Two California Department of Fish and Wildlife environmental scientists, Kelly Souza (foreground) and Elijah Portugal, collect ambient water chemistry measurements from McKee Creek in Humboldt County during June 2018. The measurements are part of a study on the health of northern California rivers and streams that are being diverted to supply water to cannabis grows.

Story and Photographs by Erin Ferguson

Cultivating Cooperation

Pilot study around headwaters of Mattole River considers the effect of legal cannabis cultivators on northern California watersheds

As the sun rose over Sacramento, four California Department of Fish and Wildlife environmental scientists were busy loading their vehicles. They stacked flow meters, bug-collecting nets and totes full of various equipment needed for a weeklong trip to Humboldt County. They brought several types of equipment to measure stream flow, not knowing what the conditions would be like. The order for packing the equipment was almost routine for the crew, as it was their fourth and final trip to collect samples for a pilot study.

The study, "A Paired Watershed Comparison of Hydrological and Biological Condition in Streams With and Without Cannabis Cultivation, Humboldt County, USA," will be published later this year and will examine the balance between the natural water resources of northern California's rivers and streams with the growing impacts of diversions attributed to the state's legalized commercial cannabis trade.

The scientists are part of CDFW's Cannabis Program and come from the department's Fisheries and Water branches. They work in collaboration with CDFW's Northern Region staff from Eureka and others to prioritize study locations, organize fieldwork, bring in necessary equipment and secure landowner access.

The study was focusing on three waterways—Eubank, McKee and Van Arken creeks—and some additional tributaries that form the headwaters of the Mattole River. Those waters typically go dry during the summer and one of the challenges the team faced was determining when that might occur.

It was August, and the growing season in Humboldt County was in full swing. They would begin with Eubank Creek, a Mattole River tributary that had ongoing cannabis cultivation in the watershed. The prioritization was based on local knowledge of cultivation sites and verified by aerial photographs.

Once in Humboldt, they navigated the winding dirt road toward the creek, the smell of maturing and drying cannabis hanging thick in the air. Some roads along the way were lined with high fences that blocked the view from the road to anything beyond. Posted onto the fences are state and local

cultivation permits. The tops of water storage tanks and hoop houses flashed in and out of sight as drivers navigated through the hills. Most of the residents in the area are wary of outsiders, evident by the number of gates that had to be opened and then closed on the way to their destination. The scientists had received permission to access the property along Eubank Creek from the landowner, something that was not always given by landowners at other locations.

One member of the team, Fisheries Branch senior environmental scientist Elijah Portugal, grew up in Humboldt County. He recognized early on how difficult it would be to conduct the pilot study without the cooperation of the landowners. He worked with CDFW regional staff and a group called Sanctuary Forest Inc., a land trust organization with a mission to "conserve the Mattole River watershed." They spent long hours—and often long weeks—building the trust of landowners to gain access to properties.

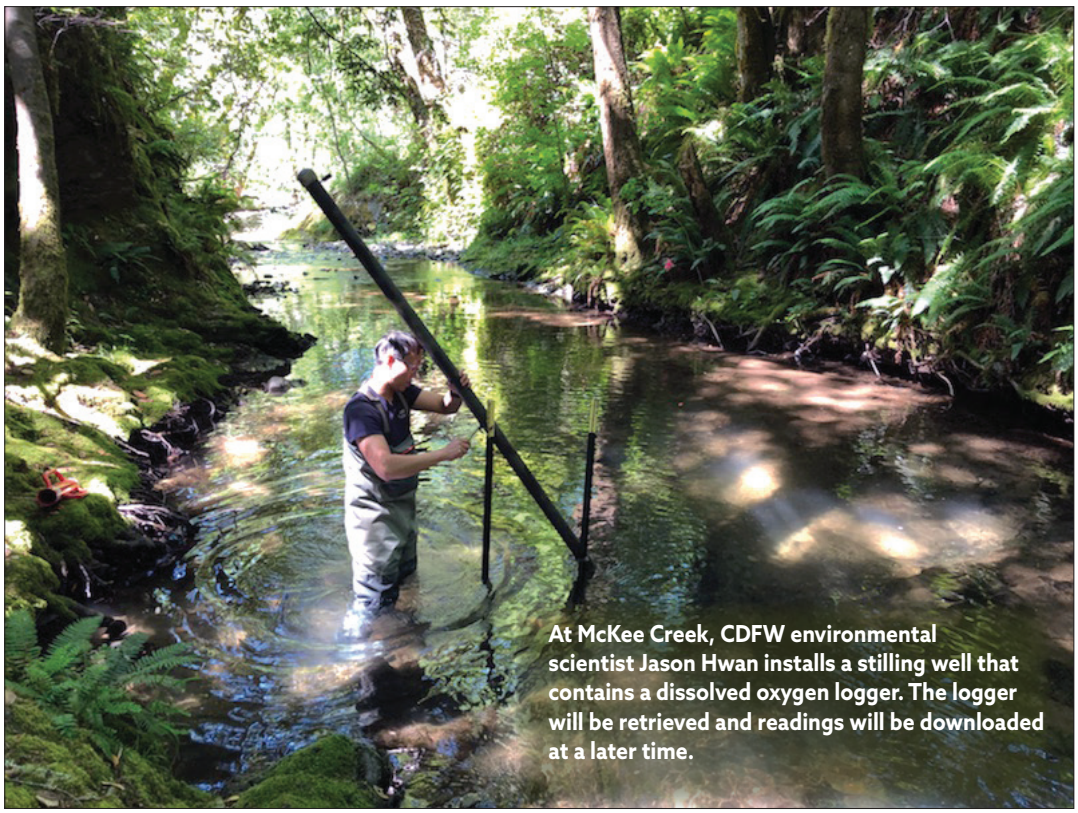
"I think within the cultivator community there is a general distrust of government agencies, and the cannabis regulatory process, specifically," Portugal said. "In some tight-knit rural areas, there is a risk of retribution from neighbors who wish to continue growing clandestinely. There is also a concern that allowing us access to collect scientific data exposes them and their neighbors to more risk from county code enforcement or other state agencies about aspects of their property that have nothing to do with cultivation."

Portugal and others convinced enough landowners to allow the study once they understood how the process actually works. Working with regulatory agencies to come into compliance does not make a landowner a target for enforcement actions. In fact, if a cultivator is working through the permitting process with CDFW, they are more likely to avoid enforcement actions by avoiding the common pitfalls of cannabis cultivation practices.

What the team found through their research was some cultivators were already using best management practices on their farms prior to legalization. Those cultivators were willing to bring their farms into regulatory compliance. For example, the landowner who had granted the team access in Eubank Creek expressed his willingness to work with CDFW.

"I grew up on this land, and my family has been cultivating here for decades," said the landowner, who agreed to speak on promise of anonymity. "We have always tried to be good land stewards so that we could continue to cultivate and not degrade our property and the adjacent stream. For this reason, I am willing to allow agencies such as CDFW access through my property so that science can inform regulatory and management decisions. I think that cooperation—and, in a way, collaboration—is the only way that scientists and cultivators can both get what they want, sustainable cultivation."

The landowner acknowledged some of his neighbors disagreed with his willingness to work with regulatory agencies. He said some were willing to risk enforcement because of the challenges they'd face to come into regulatory compliance. This was not the case for him, he said. "The risk of enforcement is more costly than taking the time to make my property better,"



At McKee Creek, CDFW environmental scientist Jason Hwan installs a stilling well that contains a dissolved oxygen logger. The logger will be retrieved and readings will be downloaded at a later time.

he said. "In the end, this is my business and I have to invest in my business if I want to thrive."

When the crew arrived at the study site, they unloaded equipment and suited up. They wanted to take water samples and stream flow measurements early on and then collect aquatic insects and download data from the monitoring equipment that had been deployed earlier in the summer.

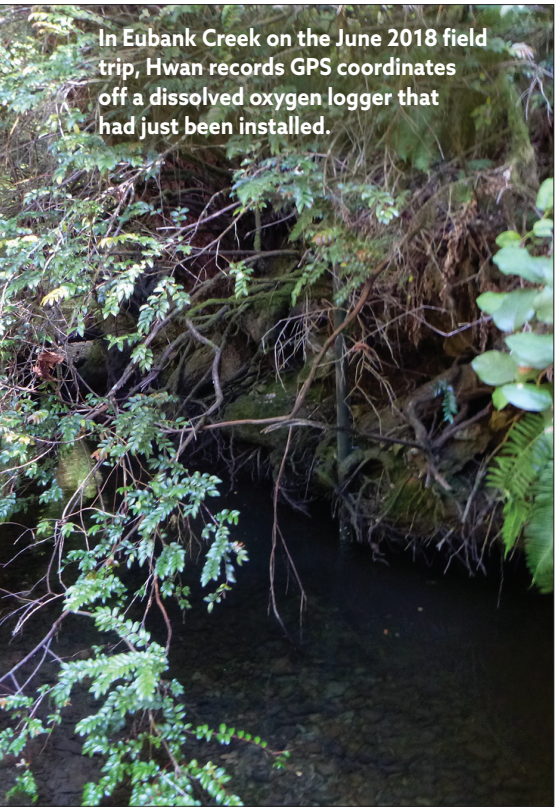
The collection of water samples needed to be done first. Loaded up with equipment, they formed a single-file line along the ridge of a grass field and descended together toward the stream. They wondered if their equipment would still be where they'd deployed it or if it had been stolen. They also hoped water was still flowing in the stream, so they could collect samples. They reminded each other about the order in which sampling would occur. Reviewing the process ensured no one action would violate the strict protocols of another. First, they would take water samples for nutrients, then ambient water chemistry. Later they would separate into two groups—one for aquatic insect collection and the other for flow measurements.

Since the pilot study began in May, the crew had been sampling the same three streams to collect aquatic insects and stream flow data. The August sampling represented the final event and would provide the researchers a full suite of data to assess biological changes over the low-flow period. They added collection of a water sample to the August trip. The sample enables researchers to assess the nutrient concentrations in a stream. However, streams must still be flowing to collect the samples. As a precaution, the trip had been moved up by a couple weeks to ensure the crew could collect that final suite of aquatic insects and flow measurements.

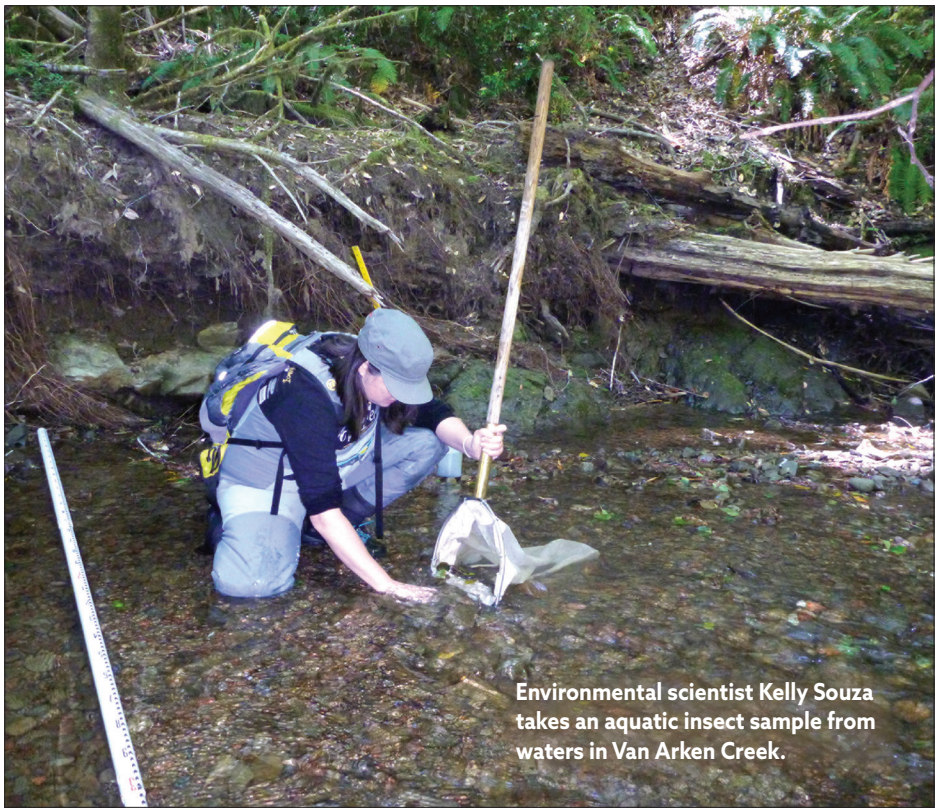
Cannabis and Instream Flow Unit supervisor Kelly Souza led the crew down to the stream. Normally, there was a large pool where the trail met the channel. But when the crew reached the pool, they found it significantly smaller, and disconnected from the adjacent riffles. Inside the pool, they found young-of-the-year steelhead swimming around. Based on the rate at which the pool habitat had shrunk, it was likely the fish would face inhospitable conditions to survive through the summer.

Souza and Jason Hwan, a senior environmental scientist with CDFW's Water Branch, hiked upstream hoping to find that the disconnected pool was an isolated occurrence. Instead, what they found was a mostly dry stream; what had been flowing four weeks earlier had been reduced to a series of small pools separated by large stretches of dry riverbed. They peered into pool after disconnected pool. Inside they found foothill yellow-legged frogs, newts, salamanders and more juvenile steelhead. The steelhead in that region normally rear for one or more years in freshwater before migrating to the ocean. They would utilize the deep portion of pools as a thermal refuge from increasing summer water temperatures and feed on aquatic insects that drift downstream from shallow riffles. But with stream flows dropping, there were no more riffles connecting the pools. Instead, dry caddisfly cases were the only evidence of the once productive riffle habitat.

Souza knelt to examine the desiccated caddisfly cases on



In Eubank Creek on the June 2018 field trip, Hwan records GPS coordinates off a dissolved oxygen logger that had just been installed.



Environmental scientist Kelly Souza takes an aquatic insect sample from waters in Van Arken Creek.

the dry exposed rocks. "It's like a freezer full of food, just going to waste," she said. "Think of all the birds, bats and other terrestrial animals that would have feasted on the emergent life stages of these insects, not to mention all the fish food this would be." A strict protocol developed by the State Water Resources Control Board (SWRCB) for aquatic insect collection stipulates that if more than three of the 21 collection transects are dry, then the sample reach is not a viable collection site. A sense of defeat loomed over the scientists as they realized they would be unable to collect aquatic insects as they had hoped.

The group somberly continued upstream to check their equipment. Three water-depth sensors had been deployed in pools throughout the sampling reach in May and four dissolved oxygen loggers installed in June. Most of the equipment remained underwater except for a single logger that hung above a mostly dry pool. Although upper Mattole headwater streams are naturally intermittent, they face an additional impairment that would continue to alter flow patterns—water diversions for cannabis.

An estimated 60 percent to 70 percent of the cannabis consumed in the U.S.—legal and illegal—is grown in California. Most of the cultivation occurs in the north coastal region known as the Emerald Triangle. This region, composed of Humboldt, Mendocino and Trinity counties, has not only endured decades of land conversion from residential development, logging and cannabis cultivation, but is home to many species that are protected under the state and federal endangered species acts. "The rivers and streams in this region have been impaired by a changing landscape for decades," said Galen Doherty, the lands program director at Sanctuary Forest. "You combine that with climate change and persistent droughts, and there is less water in the streams overall and for shorter amounts of time throughout the year."

Doherty said the way people use the water, whether for domestic or agricultural, can exacerbate the problem. Local organizations such as Sanctuary Forest have collaborated with state agencies like CDFW to accomplish common goals, such as conducting hydrological and biological monitoring in the critical systems.

Rivers and streams are complex, dynamic systems that encompass more than water flowing through a channel. Streams are home to fish, amphibians, invertebrates and aquatic plants—some of which depend on cool, clean flowing water to complete their life cycle and reproduce. Cannabis cultivators also rely on these streams to water their thirsty crops. A traditional growing season for cannabis is 150 days throughout the dry summer months. In the Emerald Triangle's Mediterranean climate, the summer represents a period of little to no precipitation and naturally low stream flows. In a previous CDFW-led study, senior environmental scientist Scott Bauer from the Eureka field office assessed the water demands of cannabis cultivators relative to available streamflow in watersheds that provide critical habitat for threatened and endangered fish and wildlife. Based on a 2010 paper produced by the non-profit medical marijuana advocate Humboldt Growers Association, Bauer and others estimated that, on average, a single cannabis plant could consume six gallons of water per day. During drought years, the water need could accelerate the speed with which streams dry up. With recent innovations in cultivation methods, such as mixed light techniques, farms can produce multiple crop cycles within the growing season, potentially increasing demand for water. An increase in water diversions for cannabis cultivation in watersheds that are already stressed from existing water demands will be detrimental to species like Coho Salmon that are already imperiled.

Researchers found that some cannabis cultivators—like the owners of the southern Humboldt County farm at left—were using best management practices and were willing to bring their operations into regulatory compliance. Above, low stream flows in McKee Creek threatens juvenile steelhead as the creek's deeper holes dry up in summer. Right, in July 2018, scientists at McKee Creek recorded a foothill yellow-legged frog, considered threatened under the California Endangered Species Act.

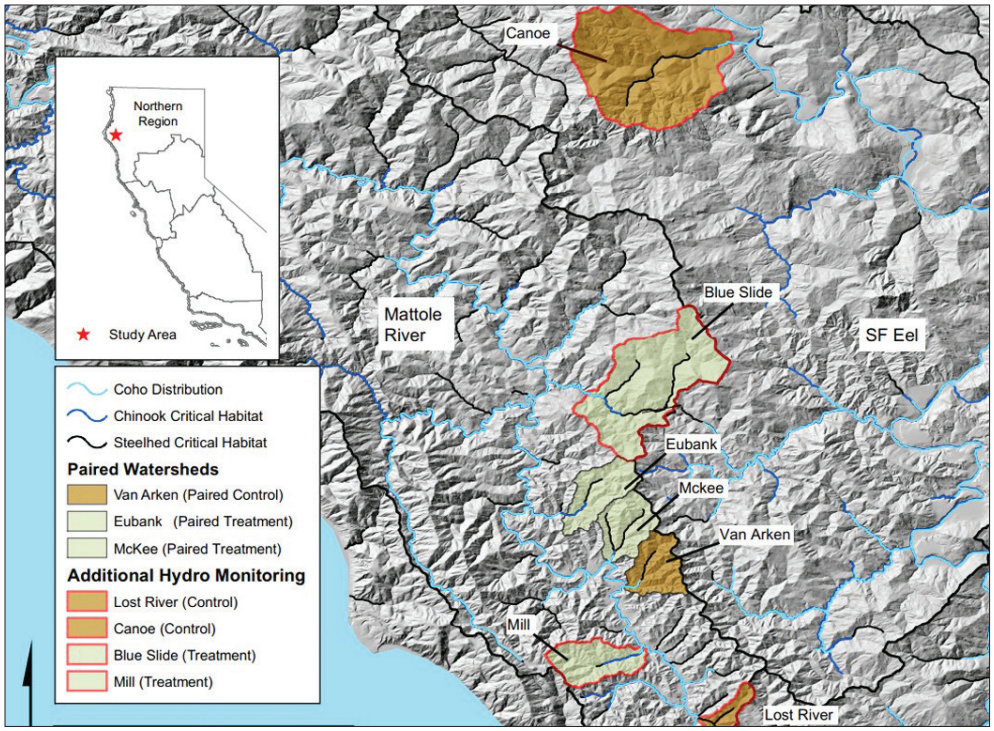
California voters approved Proposition 64 in 2016, legalizing the recreational use of cannabis as well as its commercial sale. Subsequent legislation directed the SWRCB and CDFW to evaluate water use and environmental impacts from cannabis cultivation. Any significant environmental impact will be reported to the California Department of Food and Agriculture (CDFA).

CDFW's Cannabis Program director Joshua Grover reminds himself often of CDFW's mission to manage the state's diverse resources and the habitats upon which they depend. "The department is working with state and local agencies to permit and license cannabis cultivation in California in a sustainable manner," he said. "Just like any other agricultural industry, cannabis cultivation has the potential to cause environmental impacts. Our responsibility as a natural resource agency is to avoid or minimize those impacts."

Environmental impacts associated with cannabis cultivation include a laundry list of items that include land clearing and grading, improperly designed roads, undersized culverts, erosion, diversion of surface water, improper water storage devices, nutrient loading, pesticide and rodenticide use, noise pollution, light pollution and poaching of wildlife. Although these impacts are most closely associated with illegal cultivation sites, they occur on farms where cultivators are moving into compliance. With the scale of commercial cultivation expanding rapidly, and pending legislation directing new mandates, Grover is building CDFW's Cannabis Program to manage such impacts.

The Cannabis Program began as part of the Enforcement Division. Early efforts focused on eradication of illegal grows on public lands and bringing cultivators on private lands into compliance. After Proposition 64's passage, anyone applying for an annual cannabis cultivation license from CDFA must obtain a Lake and Streambed Alteration (LSA) agreement or written verification from CDFW that their project does not need one. The agreements put a check on water diversions and requires cultivators to manage their sites in a way that lessens adverse environmental impacts and provides protection for California's fish and wildlife resources. In addition to the new regulatory tools, statewide outreach campaigns continue to inform and educate cultivators about guidelines and requirements. The program moved under the Habitat Conservation umbrella with a revamped webpage, *wildlife.ca.gov/Conservation/Cannabis*, but still maintains its enforcement orders.

As of September 2018, CDFA had issued approximately 4,800 temporary cultivation licenses statewide. CDFA officials expect the number to increase as more cultivators come into compliance with state regulations. However, even if every cultivator's property was enrolled through the proper licensing and permitting process, a watershed can only support so much cultivation. Determining the status and condition of watersheds statewide and how they may be impacted by cannabis



The pilot study looks at important habitat parameters such as quantity and quality of water and overall stream condition. It focuses on three northern California creeks that form the headwaters of the Mattole River—McKee, Eubank and Van Arken creeks. The region has a long history of cannabis cultivation, even before the state legalized it. Scientists involved in the study hope it allows the development of informed management decisions about the levels of cannabis cultivation in the upper Mattole Region. Complicating any discussion over water privileges is the salmonid habitat as the watershed supports Coho, Steelhead and Chinook Salmon, three populations protected under state and federal environmental laws.

cultivation has suddenly jumped up the priority list for everyone. Expectations that the industry will continue to expand only increases that sense of urgency. The pilot study in the headwaters of the Mattole River is the first step by the Cannabis Program to determine the impact legal cultivators may have on northern California's rivers and streams.

In this area of northern California, the cultivation of cannabis is as historic as it is widespread. Evidence of illegal grow sites extends back decades as aerial photographs capture the forest cutouts. Complicating the matter, the Mattole River and its tributaries are considered a stronghold for steelhead and the watershed supports Coho Salmon and Chinook Salmon populations, both protected by the California Endangered Species Act (ESA) and the federal ESA. The pilot study looks at important habitat parameters such as quantity and quality of water as well as overall stream condition. These parameters are measured in two streams with known cannabis cultivation and one without any cultivation. The studied streams were carefully chosen based on location, size, slope, annual precipitation, orientation and geology. This paired watershed approach allows researchers to compare results between the study streams and attribute measured differences in stream condition to cannabis cultivation as opposed to natural variability.

The tributaries flowing to the Mattole River, like many other streams in this area, are ungauged. This means that it is difficult to accurately estimate the stream flow for these systems without taking time-intensive direct measurements. In May 2018, water depth sensors were installed in the three study streams, Eubank, McKee and Van Arken creeks. Four additional water depth sensors in other Mattole headwater streams and South Fork Eel River tributaries were deployed to develop a better understanding of flow patterns and water usage throughout the summer low-flow period. Monthly visits to all the streams to record flow measurements were completed so that hydrology patterns could be visually and statistically analyzed. Dissolved oxygen loggers, which also collect water temperature data, were deployed along with the water depth sensors in the three study streams. The data collected from the loggers and aquatic insect samples comprise the water quality portion of the study.

"Oxygen levels are strongly influenced by stream flow, with oxygen levels dropping when stream flows drop," Hwan said. "There is a more pronounced effect in streams where riffle habitats dry completely in the summer because these riffle habitats are a source of oxygen for deep pool habitats. Even if there is plenty of water in some of these deep pools, there is a possibility that salmon and steelhead might not be able to survive if stream flow and oxygen levels drop below a critical level."

In addition to gathering stream flow and water quality data, aquatic insects were collected in each of the three study streams three times over the summer low flow period. Aquatic insects spend some portion, or all, of their life cycle in water. They are often used as an indicator of biological health or water quality because they are relatively stationary and respond predictably to environmental stressors such as changes in stream flow, water temperature, dissolved oxygen levels, nutrient loading, and erosion. An aquatic insect sample could not be taken in Eubank Creek in August because most of the stream, including the sampling reach, was dry. However, researchers agreed the inability to collect an aquatic insect sample didn't mean the

data set for Eubank Creek was incomplete. The rate at which Eubank Creek dried in relation to the other study streams could indicate that water diversions for cannabis cultivation exacerbated already dry conditions and eliminated aquatic habitat sooner than what would happen naturally. The inability to collect an aquatic insect sample in August and the water depth sensor data from Eubank Creek will be important pieces of the hydrology analysis.

"Results from the pilot study will give us a better understanding of the conditions that aquatic organisms like insects, amphibians, and salmonids are experiencing," Hwan said. "If water diversions for crop irrigation cause stream flow to decrease earlier than what is typically expected, stressful conditions can be prolonged for these aquatic organisms."

Back in their Sacramento office, Portugal and Hwan analyzed data collected from the headwaters of the Mattole River. Portugal, the Humboldt County native, plotted data from the water depth sensors for the three study streams. Points on the squiggly lines that showed on his computer screen marked water depth, and the decline in the slope of the lines reflected the decrease in stream flows during the summer months. He showed Hwan the results and noted how one stream decreased at a slower rate than the other two. Portugal said, "So far it seems that the two cannabis study streams are drying faster than our control stream, though the differences may be pretty minimal."

Members of the crew say they believe more work needs to be done. A manual mapping component is already underway. Analysis of aerial photographs of the study region will improve the overall estimation of cultivation sites, which would help when estimating plant counts and water usage.

Just before the pilot study publishes, researchers should have a season's worth of data on the three study streams—stream flow, water temperature, dissolved oxygen levels, water usage and aquatic insect community structure and composition. The components can be compared between the streams with cannabis to the one without. Moreover, the scientists will understand the variability in base flows from the additional four study streams.

Until results from the study can be produced, the four scientists involved remain hopeful what they've done will advance the necessary science to make informed management decisions about the levels of cannabis cultivation in the upper Mattole region. Any number of outcomes may emerge, from the possibility of establishing a regionally specific flow threshold, changing procedures for gauge installations, doubling outreach efforts to reach the cultivators before they violate the law or whatever else may be learned that can bring cooperative agreements.

Erin Ferguson is a senior environmental scientist (specialist) with CDFW's Fisheries Branch and is part of the Cannabis Program. This is the first time she has published in Outdoor California.

By late summer, scientists found long stretches of Eubank Creek with disconnected pools. The rate at which waterway dried in relation to the other study streams could indicate that water diversions for cannabis cultivation exacerbated already dry conditions and eliminated aquatic habitat sooner than what would happen naturally.