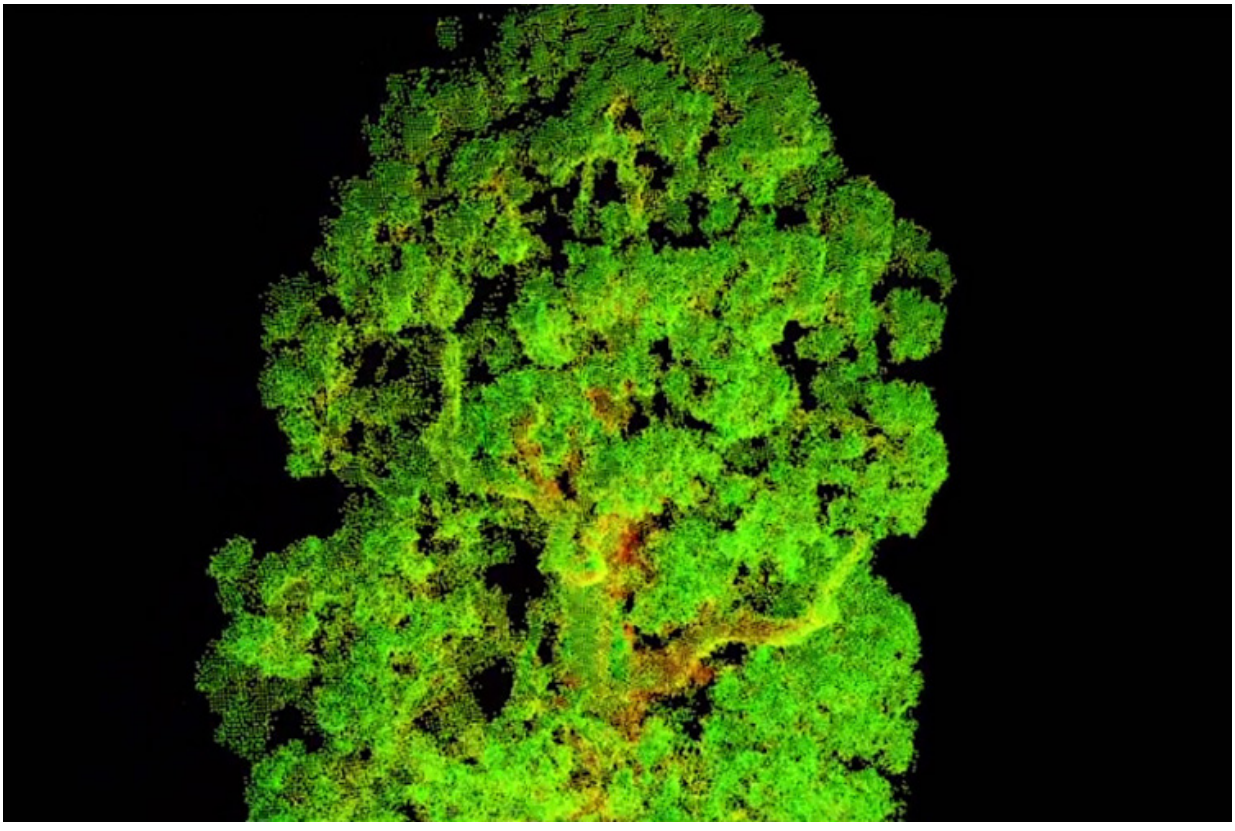
"Before, a team of five to seven people would climb and spend a week or more in one tree mapping it all around," Dawson said. "With a drone, we could do that with a two-minute flight. We can map the leaf area by circling the tree, then do some camera work inside the canopy, and we have the whole tree in a day."

After the data and photos were stitched together by a software program called Pix4D, Dawson and Crutsinger ended up with a three-dimensional

representation of the foliage that his team had never seen before – information that will be used to determine how much carbon the tree takes up each day and how much water it uses, the basis for assessing what might happen with higher carbon dioxide levels in the atmosphere and less water on and in the ground.

"With repeat flights you can watch a forest grow without ever actually measuring any trees in the forest," Dawson said. "I think drone technology holds a lot of promise to do some very innovative science over time and in three-dimensional space with a relatively cheap tool. It is really pretty amazing."

Monitoring the health of the state's iconic sequoias is just one instance of how drones, combined with state-of-the-art sensors, can benefit science, Crutsinger said.



A digital scan of the crown of a giant sequoia. Credit: University of California - Berkeley

"Drone technology is getting much cheaper, but stitching and photogrammetry are innovating at the same time," he said, referring to the science of making measurements from photos. "That is the backbone of the whole new commercial drone industry: not just the ability to capture the data, but also to process very high-resolution photos into millions of points that generate a three-dimensional model. This is going to help science but also environmental monitoring, agriculture and even construction sites."

Crutsinger, a former Miller postdoctoral fellow at UC Berkeley, is asking other scientists to propose research collaborations with Parrot in exchange for free drones, cameras and analysis software. These Climate Innovation Grants are open to any student or researcher around the world.

Monitoring a changing environment

Dawson is now assessing how best to use the initial data and the drone and camera to answer questions in plant ecology. For the giant sequoias (Sequoiadendron giganteum), which he studies in the University of California's 320-acre Whitaker Forest just outside Sequoia-Kings Canyon National Park, he anticipates learning a lot more about their physiology than can be achieved by roping onto the canopy. Knowing the leaf area alone is a key advance, since he and his team have been able to model only the trees' branches and twigs, from which they estimate leaf surface.

Todd Dawson gets a first person view of what the drone is seeing in the crown of a giant sequoia. Credit: University of California - Berkeley

"If we know how much area is there, I can tell you how many tons of carbon per meter squared per day was fixed by that forest, and how much water was used by that leaf area per day. You can start to get at rates of carbon exchanged between the tree and the atmosphere and then at rates of carbon sequestration," he said. "These are important numbers for our forecasting models, so we can say, 'If the climate goes up by 2 degrees, or it gets drier by 10 percent, what the hell is going to happen to that productivity?' All of a sudden you have power to really measure the pulse of the Earth, which is a really hard thing to do at large scales."

Dawson is keen to see how drones and specialized sensors can aid his other research, which involves not only giant sequoias but also coastal redwoods, California's oaks and the canopy epiphytes in the clouds forest of Costa Rica. But he also sees a wealth of other possibilities.

"I think this is one of the tools for 'change detection' that we are going to find is a game changer," he said. "We can do this quickly and accurately over natural lands and agricultural lands and forest that burned and places that were hit by hurricanes or droughts, and look at the changes taking place and why they are taking place much more easily than we did before."

Dawson doesn't plan to give up climbing trees, though. Some data will still need to be captured in the tree tops, if only to connect drone observations with tree physiology and ecology.

"The low-hanging fruit right now is really, what basic-level things that take up a lot of time can we replace with the drone, and what do we still need to do with boots on the ground in the field," Crutsinger said. "If we can just save time and person power, that is most of the cost of doing scientific research, particularly in ecology. We are looking to augment what already happens on the ground—or in this case the crown—and then think about what new questions we can ask as well."

UC Berkeley graduate student Cameron Williams and researcher Rikke Naesborg scaling a giant sequoia in the Whitaker forest outside Sequoia-Kings Canyon National Park. Credit: University of California - Berkeley

Provided by University of California - Berkeley