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Indoor cannabis cultivation can benefit from energy-efficient light-emitting diodes.

ENVIRONMENT

A greener grass

Can the environmental impact of cannabis cultivation be reduced?

BY JYOTI MADHUSOODANAN

About four years ago, a flurry of headlines declared that cannabis cultivation was "sucking California dry". The stories appeared in several major news outlets, many of which made the assertion that a single cannabis plant guzzles about 22 litres of water each day.

"Reading those stories made me wonder just how big an issue this was," says Van Butsic, an environmental scientist at the University of California, Berkeley. He found that the cannabis plant had also been described as being unusually thirsty by many scientists — dozens of peer-reviewed publications had cited the same 22-litre-per-plant figure. "We used that number in our earlier papers, too, because it's the only one we could find," Butsic says. "But we always wondered, where did it come from?"

As it turns out, the figure that researchers relied on was derived from an estimate in a cannabis growers' manual from 1996. And in an April preprint[1], Butsic and Ted Grantham, also an environmental scientist at Berkeley, and their colleagues presented data that suggest that the problem wasn't how much water the plants were using but, rather, the source of that water.

Despite its being one of the world's oldest crops, the production of cannabis remains somewhat mysterious. Thanks in part to decades of prohibition, little has been published about the water or energy requirements of growing cannabis. Cultivation in the laboratory is expensive because of the need for secure facilities, so researchers often turn to information from growers, as well as the law-enforcement officials who target illegal cannabis enterprises.

Those data paint a bleak picture. A 2012 study of energy use estimated that producing one kilogram of cannabis in an indoor farm is associated with 4,600 kilograms of carbon dioxide emissions — roughly equivalent to the emissions from 3 million cars[2]. Other researchers showed that the plants' water consumption has the potential to drain watersheds. And the unregulated use of agricultural chemicals is likely to be endangering wildlife in California.

Although cannabis is prohibited federally in the United States, ten US states and Washington DC have legalized the sale of recreational cannabis, or marijuana. But this change has yet to improve the data that are available to scientists. "When we first started, we spent two years documenting how many farmers were out there and where they were located," Butsic says. "For any other crop, you could find the information in five minutes, online."

As researchers gather data from government permits, satellite imagery and growers' associations, they are starting to overturn old assumptions about the environmental footprint of cannabis. But they've also found gaps in their knowledge of one of the fastest-growing industries in the United States that, if filled, should point the way to more resource-efficient growing practices.

CLANDESTINE CROP

Cannabis is native to the warm, humid climates of central and southern Asia. Despite its being banned as a recreational drug in most countries, cultivation of the crop spread worldwide as people found ways to extend the growing range of cannabis. Some growers in the Pacific Northwest of the United States resorted to razing forests on public land to hide their crops in the era before legalization, a practice that persists.

Wildlife-disease ecologist Mourad Gabriel, a co-director of the Integral Ecology Research Center in Blue Lake, California, joins law-enforcement officials on raids to study these cultivation sites. Gabriel and his colleagues monitor and sample the water, soil and plants in such areas after they have been cleared of growers and their guns.

Gabriel began his work in 2009, when a dead Pacific fisher (*Pekania pennanti*) caught his eye. He had been studying this small, weasel-like carnivore's decline in the forests of California, which researchers thought was partly the result of habitat loss. But this particular animal had died of massive internal bleeding caused by eating a banned rodenticide. Tracing the chemical's source led researchers to trespassing cannabis growers in the forests, who were using the rodenticide and other chemicals to kill pests and weeds[3]. As well as the now-endangered fisher, this cocktail of herbicides and pesticides has harmed northern spotted owls (*Strix occidentalis caurina*), among other species. Legalization of cannabis is unlikely to make a difference to this situation, Gabriel says, because such growers are often backed by drug cartels or other criminal networks.

The chemicals can also have synergistic effects that last long after cannabis cultivation ends. Gabriel compares the problem to the heavy-metal contamination of mining regions that remained after the California Gold Rush of the mid-nineteenth century. "Even if policies change, there is a long-term threat to the soil and water," he says. "We may be dealing with this for decades down the line."

Others report that cannabis might have a similarly intense impact on watersheds. In 2015,

researchers from the California Department of Fish and Wildlife in Eureka found that, in four watersheds in Humboldt County, in the north of the state, cannabis cultivation could potentially drain streams — especially because the crop's period of greatest water need coincides with California's dry season[4]. Irrigating cannabis using water from these watersheds could endanger steelhead trout (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*) and certain amphibians, the researchers also reported.

Butsic and his colleagues found that in 2012–16, cannabis cultivation sites in northern California increased in number and size[5]. Many were set up on steep slopes, which could raise the risk of soil erosion, sedimentation and landslides. Previously, Butsic had estimated that the sites contained around 300,000 plants, which would consume almost 7 million litres of water each year[6].

But these California studies didn't take into account differences in cultivation practices, whether farms relied on watersheds or how plants' needs changed as they grew. When Butsic and Graham examined data reported by legal growers enrolled in a California state programme, as part of their preprint study, they found that most farms relied on wells and stored water for irrigation[1].

The researchers also learnt that although the cannabis grew from June to October, the plants actually required 22 litres of water each day only for about three months of the year[1]. "That amount probably overestimates use earlier and later in the growing season," Grantham says. Overall, he contends, cannabis cultivation uses a similar amount of water to that of grapes, tomatoes and other vegetables. But because illegal cultivation of the crop often takes place in clandestine spots on remote mountain slopes — not fertile valley floors — it can still have a problematic impact on the smaller watersheds of such locations. It has less to do with the idea that cannabis is a particularly thirsty plant, and more to do with where it's grown, Grantham says. "These are not traditional farming areas, so even though the total demand is small, the demand relative to availability is an issue."

JORGE DUENES/REUTERS

An illegal outdoor cannabis plantation in Ensenada, Mexico.

Moving cannabis cultivation indoors introduces a different threat to the crop's sustainability: energy use. Keeping the plants alive in a windowless room requires intense light, so growers fit out facilities with the same high-pressure sodium lamps as those used in street lights. To counteract the heat that is generated by this inefficient illumination, plants are over-watered and growing rooms are furnished with heating, ventilation, and air-conditioning systems and dehumidifiers. "All these systems are fighting each other," says Derek Smith, director of the Resource Innovation Institute in Portland, Oregon, a non-profit organization that helps cannabis growers to improve energy efficiency. "It's not only an environmentally unsustainable model, it is economically unsustainable."

Smith says that when he co-founded the institute, one aim was to create a certification system to rate facilities on the basis of their environmental footprint — but there were no baseline data available. Last year, cannabis analytics firm New Frontier Data, based in Washington DC, surveyed 81 growers — representing about 1% of the legal industry — and found that the companies consumed about 1.1 million megawatt hours of electricity per year, an amount that is sufficient to power 92,500 homes[7]. When combined with an approximation of the energy use of illicit farms, the firm estimated that cannabis cultivation consumed 4.1 million megawatt hours of electricity in 2017, which is roughly the same amount of energy as is generated each year by the Hoover Dam in Nevada.

GREENING GRASS

There is little industry-wide consensus on cultivation best practice. Some outdoor growers might divert streams to water crops, whereas others pursue dry farming, which uses no irrigation. Indoors, growers sometimes choose cooler, light-emitting diode (LED) lights to substantially decrease water use. Meanwhile, others simply expand small, energy-intense facilities into larger operations. "There is a wide range of energy efficiency," Smith says. "Outdoor crops planted from seeds might have a zero footprint, while old-style indoor cultivation can be 500 times more energy intensive."

Legalization should, in theory, help the authorities to monitor energy use. But licensing can prove to be expensive for growers, who might need to hire consultants or to change production practices. Although there are no specific data available, Butsic and Grantham and estimate that only 10–20% of cannabis growers in California have permits.

A licensed, energy-efficient cannabis farm is a world away from the illegal cultivation sites that feature in Gabriel's research. Yerba Buena in Hillsboro, Oregon, for example, is the first cannabis-cultivation enterprise to rank in the top ten greenest workplaces in the state, according to magazine *Oregon Business*. "From inception, we were focused on dispelling the trend of indoor cannabis cultivation being so environmentally impactful," says Laura Day, director of operations at Yerba Buena.

The company is tucked away between other farms in Washington County, Oregon. Surrounded by vineyards, hazelnut trees and painted signs for pick-your-own strawberries, the first hints at Yerba Buena's unconventional product are its unmarked grey building, three-metre-high fence and pungent smell. The cannabis crop is housed in an industrial warehouse that once processed lavender. Windowless rooms are mostly lit with rows of white LED lights rather than hot sodium lamps. Plants grow in soil that is enriched with worm castings and guano, and are protected from attack by predatory insects rather than pesticides. The facility relies on groundwater and uses electronic meters to continuously monitor humidity, water use and temperature. Peak water consumption is about two litres per day for about two months of the plants' lives, says the company's lead cultivator, Derek Rayhorn — a volume that falls considerably short of both the commonly cited amount of 22 litres per day and Butsic and Grantham's estimate of the plant's peak water requirements.

Yerba Buena has worked with the Energy Trust of Oregon and benefited from the state's rebate policy for energy-efficient facilities. Although they've recouped US$150,000 in energy savings, the company's efforts remain a work in progress. Some rooms still have sodium lights blazing and thrum with industrial dehumidifiers that squat between rows of plants. The company's plan to replace these lights is being slowed by the steep cost of LED bulbs — $100,000 to fit out a single room in which only several hundred plants can grow, Rayhorn estimates.

It's also up to growers to work out how the same variety of plant might grow under LED lights versus sodium lights, he adds. However, the differences are clearly visible: emerging blooms on plants lit by LED bulbs are more robust, and their fragrance is less pungent and more herb-like.

Yerba Buena and other growers' efforts demonstrate that cannabis can be cultivated in a way that doesn't harm the planet. But the cannabis industry has only just begun to chart a route to a greener future. ■

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