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March 2, 2021

VIA EMAIL

Ms. Jocelyn Drake
Principle Planner
Santa Cruz County Planning Department
701 Ocean Street, 4th Floor
Santa Cruz, CA 95060
Jocelyn.drake@santacruzcounty.us

Re: Commercial Development Permit (Application #211083)
375 Old Mount Road, Felton CA 95018
Zoning Administrator Agenda for March 4, 2022

Dear Ms. Drake:

This law firm has been retained by Old Mount Protectors, an unincorporated association of residents of Santa Cruz County, opposed to the County's decision to exempt the cannabis project at 375 Old Mount Road, Felton CA 95018 (Project) from environmental review under the California Environmental Quality Act (CEQA) when environmental review is required. Among other factors, the significant impact of this Project on groundwater use at a time of severe drought and water shortages, and the further threat to this County's firefighting resources, clearly points to the need for CEQA review of this Project.

Applicant David Whitfield's application for a Commercial Development Permit involves the establishment of a proposed outdoor cultivation operation with a total allowable mature and immature commercial cannabis canopy area of up to 20,000 square feet. Cannabis would be cultivated to maturity in hoop houses with "light deprivation covers" between April 15th to October 31st. Furthermore, power would be provided to the cultivation site for supplemental lighting and fans. Harvested cannabis would be temporarily stored in two (2) 20' by 40' refrigerated trailers, and cannabis material would be transported off-site by a licensed third party-distributor. (Staff Report, p. 2.)

The County erroneously concluded that the Project is categorically exempt from CEQA review under Cal. Code Regs, tit. 14, §§ 15301,15304 and 15305. (Staff Report, p. 6.) The bald conclusions in the Staff Report cannot support depriving the local residents and this forested, mountain environment and its critical water resources with the review and protections afforded by CEQA. For the reasons stated below, this Project is not exempt from CEQA as the Project is outside of the scope of the claimed exemptions.

A. The Project is Subject to CEQA

CEQA mandates that "the long term protection of the environment... shall be the guiding criterion in public decisions." Pub. Resources Code § 21001(d). The foremost principle under CEQA is that it is to be "interpreted in such a manner as to afford the fullest possible protection to the environment within the reasonable scope of the statutory language." (*Citizens of Goleta Valley v. Board of Supervisors* (1990) 52 Cal.3d 553, 564; *Friends of Mammoth v. Board of Supervisor*s (1972) 8 Cal. 3d 247; *Mountain Lion Foundation v. Fish & Game Com.* (1997) 16 Cal.4th 105, 112.) An agency's action violates CEQA if it "thwarts the statutory goals" of "informed decisionmaking" and "informed public participation." (*Kings County Farm Bureau v. City of Hanford* (1990) 221 Cal.App.3d 692, 712.) While certain classes of projects that do not result in significant effects on the environment are categorically exempt from CEQA, "[e]xemption categories are not to be expanded beyond the reasonable scope of their statutory language." (*Id.* at 125.) As such, "a categorical exemption should be interpreted narrowly to afford the fullest possible protection to the environment within the reasonable scope of the statutory language." (*Los Angeles Dept. of Water & Power v. County of Inyo* (2021) 67 Cal.App.5th 1018, 1040.)

The burden is on the County to demonstrate that the exemption applies.

> "[A categorical] exemption can be relied on only if a factual evaluation of the agency's proposed activity reveals that it applies." (*Muzzy Ranch Co. v. Solano County Airport Land Use Com.* (2007) 41 Cal.4th 372, 386....) "[T]he agency invoking the [categorical] exemption has the burden of demonstrating" that substantial evidence supports its factual finding that the project fell within the exemption. (Ibid.)

(*Save Our Big Trees v. City of Santa Cruz* (2015) 241 Cal.App.4th 694, 710-712.)

To achieve its objectives of environmental protection, CEQA has a three-tiered structure. (14 Cal. Code Regs. §15002(k); *Committee to Save Hollywoodland v. City of Los Angeles* (2008) 161 Cal.App.4th 1168, 1185 86; *San Lorenzo Valley Community Advocates for Responsible Education v. San Lorenzo Valley Unified School Dist.* (San Lorenzo Valley) (2006) 139 Cal. App. 4th 1356, 1372-1374.) First, if a project falls into an exempt category, no further agency evaluation is required. (*Id.*) Second, if there is a possibility a project will have a significant effect on the environment, the agency must perform a threshold initial study. (*Id.*; 14 Cal. Code Regs. § 15063(a).) If the initial study indicates that there is no substantial evidence that a project may cause a significant effect on the environment, then the agency may issue a negative declaration. (*Id.*; 14 Cal. Code Regs. §§ 15063(b)(2), 15070.) However, if a project may have a significant effect on the environment, an environmental impact report is required. (14 Cal. Code Regs. § 15063(b); *San Lorenzo Valley, supra*, 139 Cal. App. 4th at 1373-1374.) Thus, the analysis begins with whether the claimed exemptions apply.

Categorical exemptions are found in the CEQA Guidelines and include certain classes of projects which are exempt from CEQA based on the California Resources Agency's determination that such projects do not have a significant impact on the environment. (Pub. Resources Code § 21084; 14 Cal. Code Regs. §§ 15300 - 15354.) However, "[t]he [Resources Agency's] authority to identify classes of projects exempt from environmental review is not unfettered ... '[W]here there is any reasonable possibility that a project or activity may have a significant effect on the environment, an exemption would be improper." (*Azusa Land Reclamation Co. v. Main San Gabriel Basin Watermaster Azusa* (1997) 52 Cal.App.4th 1165, 1191 (quoting *Wildlife Alive v. Chickering* (1976) 18 Cal.3d 190, 205-206).) Indeed, "a categorical exemption should be construed in light of the statutory authorization limiting such exemptions to projects with no significant environmental effect." (Remy, et al., Guide to CEQA (11th ed. 2006) p. 136.)

The County should be aware of how the courts would interpret the exemptions. Where the specific issue is whether the lead agency correctly determined that a project fell within a categorical exemption, the court "must first determine as a matter of law the scope of the exemption and then determine if substantial evidence supports the agency's factual finding that the project fell within the exemption." (*California Farm Bureau Federation v. California Wildlife Conservation Bd.* (2006) 143 Cal.App.4th 173, 185-186.) A court's initial determination as to the appropriate scope of a categorical exemption is a question of law subject to independent, or de novo, review. "[Q]uestions of interpretation or application of the requirements of CEQA are matters of law. [Citations.] Thus, for example, interpreting the scope of a CEQA exemption presents 'a question of law, subject to de novo review by this court.' [Citations.]" (*San Lorenzo Valley, supra*, 139 Cal. App. 4th at 1375, 1382.) As noted *supra*, "Because the exemptions operate as exceptions to CEQA, they are narrowly construed. [Citation.]" (*San Lorenzo Valley, supra*, 139 Cal.App.4th at 1382.) According to the California Supreme Court, CEQA exemptions must be narrowly construed and "[e]xemption categories are not to be expanded beyond the reasonable scope of their statutory language." (*Mountain Lion Foundation v. Fish & Game Comm.* (1997) 16 Cal.4th 105, 125; *San Lorenzo Valley, supra*, 139 Cal.App.4th at 1382. see also, *McQueen v. Board of Directors* (1988) 202 Cal.App.3d 1136, 1148.) Erroneous reliance by an agency on a categorical exemption constitutes a prejudicial abuse of discretion and a violation of CEQA. (*Azusa, supra*, 52 Cal.App.4th at 1192; *Save Our Big Trees v. City of Santa Cruz* (2015) 241 Cal.App.4th 694, 705.) This office litigated the *Save Our Big Trees* matter on behalf of the prevailing party and, thus, understands the limited scope of exemptions and their application.

The first step in determining whether a categorical exemption can be applied is a facial analysis of the language of the exemption to determine whether the project falls within the "scope" of the activity intended for exemption. (*San Lorenzo Valley, supra*, 139 Cal. App. at 1375, 1382.) Here, the County is proposing to exceed the scope of the exemptions by applying them to the proposed Project here.

1) The Project Does Not Qualify for the Class 1 Categorical Exemption under the CEQA Guidelines

The Project is not within the scope of the Class 1 Categorical Exemption. The Staff Report claims the Project is qualified for the Class 1 exemption under Cal. Code Regs., tit. 14, § 15301, which states:

> Class 1 consists of the operation, repair, maintenance, permitting, leasing, licensing, or minor alteration of ***existing*** public or private structures, facilities, mechanical equipment, or topographical features, ***involving negligible or no expansion of existing or former use***. The types of "existing facilities" itemized below are not intended to be all-inclusive of the types of projects which might fall within Class 1. ***The key consideration is whether the project involves negligible or no expansion of use.***

(Emphasis added.) However, the cultivation envisioned here is an expansion of the use, and in fact a new use, that involves hoop houses for a newly-cultivated 20,000 square feet canopy (of an entirely new, high-impact, highly-regulated crop and one that raises security concerns), extension of electricity for light and fans, new parking areas, the placement of refrigerated trailers, and the addition of employees. Even though there was a prior agricultural use, the cultivation of grapes that were dry farmed and did not use groundwater. This is not a negligible or no expansion of use. Therefore, the Class 1 Categorical Exemption does not apply to this Project.

2) The Project Does Not Qualify for the Class 4 Categorical Exemption under the CEQA Guidelines

The Staff Report also claims that the Project is exempt from CEQA review pursuant to Cal. Code Regs, tit. 14, § 15304, which "consists of minor public or private alterations in the condition of land, water, and/or vegetation which do not involve removal of healthy, mature, scenic trees except for forestry and agricultural purposes." However, the Project is not within the scope of this exemption either. The Project is a major addition of a highly regulated use to the current agricultural use of this land that will cause significant environmental impacts. The hoop houses and improvements contemplated are not minor alterations. The justification given on the proposed notice of exemption is the "The Class 4 exemption is based upon the crop change from grapes to cannabis within an existing vineyard." However, even the County Code does not treat the cannabis as simply "agriculture." The Use Chart for the agricultural use districts at County Code section 13.10.312 distinguishes between "Berry and other vine crops" and "field crops, including hay, grain, seed, and turf crops," which are both "permitted uses," and "Cannabis Cultivation (commercial)" which require Level 4 or Level 5 approval. The County cannot claim that this is a mere switching of crops that are permitted uses. Cannabis is subject to strict regulation due, in part, to its environmental impacts. Furthermore, the Use Chart states that hoop houses require a Level 4 or Level 5 approval in the Agriculture zone district. Notably, the Staff Report acknowledges that

> County oversight of water use on agricultural operations on General Plan-designated agricultural lands is limited to the issuance of permits for well construction and on-site wastewater disposal facilities (septic systems). ***Cannabis operations must meet stricter standards under County and State codes***, including certifying that water is sourced from permitted wells and/or stream diversions, water-wise irrigation Best Management Practices are employed, and measures to limit runoff volume from cultivation sites are applied.

(Staff Report, p. 4, emphasis added.)

Moreover, the Project does not propose an alteration (change) to the agricultural use of this parcel, but rather *an addition*. The grape growing would continue along with the new cannabis grow, causing significant impacts.

This Project does not fall within the minor alterations contemplated by the Class 4 Categorical Exemption.

B. Despite the Proposed Notice of Exemption's Claim to the Contrary, CEQA Guidelines Section 15300.2 Does Apply

CEQA provides for several exceptions to categorical exemptions and, if an exception applies, the exemption cannot be used, and the agency must instead prepare an initial study and perform environmental review. (*McQueen v. Bd. of Dirs.* (1988) 202 Cal.App.3d 1136, 1149; *Committee to Save the Hollywoodland Specific Plan v. City of Los Angeles* (2008) 161 Cal. App. 4th 1168, at 1187.) CEQA Guidelines §15300.2 implements the exceptions to the categorical exemptions:

> § 15300.2. Exceptions
> ....
> (b) Cumulative Impact. All exemptions for these classes are inapplicable when the cumulative impact of successive projects of the same type in the same place, over time is significant.
>
> (c) Significant Effect. A categorical exemption shall not be used for an activity where there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances.

Thus, a categorical exemption shall not be used for an activity when the cumulative impact over time is significant, and where there is a reasonable possibility that the activity will have a significant effect on the environment. (Cal. Code Regs, tit. 14, §15300.2 (b), (c).) Here, the evidence before the County demonstrates that one or more of these exceptions applies and thus a categorical exemption may not be used, and an initial study must be prepared.

1) This Project Has a Cumulative Impact Given the Growth of Cannabis in the County

This Project will have significant cumulative impact associated with use of water resources. The increasing push for cannabis cultivation in the County will strain already overstretched water resources. The County is failing to consider the immense impact on water resources that cannabis grows will cumulatively cause.

2) Cannabis Water Use is Significant and the Environmental Impacts of Such Water Use Must be Analyzed

It is a well known fact that cannabis is thirsty and consumes excessive water resources. According to a scientific article published by Bioscience, a peer-reviewed scientific journal published by Oxford University Press in collaboration with the American Institute of Biological Sciences,

> In the California north coast region, ***an estimated 22 liters (L) of water or more per plant per day are applied during the June–October outdoor growing season*** (HGA 2010). Using this water application rate and documented planting densities in greenhouses (900,000 plants per square kilometer [km2]; Bauer et al. 2015), water application rates would be approximately 3 billion L per km of greenhouse-grown marijuana per growing season. Outdoor planting densities appear to be much lower (Scott Bauer, California Department of Fish and Wildlife, personal communication, October 13, 2014), and if we assume a planting density of 130,000 plants per km, water application rates would be approximately 430 million L per km of outdoor-grown marijuana per growing season. For comparison, wine grapes on the California north coast are estimated to use a mean of 271 million L of water per km of vines per growing season (CDWR 2001, 2002, 2003, 2004, 2005). Marijuana is therefore estimated to be almost two times “thirstier” than wine grapes, the other major irrigated crop in the region.

(Jennifer K. Carah et al., *High Time for Conservation: Adding the Environment to the Debate on Marijuana Liberalization,* 65 BioSci 822 (2015), attached hereto as Exhibit A.) Notably, as the Staff Report states, the grapes on the Project site are dry farmed. Thus the entire use of ground water by the cannabis plants would be new. Based on the calculations in this peer-reviewed paper, this Project would use, at least, an astonishing 3,000,000 gallons of water per year.[1] This amount is way beyond what this drought plagued County can spare and, at the very least, requires further study.

Expert studies show that cannabis plants have great potential to negatively and substantially impact water resources. Yet the Staff Report brushes these impacts aside and simply relies on the Best Management Operations Practices (BMOP) plan for the Project. But there is no explanation of how the plan will actually mitigate water usage and to what extent, nor is the baseline availability of water explained.

2) The Project Will Have a Substantial Impact to Wildlife

Studies have shown that cannabis cultivation has the potential to create significant impacts to wildlife and vegetation. According to a study conducted by the Cannabis Research Center, a research group based at the University of California, Berkeley:

> There are several potential ways in which cannabis farming might impact wildlife, depending on the form of cultivation and specific practices on site, including:
>
> 1. Disturbance from light and noise (for example, from generators or grow lights) can alter wildlife behavior such that they avoid certain areas or become more nocturnal. Alternatively, some animals (such as moths, starlings, or rats) may actually be attracted to these disturbance sources. These disturbances can have ripple effects on entire food webs and wildlife interactions. We have seen evidence for some shifts in wildlife species found on private land cannabis farms compared to nearby sites.
>
> 2. Modification of natural vegetation (for example, clearing land for a production site, or fencing off an entire parcel) could reduce the extent and quality of wildlife habitat as well as restrict movement and access to critical resources on the landscape.
>
> 3. Unmonitored use or disposal of plastic monofilament could result in animals getting entangled and injured in lines, or ingesting plastics.

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[1] 20,000 sq feet equals 0.001858 sq km (https://www.inchcalculator.com/convert/square-foot-to-square-kilometer/), and 1 gallon equals 3.785 liters. Therefore, the 430 million liters per sq kilometer cited translates to 3,023,978 gallons of use for 20,000 sq feet of canopy (430,000,000 x 0.001858 x 3.785). And the article describes a June-October growing season, rather than the April-November season requested for this Project.

(See Exhibit B attached hereto, emphasis added.) Due to the lack of information provided in the Staff Report, it is impossible to know whether these impacts will be mitigated to a less than significant level. Courts have held improper deferral of mitigation measures occurs when "[t]he success or failure of mitigation efforts in regard to impacts...may largely depend upon management plans that have not yet been formulated, and have not been subject to analysis and review within the EIR." *San Joaquin Raptor Rescue Center v. County of Merced* (2007) 149 Cal.App.4th 645, 670. Further, the "fact that the future management plans would be prepared only after consultation with [agencies] does not cure these basic errors under CEQA, since no adequate criteria or standards are set forth... Accordingly, we conclude that the analysis of mitigation measures...was inadequate, since it improperly deferred formulation of land management aspects of such mitigation measures." *Ibid.*

3) The Project Will Have a Substantial Impact With Respect to Odor

Cannabis is a notoriously odiferous plant. Due to the nature of outdoor cultivation, it is nearly undeniable that the Project will produce odors which have the potential for significant impacts. However, the Staff Report fails to include any discussion on odor, its impacts or potential mitigation measure other than hedge rows and setback distances. (Staff Report, p. 3.) However, there is abundant literature showing that odor is a significant problem with widespread impacts. (See, for example, Exhibit C attached hereto.)

4) The County Fails to Address Security Concerns

Cannabis cultivation has well known issues concerning security. County Code section 7.128.090 requires security plans. (See also County Code § 7.128.170(O). Moreover, since this Project is purported to be a co-located project, a Master Plan is required which is designed, in part, to ensure "security and operations compatible with the surrounding neighborhood," and to reduce "environmental impacts." (County Code § 7.128.090(E)(4).) There is no indication in the Staff Report how the Master Plan ensures security and compatibility with the neighborhood, or reduces environmental impacts.

Cannabis cultivation tends to draw persons with criminal intent. That is why the industry is heavily regulated related to security. Environmental review would require analysis of public services, such as protection afforded by the Sheriff's Office and whether there are the resources to provide such services. This Project is located more than 7 miles and at least 15 minutes, up hilly, windy roads from the Santa Cruz County Sherriff's branch office in Felton. (See CEQA Guidelines, Appendix G, which requires analysis as to "Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services," including the provision of "police protection.") Because the County is erroneously exempting the Project from environmental review, these concerns will never be addressed.

The failure of the County to address environmental concerns is a violation of CEQA and thwarts the very purpose of the statute.

> The EIR is also intended "to demonstrate to an apprehensive citizenry that the agency has, in fact, analyzed and considered the ecological implications of its action." [Citation]. Because the EIR must be certified or rejected by public officials, it is a document of accountability. If CEQA is scrupulously followed, the public will know the basis on which its responsible officials either approve or reject environmentally significant action, and the public, being duly informed, can respond accordingly to action with which it disagrees. [Citation]. ***The EIR process protects not only the environment but also informed self-government.***

Laurel Heights Improvement Assn. v. Regents of the University of California, supra, 47 Cal.3d at 392, emphasis added; see also *Citizens of Goleta Valley v. Board of Supervisors, supra,* 52 Cal.3d at 554; 14 Cal. Code Regs. § 15003. The failure of the County to address impacts related to water resources, wildlife, odor, and security, as well as other impacts raised by others in these proceedings, is a violation of CEQA.

C. The Applicant is Attempting to Increase the Amount of Cannabis Cultivation Permitted by Using a Sham Co-location Process

The environmental impacts here are even more acute given the improper doubling of the cannabis allowed on the Project site. Santa Cruz County Code section 7.128.110(C)(1)(b)(i) related to Licenses cannabis cultivation in the Agriculture zone district limits single licensees on a single parcel to only 10,000 square feet of canopy. This Project is proposed to be 20,000 square feet. However, only co-located entities are permitted to cultivate a canopy of greater than 10,000 square feet on parcels zoned Agriculture. (Santa Cruz County Code § 7.128.110(C)(1)(b)(iii).) This Project, applied for by two entities created by the same family solely for the purpose of applying for co-located licenses, as the application admits, does not qualify as a co-located project nor align with the purposes for which the co-location rules were implemented and should be denied.

Finally, Pursuant to Public Resources Code § 21167(f), I am requesting that the County forward a Notice of Exemption to this office if the Project is finally approved. That section provides:

> If a person has made a written request to the public agency for a copy of the notice specified in Section 21108 or 21152 prior to the date on which the agency approves or determines to carry out the project, then not later than five days from the date of the agency's action, the public agency shall deposit a written copy of the notice addressed to that person in the United States mail, first class postage prepaid.

For the foregoing reasons, we request that you deny approval of the Project. Thank you for your consideration.

Very truly yours,
WITTWER PARKIN LLP

William P. Parkin

cc: Client
Michael Supanor (via email)

Encls

EXHIBIT A

High Time for Conservation: Adding the Environment to the Debate on Marijuana Liberalization

JENNIFER K. CARAH, JEANETTE K. HOWARD, SALLY E. THOMPSON, ANNE G. SHORT GIANOTTI, SCOTT D. BAUER, STEPHANIE M. CARLSON, DAVID N. DRALLE, MOURAD W. GABRIEL, LISA L. HULETTE, BRIAN J. JOHNSON, CURTIS A. KNIGHT, SARAH J. KUPFERBERG, STEFANIE L. MARTIN, ROSAMOND L. NAYLOR, AND MARY E. POWER

The liberalization of marijuana policies, including the legalization of medical and recreational marijuana, is sweeping the United States and other countries. Marijuana cultivation can have significant negative collateral effects on the environment that are often unknown or overlooked. Focusing on the state of California, where by some estimates 60%–70% of the marijuana consumed in the United States is grown, we argue that (a) the environmental harm caused by marijuana cultivation merits a direct policy response, (b) current approaches to governing the environmental effects are inadequate, and (c) neglecting discussion of the environmental impacts of cultivation when shaping future marijuana use and possession policies represents a missed opportunity to reduce, regulate, and mitigate environmental harm.

Keywords: agriculture production, Cannabis, biodiversity, policy/ethics, endangered species

Marijuana is the subject of heated debates over whether the liberalization of marijuana policies would benefit or harm society (Kilmer et al. 2010, Caulkins et al. 2011). Countries as diverse as Uruguay, Morocco, and the Netherlands—as well as 23 US states—are experimenting with the decriminalization of marijuana, including the states of Colorado, Washington, Oregon, and Alaska, which have legalized recreational sale and possession (AP 2014, Hughes 2014). The policy debate, which has focused on the public-health and criminal outcomes of liberalization, has largely neglected another notable source of societal harm arising from widespread marijuana use: the environmental harm associated with its commercial-scale cultivation. Where this harm has been examined by policy analysts in a legalization and policy context in Washington State (O'Hare et al. 2013), it was assumed that the environmental impacts are largely associated with energy use in indoor cultivation and will shrink in state-legal markets through regulation and other mechanisms. In that case, it was also assumed that environmental considerations are of minor importance in framing marijuana policy (O'Hare et al. 2013).

These assumptions are questionable in warm, arid, or semi-arid regions with extensive outdoor marijuana cultivation, or where state-legal/medical markets and black markets are significantly intertwined. California, where by some estimates 60%–70% of the marijuana consumed in the United States is grown (USDOJ NDIC 2007, Gabriel et al. 2013), serves as a good example of both conditions. California marijuana is primarily outdoor grown, and there is significant mixing between the medical and black markets (Short 2010, Bauer et al. 2015). Although the total area under marijuana cultivation in California is likely low compared with that of traditional Californian crops such as grapes, hay, or tomatoes, the site-specific impacts of marijuana production are significant and problematic. Illegal marijuana production in California is centered in sensitive watersheds with high biodiversity (Bauer et al. 2015), which represent habitat for several rare state- and federally listed species. The Mediterranean climate of much of the state results in the limited availability of surface water within these watersheds during marijuana's growing season. The combination of limited water resources, a water-hungry crop, and illegal cultivation in sensitive ecosystems means that marijuana cultivation can have environmental impacts that are disproportionately large given the area under production.

Like all forms of agriculture, marijuana cultivation has implications for natural resources that should be part of the current and future policy discussion. However, regulation

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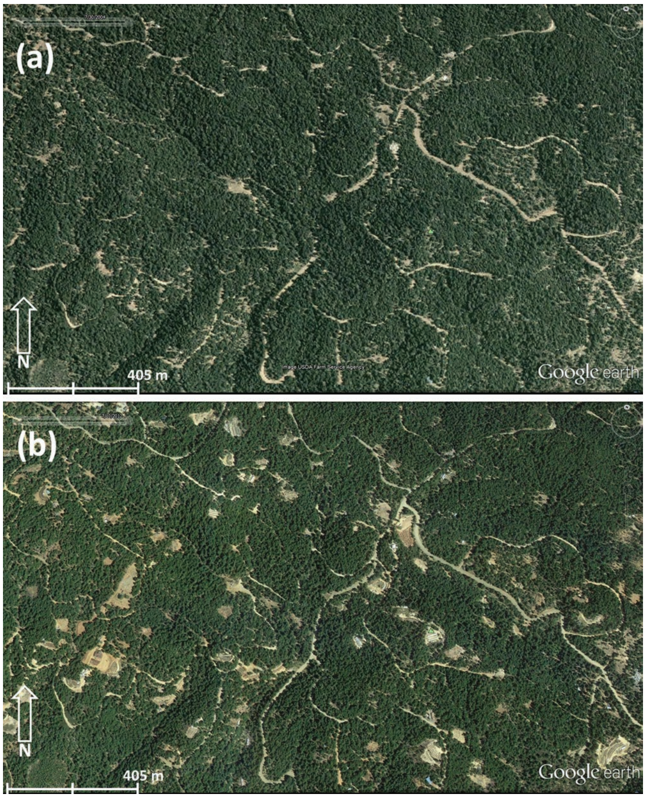

Figure 1. Land clearing, habitat conversion, and road building associated with marijuana cultivation in the Trinity River watershed (a) before conversion, 2004, and (b) after conversion, 2012. Source: Jennifer Carah; base imagery US Department of Agriculture Farm Service Agency through Google Earth (2004), and Google Earth (2012).

designed to mitigate environmental harm is more difficult to implement for marijuana cultivation than for other agricultural activities because of its unique and evolving legal status. Although many US states are legalizing recreational and medical marijuana possession and use, it remains illegal at the federal level, putting the industry in a semi-legal gray area in these states. This status separates marijuana from fully legal agricultural commodities and greatly complicates regulation of the industry. Without adopting a position on liberalization of marijuana use and possession policies, we argue here that (a) the environmental harm caused by marijuana cultivation in both the semi-legal and black-market context is significant and merits a direct policy response, (b) current approaches to and funding for governing the environmental effects are inadequate, and (c) neglecting discussion of the environmental impacts of cultivation when shaping future marijuana-use and -possession policies represents a missed opportunity to reduce, regulate, and mitigate environmental harm.

The environmental impacts of marijuana cultivation

Marijuana is a water- and nutrient-intensive crop (Cervantes 2006, HGA 2010). Its cultivation is associated with land clearing (figure 1), the diversion of surface water (figures 2 and 3), agrochemical pollution, and the poaching of wildlife in the United States (Gabriel et al. 2013, Thompson et al. 2014, Bauer et al. 2015) and internationally (Armstead 1992, McNeil 1992, Bussman 1996). Where grown indoors, it can require extensive energy inputs with potentially negative effects on climate (Mills 2012, O'Hare et al. 2013). Marijuana cultivation in California is mainly concentrated in remote forested watersheds, on private, public, and Native American tribal lands, and is largely grown outdoors (Gabriel et al. 2012, Milestone et al. 2012, Thompson et al. 2014, Bauer et al. 2015), with environmental impacts often extending far beyond the specific cultivation site (Gabriel et al. 2013, Bauer et al. 2015). Both semi-legal and black-market marijuana plantations can be harmful to water resources and aquatic life. In the California north coast region, an estimated 22 liters (L) of water or more per plant per day are applied during the June–October outdoor growing season (HGA 2010). Using this water application rate and documented planting densities in greenhouses (900,000 plants per square kilometer [km^2]; Bauer et al. 2015), water application rates would be approximately 3 billion L per km^2 of greenhouse-grown marijuana per growing season. Outdoor planting densities appear to be much lower (Scott Bauer, California Department of Fish and Wildlife, personal communication, October 13, 2014), and if we assume a planting density of 130,000 plants per km^2, water application rates would be approximately 430 million L per km^2 of outdoor-grown marijuana per growing season. For comparison, wine grapes on the California north coast are estimated to use a mean of 271 million L of water per km^2 of vines per growing season (CDWR 2001, 2002, 2003, 2004, 2005). Marijuana is therefore estimated to be almost two times more "thirsty" than wine grapes, the other major irrigated crop in the region.

Compared with more established forms of agriculture on the north coast, where abundant winter stream flow is sometimes captured and stored locally in ponds or tanks for later summer use, marijuana cultivation is typically irrigated with summer and fall surface water diversions directly from headwater streams and springs (Gabriel et al. 2013, Bauer et al. 2015). These diversions are localized in smaller, sensitive watersheds that are hotspots of biodiversity—and particularly aquatic biodiversity (Bauer et al. 2015). Although legally constructed water storage can be strategically located within a watershed network to mitigate the cumulative downstream effects of water abstraction (Grantham et al. 2010, Viers et al. 2013), surface water diversions for marijuana cultivation have been documented to significantly reduce or eliminate already low stream flow during California's Mediterranean-type dry summer season, particularly during drought years, and therefore threaten the survival of rare and endangered salmonids, amphibians, and other animals (Gabriel et al. 2013, Bauer et al. 2015).

For example, Bauer and colleagues (2015) found minimum stream flows in four northern Californian watersheds to be so low in the summer months that direct surface-water

Figure 2. A California outdoor marijuana garden adjacent to a drained wetland. The wetland was drained to irrigate the marijuana garden. Photograph: Scott Bauer.

diversions, based on small pumps operating at standard pumping rates, could dewater streams if more than one pump ran at once. For three of the four watersheds examined, existing demand for water for marijuana cultivation exceeded minimum instream flows in the summer by more than a factor of 2 (Bauer et al. 2015). These estimates can be scaled up to larger watersheds by considering the average summer water yields from larger rivers on a per-area basis. For comparison, the areally averaged water yield from the Eel River during the marijuana-growing season is approximately 50,000,000 L per km^2 per season (figure 4)—ten times lower than the estimated marijuana water requirement of 430,000,000 L per km^2 per season. Marijuana plantations, even if relatively small in area, can have a disproportionately large impact on water resources and flow.

Marijuana plantations can also pollute watersheds and poison wildlife. Pesticides, used heavily in black-market cultivation on public lands, make their way into terrestrial food chains, posing significant risks to mammalian and avian predators (Gabriel et al. 2013). For example, Gabriel and colleagues (2012) and Thompson and colleagues (2014) found that more than 80% of deceased Pacific fishers (*Pekania pennanti*) they recovered in northern California and the southern Sierra Nevada were exposed to anticoagulant rodenticides, pesticides used to control wood rats (*Neotoma spp.*) in black market–marijuana cultivation. The likelihood of exposure increased and female survival rates decreased with the presence of marijuana cultivation sites within fisher home ranges (Thompson et al. 2014). The use of these pesticides is a significant threat to fishers, which are already rare and are candidates for listing under the Federal Endangered Species Act. In addition, where marijuana growers trespass onto public and tribal lands or large industrial timberlands to grow marijuana, they often camp out for many months at a time and poach wildlife for sport and sustenance (Milestone et al. 2012, Gabriel et al. 2013).

Land terracing, road construction, and forest clearing for both semi-legal and black-market marijuana plantations remove native vegetation (Milestone et al. 2012) and increase erosion (USDOJ NDIC 2007, Gabriel et al.

Figure 3. An illegally constructed pond and water diversion associated with a marijuana cultivation site in northern California. Photograph: Scott Bauer.

2013, Bauer et al. 2015). Erosion increases fine-sediment loading into streams, damaging spawning and rearing habitat for salmon and trout, such as federally endangered coho salmon (*Oncorhynchus kisutch*; USDOJ NDIC 2007). Nonbiodegradable trash and human excrement are commonly dumped around black-market marijuana cultivation sites on public and tribal lands (USDOJ NDIC 2007). The heavy use of pesticides, herbicides, fertilizers, and petroleum fuels in both semi-legal and black-market cultivation can also contaminate watersheds (USDOJ NDIC 2007, Gabriel et al. 2013). Environmental clean-up and remediation efforts in the affected watersheds are limited, even after enforcement actions are taken, because of lack of resources and staff in state or federal agencies (Gabriel et al. 2013).

Minimal governance of environmental impacts

Because of the clandestine nature of the business, hard data on California land in marijuana production or production volumes are unavailable (Kilmer et al. 2010). Several older estimates of US marijuana-consumption rates exist, although they span a large range and incorporate significant uncertainty (Kilmer et al. 2010). Numbers range from 1 million kilograms (kg; Abt Associates 2001) to estimates from the Drug Enforcement Administration (DEA) and the United Nations Office on Drugs and Crime (UNODC) of about 4.2 million kg (Drug Availability Steering Committee 2002; UNODC 2005) and almost 10 million kg estimated by an industry insider (Gettman 2007). If we take the midrange DEA–UNODC estimate, assume that the US Department of Justice (USDOJ) estimate that California produces 60% of the marijuana consumed in the United States holds true (USDOJ NDIC 2007), and assume a $6600-per-kg price (Kilmer et al. 2010), then wholesale marijuana sales in California total approximately $16.7 billion ($11.2 billion if one assumes a lower price of $4400 per kg). Even considering the uncertainty, these estimates suggest that marijuana is the largest cash crop in California, with the next largest commodity, milk and cream, securing $6.9 billion in wholesale sales (USDA 2012).

However, marijuana cultivation is not subject to effective statewide governance (Short 2010). Cultivation for medical use was decriminalized as part of the Compassionate Use Act in 1996, specifically for ill individuals. Since the passage of that law, both the small- and large-scale cultivation of marijuana for medical purposes and the black market have increased dramatically (USDOJ NDIC 2007), particularly in the last 5 years, where watersheds in northern California have seen increases in area under production ranging from 55% to over 100% (Scott Bauer, California Department of Fish and Wildlife, personal communication, April 8, 2015). The production and sale of medical marijuana in California are currently regulated through a patchwork of county and state rules. However, all cultivation—including cultivation for medical purposes—remains illegal under federal law.

This semi-legal status greatly complicates local authority to regulate the medical market (Mozingo 2013) and sets the industry apart from traditional agriculture. For example, in recent

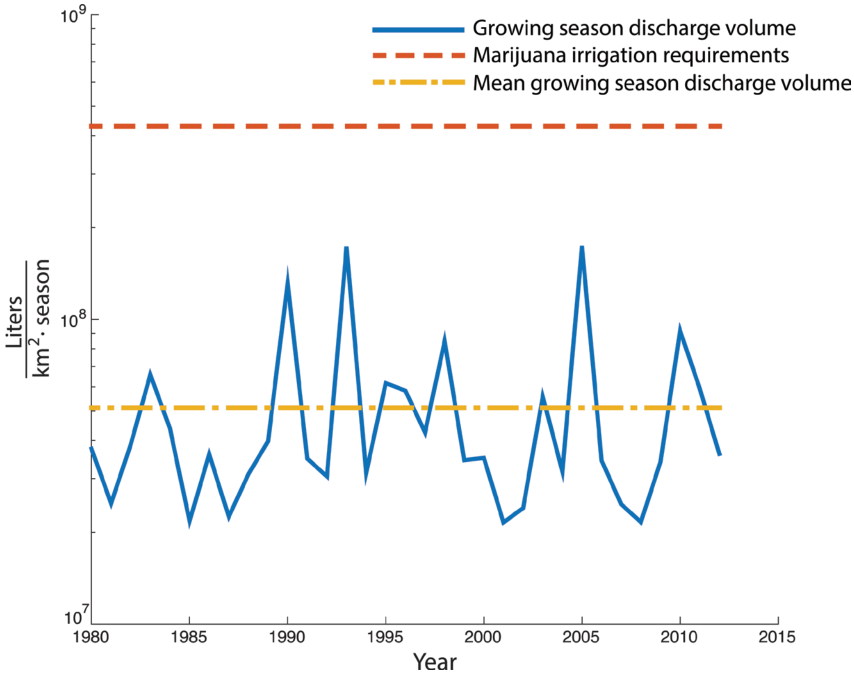

Figure 4. Actual growing season (June–October) discharge volumes (liters per square kilometer [km2] per season) for the Eel River watershed compared with mean growing season discharge volume and estimated marijuana irrigation water need. Note that marijuana water demand (on a per-area basis) exceeds water yield by almost ten times.

efforts in Mendocino County, the local authority's attempts to regulate medical markets have come into direct conflict with federal authorities, causing local officials to cease regulating the medical market (Mozingo 2013). This conflict also encourages secrecy and invisibility among producers for both the semi-legal medical and black markets, leading to lower levels of voluntary compliance with existing environmental regulation (Short 2010). The minimal regulation of medical markets further compounds the already significant intermixing of the medical and black markets in California (Short 2010). This intermixing creates further challenges for the effective enforcement of environmental laws and requires extensive coordination between natural-resource and law-enforcement agencies (Short 2010). In particular, the threat of violence associated with black market–marijuana cultivation complicates efforts and increases costs by natural-resource agencies to conduct field surveys or carry out enforcement or regulatory activities (Short 2010, Gabriel et al. 2013).

In short, the semi-legal status of the medical market and the significant intermixing of the medical and black markets complicate regulation of the industry. As a result, local marijuana-specific laws and regulations, as well as other existing state and federal environmental laws that apply (e.g., the state Fish and Game Code and Water Code and the federal Clean Water Act and Endangered Species Act) are currently inconsistently and lightly enforced (Short 2010). The lack of a robust legislative mandate to prevent and address the environmental impacts associated with marijuana cultivation adds to this challenge (Short 2010).

A lack of adequate resources also plays a significant role (Short 2010, Gabriel et al. 2013). The small number of state agents currently available to regulate this industry and others—and to enforce environmental laws—is not sufficient to adequately address the large number of marijuana cultivation sites. As an example, the State Water Resources Control Board, the agency tasked with administering water rights in California, is chronically underfunded (Grantham and Viers 2014) and already suffers from lack of staffing capacity and from permitting backlogs in processing water-rights applications for traditional water users (Little Hoover Commission 2010). Without new revenues, adding marijuana cultivators to this permitting queue will only further stretch already-thin resources.

Opportunities to reduce the environmental impacts of marijuana cultivation

There is a clear increasing trend in the liberalization of attitudes and policy toward marijuana use and possession worldwide. This trend presents an opportunity to prevent and mitigate the environmental impacts of marijuana cultivation. The legal marijuana markets currently under development feature policies that target and attempt to ameliorate some of the social and public-health consequences of marijuana possession and use. For example, Colorado and Washington State both allocate their projected $67 million and $389 million tax revenues, respectively, from legal recreational marijuana sales to state funds supporting public health and education (WOFM 2012, CLCS 2013). Current and future marijuana policies should also aim to prevent and mitigate the significant negative environmental impacts of marijuana cultivation.

If liberalization proceeds, future efforts to govern the environmental effects of marijuana production should include both incentives as well as regulatory and enforcement efforts to help legal producers comply with environmental laws and protect environmental resources. In legal markets, technical assistance and outreach programs could play a significant role in encouraging the adoption of best management practices and voluntary compliance. Similar efforts could encourage the management of stream flows that integrate human and ecosystem needs and mitigate some of the impacts of agricultural water diversion from natural systems (Grantham et al. 2010). Other incentive programs, such as certification and ecolabeling, have been used widely to help reduce the environmental externalities for other agricultural crops and could play a similar role in marijuana production (O'Hare et al. 2013). In order to overcome barriers to participation, however, incentive strategies will likely only be feasible where the legal status of production is clarified. Furthermore, additional financial resources would be necessary to initiate or expand incentive-based programs.

Whether or not marijuana policies are liberalized, improvements in the enforcement of existing environmental laws and in the implementation of regulatory programs are necessary and will require additional resources and a clear legislative mandate. For the first time, the 2014–15 California budget includes $3.3 million in funding for the enforcement of environmental laws on lands used for marijuana cultivation (Taylor 2014). Despite this promising first step, the need remains for additional dedicated funding to regulate marijuana cultivation and enforce environmental laws, to monitor the environmental impacts on public and private lands, and to support remediation and restoration in affected watersheds.

The scale of the existing marijuana markets in California and elsewhere suggests that taxation and fines could fund these measures. However, none of the $58 million–$105 million in state revenue generated each year from California's $980 million medical marijuana market is currently earmarked for environmental protection, research, or remediation (CSBE 2014). In California, the legalization of the recreational use of marijuana may be on the horizon and could generate a further $0.65 billion–$1.5 billion in tax revenue (CSBE 2009, Kilmer et al. 2010), a portion of which should be allocated to environmental protection, research, and remediation.

Some policy analysts assume that regulation in legal markets will address many environmental impacts (O'Hare et al. 2013). But, as was previously mentioned, no local markets are fully legal at the federal level in the United States, complicating state regulatory authority (PF and CACP 2015). In the most recent federal spending bill, the inclusion of a clause prohibiting the US Justice Department from spending money to enforce a federal ban on growing or selling marijuana in US states that have legalized it for medical use (Halper 2014) may help ease regulatory authority in medical markets. But existing models for state-level liberalization have taken very inconsistent approaches in addressing production and environmental impacts. Therefore, the liberalization of use and possession policies per se may not adequately prevent or mitigate the environmental impacts from large-scale commercial cultivation without deliberate consideration.

In addition, black markets (and the environmental impacts associated with black-market cultivation) are unlikely to disappear in the face of local liberalization policies (PF and CACP 2015). For example, black market–marijuana cultivation remains a problem in Colorado despite the legalization of recreational use (PF and CACP 2015). Legalization will likely increase consumption—and may increase demand for black market marijuana—depending on how markets are regulated and enforcement conducted (Keefe 2013, PF and CACP 2015). Production for export to other states will still be illegal (at the state and federal level), and addressing the environmental concerns associated with this illegal production requires a commitment to both addressing illegal production explicitly and remediating the environmental impacts from illegal production. This is of particular concern in California, because the state currently supplies such a large percentage of the marijuana consumed in the United States (Gabriel et al. 2013).

The reduction of environmental harm associated with marijuana cultivation and the enforcement of environmental laws are important social aims, regardless of the legal status of marijuana. The current levels of ambiguity and secrecy surrounding the industry impede the revelation of associated environmental impacts, as well as the creation and implementation of solutions. Inherent trade-offs and tension between marijuana cultivation and ecosystem needs exist, as they do in virtually all types of agriculture, and those trade-offs should be quantified and debated openly, as they are in other industries. There is a significant need to broaden the conversation to encompass environmental concerns and to explore how current and future marijuana policy can use both incentives and regulatory tools to prevent and mitigate the environmental damage associated with marijuana cultivation.

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References Cited

Abt Associates. 2001. What America's Users Spend on Illegal Drugs 1988–2000. Office of National Drug Control Policy. (8 April 2015; *www.ncjrs.gov/ondcppubs/publications/pdf/american_users_spend_2002.pdf*)

[AP] Associated Press. 2014. Following legalization in US, Uruguay, marijuana gets second look. Christian Science Monitor. (11 December 2014; *www.csmonitor.com/World/Latest-News-Wires/2014/0215/Following-legalization-in-US-Uruguay-marijuana-gets-second-look*)

Armstead L. 1992. Illicit narcotics cultivation and processing: The ignored environmental drama. Bulletin of Narcotics 44: 9–20.

Bauer SD, Olson JL, Cockrill AC, van Hattem MG, Miller LM, Tauzer M, Leppig G. 2015. Impacts of surface water diversions for marijuana cultivation on aquatic habitat in four northwestern California watersheds. PLOS ONE 10 (art. e0120016). doi:10.1371/journal.pone.0120016

Bussman, R. 1996. Destruction and management of Mount Kenya's forests. Ambio 25: 314–317.

Caulkins JP, Kilmer B, MacCoun RJ, Pacula RL, Reuter P. 2011. Design considerations for legalizing Cannabis: Lessons inspired by analysis of California's Proposition 19. Addiction 107: 865–871.

[CDWR] California Department of Water Resources. 2001. Irrigated Crop Acres and Water Use, North Coast Hydrologic Region. California Department of Water Resources. (11 December 2014; http://www.water.ca.gov/landwateruse/anaglwu.cfm#)

———. 2002. Irrigated Crop Acres and Water Use, North Coast Hydrologic Region. CDWR. (11 December 2014; www.water.ca.gov/landwateruse/anaglwu.cfm#)

———. 2003. Irrigated Crop Acres and Water Use, North Coast Hydrologic Region. CDWR. (11 December 2014; www.water.ca.gov/landwateruse/anaglwu.cfm#)

———. 2004. Irrigated Crop Acres and Water Use, North Coast Hydrologic Region. CDWR. (11 December 2014; www.water.ca.gov/landwateruse/anaglwu.cfm#)

———. 2005. Irrigated Crop Acres and Water Use, North Coast Hydrologic Region. CDWR. (11 December 2014; www.water.ca.gov/landwateruse/anaglwu.cfm#)

Cervantes J. 2006. Marijuana Horticulture: The Indoor/Outdoor Medical Grower's Bible. Van Patten.

[CLCS] Colorado Legislative Council Staff. 2013. Retail Marijuana Taxes. CLCS. (11 December 2014; *www.leg.state.co.us/LCS/Initiative%20Referendum/1314initrefr.nsf/b74b3fc5d676cdc987257ad8005bce6a/e3e37fa33a36873887257b6c0077ac93/$FILE/Retail%20Marijuana%20Taxes_FN.pdf*)

[CSBE] California State Board of Equalization. 2009. AB 390: Staff Legislative Bill Analysis. CSBE. (11 December 2014; *www.boe.ca.gov/legdiv/pdf/ab0390-1dw.pdf*)

———. 2014. Media Resource: Medical Marijuana/Legalization of Marijuana. CSBE. (11 December 2014; *www.boe.ca.gov/news/marijuana.htm*)

Drug Availability Steering Committee. 2002. Drug Availability Estimates in the United States. Office of National Drug Control Policy. (8 April 2015; *www.ncjrs.gov/ondcppubs/publications/pdf/drugavailability.pdf*)

Gabriel MW, et al. 2012. Anticoagulant rodenticides on our public and community lands: Spatial distribution of exposure and poisoning of a rare forest carnivore. PLOS ONE 7 (art. e40163). doi:10.1371/journal.pone.0040163

Gabriel MW, Wengert GM, Higley JM, Krogen S, Sargent W, Clifford DL. 2013. Silent forests? Rodenticides on illegal marijuana crops harm wildlife. Wildlife Professional 7: 46–50.

Gettman J. 2007. Lost Taxes and Other Costs of Marijuana Laws. Drug Science.org. Bulletin of Cannabis Reform no. 4. (27 May 2015; *www.drugscience.org/Archive/bcr4/bcr4_index.html*)

Grantham TE, Viers JH. 2014. 100 years of California's water rights system: Patterns, trends and uncertainty. Environmental Research Letters 9 (art. 084012). doi:10.1088/1748-9326/9/8/084012

Grantham TE, Merenlender AM, Resh VH. 2010. Climatic influences and anthropogenic stressors: An integrated framework for streamflow management in Mediterranean-climate California, USA. Freshwater Biology 55: 188–204.

Halper E. 2014. Congress quietly ends federal government's ban on medical marijuana. Los Angeles Times. (14 January 2015; *www.latimes.com/nation/la-na-medical-pot-20141216-story.html*)

[HGA] Humboldt Growers Association. 2010. Review of Humboldt County Medical Marijuana Health and Safety Code. Humboldt County. (11 December 2014; http://library.humboldt.edu/humco/holdings/HGA2.pdf)

Hughes T. 2014. Where America landed on marijuana. USA Today. (11 December 2014 *www.usatoday.com/story/news/politics/elections/2014/11/04/voters-deciding-on-marijuana/18485541/*)

[HGA] Humboldt Growers Association. 2010. Humboldt County 314-55.1 Medical Marijuana Land Uses. HGA. (11 December 2014; *http://library.humboldt.edu/humco/holdings/HGA2.pdf*)

Keefe PR. 2013. Buzzkill: Washington State discovers that it's not so easy to create a legal marijuana economy. New Yorker. (11 December 2014; *www.newyorker.com/magazine/2013/11/18/buzzkill*)

Kilmer B, Caulkins JP, Pacula RL, MacCoun RJ, Reuter PH. 2010. Altered State: Assessing How Marijuana Legalization in California Could Influence Marijuana Consumption and Public Budgets. RAND Corporation. (11 December 2014; *www.rand.org/content/dam/rand/pubs/occasional_papers/2010/RAND_OP315.pdf*)

Little Hoover Commission. 2010. Managing for Change: Modernizing California's Water Governance. Little Hoover Commission.

McNeil JR. 1992. Kif in the Rif: A historical and ecological perspective on marijuana, markets, and manure in northern Morocco. Mountain Research and Development 12: 389–392.

Milestone JF, Hendricks K, Foster A, Richardson J, Denniston S, Demetry A, Ehmann M, Cuvelier C, Schifsky D, Fireman D. 2012. Continued cultivation of illegal marijuana in US western national parks. Pp. 209–216 in Weber S, ed. Rethinking Protected Areas in a Changing World: Proceedings of the 2011 George Wright Society Biennial Conference on Parks, Protected Areas, and Cultural Sites. George Wright Society.

Mills E. 2012. The carbon footprint of indoor Cannabis production. Energy Policy 46: 58–67.

Mozingo J. 2013. Mendocino County spars with feds over conflicting marijuana laws. Los Angeles Times. (17 December 2014; *http://articles.latimes.com/2013/jan/20/local/la-me-mendo-pot-20130122*)

O'Hare M, Sanchez DL, Alstone P. 2013. Environmental Risks and Opportunities in Cannabis Cultivation. BOTEC Analysis Corp. (11 December 2014; *http://lcb.wa.gov/publications/Marijuana/SEPA/BOTEC_Whitepaper_Final.pdf*)

[PF and CACP] Police Foundation and Colorado Association of Chiefs of Police. 2015. Colorado's Legalization of Marijuana and the Impact on Public Safety: A Practical Guide for Law Enforcement. PF and CACP. (8 April 2015; *www.policefoundation.org/sites/g/files/g798246/f/201501/Legalized%20Marijuana%20Practical%20Guide%20for%20Law%20Enforcement.pdf?utm_source=Sue%27s+Mail+Chimp+List+Verified&utm_campaign=97e9b3c326- February_11_2015_E_Highlights_NFIA2_11_2015&utm_medium=email&utm_term=0_fcd3118b18-97e9b3c326-334338205&mc_cid=97e9b3c326&mc_eid=3a66d7e699*)

Short AG. 2010. Governing Change: An Institutional Geography of Rural Land Use, Environmental Management, and Change in the North Coastal Basin of California. PhD dissertation. University of California, Berkeley, United States.

Taylor M. 2014. The 2014–15 Budget: California Spending Plan. Legislative Analyst's Office. (11 December 2014; *www.lao.ca.gov/reports/2014/budget/spending-plan/california-spending-plan-080414.pdf*)

Thompson C, Sweitzer R, Gabriel M, Purcell K, Barrett R, Poppenga R. 2014. Impacts of rodenticide and insecticide toxicants from marijuana cultivation sites on fisher survival rates in the Sierra National Forest, California. Conservation Letters 7: 91–102.

[UNODC] United Nations Office on Drugs and Crime. 2005. World Drug Report. UNODC. United Nations Publication no. E.05.XI.10.

[USDA] US Department of Agriculture. 2012. California Agricultural Statistics 2012 Crop Year. USDA. (27 May 2015; *www.nass.usda.gov/Statistics_by_State/California/Publications/California_Ag_Statistics/Reports/2012cas-all.pdf*)

[USDOJ NDIC] US Department of Justice National Drug Intelligence Center. 2007. Domestic Cannabis Cultivation Assessment. NDIC.

Viers JH, Williams JN, Nicholas KA, Barbosa O, Kotzé I, Spence L, Webb LB, Merenlender A, Reynolds M. 2013. Vinecology: Pairing wine with nature. Conservation Letters 6: 287–299.

[WOFM] Washington Office of Financial Management. 2012. Initiative 502: Fiscal Impact through Fiscal Year 2017. WOFM. (11 December 2014; www.ofm.wa.gov/ballot/2012/502_fiscal_impact.pdf)

Jennifer K. Carah (jcarah@tnc.org) is an ecologist, Jeanette K. Howard is the lead freshwater scientist, Lisa L. Hulette is a senior project director, and Stefanie L. Martin was an associate project director at The Nature Conservancy of California, in San Francisco. Jennifer works on stream and salmonid habitat conservation and restoration. Jeanette works on freshwater systems conservation planning and water resource sustainability. Lisa directs The Nature Conservancy of California's Salmon Program, and Stefanie is a conservation program manager who focuses on evaluating the economic value of conservation and the effects of market dynamics on conservation approaches. Sally E. Thompson is an ecohydrologist who studies hydrology, spatial ecology, and water resource sustainability and David N. Dralle is a graduate student who studies mathematical methods in ecohydrology in the Department of Civil and Environmental Engineering at the University of California, Berkeley. Stephanie M. Carlson is an ecologist who studies ecology and conservation of freshwater fishes in the Department of Environmental Science, Policy, and Management and Mary E. Power is an ecologist who studies river food webs and upland river–coastal ocean linkages in the Department of Integrative Biology at the University of California, Berkeley. Anne G. Short Gianotti is a geographer in the Department of Earth and Environment at Boston University; she studies human–environment

relations, environmental governance, and sustainable development. Scott D. Bauer is a senior environmental scientist with the California Department of Fish and Wildlife (CDFW) in Eureka; he works on CDFW's Watershed Enforcement Team, a program created in the summer of 2014 to regulate and enforce existing environmental laws at marijuana cultivation sites. Mourad W. Gabriel is the executive director for the Integral Ecology Research Center, a nonprofit research organization in Blue Lake, California; he studies wildlife disease ecology and the environmental impacts associated with marijuana cultivation. Brian J. Johnson is California director of Trout Unlimited in Berkeley. Curtis A. Knight is executive director of California Trout in San Francisco. Sarah J. Kupferberg is an ecologist with McBain Associates, in Arcata, California. Sarah studies stream ecology, amphibian biology, and the impacts of hydropower facilities on aquatic resources. Rosamond L. Naylor is an economist in the Department of Environmental Earth Science at Stanford University. She studies the economic and biophysical dimensions of food security and the environmental impacts of crop and animal production.

EXHIBIT B

Berkeley UNIVERSITY OF CALIFORNIA Cannabis Research Center

Cannabis Agriculture and Wildlife

January 2021

Concerns for cannabis' potential effect on wildlife have been a recurrent part of the conversation around enforcement and management of cultivation for decades. But what scientific evidence do we actually have for these impacts? The Cannabis Research Center has been studying the interface between wildlife and cannabis since 2017, and while there is still a lot we don't know, there are some emerging themes.

Why might we be concerned about the impact of cannabis on wildlife?

Like any other form of agriculture or human modification of the natural environment, outdoor or mixed light cannabis farming has the potential to alter the ways in which local mammals, birds, reptiles, and insects interact with their surroundings. **There are several potential ways in which cannabis farming might impact wildlife, depending on the form of cultivation and specific practices on site,** including:

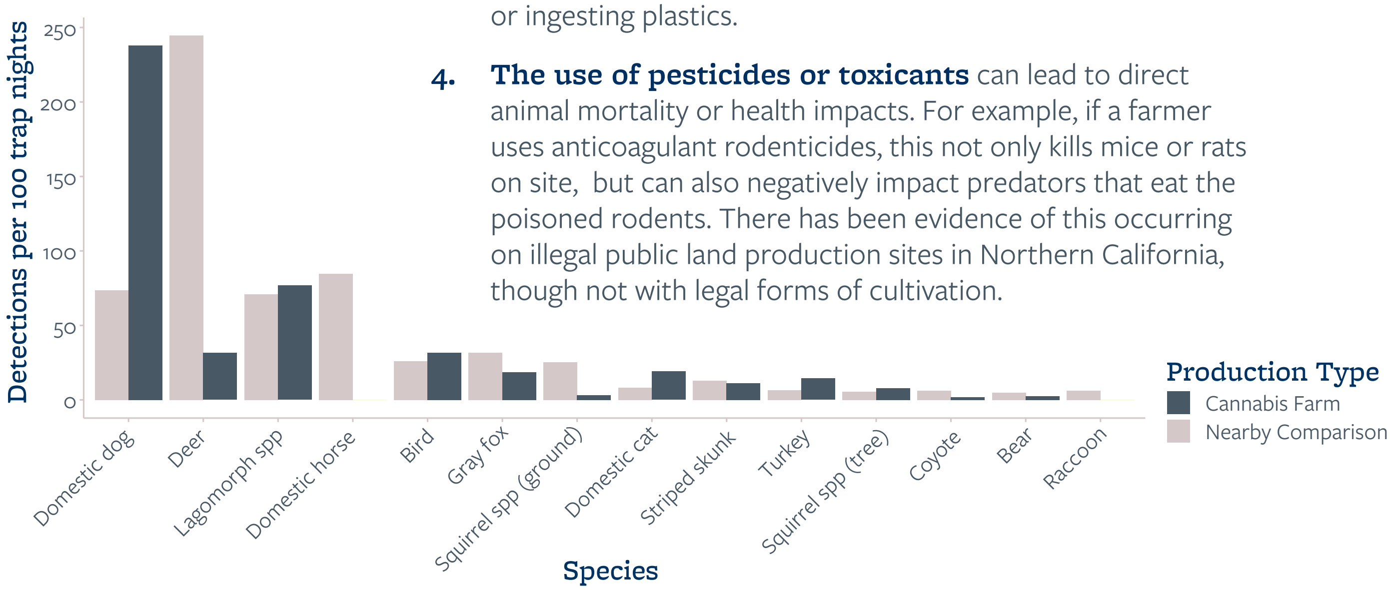
1. **Disturbance from light and noise** (for example, from generators or grow lights) can alter wildlife behavior such that they avoid certain areas or become more nocturnal. Alternatively, some animals (such as moths, starlings, or rats) may actually be attracted to these disturbance sources. These disturbances can have ripple effects on entire food webs and wildlife interactions. We have seen evidence for some shifts in wildlife species found on private land cannabis farms compared to nearby sites.

2. **Modification of natural vegetation** (for example, clearing land for a production site, or fencing off an entire parcel) could reduce the extent and quality of wildlife habitat as well as restrict movement and access to critical resources on the landscape.

3. **Unmonitored use or disposal of plastic** monofilament could result in animals getting entangled and injured in lines, or ingesting plastics.

4. **The use of pesticides or toxicants** can lead to direct animal mortality or health impacts. For example, if a farmer uses anticoagulant rodenticides, this not only kills mice or rats on site, but can also negatively impact predators that eat the poisoned rodents. There has been evidence of this occurring on illegal public land production sites in Northern California, though not with legal forms of cultivation.

Wildlife Species detected from motion activated cameras (see example, opposite page) on and nearby small-scale outdoor cannabis farms.



Berkeley UNIVERSITY OF CALIFORNIA Cannabis Research Center

Cannabis Agriculture and Wildlife

These potential impacts vary depending on the location, size, type of production, and specific site-level practices of the cannabis cultivation operation. For example, if a farm is located in an area of high biodiversity, there may be more opportunity for wildlife impacts. At the same time, the types of expected effects vary between greenhouse, outdoor, and public land production. Even within specific types of cultivation, there is variation by individual farm practices and operation size.

Are there practices farmers can take to reduce their impact on local wildlife?

Yes, and many are doing so already. While more research is needed to understand what solutions farmers have already identified and put into practice, the following **steps are likely to reduce negative impacts on cannabis farms, or even provide opportunities for positive coexistence with wildlife**:

- cover greenhouses so that any lights used inside are not visible outside
- reduce or eliminate pesticide use
- keep trash out of reach of animals and remove it from the site regularly
- minimize fencing that restricts animal movement
- leave patches of vegetation or trees intact when clearing cultivation areas.

What are some of the outstanding gaps in our understanding of how cannabis agriculture impacts wildlife?

Most existing research on the impacts of cannabis on wildlife comes from opportunistic studies on public land production sites after they have been raided by law enforcement. These sites are likely not representative of cannabis cultivation as a whole. Other studies carried out by the Cannabis Research Center have focused on observational wildlife monitoring on and surrounding small scale outdoor farms on private land. However, in both these cases, sample sizes are small and non-random. Therefore, much of what we know or infer about wildlife impacts is extremely limited.

The science on how cannabis farming interfaces with wildlife would benefit from understanding more about site-level practices and comparisons between them. This means learning from farmers themselves. Even with studies on known impacts, we are currently lacking data on the scale of these effects. Long-term and broader-scale studies will help answer these questions. And finally, we need more data to help understand the potential tradeoffs between different styles and forms of production.

For more information, visit: crc.berkeley.edu or contact vanbutsic@berkeley.edu

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EXHIBIT C

TECHNICAL PAPER

Mitigating Cannabis Odor in Grow Facilities

Caitlin D. Naske
Lead Chemical Engineer
Dynamic Air Quality Solutions
Princeton, New Jersey USA

ABSTRACT:

The legal cannabis industry is growing exponentially in North America. However, it is doing so in the absence of consistent or unified regulations and standards, especially when it comes to odor mitigation. The existing requirements vary state to state and even city to city, but generally facilities are expected to have "no detectable odor" at the edge of the property. This very ambiguous statement leaves a lot of unknowns for engineers to effectively design an odor mitigation system. Absent are the specific compounds, likely upstream levels and target downstream concentrations that would be needed for an effective system design. The following is a primer to help fill in some of the blanks for the operator and designer.

ODOR COMPOUNDS

First it is important to understand the compounds responsible for the odors. The primary culprits are a family of volatile organic compounds (VOCs) called terpenes. Terpenes are produced by a wide range of plants not limited to cannabis. In addition, cannabis terpene emissions vary based on strain, sex, age, plant part, cultivation conditions [1] [2], drying, processing and storage method [3]. Variations in terpene profiles contribute to many of the different fragrances and characteristics of the product that influence consumer preferences [4]. Although terpene profiles are often unknown or unpredictable [2] there are several terpenes found in most strains. Table 1 identifies these terpenes and includes many that are attributed to the strong and distinct cannabis odor.

Table 1. Common Cannabis Terpenes and odor compounds

Found in most strains [4]	**Strong Cannabis odor** [5] [6]	**Other common terpenes** [4] [7]
β-caryophyllene	β-caryophyllene	α-pinene
α-humulene	α-humulene	limonene
β-myrcene		linalool
		bisabolol
		(E)-β-farnesene
		β-ocimene
		terpinolene

One of the challenges of cannabis odor mitigation is the variation in terpene concentrations throughout the growth cycle of the plant, as well as throughout the various stages of processing. Terpene emissions increase as the plants grow [8], peaking when they flower, and can become further intensified during drying, curing, and processing [9]. Drying results in the loss of most of the highly volatile compounds, specifically monoterpenes (limonene, myrcene, pinene), leaving the less volatile compounds (especially caryophyllene) in dried cannabis [10].

In addition to terpenes from the cannabis plants themselves, other compounds may be present in the exhaust from other indoor sources, for example fertilizer and extraction processes (butane, propane). Different fertilizer types will produce different combinations of gas emissions and some will require targeted carbons due to the small size of the gas compounds that may be present. The article "Balancing the Nutrient Equation in Cannabis Cultivation" has a good overview of the different types of fertilizers utilized in the industry. [11].

ODOR THRESHHOLDS

Beyond knowing what compounds are in the air, the next question for system design is the odor threshold of those compounds. The odor threshold or odor detection threshold is the lowest concentration of a compound that can be detected by the human nose. A high chemical concentration does not always cause a strong smell noticeable by neighbors [6]. The most abundant terpenes in cannabis plant emissions may not be the compounds responsible for the distinct cannabis odor. For example, one study found that a mixture of four terpenes associated with cannabis odor (pinene, myrcene, limonene, and caryophyllene) had low alert responses when field tested on narcotic detection dogs trained to detect cannabis [6]. Further research is still needed to identify the odor causing compounds or combination of compounds.

The majority of grow facilities working to control odors use activated carbon filters [12]. But what is activated carbon and how does it work? Activated carbon can be made from a wide variety of materials including coal, coconut shell, walnut shell, and wood. These materials are taken and activated either by thermal activation, using steam, or chemical activation, using acid and heat. The activation forms a network of small pores creating a large surface area available for adsorption. The starting material and the method of activation lead to different pore structures, pore size distributions and quality of activated carbon. In the pores the atoms or molecules of gas are held by adsorption, a bond or force between the carbon and the gas molecule. Most adsorption occurs in very small pores called mesopores (2-50 nm) and micropores (<2 nm). Two measures of activated carbon quality include BET surface area and carbon tetrachloride (CTC) activity where 60% CTC or higher indicates a high-quality carbon.

ACTIVATED CARBON

Activated carbon can come in several different physical forms including powder, granular, pellets, paper, and honeycombs. Powder activated carbon (PAC) is used in water applications and to make other forms and structures such as extruded pellets and honeycombs. Granular activated carbon (GAC) and pellets can be used in trays or cylinders or GAC and PAC can be incorporated into pleated filter media. Honeycombs are self-supporting, structured media assembled into modules typically 2-6 inches deep.

It is important to understand that not all activated carbons and adsorbents are created equal and not all are suitable for cannabis odor mitigation. When comparing different activated carbon filters, it is important to target the compounds present. Activated carbon can remove terpenes and general VOC’s easily without any additives. However, if sulfur compounds are produced from a secondary source for example from fertilizers, additives are required to effectively capture these small compounds.

There is a wide range of activated carbon products on the market- from 1-inch filters to deep bed carbon scrubbers, all target different applications and removal requirements and each promoting their product advantages and present performance data in a variety of ways. Navigating the growing number of activated carbon suppliers can be a challenge. But understanding a few basic principles and parameters can help. The three basics are capacity, efficiency, and mass transfer zone (MTZ). Activated carbon performance is typically presented as capacity and efficiency. Generally, capacity refers to the amount of a gas that a given amount of activated carbon can remove under a given condition. Efficiency represents the upstream/downstream removal rate of the activated carbon system for a given gas at a given concentration and airflow. It is very difficult to compare filter capacities and efficiencies across different products unless they are tested under the same conditions. One standard method for testing activated carbon performance is ASHRAE Standard 145.2 designed to test full size products that are used in the field. The test provides both a lifetime estimate and a filter efficiency [13].

A critical activated carbon design factor that is often overlooked is mass transfer zone (MTZ). MTZ is the section of carbon where active adsorption is occurring, or more specifically, the depth of carbon needed for complete capture of the gas, at a given airflow and concentration. As shown in Figure 1, the MTZ (blue dashed rectangle) starts at the inlet and moves through the media as it becomes consumed. The media above the MTZ is saturated with a given gas (solid green) and no longer has active adsorption. Below the MTZ there is new media (white) that the gas has not entered yet. Most applications will have multiple contaminant gases and therefore will have multiple MTZs, one for each gas. These MTZs will vary in length and will move at different rates, which can make estimating the lifetime for a system difficult. The MTZ length determines the efficiency and effective lifetime of the media rather than its capacity. For example, a carbon can have high overall capacity, but if the MTZ is long or the media depth is short, contaminants will exit the filter and lead to odor complaints. In this example, the carbon would be replaced before it could fully utilize the total capacity.

The MTZ is not only influenced by the type, concentration and number of contaminants, but also other design factors including the area of media and airflow through the media. The higher the concentration and/or air velocity, the longer the MTZ and the more depth that is required to prevent contaminant breakthrough and downstream odors.

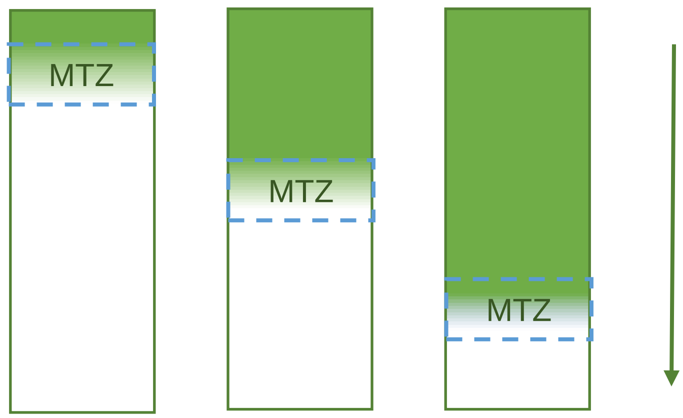


Figure 1. Progression of the mass transfer zone through a column of media

OTHER FACTORS

Outside of the activated carbon performance, there are other important factors to consider in overall system design. Whether trying to retrofit an existing system or designing a new one, pressure drop must be taken into account. Simply put, pressure drop is the resistance to airflow of the air cleaning system. Existing HVAC systems will be designed with a certain maximum pressure drop. For new and/or stand-alone systems it is an important factor that relates directly to energy consumption. It is also directly related to the format of carbon filter chosen. or example, pellet beds can be very effective, but they are very dense (think of a bag of dog food) and it takes a lot of energy to push air through them. Honeycomb modules allow for more consistent airflow and far lower pressure drops. There is a fine balance between maintaining effective odor removal and minimizing energy cost.

Another simple and often forgotten way to maintain carbon performance is to install adequate prefiltration to protect and prevent damage to the activated carbon. Debris can build up on the surface of the activated carbon over time reducing the carbon availability, inhibiting the adsorption of gases and restricting air flow. At minimum a MERV 8 filter should be used upstream of the carbon and should be replaced frequently based on the manufacture's instruction.

Below is a real-world example of improved performance when protecting activated carbon. In a field comparison of activated carbon matrices installed in a large grow facility, in System A one set of carbon modules were protected by MERV 8 particulate filters and in System B the carbon modules were protected by active-field polarized media air cleaners. The polarized media is not only a high-efficiency particulate filter, but it can also remove 40-60% of VOCs in the air stream. After 7 months of installation a carbon module from each air handler configuration was removed and returned for spent carbon analysis. This test allowed the determination of remaining carbon capacity of the field carbon compared to unused carbon. After 7 months, the inlet of System A was 55% consumed; that of System B was only 42% consumed. Similarly, the analysis of the outlets showed that System A was 46% consumed and System B was only 37% consumed. The higher loading at the inlet demonstrates how the MTZ moves through the media consuming the inlet first.

The results show that the use of the polarized media pre-filter can significantly extend carbon life. They will also remove virtually all biologicals in the airstream.

Table 2. Spent Carbon Analysis Results (% consumed)

Filter Description	Inlet (% Consumed)	Outlet (% Consumed)
Polarized Media + Carbon	42%	37%
MERV 8 + Carbon	55%	46%

As the modules become consumed over time, their efficiency will be reduced, and odors will start to breakthrough more readily and in higher concentrations resulting in detectable odor at the exhaust. After 7 months the carbon modules still had remaining life and remained in use. It is typically recommended to replace the carbon when it is approximately 70%-80% consumed if odor is not detected prior. It was estimated that this application would be able to keep the remaining carbon in place for a total time of a year before change-out.

CONCLUSION

The implementation of a comprehensive odor mitigation strategy is more than simply buying an off-the-shelf carbon filter. Beyond what is discussed above such factors as building envelope and pressurization, air change rates, and airflow patterns all make a difference. It is important to work with an engineer and/or supplier that have experience designing activated carbon systems so the result is a long-lasting solution that will effectively remove odors without increasing energy and maintenance costs.

REFERENCES:

[1] V. Allen, " Beyond Delta-9-THC and CBD: Current Evidence for Medical Benefit of Terpenes and Less Studied Cannabinoids.," May-June 2019.

[2] J. K. Booth, J. E. Page and J. Bohlmann, "Terpenes synthases from Cannabis sativa.," *Plos one,* vol. 12, no. 3, p. e0173911, 2017.

[3] A. Hazekamp, "Cannabis-from cultivar to chemovar," *Drug Testing and Analysis,* vol. 4, no. 7-8, pp. 660-667, 2012.

[4] J. K. Booth and B. Bohlmann, "Terpenes in Cannabis sativa- From plant genome to humans," *Plant Science,* pp. 67-72, 2019.

[5] Z. Haddi, "A portable electronic nose system for the identification of cannabis-based drugs.," *Sensors and Actuators B: Chemical,* vol. 155, no. 2, pp. 456-463, 2011.

[6] S. Rice and J. A. Koziel, "Characterizing the Smell of Marijuana by odor impact of volatile compounds: an applciation of simultaneous chemical and sensory analysis.," *Plos one,* p. e0144160, 2015.

[7] V. Mediavilla, "Essential oil of Cannabis sativa L. strains," *J Int Hemp Association,* vol. 4, pp. 80-82, 1997.

[8] C.-T. Wang, "Leaf enclosure measurements for determining volatile organic compound emission capacity from Cannabis spp.," *Atmospheric Environment* , vol. 199, pp. 80-87, 2019.

[9] A. Eykelbosh, "Growing at Home: Health and Safety Concerns for Personal Cannabis Cultivation.," National Collaboration Centre for Envrionmental Health, 2018.

[10] E. B. Russo, "Taming THC: potential cannabis synergy and phytocannabinoid-terpenoid entourage effects.," *British J of Pharmacology,* vol. 163, no. 7, pp. 1344-1364, 2011.

[11] B. Whipker, P. Cockson, P. Veazie, J. T. Smith and H. Landis, "Balancing the Nutrient Equation in Cannabis Cultivation," *Cannabis Business Times,* 6 September 2019.

[12] "Special Report: Cannabis Odor Control," *Cannabis business Times,* May 2019.

[13] A. S. 145.2-216, "Laboratory Test Method for Assessing the Performance of Gas-Phase Air Cleaning Systems: Air Cleaning Devices," ASHRAE, 2016.

The New York Times https://www.nytimes.com/2018/12/19/us/california-marijuana-stink.html

'Dead Skunk' Stench From Marijuana Farms Outrages Californians

By Thomas Fuller
Dec. 19, 2018

CARPINTERIA, Calif. — They call it fresh skunk, the odor cloud or sometimes just the stink.

Mike Wondolowski often finds himself in the middle of it. He may be on the chaise longue on his patio, at his computer in the house, or tending to his orange and lemon trees in the garden when the powerful, nauseating stench descends on him.

Mr. Wondolowski lives a half-mile away from greenhouses that were originally built to grow daisies and chrysanthemums but now house thousands of marijuana plants, part of a booming — and pungent — business seeking to cash in on recreational cannabis, which has been legal in California since January.

"If someone is saying, 'Is it really that bad?' I'll go find a bunch of skunks and every evening I'll put them outside your window," Mr. Wondolowski said. "It's just brutal."

When Californians voted to legalize recreational marijuana in 2016, there were debates about driving under the influence and keeping it away from children. But lawmakers did not anticipate the uproar that would be generated by the funk of millions of flowering cannabis plants.

As a result of the stench, residents in Sonoma County, north of San Francisco, are suing to ban cannabis operations from their neighborhoods. Mendocino County, farther north, recently created zones banning cannabis cultivation — the sheriff's deputy there says the stink is the No. 1 complaint.

Cannabis buds on plants at New Family Farm in Sebastopol, Calif. Jim Wilson/The New York Times

In Santa Barbara County, cannabis growers confronting the rage of neighbors are spending hundreds of thousands of dollars installing odor-control systems that were designed for garbage dumps.

The smell from commercial cannabis farms, which brings to mind a mixture of rotting lemons and sulfur, is nothing like the wafting cloud that might hover over a Phish show, pot farm detractors say.

"It's as if a skunk, or multiple skunks in a family, were living under our house," said Grace Guthrie, whose home sits on the site of a former apple orchard outside the town of Sebastopol. Her neighbors grow pot commercially. "It doesn't dissipate," Ms. Guthrie said. "It's beyond anything you would imagine."

The Science of Smell

Learn more about our often disregarded, and at times startling, superpower.

- **Perks of Evolution:** Genetic changes to our olfactory receptors have altered people's sensitivities to some odors over time.
- **Lessons From Covid:** The loss of smell and parosmia experienced by some have opened new doors to understanding the most neglected sense.
- **The Nasal Ranger:** For a half-century, Chuck McGinley has visited society's stinkiest sites in order to measure, and demystify, smell.
- **The Smell of History:** Several scientists, artists and historians are working hard to conserve the smells of our times and revive lost scents.

When cannabis odors are at their peak, she and her husband, Robert, sometimes wear respirators, the kind one might put on to handle dangerous chemicals. During Labor Day weekend, relatives came to stay at the house, but cut short their visit because they couldn't stand the smell.

"I can't be outside more than 30 minutes," Mr. Guthrie said of peak odor times, when the cannabis buds are flowering and the wind sweeps the smell onto his property. "The windows are constantly closed. We are trapped inside. There's no escape."

Britt Christiansen and her neighbors in Sonoma County banded together and sued the operators of a local pot business over the smell. Jim Wilson/The New York Times

After nearly one year of recreational sales in California, much of the cannabis industry remains underground. Stung by taxes and voluminous paperwork, only around 5 percent of marijuana farmers in the state have licenses, according to Hezekiah Allen, the executive director of the California Growers Association, a marijuana advocacy group. Sales of legal cannabis are expected to exceed $3 billion this year, only slightly higher than medical marijuana sales from last year. Tax revenues have been lower than expected, and only about one-fifth of California cities allow sales of recreational cannabis. The dream of a fully regulated market seems years off.

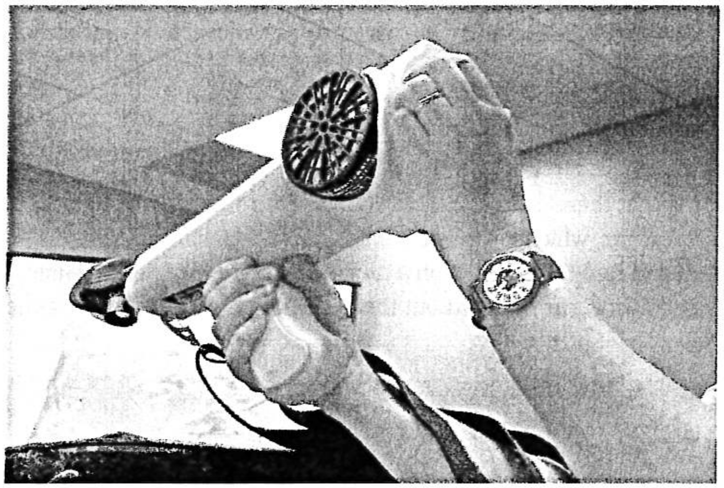
The ballot measure legalizing recreational marijuana passed in 2016 with a comfortable majority of 57 percent. Many of those complaining about cannabis odors say they were among those who supported it. They just don't want it stinking up their property, they say.

"Just because you like bacon doesn't mean you want to live next to a pig farm," said Lynda Hopkins, a member of the Sonoma County Board of Supervisors, whose office has been inundated with complaints about the smell.

The odor question is also roiling local politics.

Marijuana businesses in Carpinteria recently donated $28,000 worth of lab equipment to Carpinteria High School, according to Philip Greene, the chief of operations for Ever-Bloom, a cannabis producer that helped coordinate the donation. The high school is flanked by cannabis greenhouses that have sent odors wafting in. In the past two years, students have complained of headaches, parents have grown angry and the high school has had to warn visiting sports teams that they might encounter the odor.

The donation has not yet been made public, but is seen by some as an effort to offset the damage done by the stench. In an interview, Maureen Foley Claffey, a member of the Carpinteria School Board, said it would send a "confusing and problematic" message to students to accept it. Ms. Claffey lashed out at the superintendent, Diana Rigby, for soliciting donations from the cannabis industry at a time when members of the community are battling the stink.



A Nasal Ranger, a device that measures the odors in the air. It is in use in Colorado, the first state to legalize recreational marijuana.
Dave Kolpack/Associated Press

"Are we that desperate for cash that we are willing to take it from anyone without regard to the source and the message?" she said. "I guess money talks."

Ms. Rigby, the superintendent, did not return phone calls or email requesting comment.

In Sonoma County, hearings on cannabis ordinances at the board of supervisors overflow with representatives from the cannabis industry, who wear green, and angry residents, who wear red.

Of the more than 730 complaints Sonoma County has received about cannabis this year, around 65 percent are related to odor, according to Tim Ricard, the county's cannabis program manager.

"There's been a tremendous amount of tension in the community," said Ms. Hopkins, the Sonoma supervisor. "If I had to name an ice-cream flavor for cannabis implementation it would definitely be rocky road."

Cannabis executives recognize that pot grows can be odorous, but say their industry is no different from others that produce smells.

Dennis Hunter, right, a co-founder of CannaCraft, a marijuana business in Santa Rosa in Sonoma County, watching Matt Kulczycki filling a mold with cannabis-infused dark chocolate. Jim Wilson/The New York Times

"You have a smell issue that sometimes can't be completely mitigated," said Dennis Hunter, a co-founder of CannaCraft, a large marijuana business based in Santa Rosa in Sonoma County. "But we have dairy farms here in the area or crush season for the vineyards — there's agricultural crops, and a lot of them have smells."

Britt Christiansen, a registered nurse who lives among the dairy farms of Sonoma County, acknowledges that her neighborhood smells of manure, known locally as the Sonoma aroma.

But she says she made the choice to live next to a dairy farm and prefers that smell to the odor that drifted over from the marijuana farm next door to her house.

"We opened the door and the smell kicked us in the face," Ms. Christiansen said. Her neighbors banded together in October and sued the operators of the pot business; the case is ongoing.

One problem for local governments trying to legislate cannabis odors is that there is no objective standard for smells. A company in Minnesota, St. Croix Sensory, has developed a device called the Nasal Ranger, which looks like a cross between a hair dryer and a radar gun. Users place the instrument on their nose and turn a filter dial to rate the potency on a numerical scale. Charles McGinley, the inventor of the device, says a Level 7 is the equivalent of "sniffing someone's armpit without the deodorant — or maybe someone's feet — a nuisance certainly."

Lawmakers did not anticipate the uproar that would be generated by the funk of millions of flowering cannabis plants. Jim Wilson/The New York Times

A Level 4, he said, is the equivalent of a neighbor's freshly cut grass. "It could still be a nuisance, but it wouldn't drive you away from your front porch," Mr. McGinley said.

Standing next to a flowering cannabis bud, the smell would easily be a Level 7, Mr. McGinley said.

The Nasal Ranger is in use in Colorado, the first state to legalize recreational marijuana, but California counties and cities are still struggling with the notion that smells are subjective.

Ever-Bloom in Carpinteria is one of a number of marijuana businesses that have invested hundreds of thousands of dollars to mitigate the stink. Two previous systems failed, but the current one, modeled on devices used to mask the smell of garbage dumps, sprays a curtain of vapor around the perimeter of the greenhouses. The vapor, which is made up of essential oils, gives off a menthol smell resembling Bengay.

Dennis Bozanich, a Santa Barbara County official charged with cannabis implementation who has become known as the cannabis czar, says the essential oil odor control has been largely successful. But not every grower can afford to install it.

On weekends, Mr. Bozanich becomes a cannabis odor sleuth, riding his bicycle through Carpinteria sniffing the air for pot plants. He recently drove through the area with a reporter, rolling down the windows on a stretch of road with cannabis greenhouses. He slowed the car and puzzled over where a cannabis odor was coming from.

"I've got one stinky location right here and I can't quite figure it out," he said.

His description of the stink?

"Dead skunk."

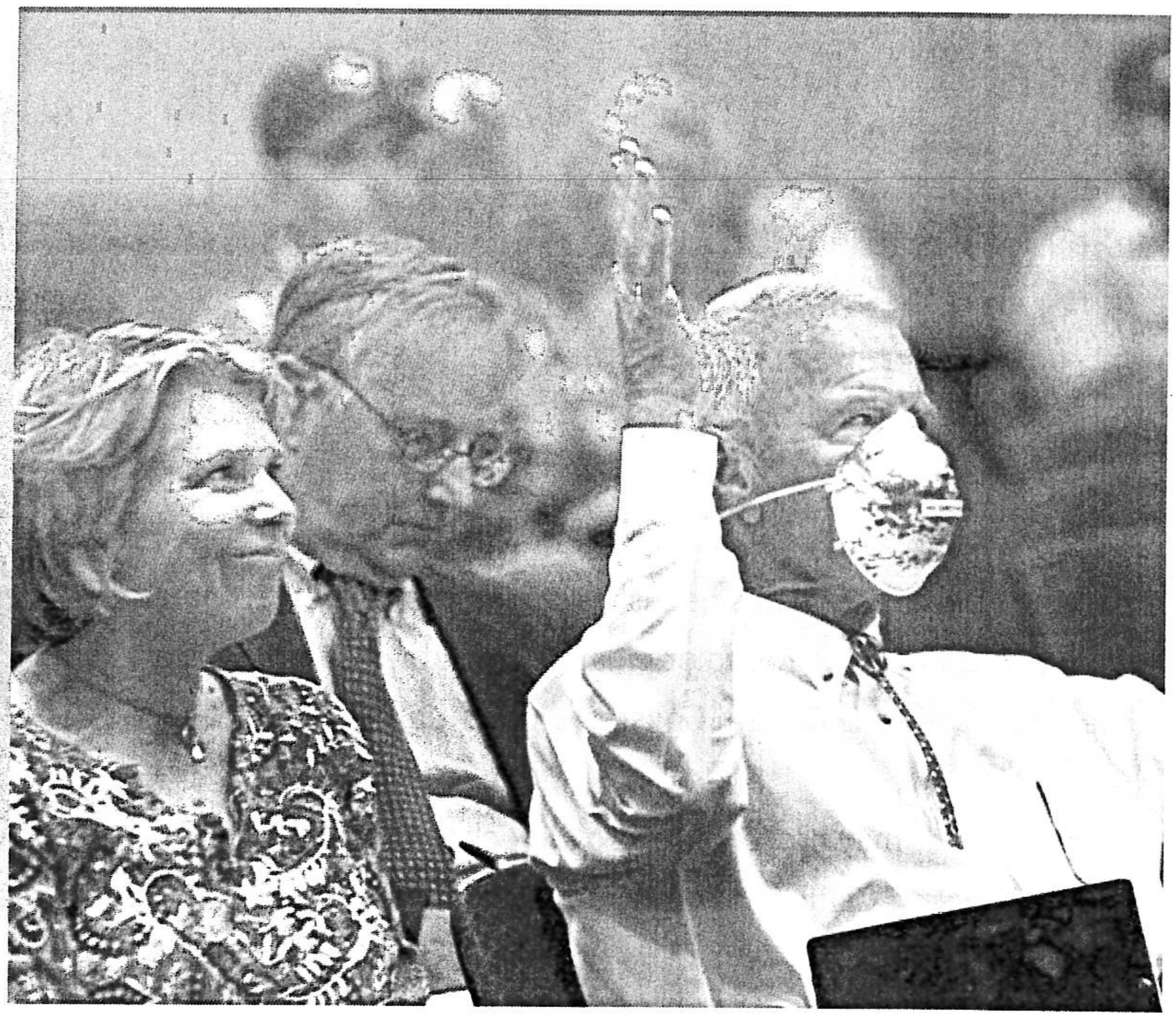
https://lompocrecord.com/news/local/odor-water-remain-concerns-for-residents-when-it-comes-to-cannabis-grows/article_3e84e980-9cd0-5914-956b-7515b6636198.html

Odor, water remain concerns for residents when it comes to cannabis grows

From the Lee President's Award - Green Rush in the 805?: Cannabis on the Central Coast - Looking at land use, money, science, law enforcement and education series

Logan B. Anderson landerson@leecentralcoastnews.com

Dec 29, 2017



Cebada Canyon resident Derek McLeish waves his hands in support of opponents of commercial marijuana grows. He w in Santa Maria on Oct. 17 to show how pervasive he believes the scent of marijuana is in the canyon.
Len Wood, Staff

A cousin to roses, strawberries, hops and nettles, cannabis is an annual flowering plant with environmental impacts that are as contested as its benefits.

Some experts believe cannabis plants need a lot of water to grow, while others dispute those claims. Meanwhile, neighbors of cannabis operations contend the plant's biggest impact hits them square in the nose, while growers attempt to mitigate those odors.

As the cannabis industry develops in California, county and local governments are weighing its potential impacts on the environment as they work to regulate it.

Water a precious commodity

Like many plants, cannabis needs water, light and mild temperatures to grow — conditions that can be found or created in Santa Barbara County — which is why growers have pinpointed the Central Coast as a potential hot spot.

Access to water may prove to be a roadblock for both county officials and growers in drought-stricken California, however, as both groups seek to preserve and protect their interests.

While cannabis needs a reliable source of water to grow, how much water remains an ongoing topic of debate.

One group of growers determined it takes one gallon of water per day to grow one pound of processed cannabis flowers, according to a 2015 study conducted by the Mendocino County Cannabis Policy Council, along with the Emerald Growers Association.

State officials peg that number at least six times higher.

The California Department of Fish and Wildlife estimated that marijuana plants use six to eight gallons of water per plant per day, according to a study state officials released on the same region in 2015.

While the debate continues, state leaders have recognized water concerns in the drought-stricken state and are requiring cannabis cultivators to prove where they plan to get their water.

"Especially if they are relying on water diverted from a stream or creek or sinking a new well, the state is going to want to see that has been done in accordance to all the state water regulations," said Dan Klemann, deputy director for the Santa Barbara County Planning and Development Department.

If the Board of Supervisors ultimately decides to allow the cannabis industry to do business in the unincorporated parts of the county, cultivators would have to prove their water needs won't impact local water resources.

“We have a local policy that says we cannot approve a permit unless you have a viable water source,” Klemann said.

For example, if a new cannabis cultivation operation is permitted to do business in the county and opted to drill a well for its water needs, county officials would verify where the well's water is coming from and whether there is enough to sustain the business through its projected goals. They would also determine if other users of the water source would be impacted.

Residents in Tepusquet Canyon, located southeast of Santa Maria, have publicly pleaded with Santa Barbara County supervisors to restrict cannabis activity in the Tepusquet Canyon area due to the scarcity of water.

Some residents have claimed the wells on their properties have gone dry during the region's recent water woes, prompting them to truck in water for their personal use.

“(Tepusquet) Canyon cannot support this industry," said Renee O'Neill, a 30-year resident of the canyon. "They are going to destroy our community by depleting our water source. At the rate they are going, the water will be gone in 10 years."

Klemann predicts that the county won’t see many permit requests for completely new cannabis operations but, rather from current agriculture operations that are either changing or diversifying their crops.

One area where growers are swapping out their regular crop for cannabis is in Carpinteria, where longtime flower-growing operations are moving to grow marijuana.

Those operations have a proven water source for their already established systems, and many growers recapture the water not used by their plants to further reduce impact on local water resources, Klemann said.

Though the process has not been set, Klemann said the county will consider water and its availability when considering any potential cannabis permits in the future.

Odor control a hot topic

As cannabis grows, it produces oils, which are an essential ingredient in its mind-altering abilities but also emit a powerful odor.

Many have compared the smell to what happens after a skunk sprays its scent gland, while others have described it as sweet and fruity. Most would agree the odor is strong.

Several communities want county leaders to make odor control a hefty part of any potential regulation or permitting process if officials ultimately decide to give the industry a green light.

“Please consider the effect of commercial marijuana production on our residential population. We are sick of smelling the terpenes emitted by illegal commercial operations in Cebada Canyon," Derek McLeish said during a county hearing on cannabis in October.

"We’ll become even sicker if full commercial agriculture and manufacturing are allowed,” he added.

To raise awareness about his concerns about cannabis on air quality near his home east of Lompoc, McLeish has addressed county leaders wearing a pollution mask splashed with green paint.

In the Carpinteria Valley, the smell surrounding the farming, storage and manufacturing of cannabis has been a key issue at public meetings.

Residents have claimed the smell of cannabis in the area has intensified in the past two years as greenhouses in the town that once used to grow cut flowers have been given a new lease on life as cannabis cultivation operations.

Area education leaders have even raised concerns with county leaders.

Carpinteria Unified School District Superintendent Diana Rigby recently wrote a letter to county leaders alerting them to "strong objectionable cannabis odors originating from agricultural operations" near Carpinteria High School.

According to Rigby, the high school, located in the 4800 block of Foothill Road, is surrounded by cannabis growers and greenhouses.

"I strongly recommend that you investigate a more effective distance (such as the 1,000 feet proposed in SLO County) to ensure that the cannabis activities are not interfering with nor compromising the safety of our students and staff at Carpinteria High School," Rigby said in her address to supervisors.

State law sets cannabis industry buffer zones around schools at 600 feet and no cannabis-related activity is permitted within the setback areas.

Though county leaders have not made any firm decisions about school setbacks in Santa Barbara County, the board only has the power to increase the setback areas, not decrease them.

Ways to kill the odor

The means to address odors associated with growing cannabis are as varied as the ways to grow the plant.

Greenhouses, or other indoor operations, can use carbon air scrubbers or other filtration systems. They could also seal their operations to prevent odors from escaping.

Odors from outdoor operations may prove more difficult to mitigate, but not impossible.

Nationwide, many landfill operations use an air freshener-like system that mists a chemical in the air, capturing and trapping odor-causing molecules.

Marc Byers, of Indiana-based Byers Scientific & Manufacturing, has been on the Central Coast recently selling another patent-pending odor mitigation system to Carpinteria-based growers.

Similar to the air-freshening systems, the Byers' machines use a waterless, proprietary chemical to capture and reduce odors in the air.

During a recent Board of Supervisors meeting, he said he's sold about a dozen systems, which he said can be interpreted as an indication that growers are serious about dealing with odor concerns since his systems "are not cheap."

Government leaders also have options when it comes to odor.

County officials could make it illegal for indoor cultivators to release any untreated or unfiltered air from their grows.

They could also restrict where cannabis is grown and increase setback areas around cannabis operations in order to reduce the impact of odor on neighbors.

Discussions on environmental impacts will continue when the Santa Barbara County Planning Commission takes up the topic of a cannabis land-use ordinance during its Jan. 10 meeting. The county Board of Supervisors also has a cannabis update meeting slated for early February.

Logan B. Anderson covers city government in Santa Maria for Lee Central Coast Newspapers. Follow him on Twitter: @LoganBAnderson.

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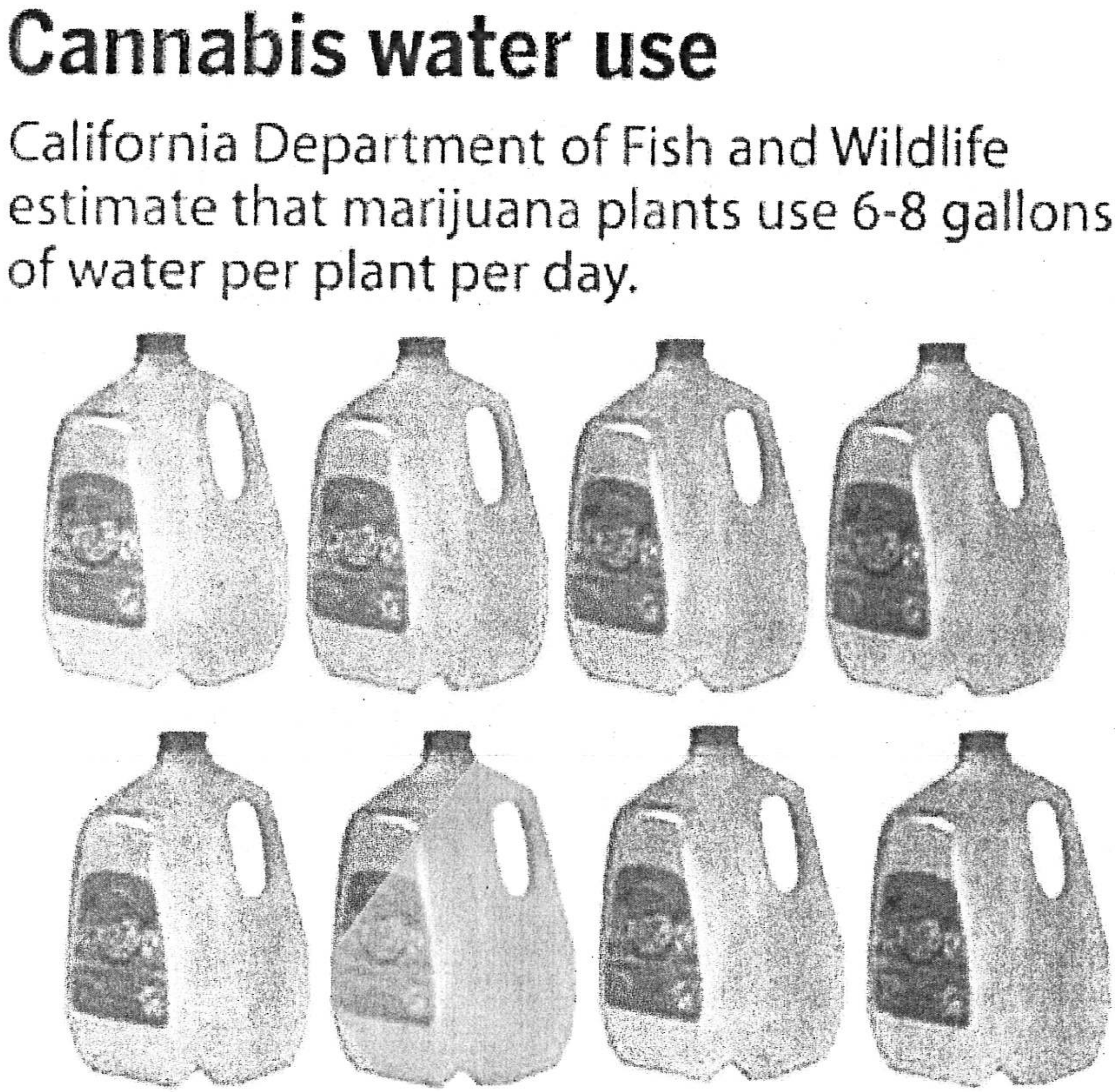
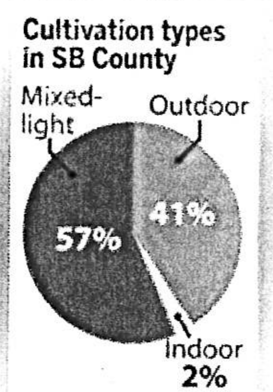
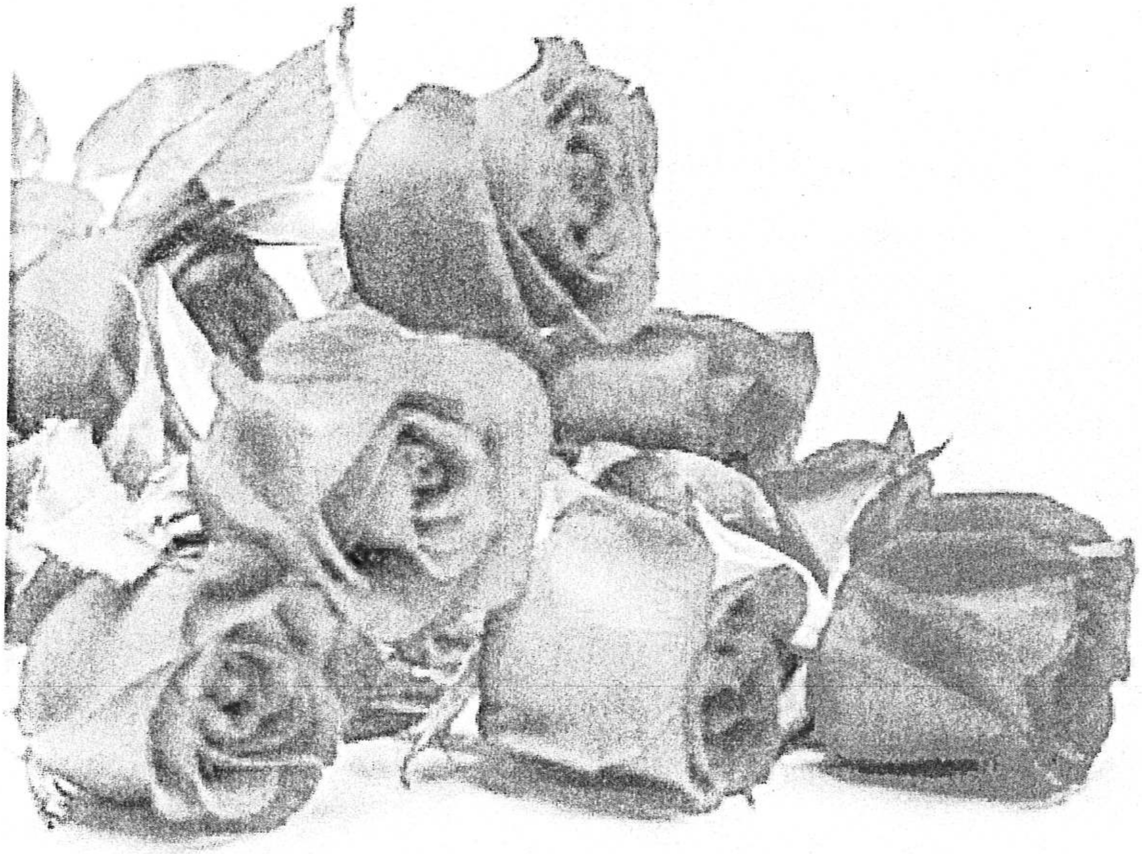


Cannabis water use
Updated Jan 5, 2018



Cultivation types

Len Wood, Staff Updated Jan 5, 2018



Roses & Raspberries: Safety, weeds, roses

County of Santa Cruz
Cannabis Licensing Office
701 Ocean Street, Room 520
Santa Cruz, CA 95060
831-454-3833
Cannabisinfo@santacruzcounty.us

Santa Cruz County
cannabis licensing

Date: March 3, 2021

Dear Ms. Drake,

On behalf of the Cannabis Licensing Office ("CLO"), I'd like to provide some additional information for your consideration of Application #211083 for commercial cannabis cultivation at 375 Old Mount Road in Felton (the "project"). The project proposes a co-location cannabis cultivation operation with a total of 20,000 square feet of cultivation space in an A (Agriculture) zone district.

Per the application materials, the project will not utilize any electricity for cultivation. Electricity will be utilized to power refrigerated trailers used to temporarily store cannabis prior to being removed from the site during harvest operations. Electricity is required to be provided to these trailers from a stationary source as generators for cannabis operations, outside of the commercial agricultural zone district, are prohibited.

The property has an existing agricultural use: grape vines. The proposed changes to the existing agricultural use are negligible and do not amount to any significant environmental impacts. Commercially grown cannabis will replace commercially grown grapes on a half-acre portion of an existing 5-acre vineyard. A 20,000 square foot area of existing vines will be replaced with cannabis plants in above-ground pots. There is no expansion of the agricultural use proposed through this application as no additional land will be used for agriculture.

Cannabis cultivation is defined by Santa Cruz County Code ("County Code" or "SCCC") Section 13.10.700-C as: "The planting, growing, developing, propagating, harvesting, drying, processing, curing, grading, trimming, packaging, or storage of one or more cannabis plants or any part thereof in any location, indoor or outdoor, including within a fully enclosed and secure building." This definition should be read consistently with the definition for cannabis cultivation set forth in SCCC 7.128, to the extent there any differences. The County considers cannabis cultivation to be an agricultural activity. Per the County Code, cannabis cultivation is an agricultural activity similar to the cultivation of any other row crop, including grape vines.

The temporary use of refrigerated trailers being brought on-site to store the cannabis plant material during harvest operations is similar to the existing vineyard uses on-site. The vineyard use includes seasonal employees and commercial vehicles are brought on-site to harvest and transport grapes off-site. The difference is the cannabis must be stored temporarily in refrigerated trucks to preserve the harvested goods prior to transporting it off-site. This is a negligible difference between the existing operation and the proposed operation. As previously stated, the County prohibits generators from being used so the refrigerated trucks will be supplied power from the existing residence. This electrical power versus generator power further decreases potential impacts.

The proposed use of hoop houses at the site is also temporary in nature. Hoop houses are not permanent structures per the County Code, and impacts from the use of hoop houses will be further mitigated as the covers are required to be removed during the rainy season. This requirement was developed with the Department of Public Works to prevent sedimentation from concentrated run off which can occur from impervious surfaces. This is also a best management practice that the State Water Resources Control Board has identified for all agricultural operations.

The project's proposed water use will be minimized on the site through the use of drip irrigation, as required by CLO's Best Management Operations Practices plan with which all cannabis businesses are required to comply. The County calculated potential water use at this site based on existing operators within the County and a recently published study by the Resource Innovation Institute, Berkeley Cannabis Research Center and New Frontier Data, Cannabis H2O Water Use & Sustainability in Cultivation, 2021 ("Berkeley Study") (Exhibit A). The Berkeley Study utilizes real world data from various cannabis cultivation sites in multiple states, including separate data for California cultivation facilities. The results of that study show the average water use for outdoor cultivation is 11.3 gallons per square foot, per year. That is equivalent to 226,000 gallons of water per year for this proposed site.

Additionally, data CLO have from another cultivator in the Santa Cruz mountains show they use on average 72,000-90,000 gallons for 10,000 square feet of canopy per year; meaning that even at the top end of this average, the project might use 180,000 gallons of water per year for 20,000 square feet of canopy. This estimated water use is below the average value observed in the Berkeley Study likely due to the County's requirements to utilize drip irrigation. It is worth repeating here that County oversight of water use for commercial agricultural operations is limited to the issuance of permits for well construction and on-site wastewater disposal facilities (septic systems), which means the County does not regulate the total amount of water used. The County employs the drip irrigation requirement as a way to minimize water use. The property has a permitted well, and it is CLO's understanding that the well can provide enough water for the project.

Notably, an average home uses 131,400 gallons of water per year. The project will likely use slightly more water than an average home at 150,000-200,000 gallons per year. A residential project that included a new residence and an accessory dwelling unit with a projected use of 150,000-200,000 gallons of water per year would be considered a minor additional use or a minor alteration. For that reason, the environmental impact of the project's water use is negligible. The proposed water to be used for the project's agricultural purpose on a parcel zoned for agriculture constitutes a minor alteration. Unlike other crops, the State of California regulates water use for cannabis operations through the State Water Resources Control Board and the Department of Fish and Wildlife. The applicant for this project obtained coverage from both agencies, meaning the water use from the on-site well has been approved by the appropriate state agencies.

The compliance with CLO's Best Management Operations Practices plan paired with frequent inspections will ensure there are no additional impacts to wildlife at the proposed site. There will be no light pollution or noise generated from the project as the outdoor cultivation does not use lighting or any significant noise producing apparatus. The existing vines that will be removed from the site will be replaced by cannabis planted in above-ground pots. Therefore, soil disturbance is not anticipated. The site is currently fenced, and the proposed operations do not include additional fencing which would prevent wildlife movement in the area.

Cumulative impacts from cannabis operations are considered when evaluating this and all cannabis projects for the purpose of CEQA review. The Cannabis Licensing Office and the Planning Department have spent significant time and resources on this issue. Our efforts include the development of a draft Environmental Impact Report ("EIR") for the County, which identified potential impacts from the legalization of cannabis. The draft EIR was never certified because the State provided a CEQA exemption for local cannabis cultivation ordinances during the legalization process. However, the County used those identified impacts in the draft EIR to develop a Best Management Operations Practices plan, which is the basis for mitigation measures for non-retail cannabis operations in the County. In terms of cumulative impacts from water use, the County has followed the science and available data from agencies in our area. In addition to the Berkeley Study cited above, the County has analyzed data from the Pajaro Valley Water Management Agency ("PVWMA"), Irrigation Rate Analysis Update Memorandum, 2013 (Exhibit B). We compared the data from PVWMA and the Berkeley Study and publicized the following table in October 2021 via an update to the Board of Supervisors (Exhibit C).

Crop	Water Use Per Square Foot Per Year (Gallons)*	Water Use Per Acre Per Year (Gallons)
Apples	3.7	162,925
Cannabis (Outdoor)	11.3	492,228
Nurseries / Cut Flowers	13.5	586,532
Cannabis (Mixed-Light)	14.9	649,044
Raspberries	15.0	651,702
Mixed Berries	15.7	684,287
Strawberries	18.7	814,628
Vegetables Row Crops	18.7	814,628
Average Water Use to irrigate lands in the Pajaro Valley	16.5	716,873

These data are critical in our understanding of water use impacts for cannabis and non-cannabis crops. The County's analysis paired with these data and collaboration with partner agencies at the state level are critical to understanding why this project does not have the potential to contribute to a significant cumulative impact on water resources. Evidence to support this assessment are:

- The inclusion of mitigation measures required by our ordinance (the Best Management Operations Practices) minimize cumulative impacts;

- The specifics of this project being an agricultural use replacing an existing agricultural use further minimize any contribution to cumulative impacts; and

- The absence of other existing or proposed cannabis cultivation sites in the vicinity of this proposed site.

This cumulative impact analysis conforms with the June 17, 2019 Memorandum published by the California Department of Food and Agriculture's CEQA Practice Recommendations from the CDFA for Cannabis Cultivation – Categorical Exemptions (Exhibit D).

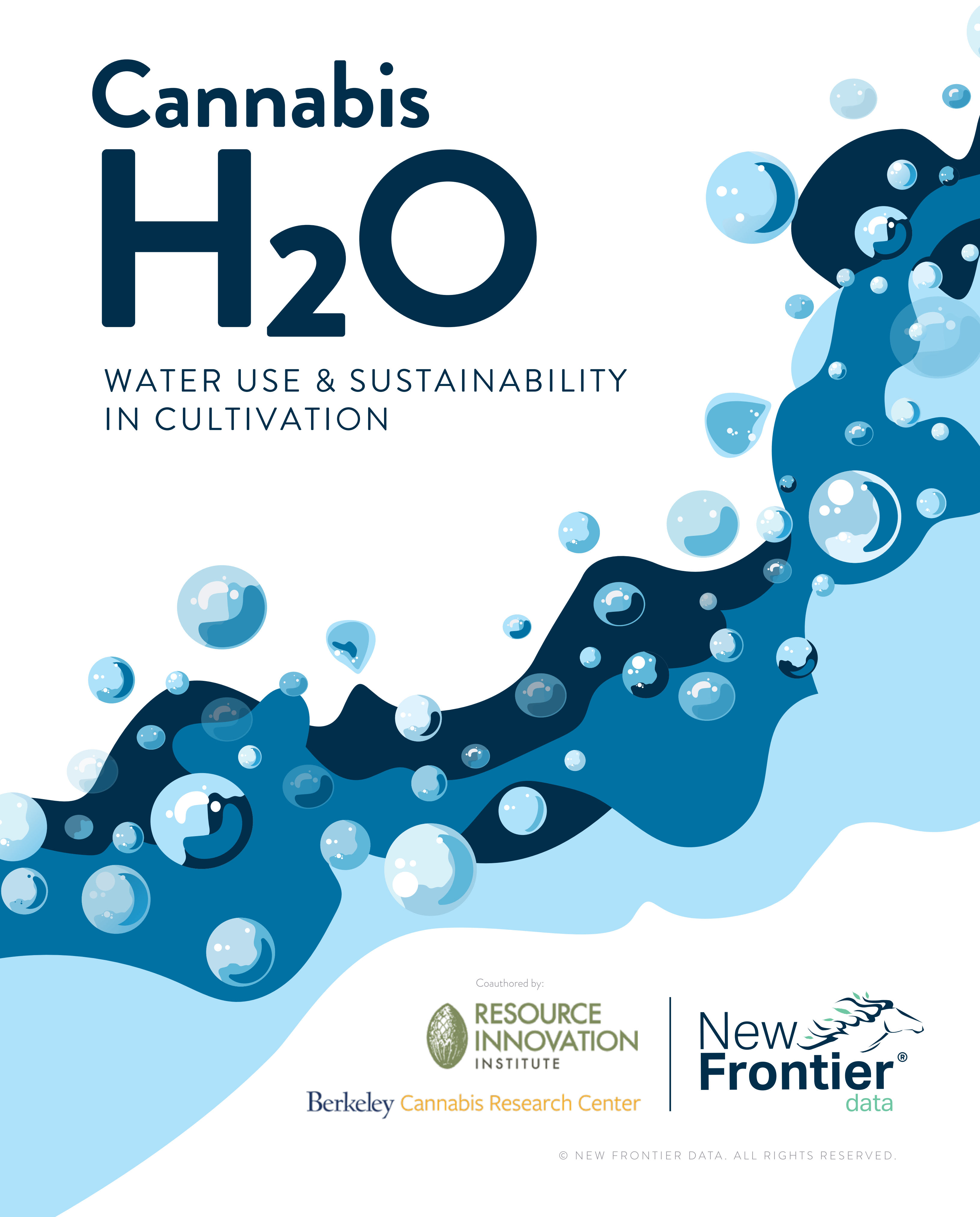
This information is intended to assist you in your determination of CEQA compliance for the proposed operations. Should you have any questions I will be available during the public hearing to address any items and provide clarity.

Samuel LoForti
Cannabis Licensing Manager
County of Santa Cruz

EXHIBIT A

Cannabis H_2O

WATER USE & SUSTAINABILITY IN CULTIVATION



Coauthored by:

RESOURCE INNOVATION INSTITUTE

Berkeley Cannabis Research Center

New Frontier® data

Contents

letter from the **Publisher**

IN A PERFECT WORLD, cannabis cultivators could focus on terrior, the particular geographical and climactic influences which (as for wine vintners) influence a seasonal crop and vintage. In today's world, however, outside concerns intrude a bit more terribly: While environmental conditions have traditionally favored Western states of the United States for the outdoor cultivation of cannabis, the 21st-century's burden of changing climate conditions is increasingly leaving them vulnerable to some of the most acute drought conditions in the country. Arizona, California, Colorado, Nevada, New Mexico, and Oregon (which collectively account for 71% of the nation's total cannabis supply, both legal and illicit) are being keenly afflicted, according to the National Oceanic and Atmospheric Administration's Drought Monitor.

To better understand and anticipate the industry's realities and responsibilities, New Frontier Data and our report partners at the Resource Innovation Institute (RII) and the Berkeley Cannabis Research Center present ***Cannabis H2O: Water Use & Sustainability in Cultivation*** to foster a fundamental understanding of how, and how much, water is used for cannabis cultivation.

It has never been more incumbent upon industry to identify how it can improve resource efficiency. Indeed, the premium to be placed on systemic responsibility becomes ever more important as the nation's legalized cannabis markets expand. Including the latest five states which mandated programs in the November elections, New Frontier Data expects the overall legal U.S. cannabis industry to grow at a compound annual growth rate of 21% through 2025, to reach $41.5 billion. That figure represents more than 3x the $13.2 billion legal market of 2019. Our projections reveal that while legal production of cannabis represented nearly a quarter of the 2020 total U.S. market (including illicit sales), that share should increase to reach 35% of the market by 2025. Conversely, the nation's illicit market is expected to see sales decline from $66 billion in 2019 to $64 billion in 2025.

During that same period, researchers expect total water use in the legal cannabis market to increase by 86%. Though some critics and opponents have seized upon water use as a policy issue, the regulated, legalized cannabis industry In California generally uses significantly less water than do some of the Golden State's other major agricultural crops (e.g., cotton, tomatoes, wheat, and corn). That noted, it is a virtual given that the trend toward longer, more acute droughts will be sustained well into the future, which lends more urgency to the Water Working Group's efforts and messaging.

Cultivators are being advised to design, build, and operate their operations appropriately to address the changing adversity of climate conditions, including longer, hotter, and drier summer growing seasons. Cultivators will need to adapt to restrictions on water access. Facility operators will be tested by evolving building standards to increase energy efficiency, reduce waste, and preserve indoor and outdoor air quality via mechanisms like California's Title 24. There will be more carefully and expensively supplied municipal water, increased cooling demand for indoor and greenhouse growers to offset higher loads, and higher operational expenses for temperature control and water management systems.

As the legal cannabis industry matures, water-use efficiency will necessarily become more important, as it likewise will for other agricultural crops. Environmental and ecological pressures will mount, including for the reduction of input and energy costs, increased protection of the environment, addressing evolving regulatory standards, and ultimately being responsible stewards not only of industry but its ecology.

As with all our reports available through New Frontier Data's online intelligence portal Equio™, we trust that readers will benefit from this fact-based assessment, our unbiased insights, and the actionable intelligence provided to continue to succeed in the global legal cannabis arena.

New Frontier Data's mission is to elevate the discussion around the legal cannabis industry globally by providing unbiased, vetted information intended for educating stakeholders to make informed decisions. We provide individuals and organizations operating, researching, or investing amid the cannabis industry with unparalleled access to actionable industry intelligence and insights, helping each to leverage the power of knowledge to succeed in a fast-paced and dynamic market.

Please do enjoy our newest report as you shape your strategy and devise your action plan within the cannabis industry!

Giadha A. DeCarcer
Founder and CEO,
New Frontier Data

Strength in Knowledge®

executive Summary

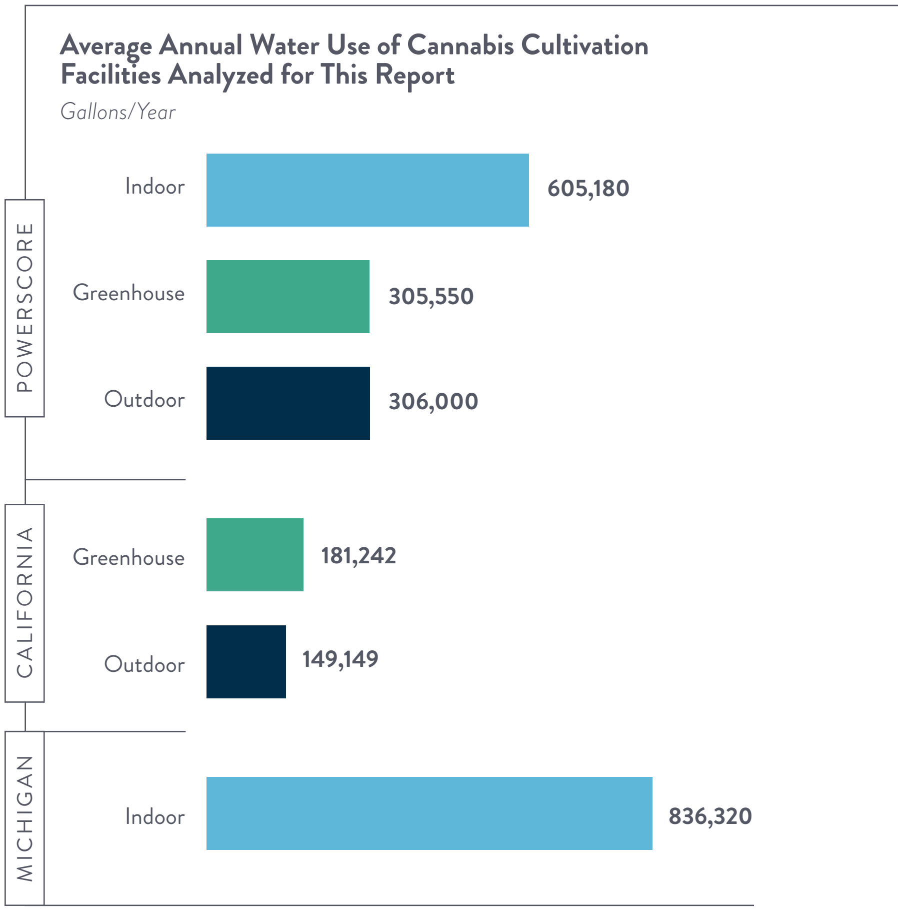
THE DRAMATIC EXPANSION of the legal cannabis industry in recent years has led to significant advances in the way that cannabis is grown. Surging consumer demand for legal products, coupled with increasing competition, has led growers to increasingly focus on improving operational efficiency to lower costs, optimize yields, and increase revenues. While substantial research has been conducted on energy use in cannabis cultivation, the use of water is far less well understood.

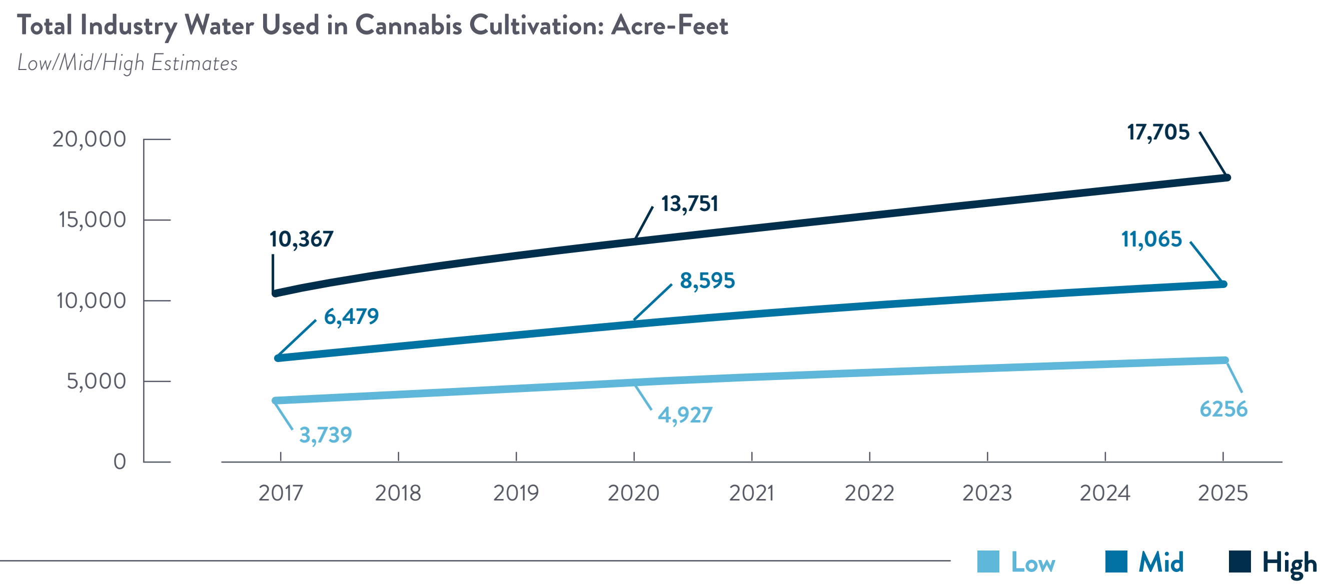
With the demand for legal cannabis forecast to double in the next five years, understanding how water is currently used — and how growers can reduce its use — is key for establishing industry practices to improve industry-wide efficiency at a critical stage in the industry's growth.

Using data collected by Resource Innovation Institute via its Cannabis PowerScore benchmarking platform and with researchers, utilities, and regulatory agencies in California and Michigan, this report explores ways that water is used by cannabis growers, establishes key benchmarks for water use across different types of facilities, identifies innovations that are driving greater water-use efficiency, and offers strategic recommendations for producers and regulators to advance water-use efficiency throughout the industry. Given the need for more data, it should be clearly understood that the numbers presented in this report are directional rather than representative of the broader regulated industry. Likewise, this report should not be conflated with a best practices guide.

Cultivation Practices Are Keys to Water Use

- Water is used in a range of ways for cannabis cultivation. Irrigation is its primary use, but water is also used to dissolve nutrients, humidify and cool the cultivation environment, and manage pests or perform cleaning.





- Irrigation practices vary widely across facilities, ranging from hand-based irrigation with hoses, to piped irrigation systems with sensors measuring ambient conditions in real time, to application of micro-pulses of water to maintain moisture levels for optimal conditions. The transition from hand-watering to drip irrigation is one of the most basic but effective steps which growers can take to being reducing their water use.

- The substrate – or medium in which the cannabis is grown – plays a critical role in irrigation, further complicating the ability to standardize disparate approaches for water use. Growers using soil can irrigate more heavily, but at only a few intervals per day, whereas an inert substrate like stonewool (or rock wool) has a high water holding capacity and can therefore be watered with lower volumes of water, up to 20 times per day.

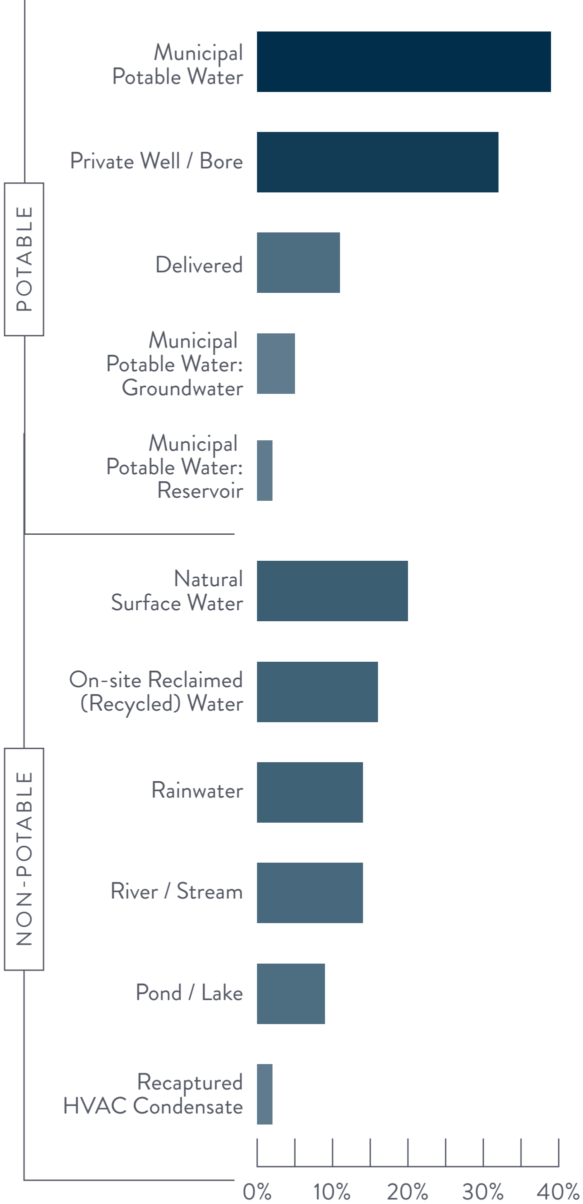
- Water efficiency (i.e., gallons/square foot) is significantly influenced by the type of cultivation facility and the number of harvests. Indoor facilities (which have five or more harvests per year) use significantly more water per square foot per year, compared to outdoor facilities (which typically yield one harvest per year). On average, facilities use 121 gallons per square foot per year, with indoor facilities averaging 209 gallons, compared to outdoor facilities averaging 11 gallons per square foot per year. The number of annual harvests is obviously significant in the cyclicality of water use, with multi-harvest facilities requiring more steady water use throughout the year, whereas outdoor facilities are likelier to see their highest rates of use in late summer and early fall, as harvests approach.

Despite Surging Production and Market Revenues, Water Use in Cannabis is Nominal Relative to Other Major Agricultural Crops

- Compared to major agricultural crops, including cotton, grapes, and corn, the total water used to grow cannabis has a nominal impact on total water use in farming.

- While a wholesale pound of rice and table grapes sell for approximately $0.71, and $0.78 respectively, a wholesale pound of smokable cannabis bud can fetch $1,500 - $3,000 or more. This stark differential means the market value of the cannabis industry grows dramatically even with only incremental increases in production.

National PowerScore Water Sources



Reclamation and Reuse Present Underutilized Opportunities to Improve Water Efficiency

- Since more than 90% of water absorbed by plants is lost through evapotranspiration, a significant portion of water used in irrigation for indoor and greenhouse environments can be reclaimed as condensate collected in the facility's HVAC systems. However, few facilities are designed to collect, store, and treat condensate.

- Concerns about spreading pathogens or heavy metals through a grown environment has been a long-standing barrier to adoption of water reclamation practices. However, with effective water-recycling solutions becoming more commonplace, cost savings from reusing treated water are driving increased adoption of reclamation solutions.

Water Sources Used Vary Widely, with Each Presenting Different Options for Efficiency Gains

- Indoor growers are the most likely to use municipal water as their primary source, whereas greenhouse and outdoor growers are more apt to use onsite wells, natural surface water, or rainwater. Space constraints often limit onsite water storage in indoor facilities, whereas large-scale storage tanks are commonly used in greenhouses and outdoor facilities, especially in areas lacking stable water supplies.

- While growers in newer legal markets (especially those in the most recent Northeastern or Midwestern markets with reliable access to water) may feel less incentivized to prioritize water efficiency when building out their new facilities, established markets have shown that increased pricing competition puts enormous pressure over time on less-efficient operators. As such, it is critical that growers plan for downward price pressure as the market matures, and identify ways to reduce operational costs early. Instituting early, cost-saving best practices for water efficiency can enable growers in increasingly crowded markets to compete more effectively.

Benchmarking Water Use is Vital to Improving Industry-wide Outcomes, but Establishing Appropriate Metrics Is Critical

- Cannabis industry regulators should consider requiring licensed growers to report their water use (as some states have done) to encourage more data collection on the little-understood aspect of cultivation while enabling industry-wide data comparisons. Enabling growers to benchmark their water efficiency against their peers' will create incentives for less-efficient operators to improve their functional performance. Using tools like the Cannabis PowerScore resource benchmarking platform enables growers to compare their water efficiency against their peers' will create incentives for less-efficient operators to improve their functional performance.

- Establishing appropriate benchmarks will be key: The type and size of a facility must be considered to enable effective peer benchmarking. Similarly, while water use per plant has historically been used as an efficiency metric, wide variations in plant sizes and lengths of cultivation cycles effectively render a per-plant metric meaningless, thus it should not be used as a comparative performance indicator.

Climate Change Is Fueling Urgency to Reduce Water Use in Key Production Regions

- Key legal cannabis markets in Western states (e.g., Arizona, California, Colorado, Nevada, and Oregon) are currently experiencing historic drought conditions, with water shortages expected to become increasingly pronounced as effects of climate change become more acute. Facing a future of both increased water scarcity and higher water costs is stirring new urgency to increase production efficiency in the country's most productive cannabis cultivation markets.

- Governments and industry regulators can play important roles by incentivizing growers to adopt water-efficiency solutions as parts of broader government efforts to mitigate impacts from climate change on the agricultural economy.

With the legal cannabis market in the U.S. positioned for catalytic growth over the next five years, and with many more countries enacting laws legalizing cannabis use, efficiency practices adopted now will play defining roles in reducing the industry's total water use during this critical stage of its growth.

About
New Frontier Data

NEW FRONTIER DATA is an independent, technology-driven analytics company specializing in the global cannabis industry. It offers vetted data, actionable business intelligence and risk management solutions for investors, operators, researchers, and policy makers. New Frontier Data's reports and data have been cited in more than 85 countries worldwide to inform industry leaders. Founded in 2014, New Frontier Data is headquartered in Washington, D.C., with additional offices in Denver, CO, and London, U.K.

New Frontier Data does not take a position on the merits of cannabis legalization. Rather, its mission and mandate are to inform cannabis-related policy and business decisions through rigorous, issue-neutral, and comprehensive analysis of the legal cannabis industry worldwide.

For more information about New Frontier Data, please visit: NewFrontierData.com.

Mission

New Frontier Data's mission is to elevate the discussion around the legal cannabis industry worldwide by providing unbiased and vetted information intended to educate stakeholders to make informed decisions.

Core Values

- Honesty
- Respect
- Understanding

Vision

Be the Global Big Data & Intelligence Authority for the Cannabis Industry.

Commitment to Our Clients

The trusted one-stop shop for actionable cannabis intelligence, New Frontier Data provides individuals and organizations operating, researching, or investing in the cannabis industry with unparalleled access to actionable industry intelligence and insight, helping them leverage the power of big data to succeed in a fast-paced and dynamic market.

We are committed to the highest standards and most rigorous protocols in data collection, analysis, and reporting, protecting all IP and sources, as we continue to improve transparency into the global cannabis industry.

Report Contributors

PUBLISHER

Giadha A. DeCarcer, Founder & Chief Executive Officer, *New Frontier Data*

EDITOR

John Kagia, Chief Knowledge Officer, *New Frontier Data*

AUTHORS

Gretchen Schimelpfenig, PE, Technical Director, *Resource Innovation Institute*

Derek Smith, Executive Director, *Resource Innovation Institute*

Chris Dillis, Post-Doctoral Fellow, *Cannabis Research Center, University of California, Berkeley*

Van Butsic, Dept. of Environmental Science, Policy & Management, *University of California, Berkeley*

ADDITIONAL ANALYSIS

Kacey Morrisey, Director of Industry Analytics, *New Frontier Data*

Noah Tomares, Industry Analyst, *New Frontier Data*

COPY EDITOR

J.J. McCoy, Senior Managing Editor, *New Frontier Data*

PROJECT MANAGEMENT

Hovanes Tonoyan, Project Manager, *New Frontier Data*

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RII TECHNICAL ADVISORY COUNCIL WATER WORKING GROUP MEMBERS

Andrew Alfred, LivWell Enlightened Health
Barb Anderson, Washington Dept. of Ecology
Chris Dillis, Berkeley Cannabis Research Center
Rob Eddy, CEA Consultancy LLC
Matthew Gaboury, House of Cultivar
Hollie Hall, Compliant Farms Certified, LLC
Michael Heaven, Argus Controls
John Kagia, New Frontier Data
Kyle Lisabeth, Silver Bullet Water Treatment
Bob McDonald, Carpinteria Valley Water District
Chuck Nora, Desert Aire
Austa Parker, Denver Water
Sara Schoenhals, HydroLogic
Elizabeth Shilling, Ceres Greenhouses
Madison Walker, Grodan
Jan Westra, Priva
Beau Whitney, Whitney Economics
Cale Winters, Rhythm CSS
Al Zylstra, Dramm Corporation

PEER REVIEWERS

Van Butsic, Berkeley Cannabis Research Center
Shaye Donald, Hawthorne Gardening Company
Jean-Pierre Fortin, Hawthorne Gardening Company
Ted Granthan, Berkeley Cannabis Research Center
Brad Hull, Integrated Bioengineering
Jesse Porter, InSpire Transpiration Solutions
Michael Robbie, Conviron
Andy Souza, TEP Engineering
Marielle Taft, Grodan
Patrick Walters, Lansing Board of Water & Light

About
Our Partners

Resource Innovation Institute

Resource Innovation Institute (RII) is an objective, data-driven non-profit organization who establishes industry standards, facilitates best practices and advocates for effective policies and incentives that accelerate conservation. With its Cannabis PowerScore benchmarking platform, RII helps producers confidentially assess the efficiency and productivity of their cultivation facilities using industry-standard Key Performance Indicators (KPIs) on energy, emissions, water and waste. RII's Technical Advisory Council brings together multidisciplinary stakeholders and subject matter experts to define best practices through comprehensive peer review. As an aggregator of knowledge, RII trains the market and informs governments and utilities about baselines and standards for resilient, high-performance production.

Cannabis Research Center

The Cannabis Research Center (CRC) is a research group based at the University of California, Berkeley. Our goal is to promote interdisciplinary scholarship on the social and environmental dimensions of cannabis production. Through scientific research and engagement with community, government, and academic entities, we advance understanding of cannabis agriculture in socioecological systems at local, national, and global scales. We seek to inform public dialogue and contribute to the development of prosperous communities and healthy environments.

Introduction

Water Used for Cannabis Cultivation

Irrigation Practices Vary Widely Across the Industry, with Many Opportunities to Improve Efficiency

Compared to other commercial horticultural sectors where decades of agricultural research and innovation have normalized cultivation practices, in cannabis (where the illicit market still accounts for the majority of crop grown) growers use a wide range of irrigation techniques ranging from high-volume/low-frequency events (where the crops are heavily watered by hand once or twice a day), to low-volume/high-frequency models where the crops receive small bursts of water 20 or more times per day, delivered via state-of-the-art, sensor-based irrigation systems.

Federal prohibition has further hampered efforts to understand resource use and efficiency opportunities, as research institutions which receive federal funding have been prohibited from conducting research on cannabis that would inform cultivation best practices. While there has been cultivation research done in other countries (notably Israel and Canada), the lessons from those studies are not always readily applicable to local conditions in the U.S.

Expansion of the legal market is leading to greater transparency into cannabis cultivation practices, and greater prioritization of efficiency and operational cost containment. As a result, growers have begun to transition from larger substrate volumes and less efficient watering techniques, to smaller pot sizes and greater integration of more precise irrigation techniques (e.g., high-frequency/low volume irrigation). No matter how water is applied, grower methods can be optimized, and opportunities to increase efficiency of water use across the industry are considerable.

Benchmarking water use, defining its best practices, and educating growers on the economic and environmental benefits of reducing their water use will be keys to ensuring that water efficiency is a priority for integration into the next stage of the legal cannabis market's growth.

Limited Analysis of Water Efficiency, and Fears that Operational Disruptions Have Slowed Progress Toward Optimizing Water Use

As the economics of cannabis have shifted with increased competition and downward price pressure, cost containment has been a critical issue for growers. Since operational efficiency was not considered a priority in the illicit market, many opportunities exist across cultivation environments to increase resource efficiency and lower costs. Some examples include: 1) reducing energy demand and consumption by using LED lighting systems; 2) switching from sole-source lighting treatments for indoor cultivation to greenhouse or mixed-light environments which use natural light; 3) leveraging automation to reduce labor costs and optimize operational performance by employing automatic trimmers or sensor based technologies to monitor and manage climatic conditions in the grow environment; or 4) analyzing use of cultivation inputs from nutrients to substrate to minimize waste and negotiate better rates from suppliers to lower expenses.

While growers may understand the positive impact of reducing water use on the environment, there has been far less research done into the role that efficient water use can play in improving an operation's bottom line. Consequently, growers often incorrectly overestimate the cost of deploying water management solutions while underestimating the impact that those strategies have on lowering business costs.

Getting growers to view water efficiency not just as an environmental benefit but as a business opportunity will be a key step in accelerating adoption of water optimization solutions for cannabis cultivation.

Legalization Is Reducing Water-Related Environmental Harm Caused By Illicit Grows on Public Land

The environmental impact of illegal (i.e., trespass) cultivation on public lands is among the less prominent but immensely consequential outcomes of unregulated cannabis production. Throughout the western United States in particular, cannabis cultivation in national forests and other public lands has had devastating effects on the ecology and watersheds where the cannabis has been grown. Trespass growers may dam streams or divert water flow for their plants, and unmanaged runoff from their operations can result in the introduction of fertilizers, pesticides, rodenticides, and other contaminants to the watershed, causing significant environmental damage downstream.

Yet, two recently published peer-reviewed manuscripts[2] provide encouraging news. Both papers show evidence how states that legalize cannabis see a decrease in trespass cannabis grows on federal lands. By extension, the decrease in trespass grows likely also leads to decreased environmental harms.

The emerging research suggests that legalizing cannabis market can lead to some environmental wins. If combined, regulatory compliance in the legal market, coupled with the economic advantage of reducing operational costs, leads to more careful management of water resources and heightened focus on minimizing water use in the legal market. In turn, an economically and environmentally successful legal market reduces the environmental harms caused by unregulated growers by undermining their profitability. All told, a water-efficient legal market has the potential to help reduce trespass growing, and may do so more effectively than could be achieved solely through increased prohibition and enforcement.

Beyond water use, legalization is stimulating some increased focus on resource use and efficiency management across the cannabis ecosystem. As noted in the 2018 Energy Report and in RII's ongoing energy and resource management research, the legal industry is driving significant gains for energy efficiency in cultivation, both as best practices become more normalized and performance-improving technologies (e.g., LED lighting systems and climate-monitoring solutions) become more widely adopted. These trends are expected to continue as the legal market expands and matures.

2. *Prestemon, J.P., Koch, F.H., Donovan, G.H. & Lihou, M.T. (2019). Cannabis legalization by states reduces illegal growing on US national forests. Ecol. Econ., 164, 106366.*

Klassen, M. & Anthony, B.P. (2019). The effects of recreational cannabis legalization on forest management and conservation efforts in U.S. national forests in the Pacific Northwest. Ecol. Econ., 162, 39–48.

Water Use in Cannabis Cultivation

WATER SOURCES

Cannabis growers use a variety of sources for both potable and non-potable water, depending on water availability in their regions and the cultivation practices used by operators (please consult the glossary for more information about each water type).

- **Potable**
  - Municipal Potable Water
  - Delivered Water
  - Private Well / Bore
- **Non-potable sources**
  - On-site Reclaimed (Recycled) Water
  - HVAC Condensate
  - Natural sources
    - Rain
    - Surface Water

WATER USE IN CANNABIS CULTIVATION FACILITIES

Generally, cannabis cultivation facilities use water in eight ways:

1) **Irrigation:** Ensuring that plants remain appropriately hydrated during their life cycle;

2) **Storage:** While some facilities irrigate directly from a water source, many facilities have temporary water storage tanks for filtration and fertigation . Operators of facilities with limited or

unreliable water supplies will often have more substantial long-term storage capacity to ensure keeping water on site for future irrigation;water storage is a key aspect for cultivation;

3) **Applying nutrients or other dissolved substances to the plants:** Many growers mix root zone inputs into their irrigation water, adjusting formulations based on plant needs at each stage of growth;

4) **Humidification:** Maintaining the optimal ambient moisture level in the grow environment (especially in indoor cultivation facilities);

5) **Cooling:** Drawing out excess heat from the grow space using HVAC and dehumidification equipment;

6) **Cleaning:** Maintenance of the cultivation equipment;

7) **Pest Control:** Water can be an effective way to keep pests off plants without applying chemical treatments; and

8) **Non-Cultivation:** Water used for 'domestic' activities like handwashing, toilets, and kitchen areas for employees.

Of these applications, irrigation is the most water-intensive application.

However, irrigation also presents the greatest opportunity for water reclamation. Since plants use as much as 99%[3] of the water they absorb to keep the leaves cool and move nutrients through the plant via evapotranspiration, the vast majority of water applied in indoor and greenhouse facilities can often be reclaimed and reused. There are two types of recapture and reuse: recapture of irrigation runoff water and recapture of HVAC condensate (water in the air from evapotranspiration).

HVAC water makes up the majority of reclaimed water. The amount of nutrient runoff water that can be recaptured depends greatly on the grow strategy (deep water culture will produce more runoff than soil). Recaptured runoff water must be treated differently than the HVAC water before reuse. Depending on the water treatment system, we sometimes find that the energy requirements for treating this water is not worth the amount of water reclaimed.

3. *Sterling, T, Transpiration – Water Movement through Plants', New Mexico State University, 2004*

A NOTE ABOUT WATER USE FOR CLIMATE CONTROL IN GREENHOUSES

Many greenhouses use evaporative cooling pads to control temperatures in warmer seasons. As a result, water use in greenhouses can triple during the summer, not just due to higher irrigation requirements, but also because when the evaporative pads are running (and pumps trickle water over them), some water runs off, typically into drains, to keep salts from accumulating in the pump reservoirs. With 24 greenhouse rooms each running off 0.5 gpm water for 8 hours on a 90-degree day, usage for evaporative cooling can exceed 5000 gallons/day.

As a result, evaporative cooling can significantly drive up water requirements in greenhouses located in hot, arid areas.

Solutions to Increase Water Efficiency in Cannabis Cultivation

Growers Have an Array of Options to Reduce Water Use

Growers use different techniques to apply water to their crops, including using a hose to water individual plants, using drip irrigation solutions, and using hydroponics, where the plants' roots are routinely flushed with a nutrient solution (examples include deep water culture, nutrient film technique, and aquaponics).

There is a wide array of ways in which technology is helping reduce water use:

DRIP IRRIGATION

Perhaps the most widely used water efficiency solution, drip irrigation systems allow growers to direct water to each individual plant without having to irrigate the entire cultivation area. Compared to using a hose to irrigate the plants, or to a flood-and-drain technique which is highly water-intensive, the precise targeting of drip irrigation[4 5] can reduce water consumption by 30% to 70%, and improve water productivity by 20% to 90% (potentially more if the hose is not turned off as it is being moved between plants, a practice which can waste as much as 50% of applied water if the plants are not densely packed together).

Research by Dr. Neil Mattson of Cornell University, for one, has shown that the efficiency of drip irrigation systems can be further enhanced through the use of substrate and ambient environment sensors which monitor each the moisture continent, temperature, humidity, and electrical conductivity of the cultivation environment in real time, and can automatically start and stop irrigation whenever conditions reach preprogrammed parameters.

SENSOR-BASED MICRO-PULSE IRRIGATION

A more advanced variant of drip irrigation systems is the use of sensor-based systems that deliver steady micropulses of water to each plant. While the technologies are not widely available at scale, researchers have found that the use of microbursts of water or nutrient solution are far more water-efficient than even drip irrigation methods which tend to saturate the grow medium, resulting in higher levels of runoff.

One agricultural researcher reported that a self-built, micro-sensor-based system used up to 20 times less water than hose-based irrigation, with equal to better crop yields. Additional benefits of such a system include:

- **Fewer pests,** such as fungus gnats and shore flies, which are attracted to the moisture in the grow medium and are often seen in heavily watered plants; and
- **The ability to simulate drought conditions** through the precise calibration of the amount of water reaching the plant: For some cannabis plants, drought conditions have been shown to stimulate production of some cannabinoids, which are becoming increasingly valuable in legal markets.

As the cannabis industry matures, the deep integration of sensor-based technologies will become more commonplace as growers seek to optimize their use of resources and maximize the performance of their crops. Already, many producers are optimizing the timing of fertigation cycles based on measurements of what is happening to the plant, by weighing plants and using measurements to determine how much of the feeding and

4. Zafari, J ,Mohammadi, N, A Review on Drip Fertigation on Field Crops, International Journal of Engineering Research & Technology, 2/12/2019

5. O'Connor, N, Mehta, K. Modes of Greenhouse Water Savings, Procedia Engineering, Vol. 159, 2016 watering cycle has been completed. Some producers are measuring the moisture content in the substrate, and using the change in moisture to determine when the plants should be fed/watered. Other growers measure the moisture content of the leaves, and use the information to decide on feeding and watering cycles as opposed to simply basing those cycles on time.

LEACHATE CAPTURE AND RECIRCULATION

Depending on the watering techniques used, 25% or more of the water applied runs off into the drain; when applying water using a hose in indoor facilities, often half of the applied water does not reach the pot. Reclaiming and reusing irrigation runoff is widely done in other horticultural sectors: The tomato sector in particular, where tight margins have driven major technological advancements to maximize water efficiency, deploys effective solutions readily replicated for cannabis. Advancements in water reclamation and discharge reduction have also largely been driven by increasingly stringent regulatory action on behalf of large greenhouse-producing countries and regions. For example, the Netherlands has a goal of zero discharge by 2027, and similarly strict regulations in Ontario are helping drive innovation and increase water-use efficiency.

However, two operational concerns have slowed adoption of reclamation and reuse for cannabis cultivation:

- **Concerns about the effort required to process reclaimed water for reuse.** Runoff from irrigation has a different nutrient profile than the solution applied to the plant, which is based on how much of each nutrient in the water the plants absorbed. Consequently, growers must carefully and routinely test runoff to determine how the nutrient profile has changed, then meticulously rebalance the solution to restore it to optimal levels. In most cases, growers must do significantly more than simply test runoff to accurately rebalance drain-recaptured solution to the correct elemental parts-per-million (ppm) contributions. The runoff profile is different due to the fact that plants remove ions from aqueous solutions at demonstrably different rates[6], so cumulative nutrient imbalances are prone to occur. Concern about errors made during the process of testing and reformulation has led many growers to conclude that it is both easier and safer to use new water.

An empirically sound strategy involves combining runoff analysis, pore water extraction analysis, and leaf tissue analysis to correctly reinject elements or fertilizers parts at appropriate doses. Such testing is almost invariably done by third-party labs rather than in house, due to the technical nature of analysis and the necessarily high frequency of instrumentation calibration.

Depending on watering techniques, 25% or more of applied water drains as runoff.

6. Bugbee, B., Nutrient Management in Recirculating Hydroponic Culture, Acta Horticulturae, 2, 2004

However, rebalancing can be achieved successfully during the process of introducing additional new water to offset nutrient loss. Sensors can supplement water-quality testing to make the process more efficient.

An alternative is to use filtration and scrub out the nutrients with processes like reverse osmosis (RO), which reduces the reuse efficiency (though 50% reuse is better than 0%).

- **The risk of distributing pathogens or other contaminants into the grow environment.** Another key concern is the risk of distributing waterborne malignant or opportunistic plant and root-zone pathogens, such as Pythium and Fusarium (i.e., root rot from pathogens that affect roots and stems), into the full operation through contaminated reclaimed water. If the reused water is not processed correctly, isolated issues with a limited number of plants can quickly spread throughout the operation, putting the entire crop at risk. For many growers, the downside risk of losing an entire crop outweighs the cost savings and efficiency gains to reclamation and reuse.

While those concerns are understandable given the high value of each cannabis harvest, they belie the reality that many well established solutions already exist to increase water efficiency in cultivation, as widely used in other horticultural markets.

RECLAMATION OF HVAC CONDENSATE

In indoor and greenhouse facilities, HVAC and dehumidification systems can capture significant proportions of the water lost through evapotranspiration. Often, reclaimed water is discarded, but given the volume of water being extracted it presents a significant opportunity for reclamation and reuse, either for irrigation or other applications throughout the cultivation facility.

There are some considerations when reclaiming condensate from HVAC and dehumidification systems:

- WATER STORAGE
  For space constrained operations, installing the large-scale water tanks needed to store all the condensate can be an issue, especially when being added to an already existing facility. However, for newly built facilities or those with room to expand, adding water storage capacity can be relatively easy and inexpensive.

- WATER PURIFICATION
  Some HVAC systems apply disinfectants or other chemicals to prevent algae and other microbiological growth in the reclaimed water. Growers must therefore plan to process chemicals that may negatively impact plant growth from the water before it is reused.

- COPPER OR ZINC CONTAMINATION
  HVAC systems that use copper piping can often accumulate significant levels of copper in the condensate (see Figure 4 for typical contaminant levels in condensate samples). Zinc can build up in systems of facilities using galvanized metal plumbing. Shifting to PVC or other leach-resistant piping can reduce the risk of heavy metal contamination when the condensate is applied to the crops. However, regular testing of condensate water for microbiological and heavy metal contamination is the best way to ensure that the condensate does not introduce adulterants to the growing environment.

FIGURE 1: Chemical Contaminants in HVAC Condensate

	Chemical Contaminant	Aluminum	Calcium	Copper	Iron	Lead	Magnesium	Nickel	Potassium	Sodium	Zinc
Condensate Samples	Practical Quantitation Limit (PQL)	0.050	1.00	0.010	0.050	0.010	0.050	0.010	1.0	1.00	0.010
	Number of Samples in Which Contaminant Detected	3	0	13	2	0	1	1	0	1	15
	Values/Range of Detected Contaminant	0.053 0.078 0.547	–	0.016 - 1.34	0.130 0.956	–	0.059	0.171	–	11.3	0.018 - 0.267
	Average of Detected Contaminant	0.226	–	0.23	0.543	–	0.059	0.171	–	11.3	0.18
	Drinking Water Primary Maximum Contamination Level (PMCL)	–	–	1.3	–	0.015	–	–	–	–	–
	Drinking Water Secondary Maximum Contamination Level (SMCL)	0.2	–	1.0	0.3	–	–	–	–	–	5
	SAWS Drinking Water Quality	<0.02	56.2 - 99.0	<0.002 - 0.379	<0.01 - 0.0191	<0.001 - 0.0163	8.99 - 18.2	0.0011 - 0.0062	1.10 - 6.53	8.08 - 23.4	<0.005 - 0.0328

REVERSE OSMOSIS (RO) FOR WATER PURIFICATION & LEACHATE RECLAMATION

Water is a common source of heavy metal contamination, particularly when sourced from rivers containing industrial pollutants. Plants deal with heavy metals by evolving either to limit root absorption, or by allowing absorption and sequestering the heavy metals where they can do less physiological harm (e.g., in the cell vacuoles or specialized proteins). Unfortunately, cannabis is one among such bioaccumulators.

RO is widely used in cannabis facilities to purify water from municipal, groundwater, or reclaimed sources. RO allows growers to apply uncontaminated water to their crops due to the effectiveness of the process in removing pollutants and adulterants from the water. It is especially important in places where municipal and groundwater has high levels of sodium, such as coastal areas in the western U.S. states. Since the cultivation techniques developed in the early markets of California, Oregon, and Washington have been adopted by growers nationally, and water-quality issues impact U.S. communities, the use of RO has expanded nationwide.

While RO has gained traction in the industry, it is worth noting that cannabis is the only major U.S. horticultural sector that uses RO for water treatment. RO water is especially helpful in cannabis because it is one of the only means to remove sodium and heavy metals from the plant, hence its widespread use in converting seawater to potable water. Given the stringent testing for heavy metals in cannabis, removal of such adulterants in water is critical for growers to ensure that their products are regulations-compliant. Growers thus err on the side of caution with the costly but effective method for treating water.

There are several reasons why RO is not more widely used in commercial agriculture:

- **RO generates a lot of waste.** While the most efficient systems can yield 1 gallon of brine (i.e., waste water) for every 10 gallons of purified water produced, less efficient systems produce 1 or 2 gallons of clean water per each gallon of brine.
- **RO energy intensive:** Running RO equipment uses a lot of electricity, offsetting efforts to reduce energy use in the cannabis operation.
- **RO water is significantly more prone to pH fluctuation:** Due to its low buffering capacity and lack of bicarbonates, maintaining RO water's optimal pH levels requires careful management to ensure optimal nutrient absorption. RO water's low TDS content of permeate allows it to absorb gaseous contaminants (e.g.,volatile organics and CO2), which tends to lower pH levels

One way to potentially reduce the high cost of using RO water as the sole source of irrigation water is to use a mix of it with municipal or ground water. However, with strict cannabis testing requirements for heavy metals and other adulterants unlikely to change, RO will likely remain commonplace in cannabis in the medium term, even as the sector is poised for innovation both to reduce cost and increase efficiency of water purification processes.

Growing Systems and Substrate Options

Choices for substrate are influenced by cultivation approaches and system choices.

CULTIVATION APPROACH AFFECTS PLANT SIZE

- **Indoor**
  - Sea of green
  - Larger plants
- **Greenhouse**
  - Medium plants (3- to 5-gallon pots)
  - Large plants (>10-gallon pots)
- **Outdoor**
  - Field/in-ground
  - Container-grown (100- to 1,000-gallon containers)
    - Cannabis plants grown fully outdoors without any structural covering are often grown to prioritize the size of individual plants. Plants may be grown directly in existing topsoil, or more often in planters or bags of imported substrate.
    - Outdoor plants often attain heights of 8 feet or more, with a diameter of over 10 feet. In comparison with smaller plants grown indoors or in greenhouses, a relatively higher proportion of biomass is dedicated to their vegetative (i.e., nonflowering) growth for structural support.

WATER MANAGEMENT APPROACH AFFECTS SUBSTRATE & LEACH PERCENTAGE

- **Hydroponic**
  - Deep water
  - Aeroponics
  - Recirculating (no leach) approaches such as deep water culture, aeroponics, top feed drip reclaim, or ebb-and-flow
- **Rock wool**
  - Drain to waste
  - Recirculating (i.e., with no leach)
- **Coir**
  - Minimal leach
  - Leach (10% to 25 %)
- **Peat**
  - No or minimal leach
  - Leach (10% to 15 % range)

Approaches to Water Disinfection

An Overview

There are typically at least two steps required for disinfecting cultivation water supplies:

1 **Pre-Treatment/Pre-filtration:** Removing organic and organic debris, including plant material, sediment, and algae.

2 **Sanitation:** A purification process which removes potentially harmful contaminants including microbiological organisms, heavy metals, and residual chemicals.

Treatment solutions can include physical, chemical, and biological systems, as summarized below. The systems are often used in combination to achieve optimal results.

PHYSICAL

Eliminate contaminants either by passing them through the treatment system, or by killing organisms in the water without removing them. Treatment methods generally do not have a residual effect on the irrigation system itself, and generally have no phytotoxic effects. Physical treatment generally does not prevent biofilm buildup or prevent clogging.

- Filtration – from sand separators to reverse osmosis
- Rapid media filtration (rapid sand, greensand, activated carbon)
- Ultraviolet irradiation
- Heat treatment (pasteurization)

CHEMICAL

Chemical treatment systems function by damaging cell membranes and/or internal cell organs, causing organism death. Chemical treatment can also prevent biofilm buildup in an irrigation system.

- Oxidizing agents
  - Chlorine & Bromine – oxidation to destroy organisms such as algae, fungi, and bacteria
    - *Bromine*
    - *Calcium hypochlorite (solid); 60-70% available Cl*
    - *Chlorine dioxide*
    - *Chlorine gas*
    - *Electro-Chemical Activation (ECA)*
    - *Sodium hypochlorite (liquid; bleach)*
  - Hydrogen Peroxide, Peroxyacetic acid
  - Ozone
- Combined Physical and/or Chemical: Advanced Oxidation
- Copper and Silver
  - Copper ionization
  - Copper salts
  - Copper / spin-out fabric liner
  - Silver

BIOLOGICAL

Biological treatment systems generally combine a number of treatment processes: physical separation, competition by other organisms, or creating an unfavorable environment for pathogens. These systems can often provide nutrient removal, and manage water that cannot be recirculated.

- Slow media filters and fluidized beds
- Constructed wetlands
- Wood chip denitrification bioreactors
- Hybrid treatment systems
- Bioswales
- Vegetated filter strips
- Land application

NOTE: Biological systems are often implemented outdoors, and are responsive to temperature. Design consideration should be given to temperature management in regions which experience extreme fluctuations during the year.

Source: Adapted from Water Treatment Guide for Greenhouses & Nurseries, West, J., Huber, A., Carlow, C., April 9, 2018

Impact of Substrate on Irrigation Frequency

Below is an overview of the most commonly used substrates used for indoor and greenhouse cultivation, in order based on prevalence of use in the legal market.

Note that the ratio of selected substrate volume to plant biomass will dictate the volume and frequency of irrigation events alongside physical properties and water-behavior characteristics. Growers may use a large volume of peat substrate that only demands low-frequency irrigation but larger volumes of water per event to reach uniform saturation. Others may have a small volume of substrate that necessitates higher-frequency irrigation but in lower volumes due to the overall lower water-holding capacity.

COCONUT COIR

Higher-frequency, lower-volume irrigation strategy: Coir irrigation can range between 1 and 12 water application events/day (depending on the size of the pot).

Coconut coir substrate has for over a decade been a very popular growing substrate in the cannabis industry. Growers like to use it because the physical and chemical properties of coir make it ideal for a range of different irrigation practices, container sizes, environmental conditions, and nutritional strategies.

Proper composition of coir (e.g., pith, fiber, and chunks) provides excellent water retention, aeration, and drainage under both frequent and less frequent irrigation practices across a variety of container sizes. The chemical properties of properly composted, washed, and buffered coir also provide an optimal pH range, while having low electrical conductivity, sodium and potassium content.

Coir is often used on its own, or mixed with perlite, commonly using a 70% coir/30% perlite ratio. It is compostable and can be sustainably produced, but coir requires significant volumes of water during the manufacturing process to remove unwanted ions that adsorb to the cation exchange sites. If sodium and other chemicals are not washed from the coir they can negatively impact growth performance.

ROCK WOOL (STONE WOOL)

Higher-frequency, lower-volume irrigation strategy (more extreme than coco coir): Grodan (the leading producer of rock wool for horticultural use) recommends up to 20 irrigation events a day, depending on the needs of the crop.

Rock wool (i.e., stonewool or mineral wool) is a fibrous material made from molten rock, spun into fibers and then formed into plugs, blocks, and slabs of varying sizes and shapes. It is an inert substrate, meaning that it does not bind any applied water and nutrition, and therefore has no influence on the availability of the nutrient solution delivered by the grower. The sterile nature of production under extreme temperatures keeps the substrate clean and free of pests and pathogens. That means that it has to be constantly irrigated with nutrient solution in order to provide nutrients to the crop.

Rock wool has a high water-holding capacity relative to its volume when compared with other substrates, due to its high volume of air. It can be irrigated with varying volumes and frequencies of water in relation to the volume of the substrate, and based on the differing needs of the plants during the cropping cycle. With uniform fibers and structure, water and nutrient contents can be controlled with minimal leachate.

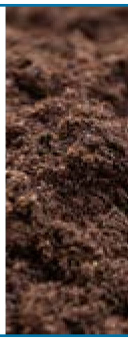
Rock wool is sometimes referred to as a “sports car” of the substrate world: It can deliver very high plant performance, but if not carefully managed it is easy to'“crash” as plant development happens extremely quickly and can require closer monitoring to ensure balanced production. Because of its low water retention, if rock wool irrigation is off or goes down, plants can more easily experience drought stress or even permanent wilting damage/death. There is a learning curve to using rock wool, especially in the cannabis industry where growers are used to irrigating once or twice a day rather than on the average of 8 to 14 irrigation events required for rock wool.

Because rock wool is inert and ions are not bound or exchanged on substrate particle surfaces, it requires a relatively high leachate percentage to keep its pore water solution elementally balanced and avoid cumulative nutrient imbalances in the plant tissue.

PEAT

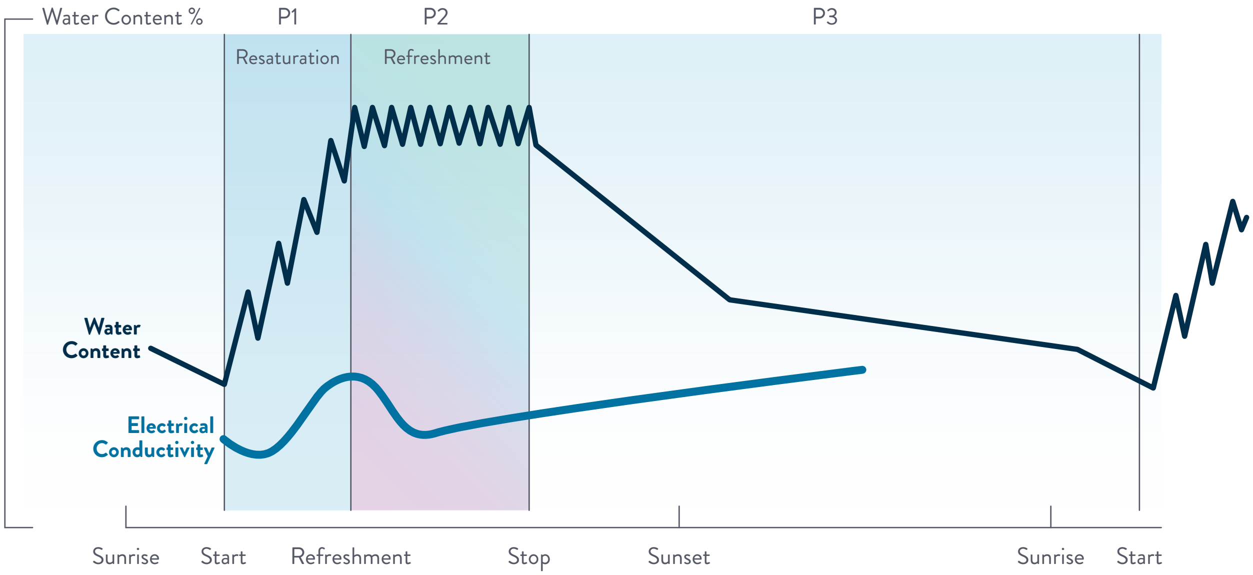
Lower-frequency, higher-volume irrigation strategy:

Peat-based mixes were historically very common in both unregulated and commercial cannabis production. They have begun to fall out of favor in commercial situations, with coir and rock wool taking the lead due to the greater precision which those options afford in managing substrate.



Peat can hold as high a volume of water as coir, but the portion of nonavailable water is greater. Sphagnum fibers are softer than coir, and cannot support as much weight. Inclusion of expanded mineral, wood fiber, or aged bark help to maintain proper aeration in those mixes.

FIGURE 2: Sample Watering Frequency Using Rock Wool



Source: Adapted from Best Practice Guidelines for Greenhouse Water Management, Grodan 2016

Peat mixes are almost always used with a high percentage of perlite in order to increase aeration of the mix, but that also decreases water retention. Other amendments include organic composts, nutrient charges, vermiculite (less common), aged bark/sawdust, and sand.

Peat mixes are a very wide-ranging category. Peat-lite mixes revolutionized the greenhouse industry back in the 1960s, as they greatly reduced costs for transporting substrate due to its light weight. Peat-lite mixes are made from a high proportion of Canadian sphagnum moss similar to the standard horticulture, with a density of 140 to 180 g/L. Peat may also be amended with various minerals and organic matters, making the mix much denser (200 to 400 g/L) with higher water retention and lower aeration.

Living soils, which blend decomposed organic ingredients (such as various compost), reproduce a natural edaphic environment with diversified microflora. The irrigation management approaches for peat-lite and living soil mixes are different, as the dynamic between water retention and aeration is much different.

WATER CULTURE

Constant application, low-volume: Plants' roots are submerged in solution, and growers typically top off the solution once or twice a week before a complete solution replacement.

Often built using a recirculating system, water culture is considered the most water-efficient cultivation technique. However, due to the high degree of sophistication required to build, operate, and maintain a water culture system, it is not an approach often used in large-scale commercial cannabis cultivation.

Understanding Substrates: When Soil Is Not Soil

It is rare to use amendments (e.g., perlite, sand, sawdust/bark, vermiculite, diatomaceous earth) on their own to grow cannabis. Peat and coco will generally be used as bases for amendments added to achieve an optimal moisture and aeration profile.

Comparatively, rock wool is always used on its own without any amendments, unless for the exception of instances where a rock wool cube is placed atop a coconut coir slab as is common in tomato, cucumber, or pepper greenhouses.

While soilless media is often referred to as soil, it is important to distinguish between the two: Soilless mixes contain no field soil, but typically one or more components like peat, coir, bark, perlite, or vermiculite.

Often, what may be referred to as "living soil" is actually soilless media, but with a highly variable mixture of different organic amendments. In opposition to hydroponics, where most or all of the nutrients for the plant are dissolved in water, all or most nutrients in living soil come from the breakdown of organic matter in the root zone. Thus, living soil can contain some percentage of field soil, or may be soilless substrate.

The two primary water culture systems are:

- DEEP WATER CULTURE: Plants roots are suspended in nutrient solution which is oxygenated with an airstone to allow for root growth. Individual plants are often grown in large (2 to 5-gallon) buckets connected by PVC piping; and
- AEROPONICS: Plant roots are suspended in the air (under some cover to prevent light infiltration). The roots are misted extremely frequently (i.e., 5 to 15 or more times hourly) with small pulses of nutrient solution.

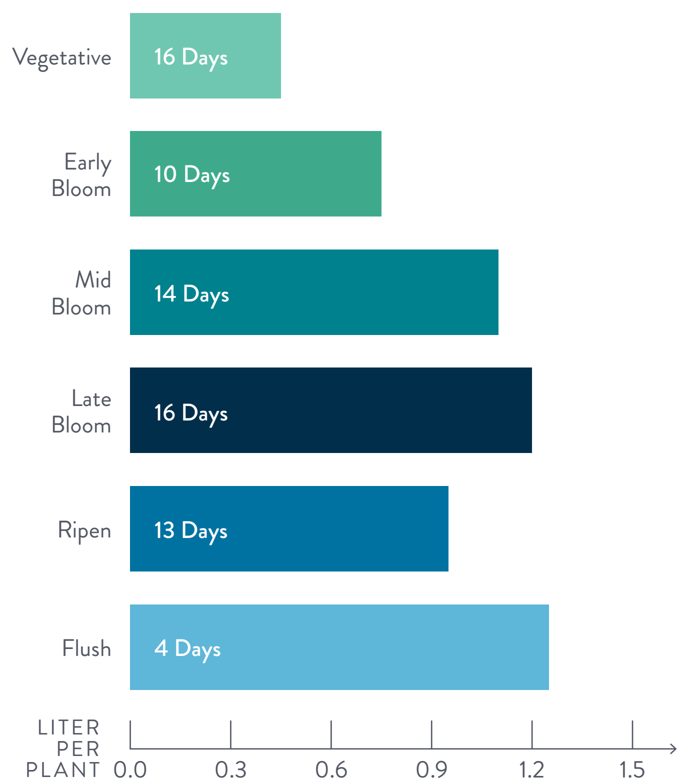
Water Use at Different Stages of Plant Growth

As demonstrated from a trial run in Quebec (Figure 3), irrigation scheduling was determined by using a tensiometer in conjunction with moisture release curve, so water use and the moisture content of the substrate was driving irrigation.

The graph is only intended to show the general water usage at different stages of growth. As the crop develops, water use increases until the ripening stage, where growers may induce drought stress on the crop. The response from the plant is supposed to increase inflorescence, dry weight, and potency.[7] There remains limited data to support it, but the practice is documented in published studies of cannabis cultivators. Water use peaks in the final stage just before harvest, when the plants are commonly flushed with the goal of eliminating any potential contaminants or adulterants before harvest.[8] Due to the industry's stringent testing requirements, permitted growers may use more water in the final stage than growers in the illicit market whose crops are not tested.

FIGURE 3: Minimum Water Usage

Indoor Cultivation 3 Gallon Pot ½ Plant/ft²



Based on Figure 3, the annual water consumption of an indoor operation would be approximately 80 to 100 gallons/plant or 40 to 50 gallons/feet² of growing area depending on the runoff percentage practices of the operator.

7. Caplan,D., Dixon, M., Zheng, Y., Increasing Inflorescence Dry Weight and Cannabinoid Content in Medical Cannabis Using Controlled Drought Stress, HortScience , May 2018

8. This practice has been shown to be largely ineffective at reducing concentrations in plants by the University of Guelph in 2017: Results "showed that the intended purpose of flushing to reduce nutrient concentrations within the bud has no effect. These data show that for the last two weeks of the flower cycle for cannabis, it was possible to use no fertilizer water for irrigation with no significant impact on yield while saving input costs on fertilizer."

Water Insecurity Risks

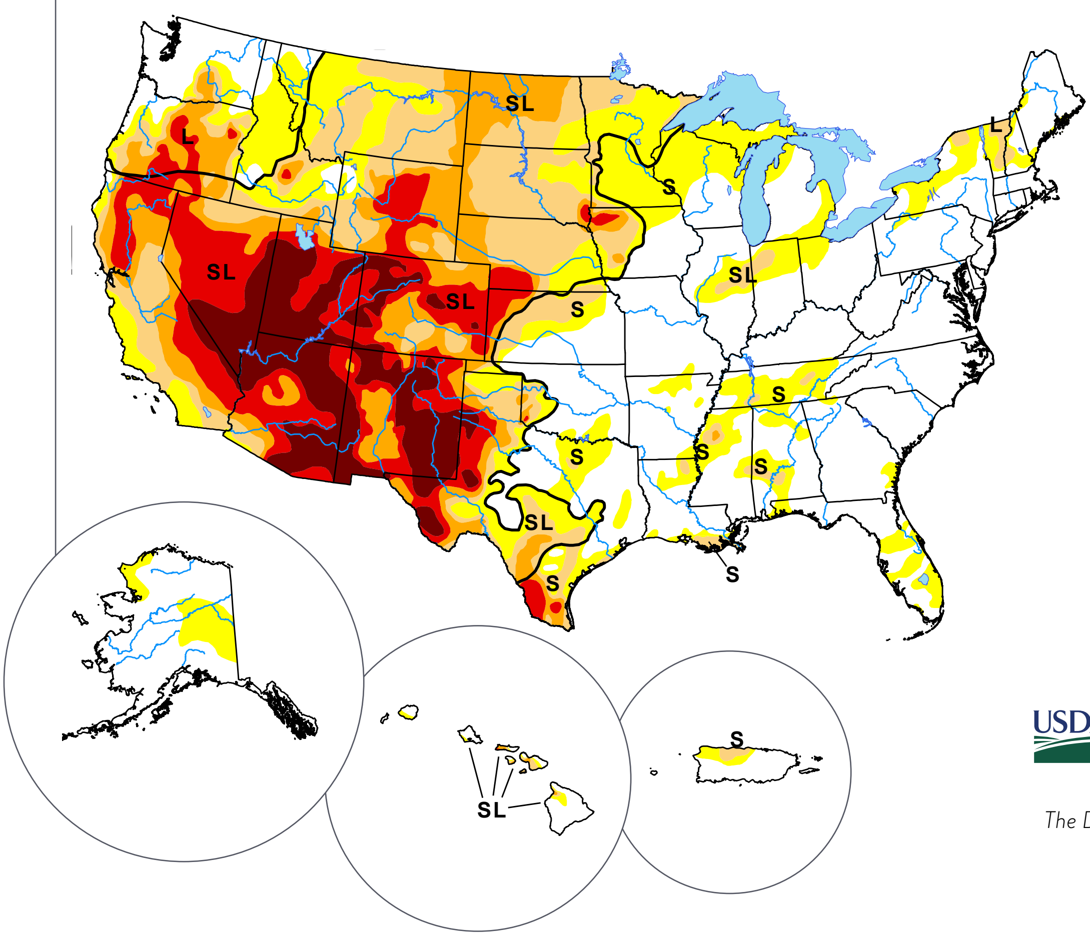
As Drought Conditions Worsen, Risks Rise in America's Most Productive Cannabis Regions

According to NASA, 2020 was the hottest year recorded in the United States since recordkeeping began in 1880; globally, the seven-warmest years recorded have all occurred since 2014. The changing climate is fueling the worst drought experienced in the U.S. in decades, accelerating water scarcity in many parts of the country while driving new urgency to address water use in cannabis cultivation.

Ideal environmental conditions have historically made the western states well suited for outdoor cannabis cultivation, but those states now face the most acute drought conditions in the country. Arizona, California, Colorado, Nevada, New Mexico, and Oregon (which collectively account for 71% of the nation's total cannabis

FIGURE 4: Drought Conditions in the United States

Feb. 16, 2021, Released Thursday, Feb. 18, Valid 7 a.m. EST



DROUGHT IMPACT TYPES

~ Delineates dominant impacts

S Short-Term, typically less than 6 mo. (e.g. agriculture, grasslands)

L Long-Term, typically greater than 6 mo. (e.g. hydrology, ecology)

INTENSITY

- **None**
- **D0 Abnormally Dry**
- **D1 Moderate Drought**
- **D2 Severe Drought**
- **D3 Extreme Drought**
- **D4 Exceptional Drought**

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary.

Source: United States Drought Monitor

FIGURE 5: Severe Drought Cycles in the United States

Percentage of the Country Experiencing D3-D4 Level Drought (1/4/20 - 2/2/21)

Source: *United States Drought Monitor*

supply, both legal and illicit) are facing severe to exceptional drought conditions according to the National Oceanic and Atmospheric Administration's Drought Monitor.[1]

Nationally, during peak drought cycles approximately one-quarter of the country experiences extreme or exceptional drought, as seen in 2002 (23%), 2012 (24%), and early 2021 (22%).

1. The Drought Monitor has been a team effort since its inception in 1999, produced jointly by each the National Drought Mitigation Center (NDMC) at the University of Nebraska-Lincoln, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Department of Agriculture (USDA).

Amidst the current prolonged and historic drought, a future of rising costs and tightening access to water are making efficiency an increasingly urgent priority.

As California is the country's largest cannabis producer, the extent of its drought over the past decade has been especially noteworthy. In the decade since 2010, not only did the entire state experience multiple consecutive years of severe drought, but between 2014 and 2017 nearly half the state suffered exceptional drought conditions (e.g., Figure 6).

While the intensity of the drought has eased slightly over the past three years, cannabis growers should assume that the trend toward longer, more acute droughts will be sustained well into the future. They should accordingly build their operations to reflect the changing climate, assuming:

- Longer, hotter and drier summers;

FIGURE 6: Drought Conditions for California
(1/4/20 - 2/2/21)

D0: Abnormally Dry
- *Soil is dry; irrigation delivery begins early*
- *Dryland crop germination is stunted*
- *Active fire season begins*

99.4%

D1: Moderate Drought
- *Dryland pasture growth is stunted; producers give supplemental feed to cattle*
- *Landscaping and gardens need irrigation earlier; wildlife patterns begin to change*
- *Stock ponds and creeks are lower than usual*

85.1%

D2: Severe Drought
- *Grazing land is inadequate*
- *Producers increase water efficiency methods and drought-resistant crops*
- *Fire season is longer, with high burn intensity, dry fuels, and large fire spatial extent; more fire crews are on staff*

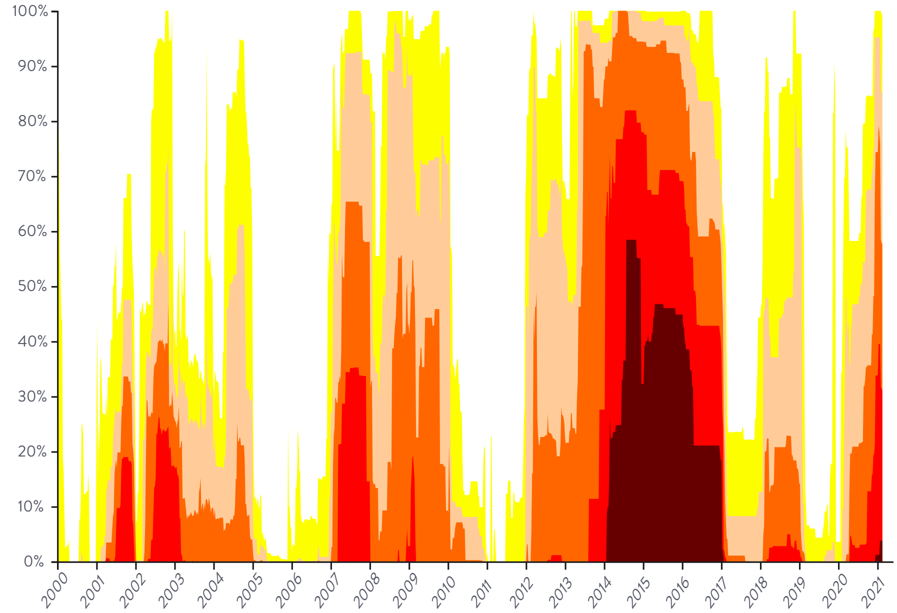
57.9%

D3: Extreme Drought
- *Livestock need expensive supplemental feed, cattle and horses are sold; little pasture remains, producers find it difficult to maintain organic meat requirements*
- *Fruit trees bud early; producers begin irrigating in the winter*
- *Federal water is not adequate to meet irrigation contracts; extracting supplemental groundwater is expensive*

31.4%

D4: Exceptional Drought
- *Fields are left fallow; orchards are removed; vegetable yields are low; honey harvest is small*
- *Fire season is very costly; number of fires and area burned are extensive*
- *Many recreational activities are affected*

3.8%



Source: *National Integrated Drought Information System*

- New restrictions on water access, water discharge volumes, and minimum effluent quality standards/monitoring as groundwater sources become more scarce;
- That states like California will iteratively tighten building codes to increase energy efficiency, reduce waste, and preserve indoor and outdoor air quality via mechanisms like Title 24, the state's triannually updated Building Energy Efficiency Standards (such regulations will have implications for HVAC, humidity control, and other environmental management systems which impact water use in the grow environment);
- More expensive water supply from public systems;
- Increased cooling demand for indoor and greenhouse growers to offset higher loads; and
- Higher operational expenses for temperature control and water management systems

Additionally, due to limited research, impacts of drought stresses on a cannabis plant's maturation and cannabinoid production remains poorly understood. For the thousands of outdoor growers in the western states, a drier, hotter future could have significant implications for which cultivars they grow, and what techniques they will need to adopt to optimize both crop yield and harvest quality.

Water Benchmarks

The ***Cannabis H2O: Water Use & Sustainability in Cultivation*** report is the combination of two original works: The first includes the U.S. cultivation estimates for both the illicit and legal markets (with all estimates based on New Frontier Data's analysis of legalized production in legal states, and careful assessment of illicit activities in non-legalized markets); the second work incorporates water-performance indicators based on data submitted by cultivators to Resource Innovation Institute's Cannabis PowerScore resource benchmarking platform. The estimated total production volume, flowering canopy, and total U.S. cannabis industry cultivation water use are respectively derived from those two sources.

Background & Methodology

This section of the report provides benchmark performance standards, and explores potential causes of performance variation. As described on page 4, all analysis herein has been performed using data aggregated by RII's Cannabis PowerScore platform.

The data here comes from multiple sources. The primary source is the Resource Innovation Institute's Cannabis PowerScore resource benchmarking platform. Cultivators and supply-chain partners throughout North America use PowerScore to submit facility details such as square footage of flowering canopy, amount of product produced, and annual resource consumption data, to receive a competitive performance benchmark comparing their operation's KPIs to others growing like them.

In summer 2020, RII expanded its Technical Advisory Council to include a Water Working Group to establish a scientific understanding of how (and how much) water is used for cannabis cultivation; the aim was to give cultivators confidence in taking steps to be more efficient, and help industry leaders, governments, and media be more accurately informed about the range of water practices in today's regulated market. Members include cultivators, regulatory agencies, academic researchers, equipment manufacturers, engineers, and substrate suppliers.

Members of the Water Working Group offered RII recommendations to expand PowerScore to accept new information about water management practices, to better inform new reports and KPIs describing resource applications, storage, and usage. RII also developed a data transfer protocol, and PowerScore was upgraded to accept submissions of portfolios of facility data, so that larger batches of self-reported data from regional regulatory agencies could be analyzed.

In autumn 2020, RII integrated data from a variety of sources, ensured representation across various locations and methods, and standardized metrics to enable a range of performance.

The Berkeley Cannabis Research Center, Resource Innovation Institute, and New Frontier Data cooperatively consolidated, analyzed, and formulated observations about the information. New Frontier Data used its extensive knowledge of the industry to help summarize the overall market, contextualize the data, and develop industry forecasts.

The teams collaborated to evaluate the data findings and articulate the most salient items to benefit readers of this report, intending to provide the greatest impact for operators, water suppliers, investors, and policymakers.

About Cannabis PowerScore

PowerScore is an online software suite of tools including a survey, facility-level performance benchmarks, dashboards, and reports. The PowerScore survey collects self-reported performance data and cultivation characteristics (e.g., annual production, monthly water consumption, flowering canopy area, cultivation approach, and substrate), to generate a performance benchmark summarizing up to 14 key performance indicators (KPIs) at the facility level. Users benefit by instantly being shown their operation's ranking relative to the rest of the PowerScore's database, through the Ranked Data Set. All data is kept anonymous.

Study Limitations

PowerScore data has potential limitations which the report authors have addressed with data quality protocols described in this section. This report analyzes self-reported data from PowerScore; user-submitted data carry the risk of being either submitted with errors, or with a different interpretation than what the survey creators intended. Since separate and dedicated water-use metering is not always available to growers, monthly water-use submissions might include water from noncultivation-related occupancy or process. For example, while a user might report monthly water usage for a facility, reported annual consumption of the operation could include water consumption for processes other than cultivation, leaving undetermined the portion of water used for cultivation alone.

In an attempt to minimize errors from self-reported data, the report's authors have removed outlier submissions with the guidance of members of RII's Technical Advisory Council and Water Working Group. Facility records using application rates and outputs from water management systems are considered records of the highest quality; those using best guesses were removed from the dataset when records noted the characteristic.

In most cases, users submit data to PowerScore on their own accord, and are not compelled by their regulators. While in most regions power and water consumption information is not required by regulators, there is a growing trend in states and municipalities to mandate reporting. Beginning in summer 2020, cultivators in Massachusetts began complying with energy and water-reporting requirements, and some facilities in the Ranked Data Set contain the required information. For records voluntarily submitted, there is potential for a submission bias wherein the data overrepresents cultivators who are actively engaged in improving their environmental performance. Future iterations of this work will continue to utilize larger and less potentially biased datasets, as more states' regulators require benchmarking and reporting of the industry's resource efficiency metrics. Likewise, future reports will also feature aggregate data from a broader geographical distribution of data.

The analysis in this report focuses specifically on facility-level water used in cultivation. It is important to note that there is additional water embedded within the supply chain and other processes that is not accounted for in this analysis. The estimates in this report do not include other areas such as the water used for controlling environmental conditions with heating, cooling, and humidification equipment, post-harvest processing (i.e., production of extracts and derivatives), irrigation water production and treatment outside the facility, or water used for power generation equipment.

Assumptions & Model Estimations

Developing market estimates for national water use estimates for cannabis required key assumptions due to the data limitations in the cannabis industry. Key data challenges include:

1) **Limited production data availability:** Very limited information is available about production practices in the illicit market which accounts for the majority of cannabis grown in the U.S. In the legal markets, data collection on production varies widely across markets. As such, the model relies heavily on consumption data and the limited data available from regulated markets (i.e., Colorado) to estimate overall production volumes.

2) **Widely divergent cultivation practices:** Across the legal and unregulated markets, growers use widely varied practices to cultivate practices. Differences include:

   - **Number of harvests per year.** Some growers only harvest once a year, others, especially in indoor facilities, can harvest five or more times per year
   - **Plant sizes.** Correlated to harvest frequency, growers with low harvest frequency will produce crops that can be 10 feet tall or taller, whereas plants in a frequent harvest facility may only reach 3-4 feet.
   - **Substrate variance.** The substrate, or medium in which the crop is grown, varies widely, from soil and peat, to rockwool and hydroponics. Each substrate used requires different watering techniques, adding further complexity to estimating average water use.
   - **Plant density.** Space-constrained facilities often pack the plants tightly together, whereas outdoor facilities in particular tend to have wide spaces between plants. This significantly influences both the estimates for water used and the yields per square foot.

3) **Changes in production practices for smokable flower versus value added (extract-based) products.** Historically, cannabis buds were sold for smoking (loose flower and pre-rolls) whereas the plant's leaves and trim from preparing the buds was sold for extraction. However, as the market for extracts has grown, some growers are now producing plants which are fully intended for the extracts market. Production for extraction-only remains a small proportion of all cultivation in the U.S.

Assumptions

Production volume per dollar of revenue earned.

Based on the sales revenue data collected, we developed an estimate for the volume of production required to meet the retail demand. This estimate was based on the production volumes reported in Colorado, the country's most mature cannabis market.

KEY ASSUMPTION: The revenues earned in Colorado per pound of cannabis produced are an effective proxy for production practices across the country due to the longitudinal data available, and the mix of cultivation facility types used in the state.

Pounds of smokable flower produced.

The estimates for pounds produced are for smokable flower only. It does not include the biomass weight produced from trim of leaves. The smokable bud estimates are based on the cured finished product, not on the wet weight at the time of harvest.

KEY ASSUMPTION: The trim and leaf used to produce extracts is from the same plants from which the smokable bud is harvested. As such the square footage used to produce smokable flower is the same as what is used to supply the extract market.

Percentage of production for import/export.

The illicit market accounts for most of the cannabis consumed in the U.S. Most states are net importers of cannabis, relying on exports primarily from California. Based on analysis of data from the U.S. government's cannabis eradication program, and inputs from industry and cannabis policy experts, we developed estimates for total production in each state based the estimated volume of domestically produced and imported cannabis.

KEY ASSUMPTIONS:

- Cannabis imports only apply to the illicit market. All legal market products are produced within the states where they are sold.
- The volume of imports declines over time as legal markets are established in each state.

Distribution of facility types in each state.

Based on analysis of licensing data (where available) and discussions with in-state operations experts, we estimated the proportion of indoor, greenhouse, and outdoor facilities in each state. Generally, states which experience more extreme weather were more likely to have indoor and greenhouse facilities, whereas those in more temperate regions were more likely to grow outdoors.

KEY ASSUMPTION: The proportion of indoor, greenhouse, and outdoor facilities in each state are similar in the legal and illicit production facilities within each state.

Average yield per square foot of flowering canopy.

To determine the average yield per square footage and facility type, we reviewed existing market data and polled licensed cannabis producers operating in different U.S. markets. These estimates were used to great the national aggregated estimate for total square footage used to grow cannabis. Due to the limited number of inputs, the estimated values can significantly influence the total national estimates for production scale.

Square footage of Flowering Canopy vs. Square Footage of Total Canopy or Total Facility Size.

There are three common metrics used for cannabis facilities:

- **Flowering canopy:** The area used to grow the plants during their final stage of growth before harvest.
- **Total Canopy:** The square footage used to grow plants during the seedling, vegetative, and flowering stages.
- **Total Facility Size:** The total size of the cultivation facility, including canopy, production areas, offices, etc.

KEY ASSUMPTION: For purposes of this report, the canopy areas referenced are for *flowering canopy only* since the surveyed growers measure their yields per square foot of flowering canopy.

Water Data Sets

Three sets of data are included in the PowerScore analysis: the national PowerScore Ranked Water Data Set, the Northern California 2019 dataset, and the Michigan 2020 dataset.

The use of these datasets is opportunistic, yet also provides a good snapshot of current cannabis production. Each dataset has its own strengths. The national PowerScore data is broadly representative of cannabis production across the United States, and provides data from many of the largest producing regions. The Northern California data is by far the largest dataset, and therefore may provide the most reliable picture of regional water use. The Northern California data is nevertheless important, as that area still contains the majority of California's permitted cannabis farms, and likely a majority of unpermitted farms also. The Michigan dataset provides a glimpse into water use in a rapidly changing new market.

> The use of these datasets is opportunistic, yet also provides a good snapshot of current cannabis production.

POWERSCORE RANKED WATER DATA SET

The PowerScore Ranked Water Data Set contains 44 total records with complete water KPIs. These records include indoor facilities, greenhouses, and outdoor farms in nine states (i.e., California, Colorado, Illinois, Maryland, Massachusetts, Ohio, Oregon, Vermont, and Washington).

Each PowerScore record reports flowering canopy square feet, annual production, and gallons of water both stored and applied by month.

Also provided is limited plant count data, with plant counts extrapolated from total canopy square feet (per plant gleaned from the Northern California 2019 Data Set for mixed-light and outdoor farms).

Within the set of 44 facility records, there are several subgroups of facilities:

The PowerScore Ranked Water Data Set is biased towards smaller operations, with less representation of larger farms. The average flowering canopy area is 44,900 square feet for outdoor farms, 10,400 square feet for greenhouse operations, and 6,210 square feet for indoor facilities in this data set. That farm size is significantly smaller than farm size data in California. Analysis by UC Berkeley using government data and aerial imaging analysis shows that larger farms make up a significantly higher proportion of California's total canopy than do smaller ones: Farms with over 30,000 square feet account for 71% of permitted canopy, and 35% of unpermitted farms.

The report's analysis of total water use was based on the distribution of square footage in each group, not the percentage of PowerScore records in each category.

FIGURE 7: PowerScore

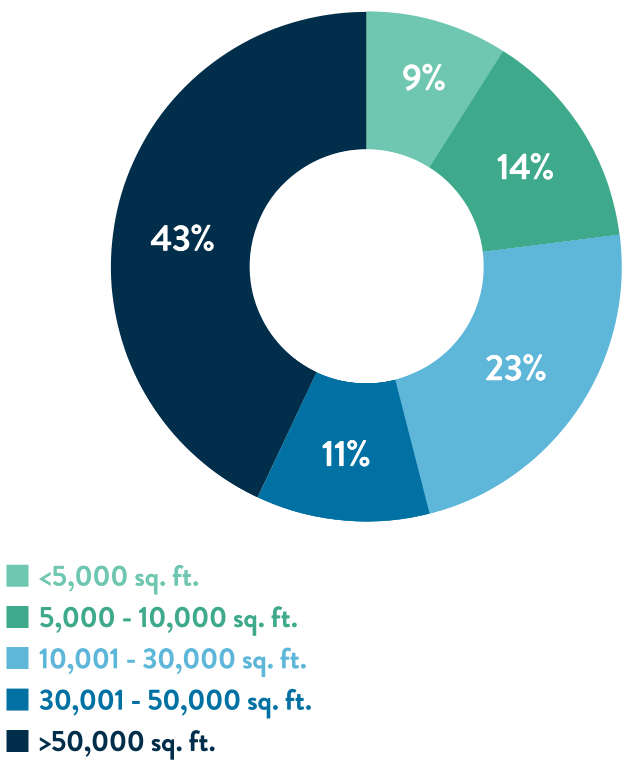
Flowering Canopy Square Feet	PowerScore Ranked Water Data Set	California Percentage of Canopy Square Footage by Farm Size: California Permitted Farms % sq. ft.	California Non-Permitted Farms % sq. ft.	California Average % Total sq. ft.
<5,000 SF	**51%**	2%	16%	**9%**
5,000 - 10,000	**13%**	12%	16%	**14%**
10,001 - 30,000	**15%**	14%	32%	**23%**
30,001 - 50,000	**13%**	11%	10%	**11%**
>50,000	**8%**	61%	25%	**43%**

Figure 7 illustrates the distribution of PowerScore Ranked Water Data Set records by flowering canopy size, compared against UC Berkeley's assessed distribution of permitted and non-permitted California farm sizes.

Nearly half of the PowerScore Ranked Water Data Set records are for indoor facilities, with the data regionally concentrated primarily between the Pacific Northwest and New England.

For indoor facilities, water use is more heavily influenced by the plants than by the outdoor environment, due to the greater insulation from exterior conditions. Consequently, limited variance in water use is expected between identically designed indoor facilities across the country.

FIGURE 8: California Average % Total sq. ft.

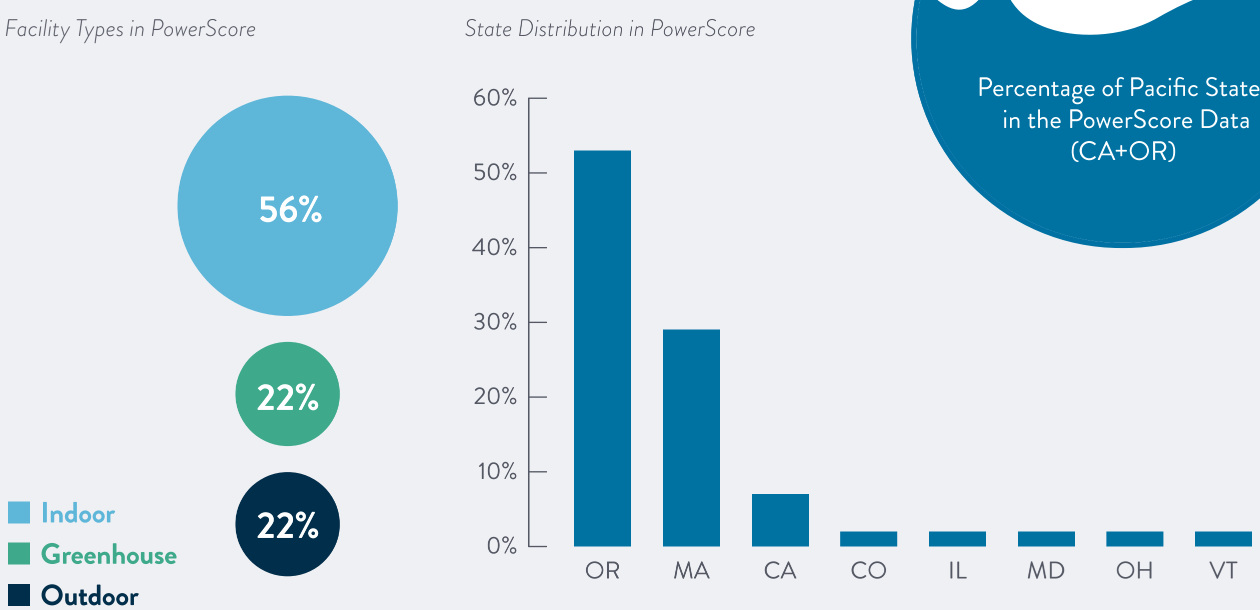


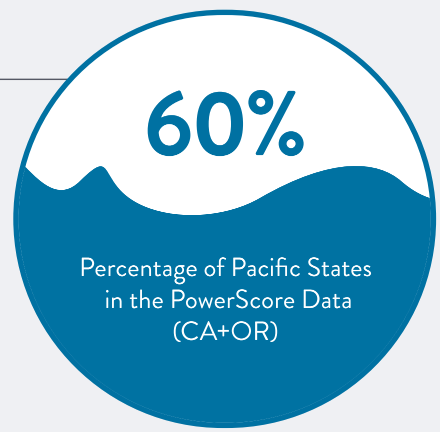
However, the wide variance in climatic conditions nationally means that exterior conditions will have far greater impact on resource use in greenhouse and outdoor operations. As such, while this analysis provides an illustrative view into the industry's water use, and identifies opportunities to increase water efficiency, it does not capture the regional variance of non-indoor facilities across the country.

RII will continue to work to capture data from nationally distributed operators as legal markets extend across the northern states (e.g., Michigan, Illinois, Montana) which experience mild summers and long, cold winters, across southwestern states (e.g., Arizona and New Mexico) with warmer, drier conditions, and into southern states (e.g., Florida, Georgia, Louisiana, Oklahoma) which experience hot, humid conditions.

The PowerScore Ranked Water Data Set records represent facilities using several cultivation techniques that could influence water usage for cultivation.

FIGURE 9: PowerScore Records by State & Cultivation Approach





The PowerScore Ranked Water Data Set records represent facilities using a variety of water sources, including potable and natural water sources.

FIGURE 10: National PowerScore Water Sources

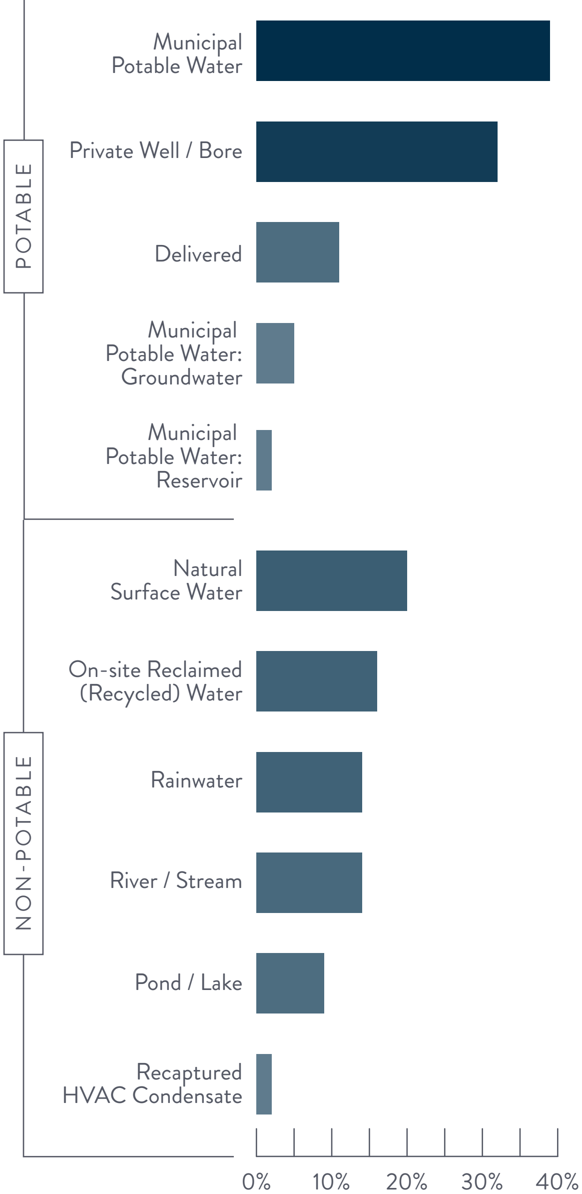


FIGURE 11: Potable Water Sources

by Facility Type

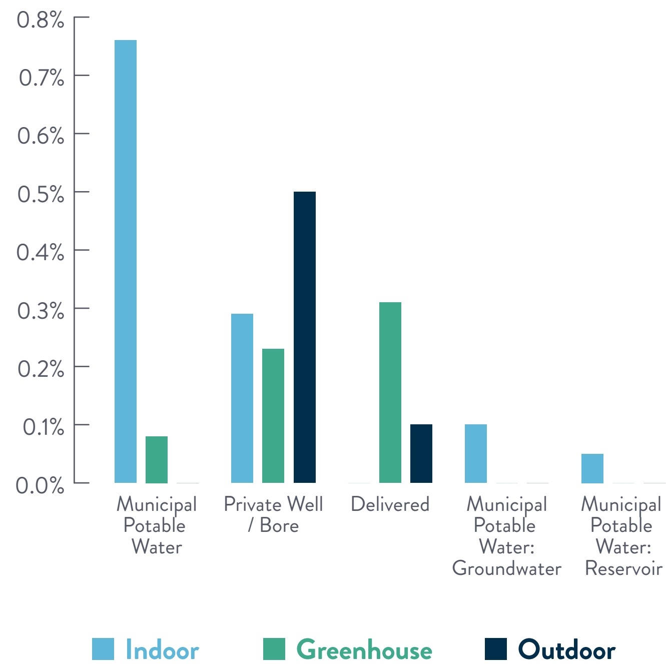
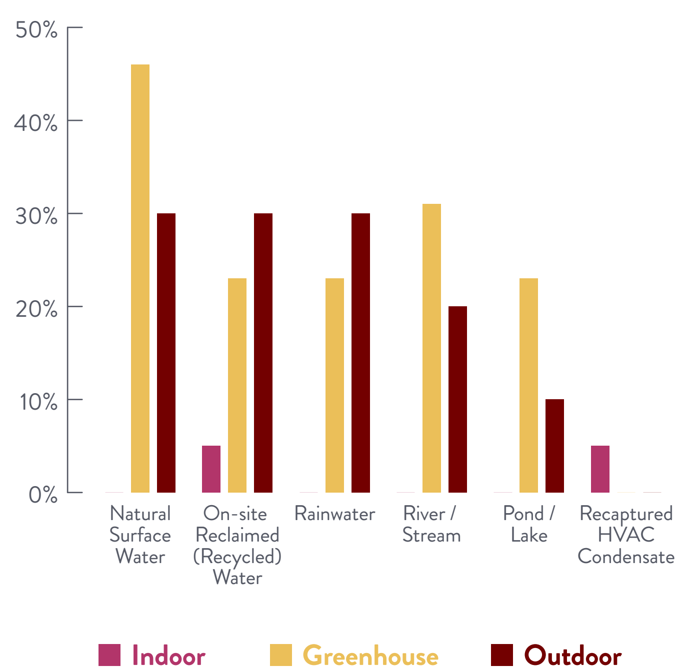


FIGURE 12: Non-Potable Water Sources

by Facility Type



NORTHERN CALIFORNIA 2019 DATA SET

The Northern California 2019 Data Set contains 618 records covering greenhouses and outdoor farms in Mendocino, Humboldt, Trinity, and Sonoma counties that have received cultivation permits from the state of California. The data was obtained via a Public Records Act request to the California Water Boards. Each record reports a plant count, total canopy square feet, and gallons of water stored and applied monthly. The dataset does not contain production data.

The Northern California 2019 Data Set is biased towards small- to medium-sized operations, and has less representation of larger farms. In the data set, the average flowering canopy area for outdoor farms is 12,650 square feet, and 10,200 square feet for greenhouse operations.

The Northern California 2019 Data Set has a concentration of greenhouse facilities (i.e., operations using supplemental light).

FIGURE 13: California Cultivation Facility Data
by County

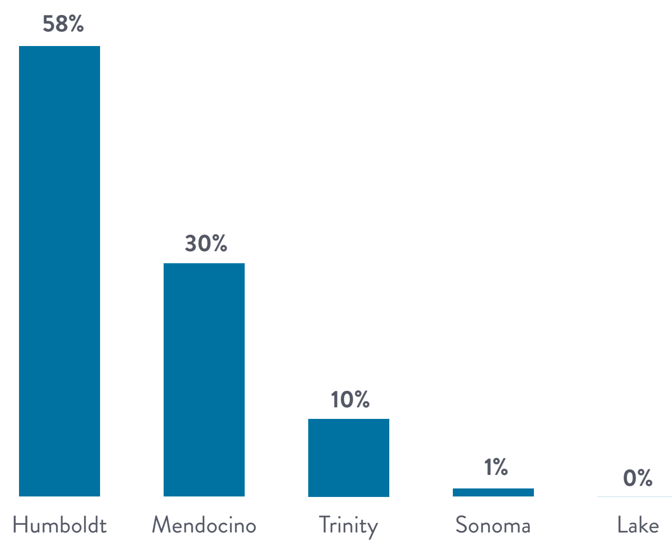
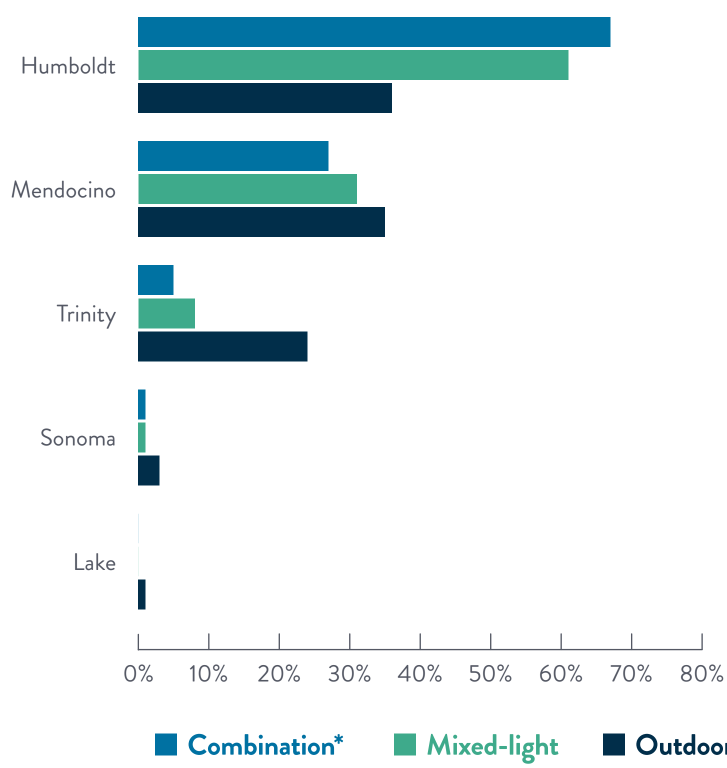


FIGURE 14: California Cultivation Facility Type
by County



** Farms with canopy area both outdoors and in mixed light environments*

FIGURE 15: California Average Canopy Area
by Facility Type

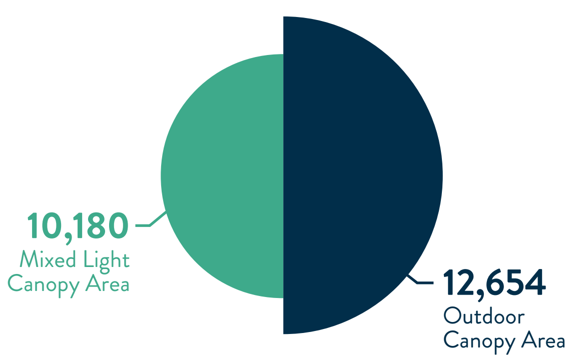


FIGURE 16: California Primary Source of Water

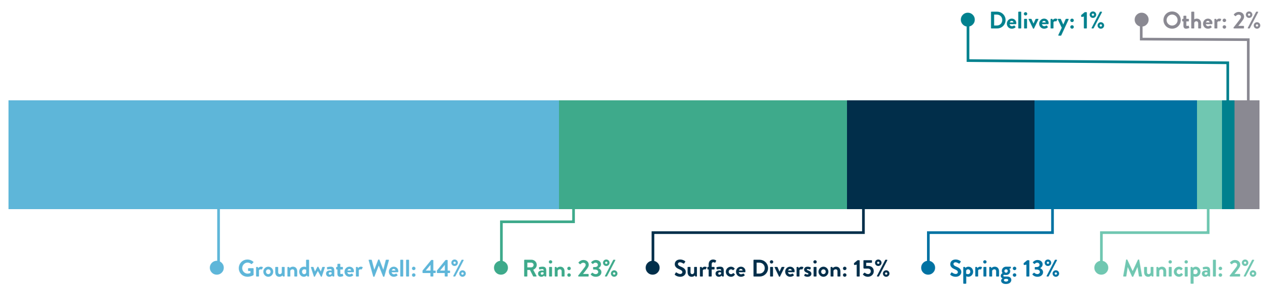


FIGURE 17: California Secondary Source of Water

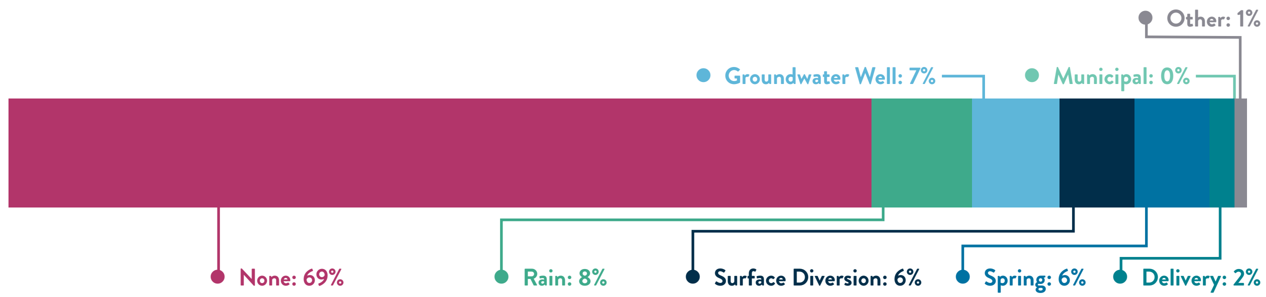
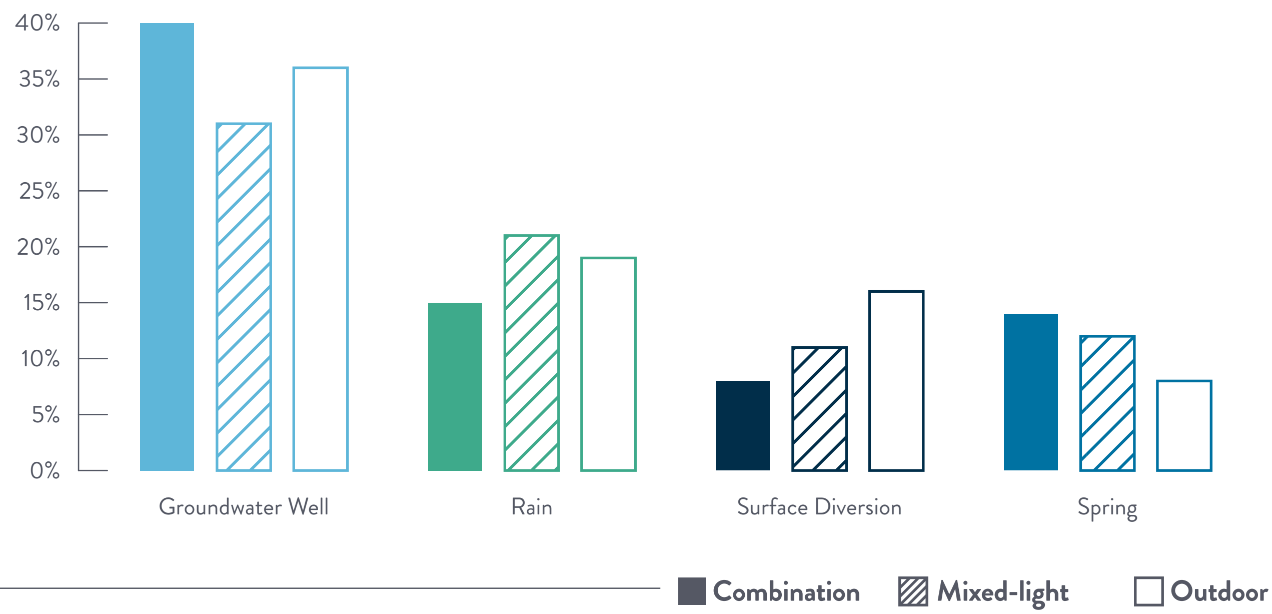


FIGURE 18: California Primary Sources of Water

by Facility Type



MICHIGAN 2020 DATA SET

The Michigan 2020 Data Set represents 12 indoor facilities licensed in Lansing, Michigan. The indoor facility records report gallons of water applied by month of year. All facilities in the data set are served by the local public water system. Information about storage infrastructure is undetermined.

The dataset does not provide plant count data, but regulations in Michigan limit plant count:

- CLASS A – 500 Plants Med/100 Plants for Adult Use (AU)
- CLASS B – 1,000 Plants Med/500 Plants for Adult Use (AU)
- CLASS C – 1,500 Plants Med/ 2,000 Plants for Adult Use (AU)
- EXCESS LICENSE – 2,000 Extra Plants (Medical)

Class C licenses are the license type for 92% of the records in the Michigan dataset.

Water Sources

A majority of mixed-light (50%) and outdoor (56%) facilities in Northern California use groundwater wells as water sources. Most (61%) mixed-light facilities also use tanks of stored water, and nearly a quarter (23%) use rain as a water source. Six in 10 mixed-light facilities (61%) and nearly half of the outdoor facilities (48%) use tanks, while one-quarter (23%) of mixed-light facilities and 17% of outdoor farms use rain as a water source.

It is worth noting that facilities using rainwater often collect the rainwater during the offseason, due to the limited rainfall during summers when the crops are being grown.

All indoor facilities in the PowerScore Ranked Data Set use potable water for source water. No indoor facilities use natural surface water, but 5% use on-site reclaimed water from use of recovered condensate from HVAC and dehumidification equipment. No indoor facilities in the PowerScore Ranked Data Set rely on rain as a water source, and none has water delivered to their facility.

Growers in other parts of the country, especially the water-rich Northeast and Midwest states are more likely to rely on public water than invest in building onsite groundwater supplies. Furthermore, these areas are less likely to see major water disruptions due to drought and are therefore less likely to need redundancy systems to back up their primary water supply.

Key Benchmarks

The table below shows four key benchmarks for tracking a cultivation organization's water performance by cultivation approach from PowerScore, California, and Michigan. Ranges are used to describe water performance of varying cultivation approaches. More detail is provided on each key performance indicator in the following sections:

1) **Water Productivity**
2) **Water Efficiency**
3) **Water Demand**
4) **Water Storage**

NOTE: LIMITATIONS OF MEASURING WATER USE PER PLANT

Early efforts over the past decade by state environmental agencies to quantify water efficiency of cannabis production facilities used unit metrics such as gallons per plant as a baseline for typical performance. However, with the extremely broad range of planting densities —which can range from as low as 300 plants per acre in outdoor farms to as many as thousands of plants per acre indoors — the plant size and duration of the cultivation period range so widely that they render any water-use per plant comparison meaningless. Therefore, an attempt has been made to develop efficiency measures that are comparable across plant densities.

FIGURE 19: Key Metrics on Cultivation Facility Water Use

PowerScore

	Indoor	Greenhouse	Outdoor
Water Facility (Gallons/sq. ft.)	198	79.9	10.8
Average Monthly Usage	87,436	27,833	25,500
Total Annual Usage	649,000	334,000	306,000
Water Productivity (grams/gallon)	3.74	1.88	3.13

California Cultivation Facilities

	Combination	Mixed-Light	Outdoor
Water Facility (Gallons/sq. ft.)*	11.4	14.9	11.3
Average Monthly Usage	15,921	15,104	12,429
Total Annual Usage	206,977	196,346	161,578
Storage Gallons / Canopy Square Feet	12.2	14.8	9.99
Total Annual Storage	221,403	194,960	174,028

** Collected as applied gallons per square foot.*

Michigan Cultivation Facilities

	Average
Average Monthly Usage	64,629
Total Annual Usage	775,543

Water Productivity (grams/gallon)

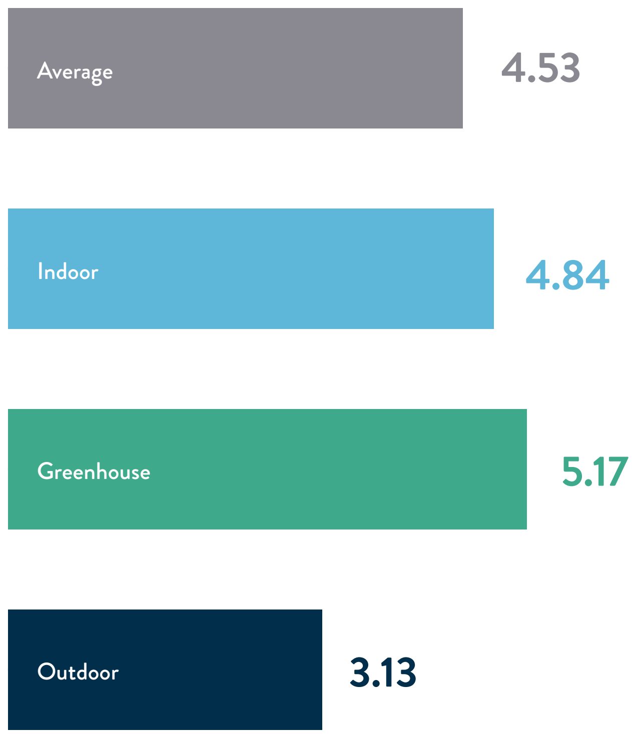
Of all metrics relevant to water consumption, water productivity best represents how efficiently a cultivator is using water to produce cannabis. The metric represents a cultivator's cannabis output relative to water input. Over a 12-month period, cannabis output is measured in grams of dry (trimmed) flower produced, with water input measured in gallons of water applied for irrigation. A higher value for water productivity indicates more effective use of water as a resource.

PowerScore Water Productivity (grams/gallon)

Data from the PowerScore Ranked Water Data Set show average water productivities of 4.8, 5.1, and 3.1 grams per gallon for indoor, greenhouse/hybrid/mixed-light,[9] and outdoor cultivation operations, respectively.

The average water productivity of the PowerScore Ranked Water Data Set shows greenhouse facilities achieving the best grams per gallon, using the least amount of water per gram of cannabis produced, closely followed by indoor facilities. Outdoor facilities had the lowest yield per gallon.

FIGURE 20: PowerScore Water Productivity
Grams/Gallon



> The PowerScore Ranked Water Data Set shows greenhouse facilities achieving the best grams per gallon, using the least amount of water per gram of cannabis produced.

9. *Facilities are categorized as hybrid type if they are designated as a greenhouse, or if the data for the latest plant growth stage reports using both sunlight and electric light. The average water productivity performance of greenhouses compared to outdoor farms may be influenced by outdoor farms generally including total land area in their flowering canopy area totals; having wider spacing between the plants, they may appear to be more efficient because their farm footprint is much larger than their true flowering canopy area, giving them a much larger denominator.*

Water Efficiency (gallons/square foot)

The metric describes a cultivation facility's annual application of water for irrigation per unit of area. A lower value for water efficiency indicates more effective use of water as a resource.

Energy industry professionals are presumably familiar with energy use intensity (EUI), a metric used for characterizing building energy consumption, and often used in benchmarking exercises. While water-use intensity (WUI) is similar, it typically is divided by total (i.e., gross) building area for other kinds of buildings, whereas the version of the metric in question uses flowering canopy (rather than total building area) as the relevant definition of area, as PowerScore also uses for energy KPIs. Canopy is defined as the tray-and-table area used for plant production, not the total area available for planting (excluding all aisles, walkways, and noncultivation areas). Flowering canopy includes only tray-and-table area used for flowering cannabis plants (excluding canopy area for younger plants).

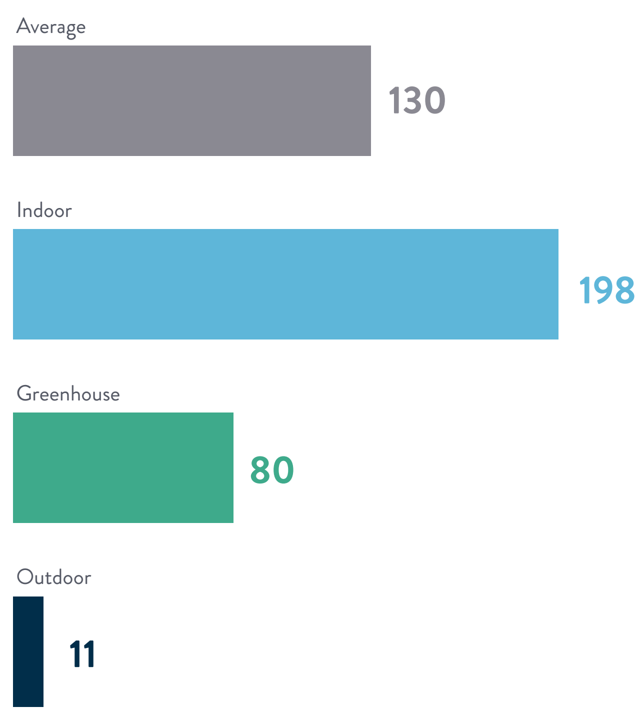
It is worth noting that the reported canopy of outdoor grows is more likely to include non-water-using areas between plants than in greenhouse grows, where the plants are typically more densely planted together. That thereby lowers the water usage by area for outdoor farms, since the area measurement includes a larger overall footprint than is being actually used for cultivation. Additionally, the variability in plant spacing and plant sizes in outdoor farms makes it impossible to create a uniform way to account for the unused space between plants.

Also, when applying any metric with area in the denominator, it is worth considering how a given site's utilization might impact results. Consider a new facility that is still ramping up production, or one that reduces output in response to low prices during the outdoor harvest months: Compared to a facility of identical size and efficiency that operates at 100% utilization, the water efficiency at the lower utilization facility will be lower (despite electricity productivity being the same). The dynamic is likely expressed in some of the Cannabis PowerScore data.

PowerScore Water Efficiency (gallons/square foot)

Data from the PowerScore Ranked Water Data Set show average water efficiencies of 198, 80, and 11 gallons per square foot of flowering canopy for indoor, mixed-light, and outdoor cultivation operations, respectively.

FIGURE 21: PowerScore Water Efficiency
Gallons/sq. ft.



The average water efficiency of the PowerScore Ranked Water Data Set shows outdoor farms attaining the best water efficiency, using the least amount of water per area of flowering canopy.

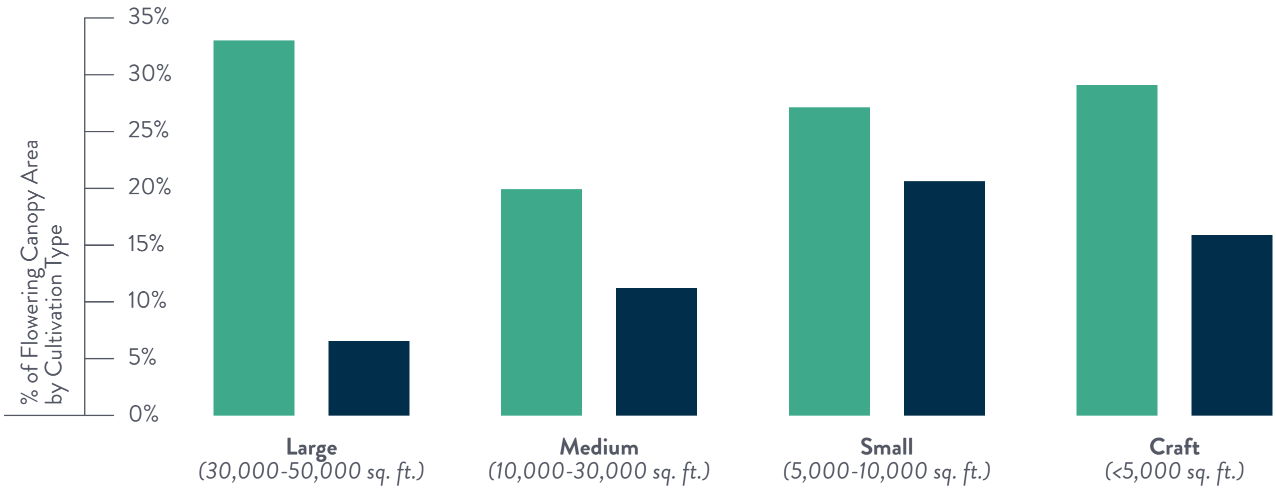
The indoor operations have the highest water use per square foot. At nearly 200 gallons/sq. ft., the PowerScore indoor reported averages are significantly higher than typically seen range between 50-73 gallons/sq. ft. This suggests the PowerScore participants may be running more harvest cycles per year than average, thereby driving up their use.

Northern California Water Efficiency (gallons/square ft)

Data from the Northern California 2019 Data Set show a range of average water efficiencies of greenhouse and outdoor facilities by flowering canopy size. Greenhouses range between 20-33 gallons per square foot of flowering canopy per year, while outdoor operations achieved better average water efficiency values of 6.5-21 gallons per flowering canopy square foot.

FIGURE 22: California Annual Water Use

Gallons Applied per Flowering Canopy Area sq. ft.



Facility Type	Annual Gallons Applied per Flowering Canopy Area			
	Large (30,000 - 50,000 sq. ft.)	Medium (10,000 - 30,000 sq. ft.)	Small (5,000 - 10,000 sq. ft.)	Craft (<5,000 sq. ft.)
Greenhouse	33.0 14 records	19.9 72 records	27.1 123 records	29.1 62 records
Outdoor	6.54 7 records	11.2 26 records	20.6 71 records	15.9 19 records

Greenhouse ■ Outdoor ■

Water Demand (gallons/month)

The metrics herein describe a cultivation facility's water consumption per month, to represent how much water each facility and plant demands as they produce cannabis. There are two kinds of water demand: storage demand, and application demand. Storage demand conveys how much water is held on-site, and can be described using gallons per year and per month. Application demand also describes how much water per year and per month.

The PowerScore Ranked Water Data Set collects both application and storage water demand to understand the related activities of water application and water storage, and to make the data more comparable across all data sets and types of facilities.

The Northern California Data Set and the Michigan Data Set describe only application water; California dataset does not distinguish water storage demand from water application demand, and instead distinguishes applied water demand that is served directly by water sources and demand served by stored water.

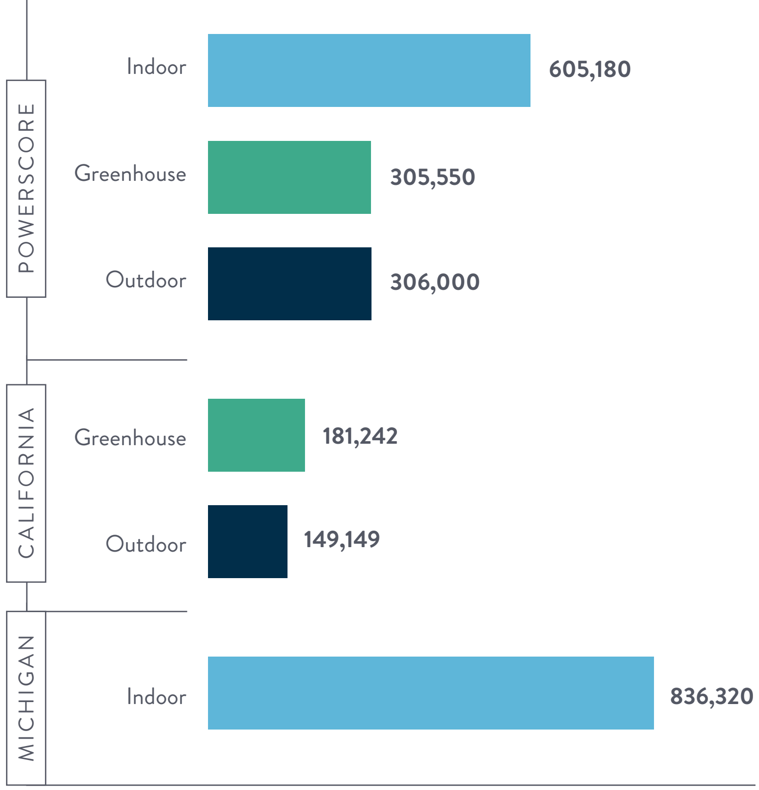
Facility Water Demand (gallons/year)

Facilities in the PowerScore Ranked Water Data Set show average annual water usage of 605,180; 305,550; and 306,000 gallons per year for indoor, mixed-light, and outdoor cultivation operations, respectively.

Facilities in the Northern California 2019 Data Set show average annual water usage of

FIGURE 23: Average Annual Water Use

Gallons/Year



181,242 and 149,149 gallons per year for mixed-light and outdoor cultivation operations, respectively.

Indoor facilities in the Michigan 2020 Data Set show average annual water usage of 836,320 gallons per year.

Facility Water Demand (gallons/month)

Indoor facilities in the PowerScore Ranked Water Data Set show average monthly water application rates of 69,200 to 124,000 gallons per month, with peaks in each of March, June, September, and December. There are three months between each peak, which coincides with the interval between harvest cycles of mature cannabis (three-month plant lifespan). Some reasons why cyclical peaks emerge in the small data set of 23 records may include:

FIGURE 24: PowerScore Average Monthly Water Use

Gallons Applied per Month

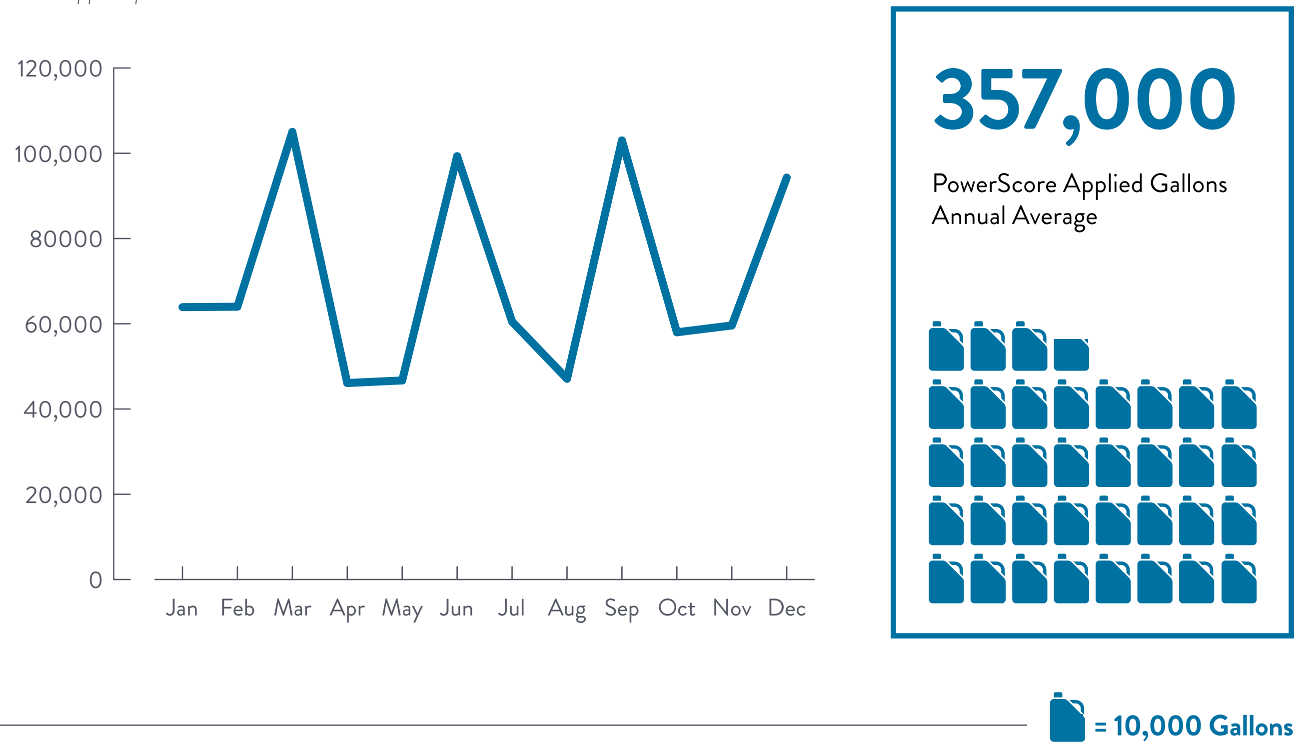


FIGURE 25: California Average Monthly Water Use

Gallons Applied per Month

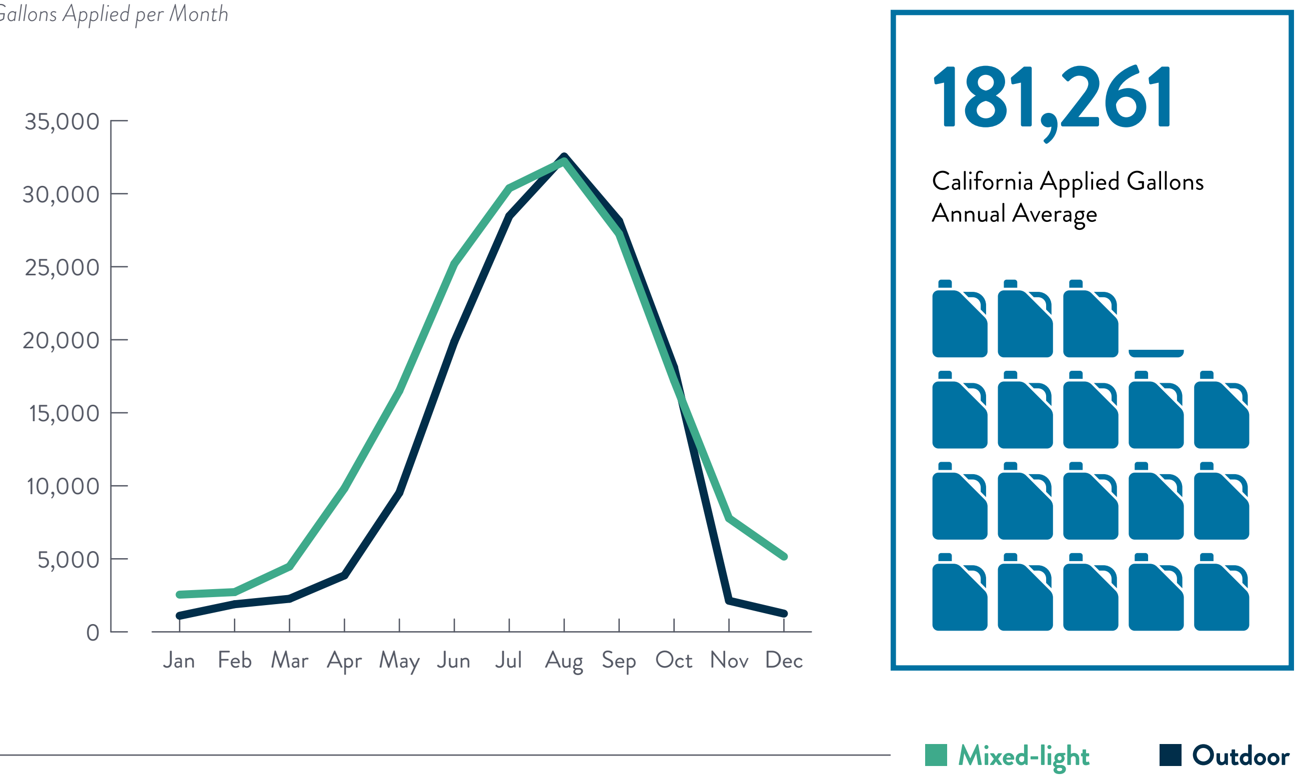
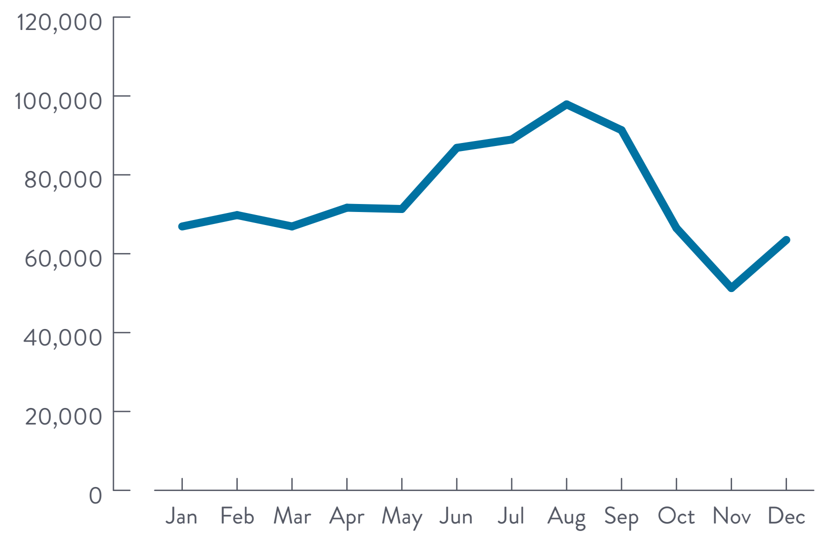
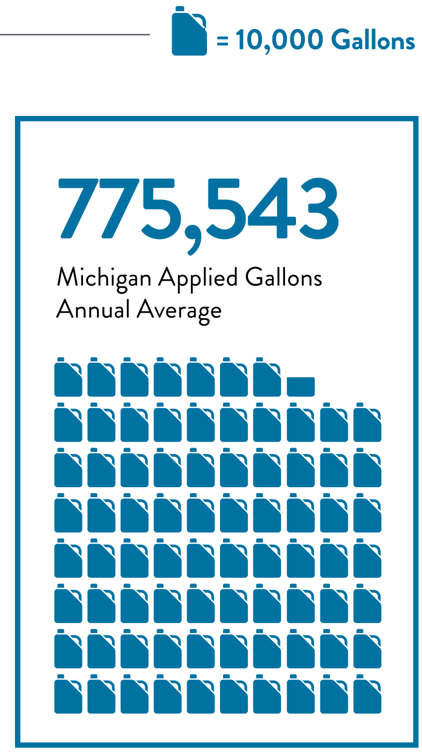


FIGURE 26: Michigan Average Monthly Applied Gallons





- The cultivators are predominantly single harvests at one time, instead of perpetual harvests throughout the year;
- Legalization schedules may take effect at the beginning of a calendar year; or
- Christmas and summer representing the biggest months for demand, so cultivators may sync with sales demand

Greenhouse operations in the Northern California Data Set show average monthly water application rates of 2,547 to 32,211 gallons per month, with peaks from June to September. Outdoor farms in the Northern California Data Set show average monthly water application rates of 1,102 to 32,546 gallons per month, with June to September also representing a peak period.

Some reasons why cyclical peaks may emerge in the data set include:

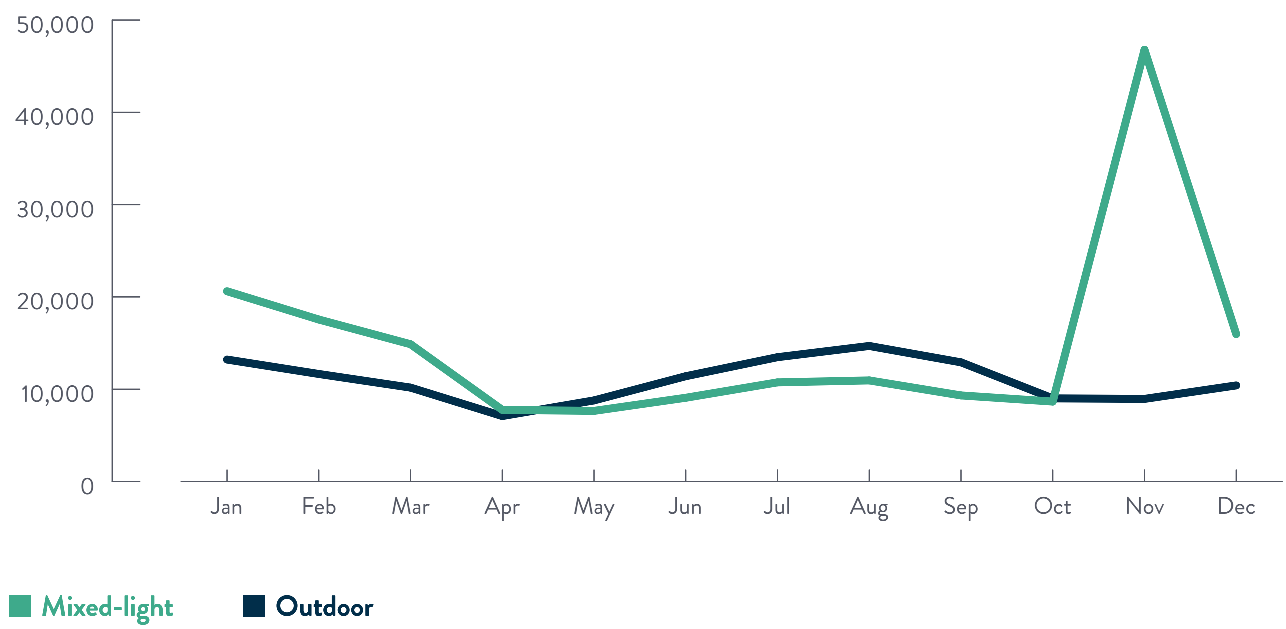
- Facilities cultivating sun-grown cannabis, and those using supplemental light, are affected by seasonal changes in photoperiod and intensity of solar radiation; and
- June through September is the warmest period among California's seasons.

Indoor facilities in Michigan show average monthly water application rates of 47,100 to 105,000 gallons per month, with peaks in June to September. Compared to the PowerScore Ranked Water Data Set facilities, Michigan facilities have lower peak water application rates.

- Some reasons why cyclical peaks do not emerge in this small data set of 12 records may include:
- Some cultivators getting started in their first year of operations, with data not yet representing fully typical water application rates.

FIGURE 27: California Average Monthly Water Storage

Gallons Stored per Month



Water Storage Rates (gallons/year & gallons/month)

Mixed-light facilities in the Northern California Data Set show average monthly water storage rates (i.e., average amount of water stored on-site each month) of 7,654 to 46,774 gallons per month, with peak storage in November. Outdoor farms in the Northern California Data Set show average monthly water storage rates of 7,094 to 14,686 gallons per month, with peak storage in August. Input to storage from surface water or springs is generally prohibited from March to November in Northern California. Therefore, most input to storage from April to October likely comes from wells, and is most likely not long-term storage.

Average Water Stored by Facility Type

Gallons Stored by Month

Month	Mixed-light	Outdoor
January	20,615	13,214
February	17,552	11,652
March	14,876	10,176
April	7,762	7,094
May	7,654	8,788
June	9,075	11,409
July	10,742	13,471
August	10,954	14,686
September	9,328	12,913
October	8,663	9,010
November	46,774	8,953
December	15,968	10,412

total industry
Water Consumption

U.S Cannabis Industry Size & Demand Outlook

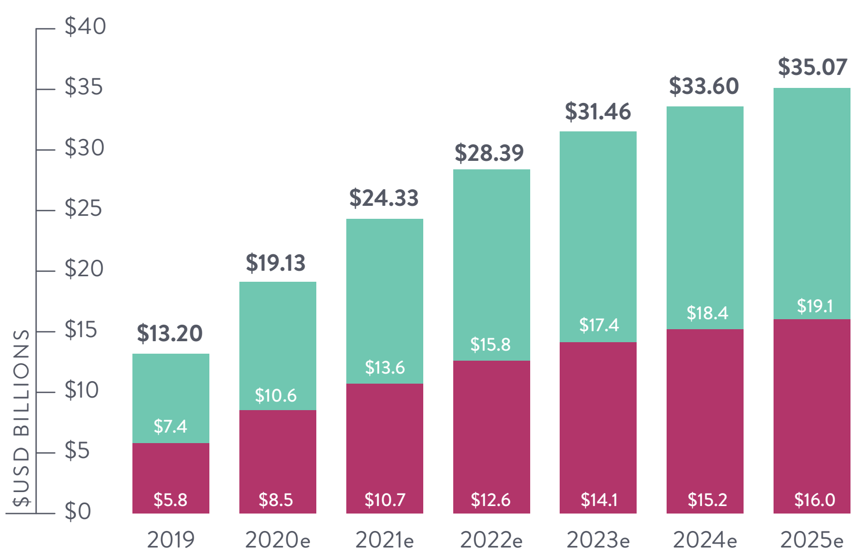
U.S. Cannabis Industry Growth & Market Outlook

The U.S. cannabis industry is experiencing surging growth, driven both by continued expansion of legal markets and rising consumer demand. With the market growing at a compound annual growth rate of 18%, legal market sales in 2020 are estimated at $19.1 billion, rising to over $35 billion by 2025. However, despite the legal market's growth, the illicit market continues to be the primary source for the majority of cannabis consumers, generating $67 billion in sales in 2020 alone.

Collectively, total U.S. consumer spending on cannabis totaled $86 billion in 2020, and is forecast to grow to over $105 billion by 2025.

The growth in revenue is fueled by rising rates of cannabis use in the U.S. According to the National Survey on Drug Use and Health, the prevalence of past-month cannabis use among adults aged 18+ increased 50% between 2010 and 2018, from 6.8% to 9.5%. By 2025, the prevalence of adult cannabis use is forecast to reach 12.5%, an 85% increase from 2010.

FIGURE 28: Growth of the U.S. Legal Cannabis Industry
2019-2025 est. ($USD billions)



2019-2025 GROWTH RATES (CAGR)

18%

TOTAL LEGAL SALES

Legal Adult-Use Sales: 17.2%

Legal Medical Sales: 18.3%

Legal Adult-Use

Legal Medical Use

Note: Market size projections are based solely on the state markets that have passed medical and adult-use legalization initiatives as of August 2020, and do not include assumptions for any additional states that may pass legalization measures in the future.

The legal market's growth is driven by the growing number of states that have passed medical or adult-use measures. In 2020, four states (Arizona, Montana, New Jersey, and South Dakota) passed adult-use measures, and two (Mississippi along with South Dakota, again) approved medical measures, increasing the number of adult-use states to 15, with 36 states legalizing medical use. While the forecasts account for only those states where cannabis is currently legal, large markets including New York, Florida, and Pennsylvania are all expected to pass adult- use measures in the next two years, while Texas and Southeastern states including Alabama, Georgia, and the Carolinas are expected to advance medical-use legalization.

KEY TRENDS DRIVING INCREASED DEMAND FOR CANNABIS

A convergence of market factors is driving increased demand for cannabis in the U.S.

SCIENTIFIC AFFIRMATION OF THE THERAPEUTIC APPLICATIONS FOR CANNABIS

There are over 60 medical conditions for which states permit patients to use medical cannabis, ranging from cancer and chronic pain, to glaucoma and multiple sclerosis. Further, some states including California and Oklahoma allow physicians to recommend cannabis for any condition for which the provider believes the patient might benefit.. With a large body of scientific research patient testimonials affirming medical cannabis, a growing proportion of the population are integrating cannabis into their treatment options.

DIVERSIFICATION OF CONSUMER PRODUCTS AND USE CASES

In the illicit market, smokable flower and concentrates, including vapes, are the most widely consumed product forms. However, in legal markets, well-capitalized companies have been able to develop increasingly elegant value-added products ranging from infused edibles and beverages, to cosmetics, suppositories, and feminine care products. These noncombustible products create new use cases for cannabis, enabling consumers to integrate cannabis into their lives in novel ways. While flower remains the most popular product among legal markets, over the past six years its share of sales has fallen from over 90% to approximately 50% in mature adult-use markets like Colorado. The trend is expected to accelerate as more states legalize, and as consumers across the country are more exposed to the value-added product segment.

SHIFTING SOCIAL ATTITUDES.

Public attitudes around cannabis have shifted dramatically in recent years. Fully two-thirds of Americans now support full legalization, and (per a 2020 Gallup study) 70% of Americans view smoking cannabis as morally acceptable. The erosion of cannabis stigma has resulted in its being consumed in many more social settings than where it was considered acceptable even a few years ago, providing infrequent consumers with more use occasions while displacing some alcohol sales. Displacement of alcohol sales by cannabis is expected to be a durable long-term trend, especially among younger consumers maturing in environments where cannabis is increasingly viewed as equally acceptable, legal, or safer than alcohol.

National Water Use In Cannabis Cultivation

Estimating Total Production Volume

To estimate the total water used in U.S.cannabis cultivation, the first step was to determine the quantity of cannabis produced to serve U.S. demand. Using production data from Colorado (which shows how much cannabis was produced to serve the retail demand), we developed a national estimate for cannabis flower production by facility type.

For 2020, we estimated that 34 million pounds of cannabis flower were produced to serve U.S. consumers across both legal and illicit markets, with a production forecast to rise to nearly 41 million pounds by 2025. The legal market accounted for approximately one-quarter (23%) of the market's supply.

FIGURE 29: Share of Market, Pounds Produced

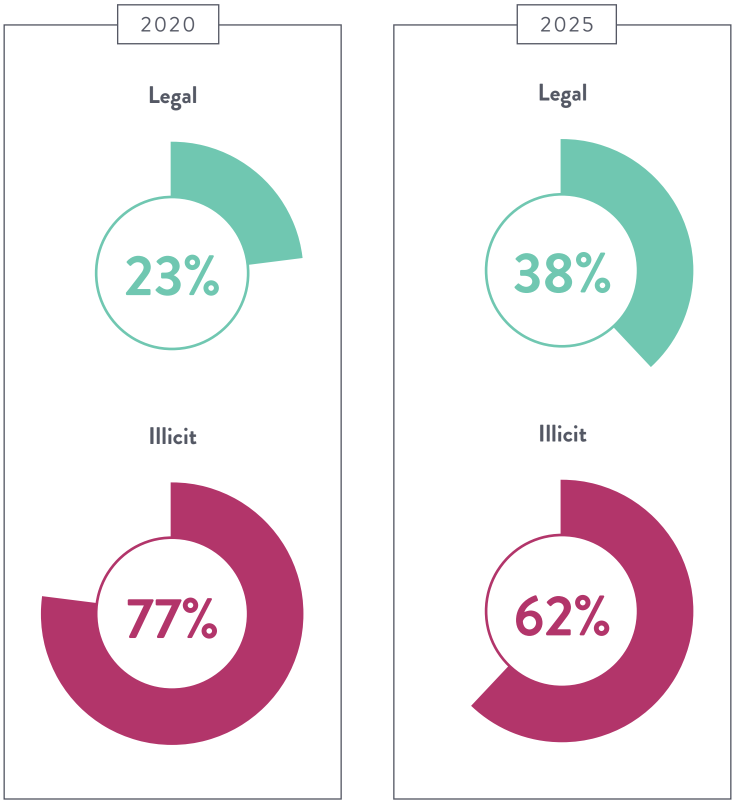
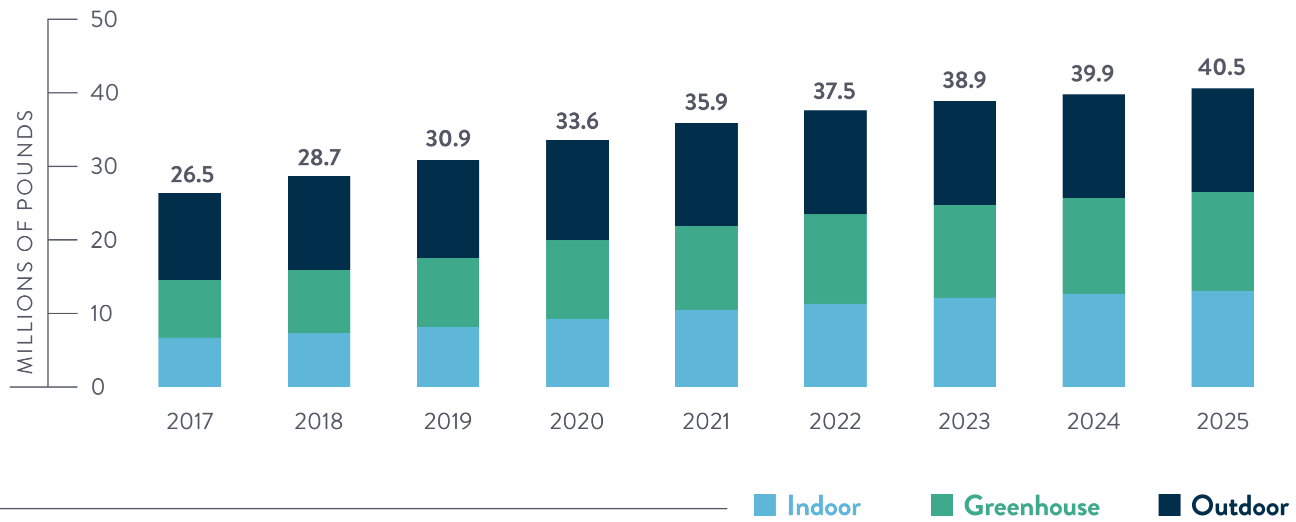


FIGURE 30: U.S. Total Cannabis Cultivation

by Facility Type, 2017-2025



LEGAL MARKET PRODUCTION

With the strong growth of the legal market, including the addition of five new legal states following the 2020 election, U.S. legal production is forecast to grow 102% between 2020 and 2025, from 7.7 million pounds to 15.6 million pounds. Since many of the newly legal states are in areas with suboptimal environmental conditions to produce cannabis outdoors, most of the growth in production will be in indoor and greenhouse/mixed-light facilities.

ILLICIT MARKET PRODUCTION

Outdoor production dominates the illicit market, accounting for nearly half (48%) of all production, in large part due to California's outsized share of cannabis sold across the U.S. Compared to the legal market, the illicit market is forecast to decline by 4% between 2020 and 2025, underscoring the increasing role that the legal market is playing is disrupting the illicit market.

Facility Size Estimates

Based on input provided by RII's Technical Advisory Council and Water Working Group, and consultation with other growers in the legal market on the average yields per square foot of flowering canopy, we developed high-, medium-, and low-range estimates for the amount of square footage required to meet the national production volume.

FIGURE 31: U.S. Legal Cannabis Cultivation
by Facility Type, 2017-2025

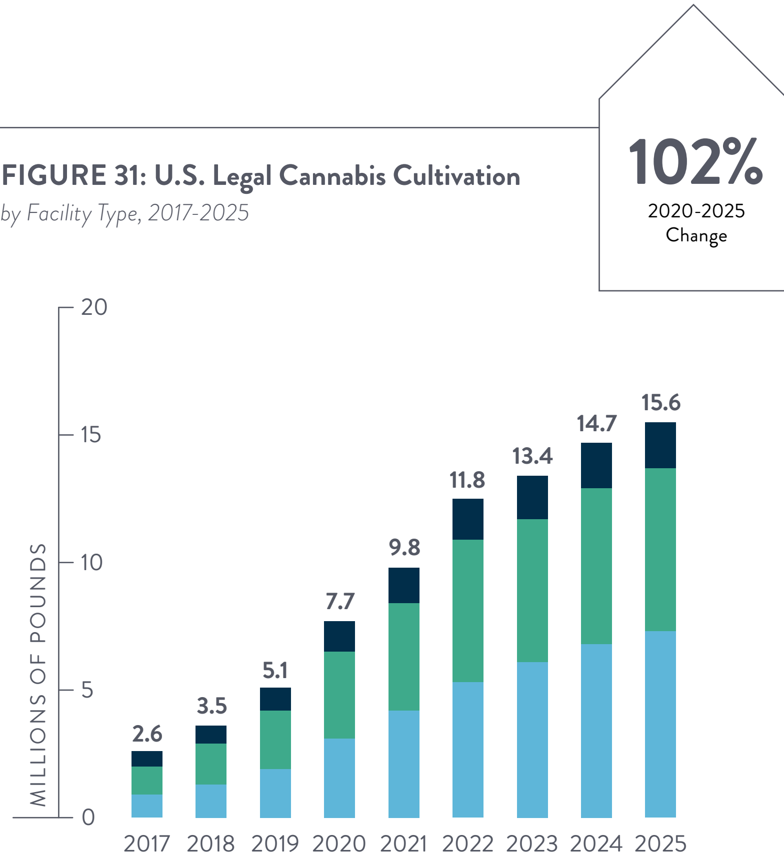


FIGURE 32: U.S. Illicit Cannabis Cultivation
by Facility Type, 2017-2025

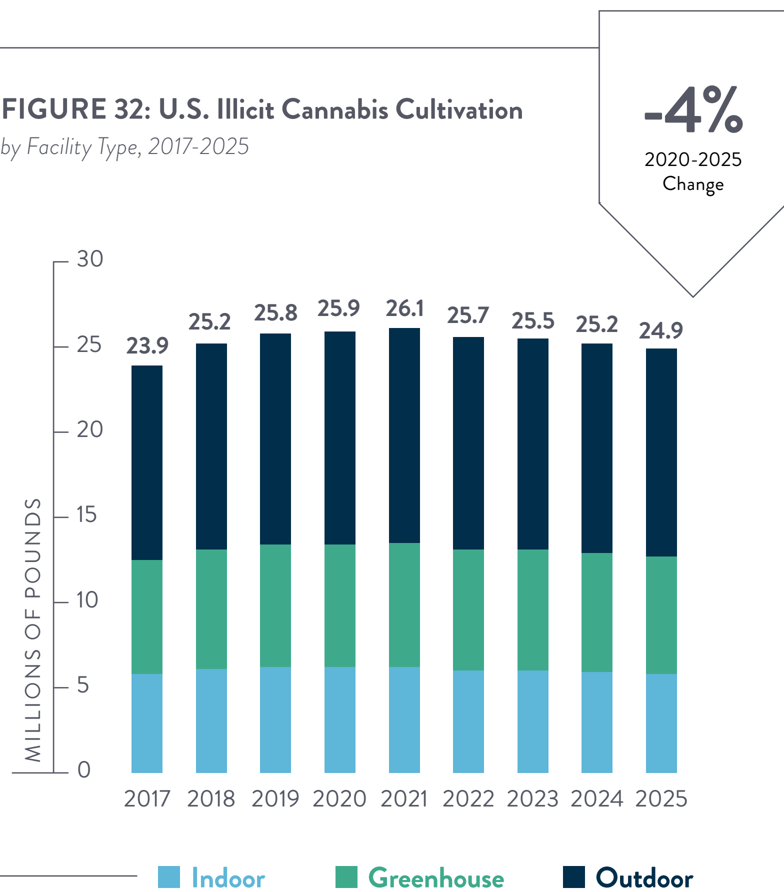


FIGURE 33: 2020 Share of Sq. Footage
Mid-Range Estimates

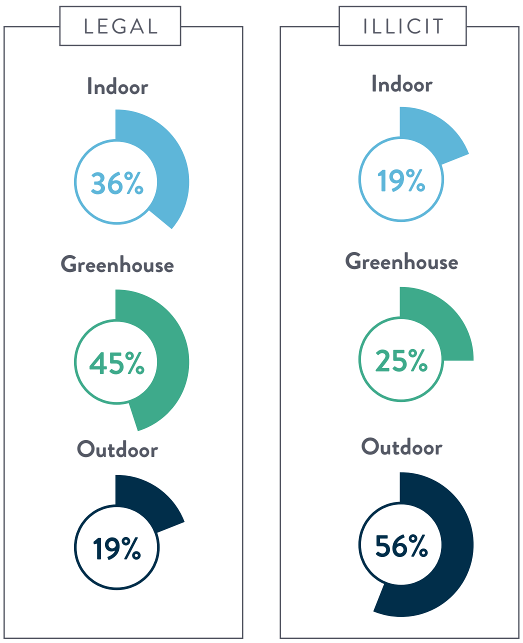
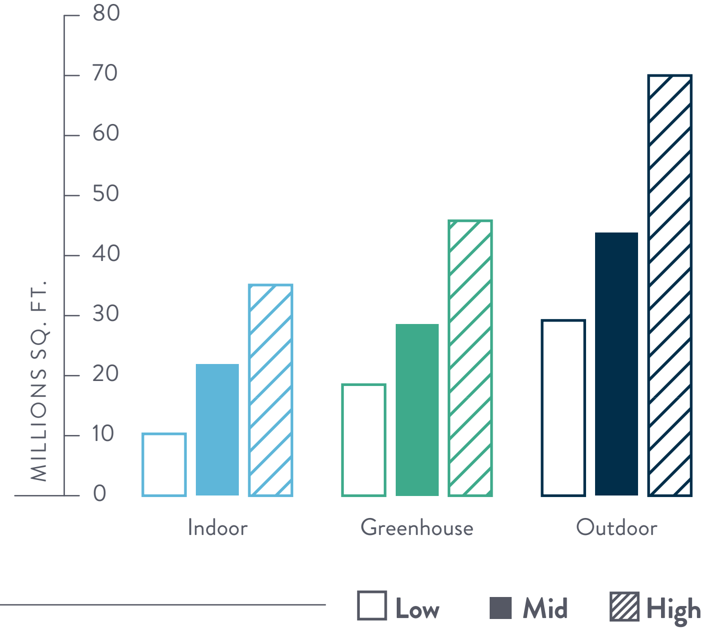


FIGURE 34: 2020 Cannabis Cultivation by Facility Type
Low/Mid/High Estimates



In 2020, the estimated square footage for indoor flowering canopy ranged from 10.3 million to 35 million square feet; greenhouse flowering canopy ranged from 18 million to 45 million square feet, and outdoor canopy ranged from 29 million to 70 million square feet.

Based on the mid-range estimate, 94 million square feet of flowering canopy was harvested in 2020, and is forecast to grow to nearly 112 million square feet by 2025.

Under the mid-range estimate, legal flowering canopy accounts for approximately one-fifth (36%) of the 112 million total square feet of flowering canopy in the U.S.

FIGURE 35: Total Sq. Footage Used to Grow Cannabis
Single Annual Harvest, Low/Mid/High Estimates

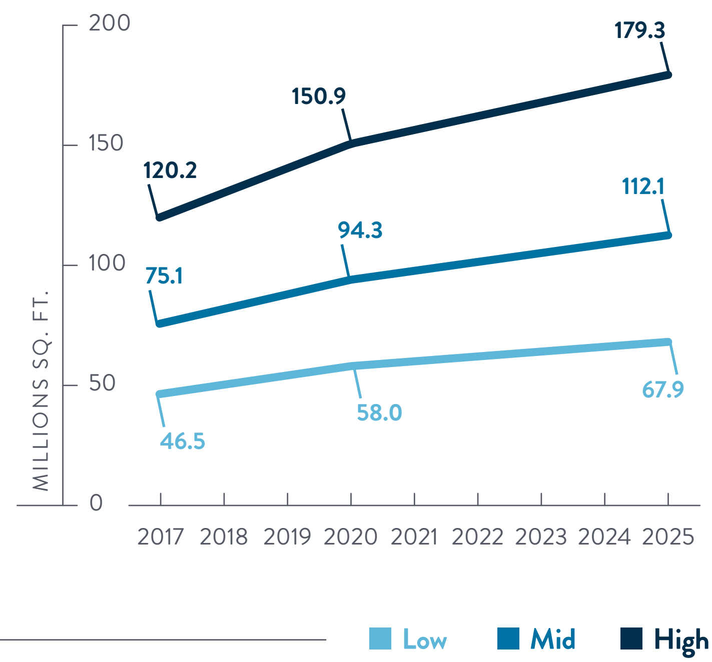
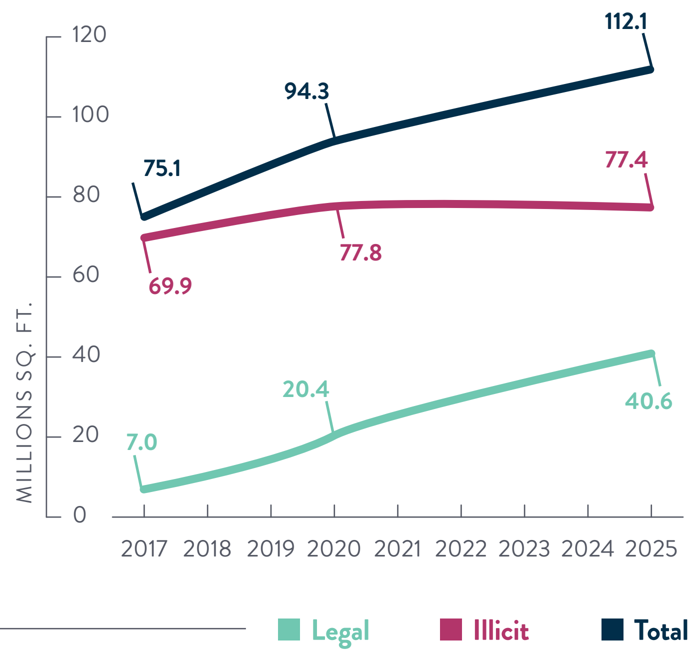


FIGURE 36: U.S. Cannabis Cultivation Total Sq. Footage

by Market, Mid-Range Estimates



Operational Flowering Canopy

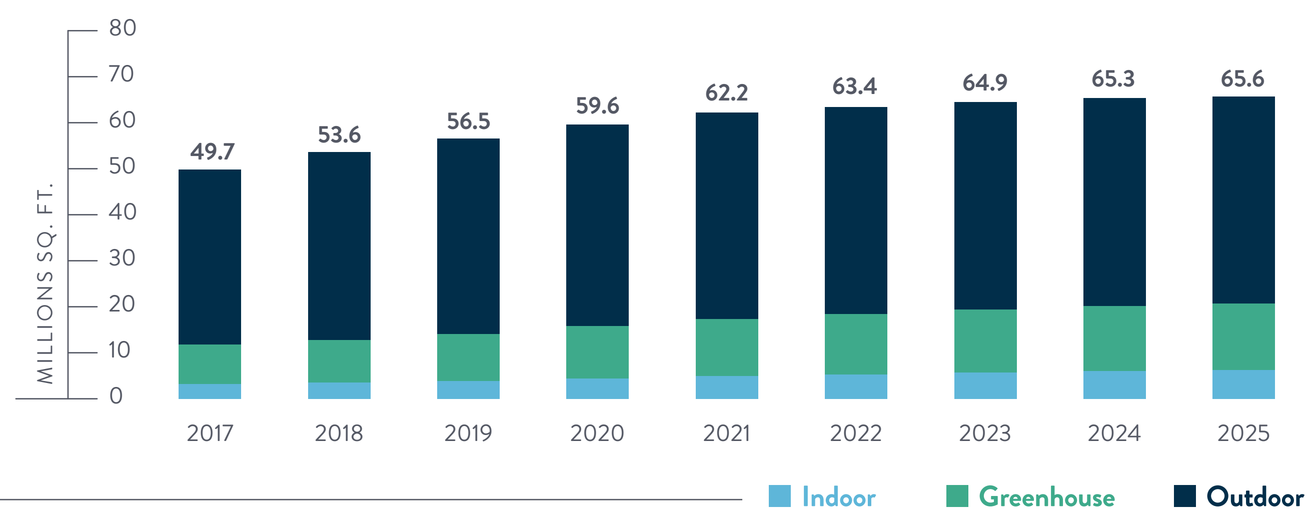
One of the challenges in measuring the operational square footage used to produce cannabis in the U.S. is the variance in the number of harvests per year within each type of facility. Typically, while outdoor growers only harvest once a year, greenhouse growers can harvest two or three times per year, and indoor growers can harvest five or more times per year.

Assuming the multiple harvests for indoor and greenhouse growers above, and a single harvest for outdoor growers, there was an estimated 60 million square feet of operational flowering square footage in 2020, growing to 66 million by 2025.

FIGURE 37: Typical Number of Harvests per Year

Indoor	Greenhouse *without Supplemental Light*	Greenhouse *with Supplemental Light*	Outdoor
5	3	2	1

FIGURE 38: U.S. Total Sq. Footage of Flowering Canopy



Water Usage

Data provided from Northern California established a baseline for applied water and storage capacity across cannabis cultivation operations. While the water use data in California may not be fully representative of operational practices elsewhere in the country, as the country's largest cannabis producer, the state's data offers valuable perspective on water use in the country's most consequential cannabis market.

Extrapolating the California usage data to the national market, we estimate that cannabis producers apply nearly 700 million gallons of water to their crops, and store nearly 850 million gallons of water for their operations.

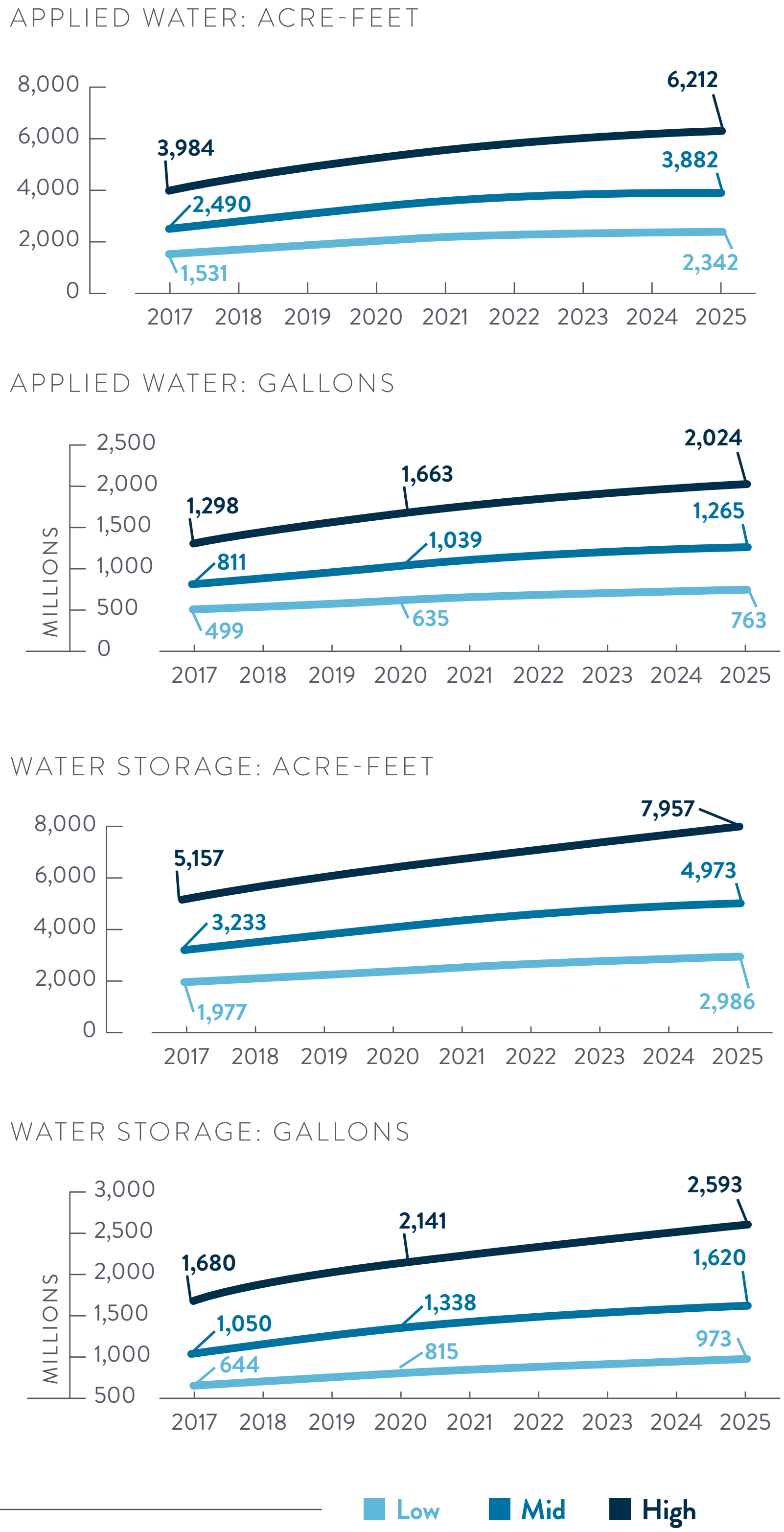
RII's PowerScore: Total Water Usage

The RII PowerScore data offers a more expansive view on the total volume of water used to cultivate cannabis. Extrapolating the acre-feet used per acre of flowering canopy yields an mid-range estimate of 8,595 acre-feet of water being used annually across the industry. Water use is forecast to rise to 11,065 acre-feet by 2025.

The illicit market will remain the primary driver of water use over the

FIGURE 39: Water Use in Cannabis Cultivation

Low/Mid/High Estimates



next five years, accounting for 83% of water use in 2020, and declining to 69% in 2025. However, water use in the legal market is expected to increase dramatically, rising 68% between 2020 and 2025 as the currently legal markets operationalize and build capacity to meet surging consumer demand.

The shifting economics of cannabis, with greater focus on efficiency and reducing resource use, will drive down production costs in the legal market, making it more competitive against the unregulated market.

FIGURE 42:
Change in Total Water Use
by Market Type

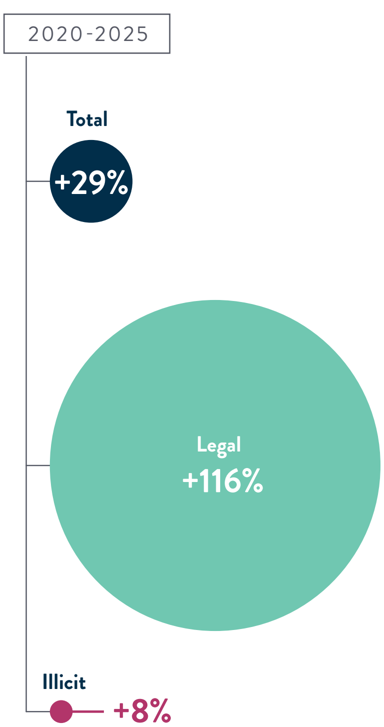


FIGURE 40: Water Use in Cannabis Cultivation
Low/Mid/High Estimates

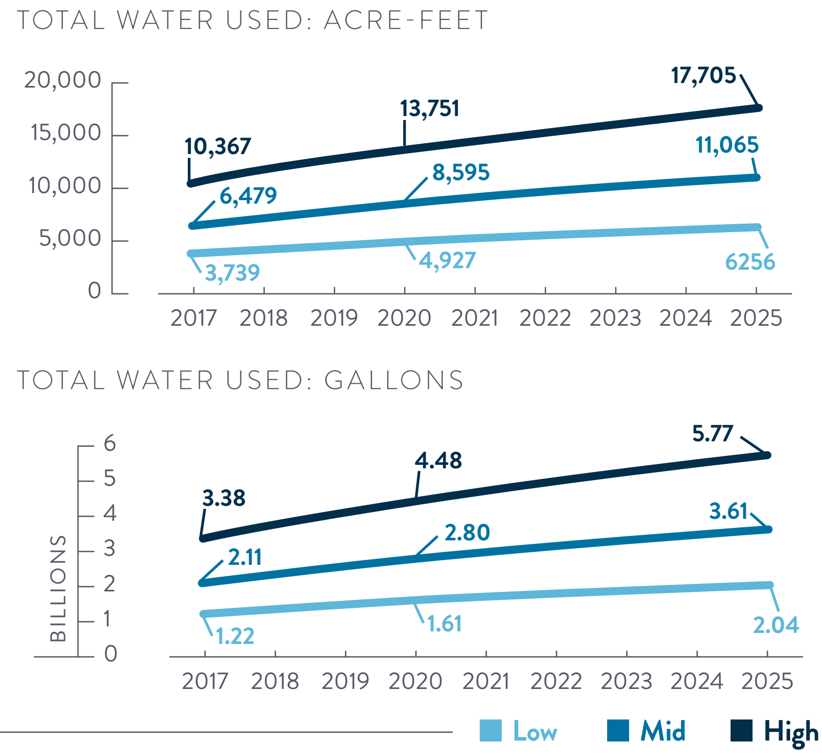
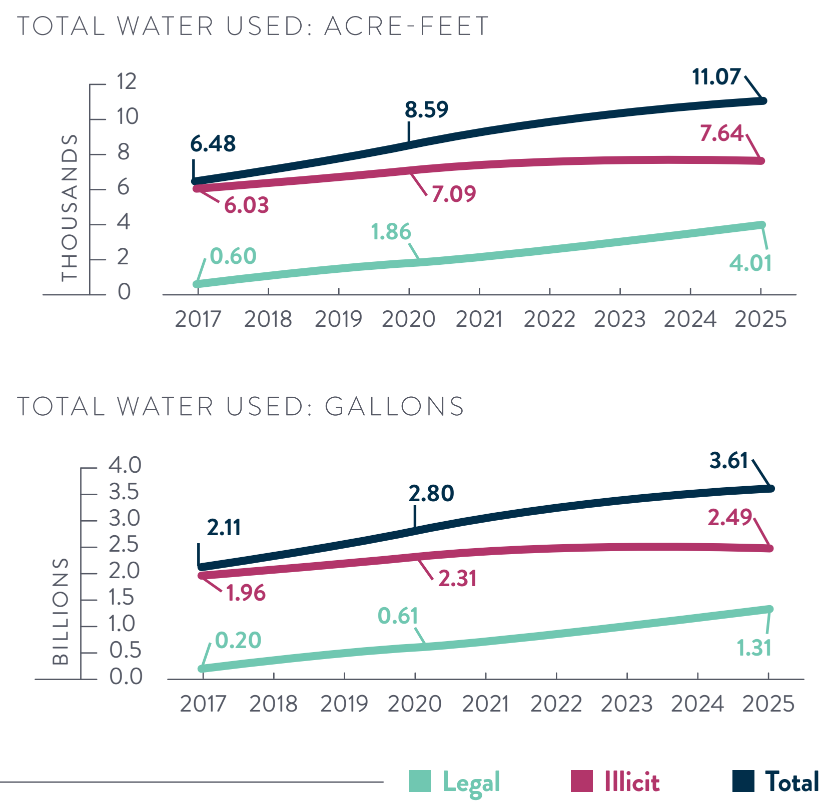


FIGURE 41: Water Use by Market Type

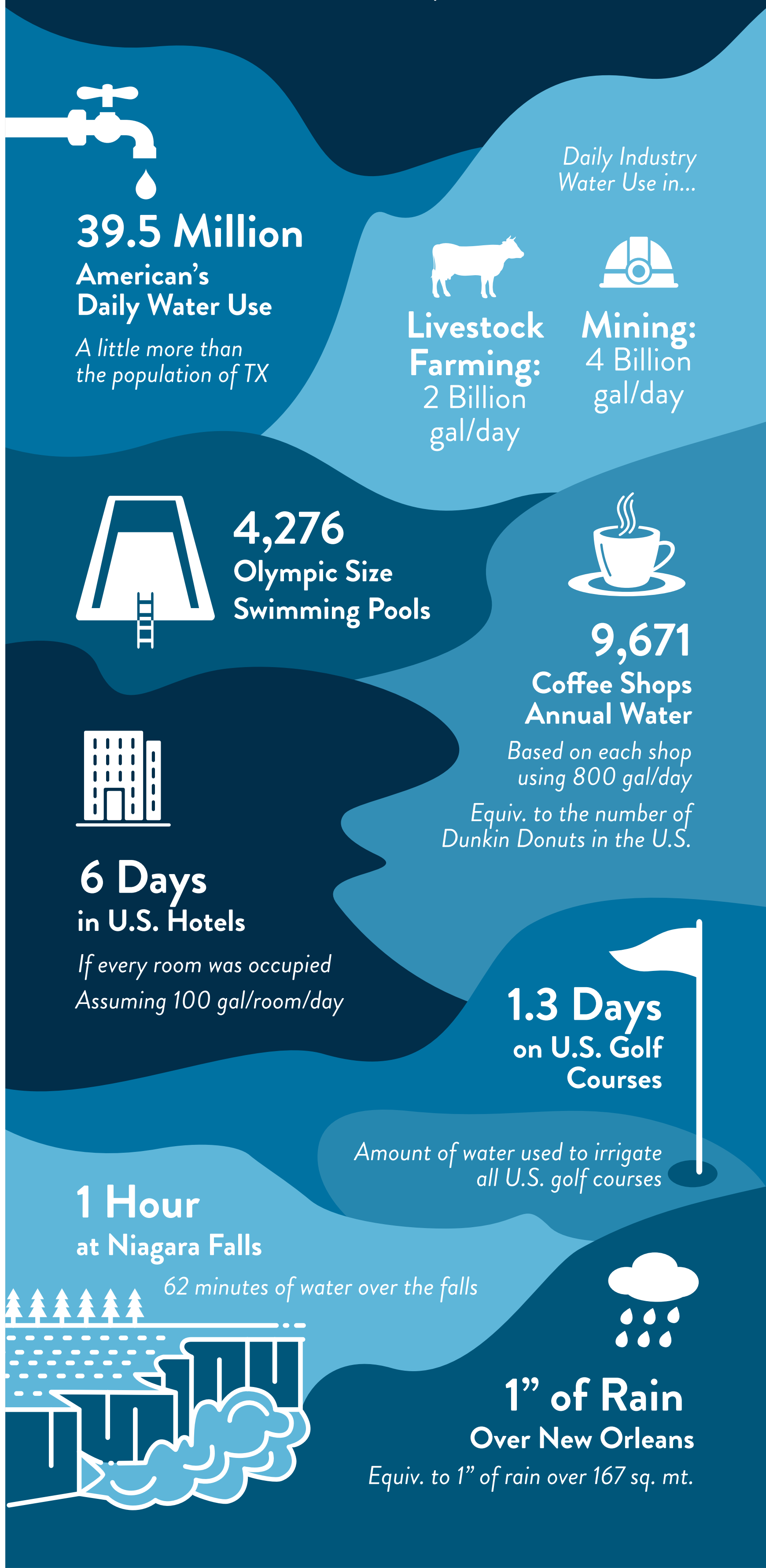


Estimating Water Use Per Plant

Estimating the water used per cannabis plant is challenging, due to the wide variability in the number of plants grown per acre. Outdoor growers seeking to maximize the size of their plants may grow as few as 300 plants per acre, whereas indoor growers may choose a far more densely packed approach for thousands of plants per acre. The extremely high variability in plant size and length of cultivation cycle makes it impossible to create meaningful comparisons of water use per plant across different facilities with widely varied operational practices. Consequently, the wide ranges render meaningless any attempts to establish a per-plant benchmark, because plant density is so heavily dependent on the grower's preferred approach.

Equivalencies: Cannabis Cultivation Water Use in Context

At 2.23 billion gallons per year, the water use in cannabis is equivalent to...



Case Studies

Case Study #1

UNDERSTANDING THE ENVIRONMENTAL IMPORTANCE OF WATER STORAGE IN NORTHERN CALIFORNIA

The Medicinal and Adult-Use Cannabis Regulation and Safety Act (MAUCRSA) creates the general framework for the commercial regulation of medicinal and adult-use cannabis in California. A feature of the act is that it granted ability to the California Department of Fish and Wildlife and the state's Water Boards to provide the licensing authority with data showing that a watershed is significantly adversely impacted by cannabis cultivation. The licensing authority may then limit the number of plants or licenses within an impacted watershed. Elijah Portugal is a senior environmental scientist with the California Department of Fish and Wildlife, working with the cannabis and instream flow unit which assesses cannabis impacts on the environment, and helps to guide CDFW decision-making. Since the program's inception, Portugal and other CDFW scientists have been developing studies and protocols to monitor the interaction between cannabis water use and stream health. "Many of the watersheds where cannabis has historically been grown are important habitats for threatened or endangered salmon and steelhead trout" Portugal has noted. "Through a two-year pilot study conducted solely in the headwaters of the Upper Mattole River Watershed, we did not document a systematic trend of flow impairment due to cannabis, but we did document some flow impairment in one of our study streams. Specifically, we documented that water withdrawals, primarily for cannabis, reduced streamflows to a hazardous level ~ 2 weeks earlier during the baseflow period than would have occurred without any water use. Our monitoring and research efforts are focused on understanding the relationship between cannabis and the environment. We are especially concerned about watersheds that have experienced recent, unregulated growth in the cannabis industry, and also contain populations of salmon or other threatened or endangered species."

The need for such a program stems from the unique climate and geology of Northern California. "In Northern California, we have a Mediterranean-type climate where we typically don't get rain in the summertime. Even in the absence of any human water use, it's common for streams to be at base flow, or in the case of intermittent streams completely dry for much of the late summer," Portugal explained. "This is a time when Northern California streams are the most vulnerable to dewatering. The endangered salmonids and other aquatic and amphibian biota that require sufficient instream flow are going to be even more impacted than they already are, if cannabis cultivators are diverting during this period."

The regulated cultivator community is required to forbear from surface water diversions from April 1-October 31, but a large portion of cultivators in the state are not in the regulated market, and are likely diverting during the late summer period. Of additional concern to CDFW is the prevalence of late summer well use to meet cannabis water demand. Currently there are no requirements for well users to refrain from pumping groundwater for cannabis during the low flow period, but fundamental principles of hydrology and the primary literature reveal that groundwater and surface water are connected but – over extremely variable timescales. This means that, depending on the underlying lithology and proximity to the stream and characteristics of the well itself, much well use can have little to no impact on surface water, but in some cases it can impact surface water. The timing of low streamflow presents an issue generally for cannabis diverters, because the months that have the lowest natural stream flows are also the months that require the most irrigation for cannabis. Cannabis farmers need to irrigate the most during this time period, so there is potential for competition and conflict.

One important way to potentially mitigate conflict is through water storage. “Storage is really critical from our perspective,” Portugal notes. “Essentially, if a cultivator has enough storage through permitted off-stream ponds, water tanks, bladders or other means, they are able to irrigate in the summer without reducing base flows.” That is because the Northern California region receives plenty of rain in the winter, and farmers therefore can either store water directly from rain or pump water from streams in the winter, when water is more abundant.

“Farmers can take flow during the wetter winter months, and use that to meet late summer water demand,” Portugal explains. “That really is the best way that farmers can minimize or eliminate streamflow impacts. If they're not extracting water from the watershed during its most vulnerable period, that's great, and that's supported by CDFW.”

Case Study #2

GETTING BACK TO BASICS

In nine seasons working at Humboldt Nation Farms, Dave Stanley had a firsthand view of massive changes impacting the cannabis industry. Now the operations manager, Stanley's tenure includes the farm's maturation during California's medicinal and recreational rollouts. While the farm has strictly adopted California's stringent licensing requirements, including handicapped-accessible parking and building codes, the farm itself has not greatly changed since Proposition 64 in 2016.

Stanley said the farm cultivates about 7,200 square feet of canopy, which at any time holds between 1,200 to 1,600 plants. The plants are grown in raised beds primarily composed of soils nourished over 15 to 20 years. The farm is terraced, with sufficient water resources from a 500,000-gallon, rain-fed pond.

"We have always emphasized caring for the soil, and believe that we can make the farm better all the time," Stanley said. He has adopted a back-to-basics watering approach over the past few seasons. "We had trouble with our drip irrigation system, primarily because of the terraced nature of the farm. With my assistant, we now water every plant by hand, usually every other day."

Watering 1,400 plants by hand is neither quick nor easy. "I start at the top, and my partner starts at the bottom of the terraces," Stanley said. "It takes us about two hours to complete the job." To facilitate the watering technique, plants are planted in small, dug-out bowls in the soil. "We then flood the bowl each time we water, basically flood-irrigating every plant individually."On average, that means a five-second squirt for each plant, equal to about a half-gallon.

While the growing techniques have not radically altered due to regulations, there have been a few unexpected changes. First, water use is now closely measured and recorded. "In the old days, the theory was not to write anything down. Now, we can record our water use and other data. This allows us to improve our farm," Stanley said. Another unintended consequence has to do with the use of hay mulch. For years, Humboldt Nation had used hay mulch to help conserve water. Yet, it is difficult to obtain organic hay. "If we used hay that happened to have any pesticide residue on it, it could get into our plants and we could fail a test," Stanley said, adding that "it is just not worth the risk." Subsequently, Humboldt Nation no longer uses any mulch, and Stanley suspects that the hard crust that forms after watering effectively prevents water from evaporating.

While watering by hand is time-consuming, it offers many benefits. "We always have plants at the end of the rows that get more sunlight; by hand-watering, we are able to make sure these plants get just a bit more water." Beyond precision water application, there are other, larger benefits. "Because we are watering by hand, we see every plant, at least every other day," Stanley said. "This allows us to really observe our plants, and catch problems early on."

Key Takeaways
& Strategic Recommendations

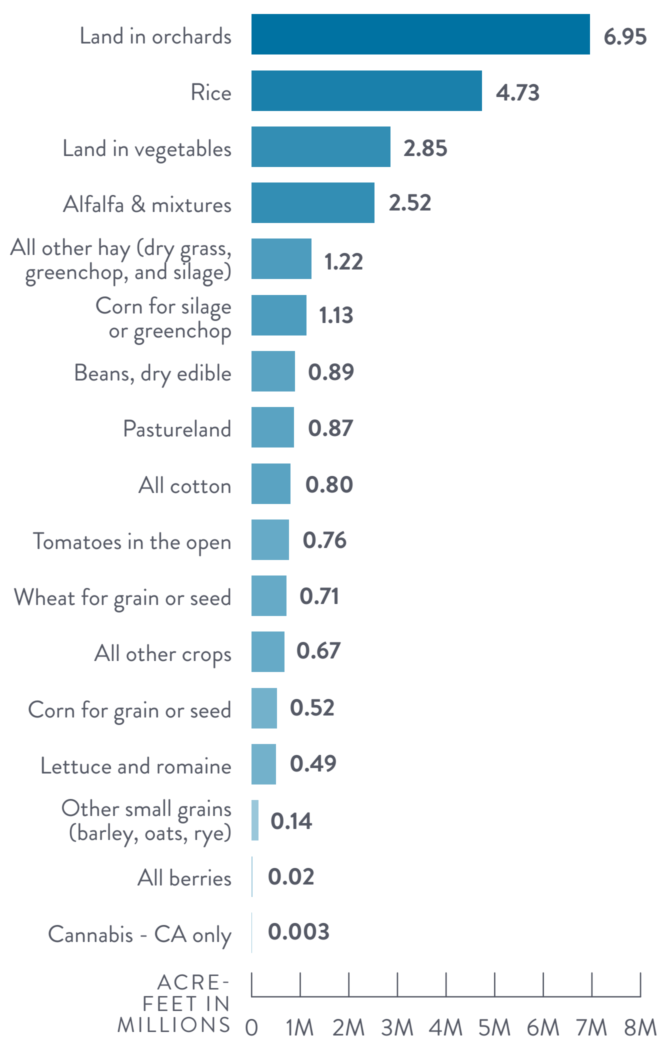
Cannabis is Not a Major Contributor to Water Use in U.S. Agriculture

As states like California have faced increasingly acute water shortages, the fast-growing cannabis industry has often been blamed for drawing down the state's water supply. That assessment is often based on an incorrect correlation between large revenues earned by the cannabis industry and production levels seen in other high-revenue cash crops. However, whereas wholesale pounds of cotton, rice, and table grapes may sell for about$0.60, $0.71, and $0.78, respectively, a wholesale pound of smokable cannabis bud can fetch $1,500 to $3,000 or more, depending on the quality. Consequently, the market value for the cannabis industry grows dramatically, even with only incremental increases in production.

Furthermore, relative to other major crops, cannabis requires significantly lower production volumes to meet consumer demand. For example, approximately 2.5 pounds (40 ounces) of grapes are required to produce a bottle of wine; by comparison, 40 ounces of smokable bud is over 3x more cannabis than

FIGURE 43: Water Use in California's Top Agricultural Crops*

Total Acre-Feet Applied



** Water use estimates for non-cannabis use crops are from 2013. Cannabis water use estimates are from 2020.*

Source: Johnson, R., Cody, B., California Agricultural Production and Irrigated Water Use, Congressional Research Service, June 30, 2015, New Frontier Data a frequent consumer would use in a calendar year. The low-volume nature of cannabis means that even as the industry grows it will continue to have limited impact on the overall use of water in California or across the country.

This analysis demonstrates that the volume of water used to grow cannabis is poised to increase significantly as demand for cannabis (especially in the legal market) surges. However, compared to typical major crops in the U.S. agricultural economy, the cannabis industry has a nominal impact on water used for farming. The impact of the industry's water use may be more pronounced in the drought-prone areas in the Western states. However, even in California and Oregon – two of the country's largest cannabis production markets – the volume of water use is dwarfed by other crops (e.g., fruit trees, grapes, corn, cotton, and rice). The industry is well positioned to improve the efficiency of water use as best practices become better known and water-efficiency solutions become more widely adopted. However, those gains will have greater impact on the bottom line for producers than against the national agricultural water supply.

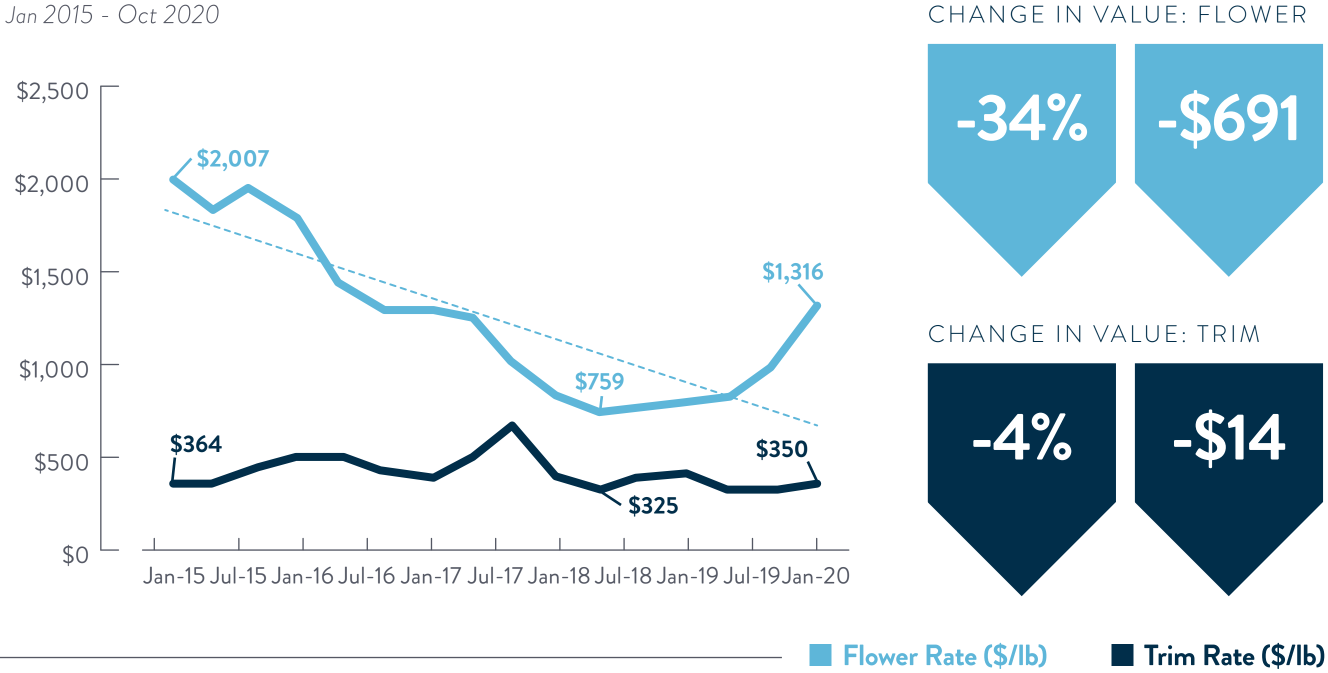
A Competitive Cannabis Market Demands Water Efficiency

Surging Popularity of Value Added Products is Driving Increased Demand for Cannabis Biomass

Cannabis, the plant, can be grown to produce varying types of biomass. The 2018 Farm Act removed hemp (defined as cannabis with <0.3% THC) from the federal Schedule 1 controlled substances list, making it an ordinary agricultural commodity. Cannabis is grown to produce a few different industrial and

FIGURE 44: Average Market Rate for Cannabis Flower & Trim in Colorado

Jan 2015 - Oct 2020



agricultural products: fiber, seed, and flower. Flower can be harvested to be delivered to customers directly as smokable products, or can be refined further to be manufactured into value-added products.

The share of flower sales has fallen dramatically as the popularity of value-added products has surged, expanding the volume of cannabis biomass that must be produced to meet the production requirements for several new product categories.

Nationally, the share of flower across markets varies widely, influenced by the maturity of the market, regulations governing the sale of flower and other value-added options, and the structure of the operators in each market (i.e., in vertically integrated markets, non-flower products tend to emerge more slowly than in markets where individual licenses can be obtained for each point in the supply chain).

> Over time, value-added products will ultimately account for half or more of all product sales.

Generally, however, the trend toward a highly diversified product environment is consistent across all markets, with flower remaining the leading category, but over time value-added products will ultimately account for half or more of all product sales.

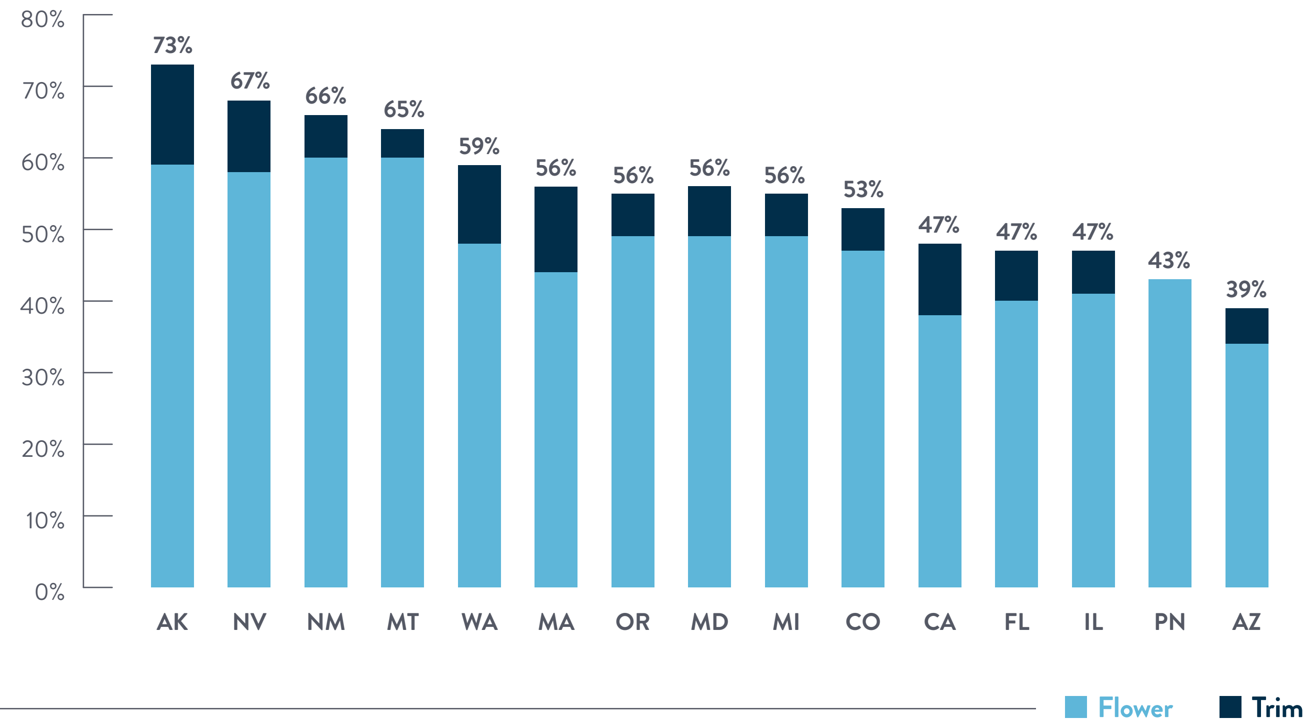
The Shifting Economics of Cannabis Underscores the Imperative for Operational Efficiency

The wholesale price of cannabis has been on a steady downward trajectory, driven by increased competition in the legal market as the number of licensed producers has risen, and greater efficiencies and economies and scale. Since 2015, the average price per pound in Colorado has fallen by one-third (34%), with the prices recovering significantly following a 61% decline to less than $800 per pound in the fall of 2018.

In the early period of high wholesale prices, low competition, and abundant resources, growers have little incentive to invest heavily in optimizing their efficiency but the speed at which market conditions shifted left inefficient operators unprepared to compete. Some companies, however, have recognized early the utility of maximizing efficiency early. In Oregon, Eco Firma Firms was a notable example, as the company brought its production cost per pound below $200/lb when many in the state were producing at two to four times that cost, and the company was able to continue to enjoy comfortable margins even as the average wholesale price per pound fell below $750.

Across the most mature markets, growers who have been unable to compete when prices were at their lowest were forced to sell or close their businesses. The loss of less efficient operators has eased some competition and allowed prices to rebound. However, with the market's continued evolution, including the continued evolution of consumer demand, the accelerating fragmentation

FIGURE 45: Flower & Pre-Roll Share of Sales in Select States
Oct 2020



of the consumer product environment, and the prospect of federal legalization over the next few years, growers must continue to work to maximize returns by prioritizing efficiency across their operators.

Not only will the most efficient growers be able to compete most effectively, they will be best positioned to secure investment capital, and will be the most attractive targets for acquisition as the industry consolidates and builds national and international scale.

To address the need for more data, governments should consider requiring producers to report their annual usage, as some U.S. states have done. Cannabis is in a unique position relative to other agricultural markets, as the legal market to serve most of the future demand remains very nascent. For now, governments and industry regulators have a shared opportunity to establish data collection and benchmarking processes to support the industry's future growth while the industry is in urgent need of performance metrics to inform industry-wide performance improvements. Governments should work with licensed operators to develop reporting protocols for resource use; while burdensome for growers to comply with, such protocols can provide a feedback mechanism to let them compare their performances against their peers', and make it easier to identify and share best practices among the industry's leaders. Resources such as Resource Innovation Institute's PowerScore tool offer a ready-made solution for secure deployment to collect high-value data for both regulators and operators.

The cannabis industry is primed for breakthrough advances in water efficiency, but significant research and knowledge-sharing will be required to capture and disseminate best practices. Governments, industry stakeholders, and others (e.g., philanthropic environmental foundations) should consider funding research and education about best practices for water efficiency. Lack of understanding about how growers can optimize their water use has led to too many inefficient practices being adopted from the unregulated market. However, with hundreds of new cannabis cultivation operations now positioned to come online in coming years as more states legalize medical and adult use, the value of investing in such knowledge-sharing can pay major dividends if done while the industry is at its infancy, before major investments are dedicated to new operations.

Analysis of water practices should not be performed on a "per plant" basis, and instead should consider a more thorough assessment of productivity, efficiency, demand, storage, and consumption. Growers use widely varied plant-management practices, making it extremely difficult to established normalized metrics for water use on a per-plant basis. While per-plant comparisons may be of value when comparing similar facilities with identical cultivation practices, using performance metrics that are pegged against size, yields, and total demand enables more effective comparative benchmarking industry-wide.

The industry should strongly encourage establishment of data-driven voluntary standards and recognition of top performers. In the emerging, quickly evolving market of legal cannabis, regulations can lag behind significant market developments. As such, waiting for government mandates about sustainability standards or dissemination of industry best practices will result in needlessly lost opportunities at a key period in the industry's growth. Industry trade groups at state and national levels should work aggressively to incorporate sustainability benchmarking and knowledge-sharing, and recognize those achieving the greatest improvements in efficiency.

Water impacts beyond direct runoff and discharge should also be evaluated. Other agricultural sectors are beginning to examine impacts from cultivation operations such as transportation, whereby fragments of vehicle tires have been found to cause fish die-off, and the cost of vehicular water transportation contributes to the industry's carbon footprint for water use. Similarly, though the widespread use of energy-intensive reverse osmosis may allow growers to reclaim and reuse water, it adds to overall production costs and resource inefficiencies due to those high energy requirements. As the industry works to develop resource-use metrics, operators and resource-management stakeholders should think expansively (and creatively) about how best to measure the total impact of all the inputs used to produce cannabis, and to measure the most efficient approaches based on the increasingly diverse solutions available to the market.

Conclusion

AS THE CANNABIS INDUSTRY matures, water use efficiency will become more important, as it has for other agricultural crops. Pressures to use water efficiently will mount from multiple channels including - reducing input and energy cost, protecting the environment, meeting regulatory standards and simply being good stewards.

We recommend that industry and regulators focus efforts on the following areas:

1. When grown outdoors, water for cannabis production should be assessed like any other agricultural crop and be subject to state and local regulations that apply to other crops. Our research indicates that cannabis neither uses a massive share of water or uses more water than other agricultural crops. Applying the same standards to cannabis as to other agricultural crops will correctly categorize outdoor grown cannabis as an agricultural crop.

2. In areas where there may be conflict between water use for cannabis and environmental concerns, regulators and the industry should focus (1) on the timing of water use and (2) the potential of storage to mitigate environmental conflict. Our results show that in many parts of the country legal cannabis farmers have ample water storage to satisfy their needs. In areas where storage is insufficient, increasing storage should be a priority for farmers and regulators.

3. Our research shows there are still massive differences between cannabis production techniques and to some extent this variation also is seen in our water use data. None-the-less, water efficiency is not the most important metric for most cannabis farmers. As farmers continue to experiment and improve, we expect to see water use be a more important part of cannabis farming decisions and expect new plant varieties and growing techniques to be developed that increase water use efficiency.

4. As indoor production continues to grow, especially in areas that have unfavorable climatic conditions for outdoor growing, we expect more cannabis users to rely on municipal water sources. Yet, it is unclear if municipal water suppliers are equipped to work with the cannabis industry. We suggest outreach efforts between the cannabis industry and municipal water suppliers to incentivise efficiency where possible.

Glossary

ACRE-FOOT: The acre-foot is a non-SI (i.e., International System of Units) unit of volume commonly used in reference to large-scale water resources, such as reservoirs, aqueducts, canals, sewer flow capacity, irrigation water, and river flows. An acre-foot equals approximately an eight-lane swimming pool (e.g., 82 feet long, by 52 feet wide, by 9.8 feet deep) OR a unit of volume equal to the volume of a sheet of water both one acre (0.405 hectare) in area and one foot (30.48 cm) in depth, i.e., 43,560 cubic feet (1,233.5 cubic meters).

AEROPONICS: The process of growing plants in an air or mist environment without the use of soil or an aggregate medium.

AQUAPONICS: Aquaponics refers to a food production system that couples aquaculture with hydroponics in a symbiotic environment whereby the nutrient-rich aquaculture water is fed to a hydroponically grown plant, involving nitrifying bacteria for converting ammonia into nitrates.

CATION: Positively charged ions. The essential soil cations are ammonium, calcium, magnesium, and potassium. They are critical for any plant to grow and flourish. Additional soil cations include sodium, aluminum, and hydrogen.

COCONUT (COCO) COIR: Coir, or coconut fiber, is a natural fiber extracted from the outer husk of coconut and used in products including floor mats, doormats, brushes, and mattresses. Coir is also the fibrous material found between the hard, internal shell and the outer coat of a coconut.

CONDENSATE: Water that accumulates as a result of condensation within a cultivation facility's heating, ventilation, and air-conditioning (HVAC) system.

DIATOMACEOUS EARTH: Diatomaceous earth consists of fossilized remains of diatoms, a type of hard-shelled protist. Diatomaceous earth has myriad industrial and horticultural applications, including non toxic pest control.

EVAPOTRANSPIRATION/TRANSPIRATION: Evapotranspiration is the sum of water evaporation and transpiration from a surface area to the atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies.

ELECTRICAL CONDUCTIVITY: The ability of water to conduct an electrical current; important because it can detect how much dissolved substances, chemicals, and minerals are present in the water. Higher amounts of the solutes will lead to a higher conductivity. While pure water has very low conductivity, sea water comes with much higher conductivity. Even a small amount of dissolved salts and chemicals can heighten the conductivity of water.

DELIVERED WATER: Water taken from a source and delivered to a user for either indoor or outdoor watering.

GREENHOUSE CULTIVATION: Greenhouse cultivation is the unique farm practice of growing crops within sheltered structures glazed with a transparent, or partially transparent, material like a hoop-house, glasshouse, conservatory, hothouse, or similar structure. The main purpose of a greenhouse is to use the sun to provide as much light energy for plants as possible, employing supplemental electric light as needed, and to protect crops from unfavorable weather and various pests.

HYDROPONICS: Hydroponics is a type of horticulture and a subset of hydroculture, which is a method of growing plants (usually crops) without soil by delivering nutrition and fertilizer via an aqueous solvent (e.g., water).

INDOOR CULTIVATION: Indoor cultivation is a farm practice of growing crops in sheltered structures with sole-source electric light. The main purpose of indoor cultivation is to control the growing environment more precisely to maintain optimal growing conditions and extend growing seasons.

LEACHATE: A leachate is any liquid that, in passing through matter, extracts either soluble or suspended solids, or any other component of the material through which it has passed.

LEACHATE PERCENTAGE: Volume of leachate divided by the volume of nutrient solution given to the crop.

LIVING SOIL: Living soil or no-till soil is a growing medium rich with organisms which function as their own ecosystem, breaking down organic and inorganic matter and providing nutrients to plants and other surrounding organisms. Often it is a soilless substrate, but with a highly variable mixture of different organic amendments.

OUTDOOR CULTIVATION: Outdoor cultivation is a traditional farm practice of growing crops in the ground without artificial lighting. Outdoor cultivation may allow for lower operating costs, but less control over the plant's growth cycle.

PERLITE: Perlite is a volcanic glass treated with heat to produce an especially lightweight material. In potting soil, perlite is a nonorganic additive used to aerate the substrate.

PH: Potential of hydrogen (pH) is a scale used to specify the acidity or basicity of an aqueous solution. Acidic solutions (i.e., solutions with higher concentrations of H+ ions) are measured to have lower pH values than found in basic or alkaline solutions.

REVERSE OSMOSIS: A water-purification process that uses a partially permeable membrane to separate ions, unwanted molecules, and larger particles from drinking water.

ROCK WOOL: Rock wool is a lightweight, hydroponic substrate made from spinning molten basaltic rock into fine fibers formed into a range of cubes, blocks, growing slabs, and granular products. The product is chemically and biologically inert (i.e., ions are not bound or exchanged on substrate particle surfaces) and creates an ideal growing medium for hydroponic growing strategies.

POTABLE: Fresh water appropriate for human consumption, drawn from public drinking water supply systems or private wells.

MUNICIPAL POTABLE WATER: Water for public supply which has been determined to be fit or suitable for drinking.

NATURAL WATER SOURCE: Non-potable water occurring naturally (e.g., rainwater, surface water, or well water).

PRIVATE WELL / BORE: A private water source taken directly from the earth, e.g., when a hole is drilled to the aquifer for a pump system to deliver water to the surface.

NON-POTABLE: Not fit or suitable for drinking, but possibly of use for other purposes, depending on quality.

ON-SITE RECLAIMED (RECYCLED) WATER: Recycled water generally refers to treated domestic wastewater used more than once before passing back into the water cycle. The terms "reused" and "recycled" are often used interchangeably. . Reclaimed water is not reused or recycled until it is put to some purpose. It can be reclaimed and usable for a purpose, but not recycled until somebody uses it.

MIXED-LIGHT: Mixed-lighting refers to a lighting situation where both natural and artificial or supplemental lighting sources are utilized during the growth cycle.

PHYTOTOXIC: Toxic to plants.

SUBSTRATE: Substrate is the base on which cannabis plants grow. In agriculture, soil is the most common substrate. For cannabis, growers often use other media, including rock wool, coir, or peat.

SUPPLEMENTAL LIGHTING: Supplemental lighting, is often used in greenhouses, and refers to any additional quantity and quality of illumination not obtained by the general lighting system to support or increase crop production.

VERMICULITE: A group of hydrated laminar minerals. Horticultural vermiculite is processed with heat and expanded into pellets which can improve water and nutrient retention.

WATER DEMAND: A key benchmark in measuring water for cultivation, water demand is a measure of gallons applied per month or year.

WATER EFFICIENCY: A key benchmark in measuring water for cultivation, water efficiency is a measure of gallons applied per flowering canopy square feet.

WATER PRODUCTIVITY: A key benchmark in measuring water for cultivation, water productivity is a measure of gallons applied per gram of dry cannabis flower.

Appendix 1

U.S. Drought Monitor Classification Definitions

Category	Impact
D0	• *Soil is dry; irrigation begins early* • *Dryland crop germination is stunted* • *Active fire season begins* • *Winter resort visitation is low; snowpack is minimal*
D1	• *Dryland pasture growth is stunted; producers give supplemental feed to cattle* • *Landscaping and gardens need irrigation earlier, wildlife patterns begin to change* • *Stock ponds and creeks are lower than usual*
D2	• *Grazing land is inadequate* • *Producers increase water efficiency methods and drought-resistant crops* • *Fire season is longer, with high burn intensity, dry fuels, and large fire spatial extent; more fire crews are on staff* • *Wine country tourism increases, lake and river-based tourism declines; boat ramps close* • *Trees are stressed; plants increase reproductive mechanisms, wildlife diseases increase* • *Water temperature increases, programs to divert water to protect fish begin* • *River flows decrease; reservoir levels are low and banks are exposed*
D3	• *Livestock need expensive supplemental feed, cattle and horses are sold; little pasture remains, producers find it difficult to maintain organic meat requirements* • *Fruit trees bud early, producers begin irrigating in the winter* • *Federal water is not adequate to meet irrigation contracts; extracting supplemental groundwater is expensive* • *Dairy operations close* • *Marijuana growers illegally tap water out of rivers* • *Fire season lasts year-round; fires occur in typically wet parts of the state; burn bans are implemented* • *Ski and rafting business is low, mountain communities suffer* • *Orchard removal and well drilling company business increase; panning for gold increases* • *Low river levels impede fish migration and cause lower survival rates* • *Wildlife encroach on developed areas; little native food and water is available for bears, which hibernate less* • *Water sanitation is a concern, reservoir levels drop significantly, surface water is nearly dry, flows are very low; water theft occurs* • *Wells and aquifer levels decrease, homeowners drill new wells* • *Water conservation rebate programs increase, water use restrictions are implemented; water transfers increase* • *Water is inadequate for agriculture, wildlife, and urban needs; reservoirs are extremely low, hydropower is restricted*
D4	• *Field are left fallow; orchards are removed, vegetable yields are low; honey harvest is small* • *Fire season is very costly; number of fires and area burned are extensive* • *Many recreational activities are affected* • *Fish rescue and relocation begins; pine beetle infestation occurs; forest mortality is high; wetlands dry up; survival of native plants and animals is low; fewer wildflowers bloom; wildlife death is widespread; algae blooms appear* • *Policy change; agriculture unemployment is high, food aid is needed* • *Poor air quality affects health; greenhouse gas emissions increase as hydropower production decreases; West Nile Virus outbreaks rise* • *Water shortages are widespread; surface water is depleted; federal irrigation water deliveries are extremely low, junior water rights are curtailed; water prices are extremely high; wells are dry, more and deeper wells are drilled; water quality is poor*

Source: United States Drought Monitor

Appendix 2
Imperial to Metric Conversion

Imperial		Metric	
1	Gallons	**3.79**	Liters
1	Gallons/Sq. Ft.	**4.07**	Centimeter
1	Square Feet	**0.09**	Square Meters
1	Acres	**4046.86**	Square Meters
1	Acrefoot	**1233.48**	Cubic Meter
1	Ounce	**28.35**	Gram
1	Pound	**452.60**	Gram

Appendix 3

Acceptable Ranges for Chemical Properties in Irrigation Water

Chemical Property	Acceptable Range for Most Container-Grown Woody Crop	Acceptable Range for Most Container-Grown Herbaceous Perennials/ Greenhouse Crops	Acceptable Irrigation Purposes in a Greenhouse Using Soilless Substrates (Rockwool, Oasis, Peat or Coir)
pH	5.0-7.0	5.0-7.0	5.0-7.0
EC *(electrical conductivity - a measure of soluble salts)*	<1.75 mS/cm	<1.0 mS/cm	<1.0 mS/cm
Calcium Carbonates (CaCO3)	<150 ppm	<120 ppm	<120 ppm
Bicarbonates (HCO3)	<150-200 ppm (lower if not leached with rainfall)	<100-150 ppm (lower if not leached with rainfall)	<100-150 ppm
Sodium (Na)	<70 ppm	<60 ppm	<60 ppm
Chloride (Cl)	<140 ppm	<100 ppm	<100 ppm
Sulphur (S)	<70 ppm	<70 ppm	<70 ppm
Sulphates (SO4)	<200 ppm	<200 ppm	<200 ppm
Iron (Fe)	<0.5 ppm	<0.5 ppm)	<05. ppm
Boron (B)	<0.8 ppm	<0.5 ppm	<0.5 ppm
These are guidelines only. Crops will vary greatly in their sensitivity to soluble salts and water chemical properties.			

Adapted from: West, J, Huber, A, Carlow C, Water Treatment Guide for Greenhouses & Nurseries, April 9, 2018

Appendix 4
Comparing Yields and Market Values of Leading California Crops

	Production (1,000 tons)	Total Wholesale Value ($1,000)
Cannabis - CA Production (Instate + Exports)*	9.6	$24,765,680
Cannabis - CA Production- For Instate Demand Only**	2.6	$6,799,067
Grapes, All	7,130.0	$6,254,211
Almond (Shelled)	2,280.0	$5,468,040
Pistachios	987.0	$2,615,550
Berries, All Strawberries	1,443.5	$2,340,315
Oranges, All	5,327.0	$1,121,566
Walnuts	676.0	$878,800
Hay, Alfalfa & Other	5,682.0	$769,826
Rice	2,431.8	$755,763
Lemons	966.0	$681,564
Cotton, Lint All	216.5	$548,816
Avocados	171.0	$383,485
Plums and Prunes	190.2	$345,540
Berries, Raspberries	80.1	$331,088
Peaches, All	479.0	$304,213
Potatoes, (Excl. sweet)	772.9	$258,625
Potatoes, Sweet	435.1	$198,912
Cherries, Sweet	44.8	$140,395
Berries, Blueberries	36.3	$139,755
Nectarines	120.5	$104,626
Dates	30.0	$86,109
Grapefruit, All	564.0	$78,872
Cottonseed	339.0	$78,725
Pears, All	161.5	$77,344
Apples	125.0	$71,000
Beans, Dry	59.6	$68,885
Wheat, All	348.2	$68,167
Sugar Beets	1,092.0	$52,761
Grain, Corn	314.9	$52,570
Olives	53.6	$40,523
Apricots	31.7	$38,055
Oil Crops*	121.5	$37,797
Kiwifruit	37.8	$32,886
Barley	43.1	$8,578
Pecans	3.7	$7,400
Oats	6.7	$1,448

** Yield in smokable flower only. Does not include mass of leaf, trip, or bud for extraction. 2019 values. Assumes wholesale market half the value of the retail market (based on prevailing mark-up rates).*

*** Model assumes that California produces approximately 57% of all cannabis consumed in the U.S., with most products sold outside of the state. The state's share of national production will continue to fall as more states legalize.*

Source: California Agricultural Statistics Review 2018 -2019, California Department of Food & Agriculture

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EXHIBIT B

MEMORANDUM

DATE: December 13, 2013
MEETING OF: December 16, 2013
TO: Mary Bannister, Brian Lockwood, Kirk Schmidt, Erin McCarthy
FROM: Casey Meusel & Marcus Mendiola
RE: Irrigation Rate Analysis Update

Background
The Pajaro Valley is an overdrafted groundwater basin that is also impacted by seawater intrusion. The Basin Management Plan Update, developed in 2012, presents a strategy to balance the basin though implementation of seven projects and programs that can be lumped into three categories: 1) Increased irrigation efficiency; 2) Optimize the use of existing supplies, and; 3) Develop new supplemental water supplies. Conservation, with a target of reducing groundwater extractions by 5,000 acre-feet per year (AFY) is a key component of the plan

In an effort to quantify the range of water use per crop type and identify potential candidates for irrigation efficiency training, PVWMA staff was tasked with completing a spatial analysis irrigated acreage and groundwater production. Staff utilized geographic information systems (GIS) based mapping software to measure the observed irrigated acreage (based on aerial imagery from 2012) on parcels within the Pajaro Valley. Measured irrigated acreage on the parcel and ranch scales was compared with metered groundwater production data collected during the approximate time period September 1, 2011 through August 30, 2012 (PVWMA meter read data 2011 Q4 → 2012 Q3). Dividing groundwater production by measured irrigated acreage on a site by site basis provides a localized irrigation rate in terms of Acre-Feet per Irrigated Acre (AF/IA) for the study year. By incorporating land use data collected by staff during a June 2012 survey, the resultant irrigation rates were compared against matching crop types in multiple locations throughout the valley, providing a range in water use values per crop that can be used in the future to help target the use of limited irrigation efficiency training funds.

In theory, completing this type of analysis should be very straight forward; however, in practice staff encountered multiple issues. Below we discuss the three analysis approaches used thus far and the issues encountered.

Broad Stroke Analysis
From past projects and time in the field, we know that some parcels in production do not have a well on the property while other parcels may have multiple wells. Commonly, a single well serves more parcels than just the one on which it is located. With respect to land use, many parcels are used to grow multiple crops adding complexity when the goal is to compare irrigation rates for similar crops. In an early exercise to reduce complexity and look for trends valley-wide, we decided to exclude the land use data calculate an irrigation rate on a parcel by parcel basis by summing the total groundwater production and dividing by measured irrigated acreage. The results showed a wide range of irrigation rates spanning from 0-131 AF/IA, confirming that some wells used to irrigate multiple parcels. Some parcels known to be in production had calculated irrigation rates of 0 AF/IA, while other parcels showed irrigation rates than 8[bsl1] AF/IA (suggesting the well serves multiple parcels).

To address these issues we began to make assumptions of which well or wells served which parcel or parcels based on available maps and field checks. We utilized aerial photos, parcel maps, land use survey data, CDS ranch Maps, and staff knowledge to make educated guesses. At the conservation working group meeting held on October 25, 2013, we presented examples of various situations for which we were making assumptions. The least complicated cases were those with a single well located on or near multiple parcels with a single land use designation. In the more complex cases there were multiple wells that likely served multiple parcels with multiple land uses. The working group acknowledged assumptions would need to be made moving forward and recommended the scale of the analysis be broadened to a ranch level. The group also suggested that PVWMA staff analyze the "best case scenario" parcels on which there was a single well on a parcel with a single land use.

Ranch Level Analysis

Prior to the October 25 meeting, we used aerial photos, parcel maps, land use data, CDS ranch maps, and staff knowledge to make assumptions with respect to which parcels were sharing a well(s) for irrigation. We evaluated 164 sites in this manner and the results were more realistic than when we looked soley at water use by parcel. Water usage ranged from 0.1-9.9 AF/IA, with an average of 2.2 AF/IA.

At the meeting it was brought to our attention that the County Ag Commissioners generate ranch maps that delineate the agricultural ranches in Santa Cruz and Monterey Counties. We were able to obtain GIS layers of the 2012 Ranch Maps for both counties and incorporate them when making judgments of which parcels share common wells. We analyzed forty-two presumed ranches of a single land use type. Three additional ranches with more than one type of land use were also evaluated. The resulting water usage ranged from 0.3 to 5.6 AF/IA with an average of 2.2 AF/IA. Presented in Fig. 1 are the irrigation rates of the forty-five presumed ranches.

Analysis of Parcels with Isolated Land Use and a Single Well

Combing through land use and parcel layers to identify parcels with an isolated land use type and a single well resulted in a total of fifty-four unique parcels from Santa Cruz and Monterey Counties. Presented in Fig. 2 are the calculated irrigation rates of the fifty-four parcels representing five land use types. The figure illustrates that even amongst these best case scenario parcels, outliers still exist. For example, site 26 is calculated to use over 8 AF/IA to grow raspberries/blackberries, site 41 is calculated to use over 10 AF/IA to grow strawberries, and site 54 is calculated to use over 6 AF/IA to grow vegetable row crops. These outliers are likely due to the well supplying water for more than just the parcel where it is located. With the exception of the three outlier parcels, the rest of the calculated values more closely approximate actual water usage values that we hear from growers anecdotally, and they demonstrate variation amongst growers of the same crop type.

Things to Consider

Each of the three analyses used have helped shape the direction of how to proceed in this project. As it stands, the broad stroke approach is incapable of accounting for the fact that wells supply water to multiple parcels. When using educated guesses to create ranches to account for this variable, it drastically reduces the number of unrealistic irrigation rate values. The analysis of fifty-four parcels with a single isolated land use and a single well confirmed that there is variability in the irrigation rates amongst growers of the same crop. While this exercise was beneficial, in order to evaluate the entire Pajaro Valley it is unavoidable that we will need to group parcels into assumed ranches.

There are two persisting issues that merit discussion amongst this working group prior to continuing a ranch level analysis of the entire Pajaro Valley. The first is that in spite of recently acquiring the 2012 Ranch Maps, ranch composition still remains uncertain. The county ranch maps contain data gaps as well as overlaps in the datasets. Agriculture Commissioners maintain ranch maps primarily for the purpose of tracking pesticide application. The Santa Cruz County ranch maps fail to delineate any organic farming operations. Both Santa Cruz and Monterey county ranch maps contain an abundance overlapping ranch polygons creating even more confusion. The ranch maps do provide helpful information however, we cannot solely rely on them. Instead we suggest that we incorporate the ranch maps along with aerial photos, parcel maps, land use survey data, CDS Ranch maps, and staff knowledge to continue making educated guesses as to which parcels compose a single ranch entity.

The second and more challenging issue that remains is how can we evaluate ranches that have multiple land uses. It is easy to calculate an overall irrigation rate for an entire ranch, but if we want to compare grower's irrigation efficiency for the same crop type, we will have to conceive of a way to do so. A potential method we have discussed to do this is by creating a matrix of sorts that will classify ranches with multiple land use types into comparable classifications. This matrix would entail some sort of numerical scale ranking land use types from least to most water intensive. We then could utilize ArcGIS tools to find an average matrix value for the ranch that incorporates weighting the size of the area used for each land use type. Ranches can then be compared to those with similar rankings to identify growers who could benefit most from irrigation efficiency training.

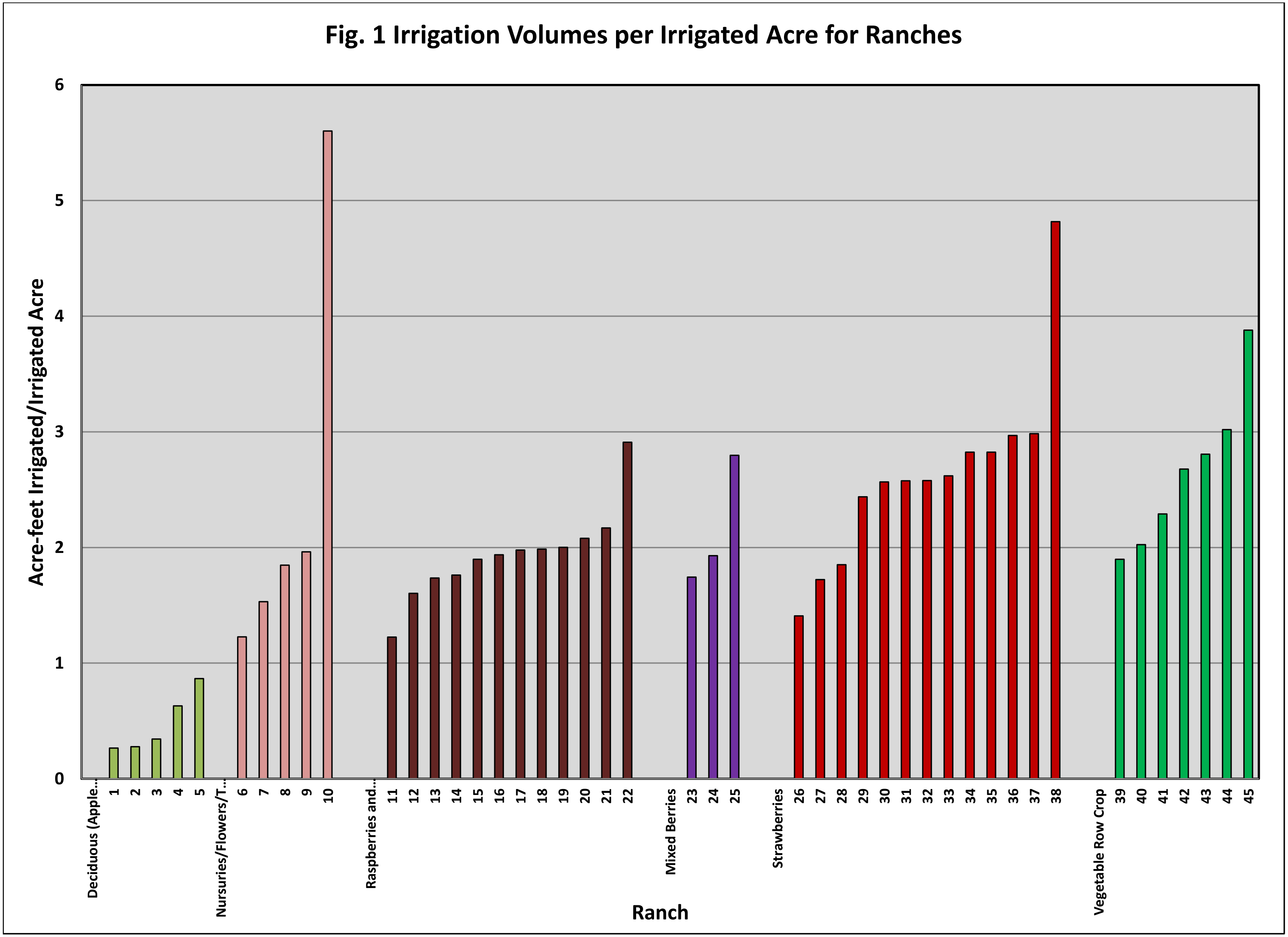

Fig. 1 Irrigation Volumes per Irrigated Acre for Ranches
Acre-feet Irrigated/Irrigated Acre
0
1
2
3
4
5
6
Deciduous (Apple...
Nursuries/Flowers/T...
Raspberries and...
Mixed Berries
Strawberries
Vegetable Row Crop
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45
Ranch

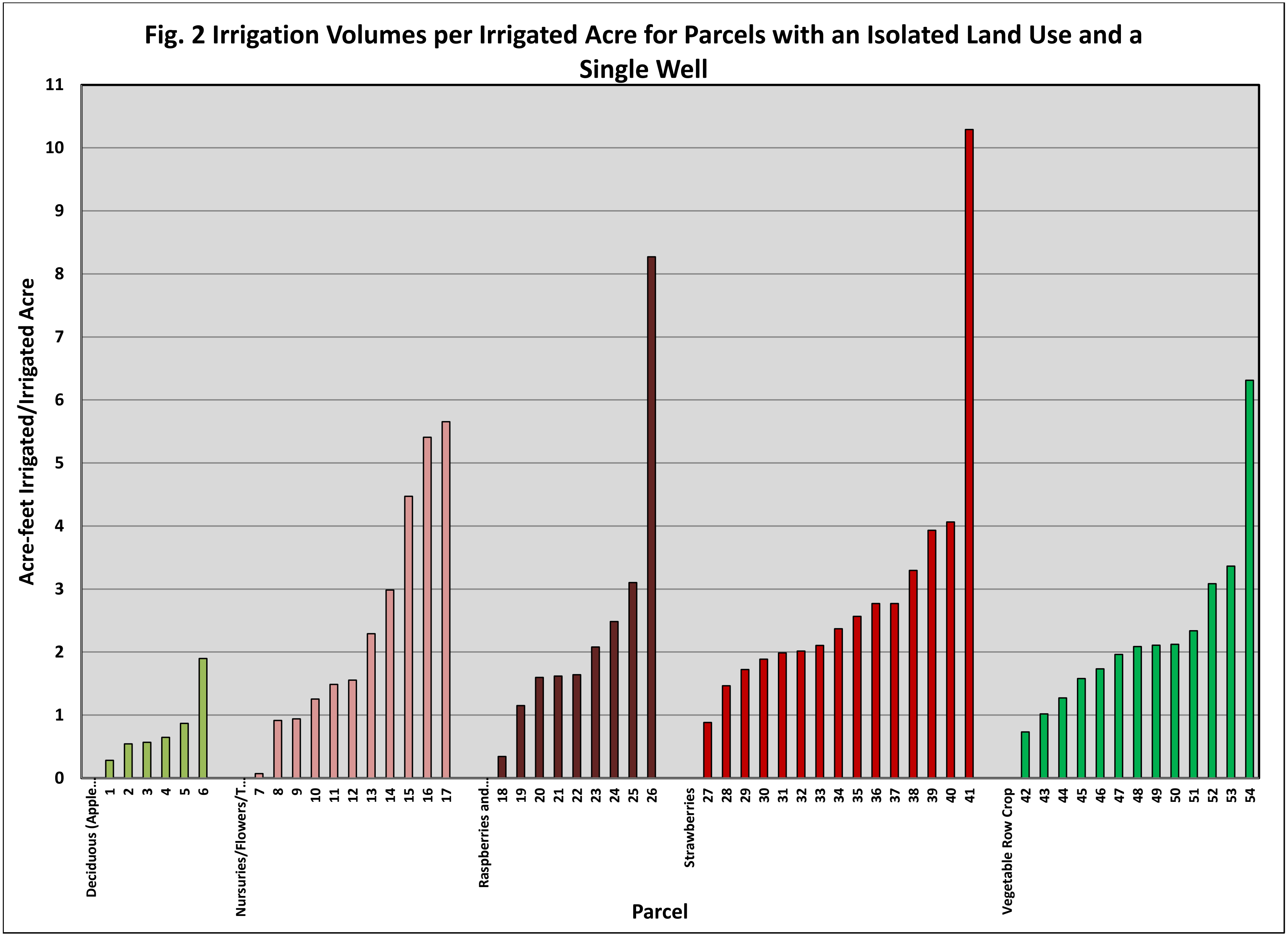

Fig. 2 Irrigation Volumes per Irrigated Acre for Parcels with an Isolated Land Use and a Single Well
Acre-feet Irrigated/Irrigated Acre
0
1
2
3
4
5
6
7
8
9
10
11
Deciduous (Apple...
Nursuries/Flowers/T...
Raspberries and...
Strawberries
Vegetable Row Crop
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54
Parcel

EXHIBIT C

County of Santa Cruz Board of Supervisors
Agenda Item Submittal
From: County Administrative Office
(831) 454-2100
Subject: Cannabis Licensing Moratorium and Setback Analysis
Meeting Date: October 19, 2021

Recommended Action(s):

1) Consider report on updates and potential changes to the Non-Retail Commercial Cannabis Program.

2) Provide specific direction to staff regarding amendments to the Non-Retail Commercial Cannabis Program codified in the Santa Cruz County Code.

3) Determine whether or not to extend a temporary moratorium on the issuance of cannabis business licenses on CA parcels that are within 500 feet of a residence on a residentially-zoned parcel.

4) If the Board chooses to extend the temporary moratorium, adopt an ordinance to extend the moratorium for 10 months and 15 days by a four-fifths vote pursuant to Government Code Section 65858.

5) Direct staff to bring any proposed changes to the Non-Retail Commercial Cannabis Program to the Planning Commission for a recommendation to the Board.

Executive Summary
The purpose of this item is to provide the Board with options regarding potential changes to the Non-Retail Commercial Cannabis Program regulations related to activity in the Commercial Agricultural zones contained in Santa Cruz County Code (SCCC) Chapters 7.128 and 13.10 as well as the current moratorium on pending and new cannabis licenses. Specific draft ordinance changes will be presented to the Board at a later date, pending the outcome of today's Board direction and decisions. Ordinance changes must also be considered by the Planning Commission prior to a public hearing with the Board.

Background
From the passage of the original ordinance in 2018 regarding the regulation of non-retail cannabis licensing activities, which was created with significant community and Board input over a two-year process, the Cannabis Licensing Office has been committed to balancing the needs of the industry with environmental protection and neighborhood preservation throughout the County. As such, the original ordinance has been amended several times since its inception as core questions and issues have arisen while the industry grows and matures.

In May 2018, the Board adopted the first non-retail cannabis licensing ordinance, which contained setbacks to sensitive receptors. Those setbacks applied to all zone districts and included:

- 200 ft setback for indoor cultivation from any habitable structure on a neighboring parcel; and
- 400 ft setback for outdoor cultivation from any habitable structure on a neighboring parcel.

In June 2019, the Board adopted changes to the non-retail cannabis licensing ordinance which included various updates to align the County Ordinance with State law, including the addition of nursery and processor license types.

In June 2020, the Board adopted additional changes to the non-retail cannabis licensing program which clarified that cannabis cultivation is an agricultural activity, it allowed cannabis cultivation and distribution in the CA zone as a principally permitted use in line with other commercial agricultural operations, and per the Board's direction the setbacks in the CA zone district were decreased to 100 feet for all types of cultivation.

On August 24, 2021, the Cannabis Licensing Office (CLO) presented a quarterly report on licensing activities for the 2021-21 fiscal year. At that meeting, a Board member identified and elevated community concerns regarding neighborhood conflicts arising from cannabis cultivation in the Commercial Agricultural (CA) zone that were adjacent to or near residentially zoned properties. The Board requested the following from the Cannabis Licensing Office:

- To evaluate the impacts of a potential code modification to non-retail cannabis cultivation which would prohibit cultivation of cannabis on a CA property that is adjacent to residential zoned parcels and within 500 feet of such parcels;

- To report on applicants and existing license holders which would be in conflict with this potential code modification including how many there are and potential mitigation measures;

- To bring back language which would institute a moratorium on applications in process and any potential new licensees while the Board deliberated on the above proposed prohibition and County Code changes;

- To create a noticing applicability and community input process for non-retail license applicants which mirrors the process approved for the retail operations; and,

- To provide options for the Board to consider which would help the cannabis industry or increase tax revenue.

On September 14, 2021, staff provided for the Board's consideration an interim urgency ordinance to impose a temporary moratorium on the issuance of cannabis business licenses on CA parcels adjacent to residentially-zoned parcels. In addition, staff provided details on the number of CA zoned parcels (773) and applicants in process

(29) that would be impacted by the suggested prohibition of cannabis cultivation in the (CA) zone that were adjacent to or within 500 feet of a residentially-zoned parcel. Analysis included all General Plan zoned parcels which would allow for a residential dwelling including the designations RA (Residential Agriculture), RR (Rural Residential), R-1 (Single-Family Residential), RM (Multifamily Residential), RB (Ocean Beach Residential), and SU (Special use).

At that meeting, the Board adopted a temporary moratorium on the issuance of cannabis business licenses on CA parcels that are within 500 feet of a residence on a residentially-zoned parcel. Additionally, the Board requested that staff return with an analysis of the proposed prohibition in the CA and an assessment of the impacts a 500-foot setback from a residential structure (rather than parcel line) would have and that SU designations be removed from consideration during the analysis. It was also noted during Board discussion that RA properties over 5 acres are allowed to grow a limited amount of cannabis per the current ordinance and that staff would also analyze those RA parcels over 5 acres in relation to the CA parcel prohibitions.

Analysis

Conflicts between residential and agricultural uses are not new or unique to our county. The extensive work that went into crafting the non-retail cannabis ordinance is a testament to the receptiveness of this Board, staff and community members, who identified and mitigated these concerns through code. Specifically, these concerns are addressed in both Chapter 7.128 and 13.10 of County Code via the Best Management and Operational Practices (BMOP). Cannabis cultivation has more restrictions than any other commercial agricultural crop. Unlike other crops, cannabis cultivation has operating hour restrictions, noise restrictions, visual restrictions, water use restrictions, stormwater drainage restrictions, herbivory control restrictions, riparian buffers and irrigation restrictions.

<u>Community Concerns and the Current Ordinance</u>

At the September 14, 2021 meeting, community members testified to concerns they had with commercial cannabis operations being adjacent to residentially-zoned area. Those concerns included guns on cannabis sites, noise, water use, traffic, and odor. Additionally, they stated the draft environmental impact report (EIR) identified these as unmitigated issues.

Staff notes that many of these concerns were in fact addressed within the ordinance itself or the BMOP governing non-retail activities. Specifically:

1) Guns are not allowed on cannabis sites and no guns have been found on licensed sites. From speaking with community members about this concern it was revealed this concern is based on the quarterly reports presented to the Board. Those reports included a summary of enforcement actions taken by the Sheriff's Office which include gun seizures. Guns seized by the Sheriff's Office have been seized from <u>illegal</u> operations. No guns have been seized from any licensed site and no guns have been observed at any licensed site.

2) Excessive noise is not allowed on cannabis sites, unlike other farming activities which are specifically exempted by county noise ordinance. As of September 24,

2021, the CLO has received one noise complaint related to a licensed operation, this complaint was investigated and found not to be in violation of County Code. The source of the noise was identified and the operating equipment generating the noise was removed from service and replaced within 72 hours, which remedied the concerns of the neighbor.

3) Water use is a concern on cannabis sites just as it is on any agricultural operations. Water use is minimized on cannabis sites through the use of drip irrigation as required by the BMOP, which is integrated into SCCC 7.128.170. Cannabis cultivators must obtain clearance from the Department of Fish and Wildlife to utilize water from groundwater wells to ensure they are not impacting surface water bodies. To better assess cannabis water use staff researched various sources. The table below represents data on cannabis from the Resource Innovation Institute, Berkeley Cannabis Research Center and New Frontier Data, *Cannabis H2O Water Use & Sustainability in Cultivation,* 2021 and data on other crops from the Pajaro Valley Water Management Agency, *Irrigation Rate Analysis Update Memorandum*, 2013. These reports provide context for cannabis water uses versus other commercial crops commonly found in our county.

Table 1: Comparison of Water Use

Crop	**Water Use Per Square Foot Per Year (Gallons)***	**Water Use Per Acre Per Year (Gallons)**
Apples	3.7	162,925
Cannabis (Outdoor)	11.3	492,228
Nurseries / Cut Flowers	13.5	586,532
Cannabis (Mixed-Light)	14.9	649,044
Raspberries	15.0	651,702
Mixed Berries	15.7	684,287
Strawberries	18.7	814,628
Vegetables Row Crops	18.7	814,628
Average Water Use for irrigate lands in the Pajaro Valley	*16.5*	*716,873*

* Square foot of the operational area not the actual canopy

Another analogy for cannabis cultivation and water usage is a comparison to home use. An average home uses 131,400 gallons per year which is approximately 18,000 more gallons of water than a 10,000 square foot outdoor cultivation site.

4) Traffic was a concern raised by some community members. The Pajaro Valley has a history of high dollar truck or table ready agricultural crops which include extensive transportation needs. Cannabis operations are more labor intensive than

apples and in line with berry production, cut flower and ornamental nursery uses. Cannabis operations are required to reduce the vehicle miles traveled to and from there sites via carpooling and the use of vanpools. This requirement has not been enforced recently due to social distancing requirements associated with COVID-19. These requirements will be enforced once health guidelines change. The CLO has received complaints associated with traffic at a site in Corralitos. Traffic concerns at the site have been resolved via staggering shifts and the movement of the entry gate at the site. Agriculture is not a static industry, and the evolution of that industry locally includes the cultivation of berries, which came after culinary herbs cut flowers, ornamental nurseries, which came after apples, etc. As crops have changed labor demands and the need for transportation has also shifted.

5) Odor was a concern raised by community members. Cannabis plants generate an odor that can be smelled beyond the property boundary of the cultivation sites. The same odor is generated by industrial hemp plants. Currently, registered hemp cultivation occurs in nearly four times the acreage of commercial cannabis production and hemp parcels abut 45 residentially zoned parcels. To date, the CLO has received odor complaints about two licensees, only one of which has been verified by the Monterey Bay Air Resources district.

6) Lastly, the community concern about the draft EIR identify these impacts as being unmitigable and being the basis for why the report was not finalized does not reflect the history of that report or its findings. The draft EIR was not finalized because the State determined it would not accept programmatic EIR's for cannabis related activities. The State required localities to do individual site-specific California Environmental Quality Act (CEQA) determinations. Facing this new reality, the County utilized the impacts identified in the draft EIR to develop the BMOP. The impacts were assessed individually, and mitigation measures were identified. All impacts and mitigation measures were compiled into the BMOP, and all non-retail cannabis operations must comply with these requirements. Each cannabis applicant must address all aspects of the BMOP prior to obtaining a license and the CLO inspects sites for compliance with these quarterly. In addition to the county requirements cannabis cultivators must comply the Cannabis general order, from the State Water Resources Control Board. The requirements of the Cannabis General Order are centered around erosion minimization and water discharges to prevent surface and ground water impacts from cannabis cultivation.

It is also important to remember that all cannabis operations are inspected quarterly and issued notices of correction or violation if they are not operating in accordance with their license and use permit(s). In addition, cannabis operations are licensed annually, and the County always has the option to refuse to renew a license should the operations be out of compliance consistently throughout the previous year.

<u>Agricultural Protections in County Code</u>

Cannabis is defined as agriculture by both State and local definitions and there are several relevant chapters of County Code which are relevant to cannabis cultivation in the CA zone district. SCCC 13.10.311 defines the purposes of agricultural zone districts, which are to preserve the commercial agricultural lands, to maintain the economic integrity of farms and to implement the agricultural preservation policy of

SCCC 16.50.010 all while encouraging commercial agricultural uses to the exclusion of other land use which may conflict with it. Previous policy makers have affirmed that it is in the public interest to preserve and protect commercial agricultural land for exclusive agricultural use and to enhance and encourage agricultural operations within the County, and that certain agricultural land in the County, not presently of commercial value, also merits protection. They also found that nonagricultural development adjacent to these lands often leads to restrictions on the County's agricultural industry as a whole.

In order to address areas of conflict between commercial agriculture operations and residential areas that have been developed near such operations the County Code goes on to protect agricultural activities through a notification and disclosure which is required for all real estate transactions in the County. That disclosure reads:

"Santa Cruz County has a strong rural character and an active historical agricultural sector. As a property owner or lessee, you should be prepared to accept properly conducted agricultural practices that are allowed for in Federal, State and County laws and regulations, are consistent with accepted customs and standards, and are operated in a non-negligent manner. Accepted agricultural practices that may cause inconveniences to property owners during any 24-hour period may include but are not limited to: Noise, odors, fumes, dust, smoke, pests, operation of farm equipment, storage and application and disposal of manure and the application of pesticides and fertilizers by ground or air. The County of Santa Cruz will not consider an agricultural practice to be a nuisance if implemented in accordance with Federal, State, and local law. Nothing herein is intended to limit rights under Federal, State, and local regulations governing pesticide use."

In addition to this disclosure agricultural lands have setback requirements for habitable uses within 200 feet of parcel lines to prevent or minimize potential conflicts between existing or future agricultural and residential uses. When a property owner chooses to pursue residential development in an agricultural buffer, they must acknowledge that they may be subject to inconvenience or discomfort arising from the use of the adjacent agricultural lands. Additionally, the acknowledgement is recorded and binding on that property owner and all future owners as described in SCCC 16.50.090.

SCCC 13.10 and 16.50 are intended to protect agricultural uses against all other land use which conflict with it. The protections afforded to agricultural operations by County Code are intended to protect agricultural operations from residential conflicts. The Agricultural Policy Advisory Commission (APAC), *Recommendations Regarding the Draft EIR on the Proposed Cannabis Cultivation and Manufacturing Ordinances*, from November 2017 further reinforced these protections are applicable to cannabis.

Cannabis cultivation does have some unique safety concerns due to its history of illegality and because of its high dollar value in the marketplace. As the market matures, prices drop, and illegal operations are abated and eliminated cannabis will simply become the growing of a plant in the ground so that it can be sold on a commercial market similar to any other agricultural crop.

<u>Assessment of Impacted Parcels</u>

During the many deliberations on the original proposed ordinance, the Board stated that in order to best preserve environmental and neighborhood protections, it was preferable to encourage cannabis production in CA zoned areas while limiting its production in other areas. This led to the current limitations on both canopy size and minimum acreage required for growing cannabis on non-CA-zoned lands.

There are currently 1,462 parcels zoned CA throughout Santa Cruz County representing a total of 43,624 acres. These parcels are primarily concentrated in the South County in Districts 2 and 4, with a scattering of parcels located in the rest of the county, including along the north coast in District 3. The following table shows the total CA zoned parcels by district.

Table 2: CA Zoned Parcels by District

	District 1	District 2	District 3	District 4	District 5	Total Parcels	Total acreage
CA Zoned Parcels	30	691	82	628	31	1,462	43,624

The following data was presented via a map at the September 14 meeting on CA parcels that abutted or were within 500 feet of a residential zoned parcel (including SU) as requested at the August 24th Board meeting. Staff has updated this data to show it by district. It is presented in the table below.

Table 3: CA Zoned Parcels by District with August Prohibitions

	District 1	District 2	District 3	District 4	District 5	Total Parcels	Total acreage
CA Zoned Parcels	30	691	82	628	31	1,462	43,624
Less CA parcels abutting or within 500 feet of a residentially zoned parcel	30	450	64	201	28	773	21,670
CA parcels available for licensing	**0**	**241**	**18**	**427**	**3**	**689**	**21,954**

In accordance with directions provided at the September 14 meeting the following data presents CA parcels that abut or were within 500 feet of a residential structure (excluding SU parcels) from the CA parcel line.

Table 4: CA Zoned Parcels by District with September Prohibitions

	District 1	District 2	District 3	District 4	District 5	Total Parcels	Total acreage
CA Zoned Parcels	30	691	82	628	31	1,462	43,624
Less CA parcels within 500 feet of a residential structure from CA parcel line	30	378	28	132	24	592	15,915
CA parcels available for licensing	**0**	**313**	**54**	**496**	**7**	**870**	**27,709**

In addition, staff looked at RA parcels of 5 acres or more which abut CA zoned parcels. This is because these RA parcels are allowed to grow a limited amount of cannabis (1.25% of parcel on 5 to 10 acres up to a maximum of 5,100 square feet or up to 10,000 square feet on parcels greater than 10 acres). The logic in looking at these parcels was that an RA neighbor to CA zoned parcels, who could also grow cannabis on their land, might not have the same objections to a cannabis operation next door and those parcels could be eliminated from the prohibitions. The following data shows information on RA zoned parcels eligible to grow cannabis abutting CA zoned parcels.

Table 5: RA Zoned Parcels by District Abutting CA Zoned Parcels

	District 1	District 2	District 3	District 4	District 5	Total Parcels	Total acreage
RA parcels 5 acres or more	405	438	163	77	318	1,401	15,011
RA parcels 5 acres or more abutting a CA zoned parcel	32	104	14	33	5	188	2,739

Staff also assessed the impact to applicants currently in process for their cannabis license. Some are working on meeting their use permit conditions of approval, building out their facility to become operational as well as those who have submitted pre-applications (in yellow) to start the licensing process. There was no change to the number of impacted potential licensees based on the modification suggested in September.

Table 6: Potentially Impacted Licensees with August or September Prohibitions

Supervisorial District	Total Potential Licenses	Current Applications in review	Current Licenses on the Parcel
2	5	1	1
4	3	0	1
4	7	0	2
2	2	1	0
2	2	1	0
Subtotal	**19**	**3**	**4**
2	1	0	0
2	2	0	0
2	2	0	0
Subtotal	**5**	**0**	**0**
Grand Total	***24***	***3***	***4***

The total potential licenses, excluding those that are in the pre-application phase represent approximately 22,000 sq ft of indoor canopy cultivation, 530,000 of greenhouse canopy operations, 20,000 sq ft of hoop house canopy cultivation, 150,000 sq ft of greenhouse nursery operations and 22,000 sq ft of outdoor canopy cultivation. The total value of the potential revenue loss of CBT is estimated at about $2.5 million should these potential licensees be eliminated from pursuing their current license application.

Options for Addressing CA Zoned Parcels

Taken all together, this data presents various options for discussion and consideration by the Board in order to provide staff with specific policy direction for ordinance changes.

Option 1: Maintain current ordinance. This allows for a 100-foot setback on any CA zoned parcel. This is measured from the cultivation area to adjacent property parcel line. Based on the community concerns expressed this is not a preferred option.

Option 2: Update the ordinance to disallow cannabis cultivation on CA parcels that abutted or were within 500 feet of a residential zoned parcel per the current moratorium. This option has the potential to address some community concerns such as noise, odor and transportation impacts and water use from residential neighbors. It eliminates 773 or 52% of the CA zoned parcels for potential cannabis operations representing 21,670 acres and takes parcels out of consideration, no matter what their size or how far a cultivation site may actually be from a habitable structure. For example, a large parcel may be able to locate a cannabis operation acres away from a residence but the parcel would be eliminated simply because it abuts or is within 500 feet of a residentially zoned parcel.

Option 3: Update the ordinance to disallow cannabis cultivation on CA parcels that are within 500 feet of a residential structure from the CA parcel line per the September 24th Board discussion. This option is similar to option 2 in terms of the advantages and disadvantages. It eliminates 592 or 40% of the CA zoned parcels for potential cannabis operations representing 15,915 acres.

While it is difficult to assess the potential tax impacts due to the highly fluctuating market process for cannabis, the various options for growing (nursery, flower, full plant), and the likelihood of any of this "lost" production area actually being used for cannabis, staff has estimated the following potential tax revenue impacts as follows.

Table 8: Potentially Revenue Losses

	August Option	September Option
Total eliminated parcels	773	592
Representing total "lost" acreage	21,670	15,915
Maximum amount of cannabis allowed (5%)	1,084	796
Reduce by 60%	433	318
Acreage converted to Square feet	18,878,904	13,865,148
Approximate sales Value per sq ft (outdoor)	$ 9.63	$ 9.63
Approximate Gross Sales Potential	$ 181,803,846	$ 133,521,375
Potential loss of tax revenue (6% of gross receipts)	$ 10,908,231	$ 8,011,283

* Assumes only 40% of potential properties will grow cannabis

Option 4: Revise setbacks in CA to align with the original code approved. This includes a 400-foot setback from residence to outdoor grow area, which is twice the setback than allowed in other agricultural operations. The original code also allowed for exceptions down to 100 foot subject to a Level V use permit (as allowed for all other zone districts). Further define setbacks for indoor cultivation to be 100 ft from residences to cultivation area and 50 ft from nursery operations to residences. The advantage of this option would allow for site specific evaluations which can be a better way to address specific neighborhood concerns without a broad stroke elimination of eligible parcels. It also aligns the CA zone with all other zone districts that allow cannabis cultivation. In addition, exceptions to setbacks would require a public hearing, allowing for community input and adjudication by an impartial administrator. This option also honors the protections for agricultural production as codified in SCCC16.50.095 while doubling the setbacks for any other agricultural operation.

Option 5: The same as option 4 with increased setbacks of 500 feet for outdoor cultivation, 200 feet for indoor cultivation and 100 feet for nursery operations.

Thus, far the code along with the use permit public process and imposed conditions has been an effective tool in maintaining the balance between the nascent cannabis industry, environmental and neighborhood protection and use of the CA zone as previously deemed the most appropriate zone for cannabis cultivation by the Board.

Thus, staff recommends the choice of either option 4 or 5 to address the conflicts inherent in agricultural production near residential use while also allowing the ever-evolving cannabis industry to respond more appropriately to specific neighborhood concerns.

Current Licensees and CA Zone Changes

At the September 14th meeting, the Board clarified that current licensees would be allowed to continue in their licensed operations and not be impacted by any ordinance changes at their license renewal period.

Moratorium Options

At the September 14 meeting, a moratorium was implemented on any new applications as well as on any applications in process in order to allow the Board time to consider its many options regarding regulations in the CA zone and to give staff specific directions for an ordinance change. A few Board members expressed concern over the length of the moratorium and staff is providing options for Board consideration on the moratorium.

Option 1: Leave the moratorium in place as is, halting the acceptance of any new applications for cannabis licensing and freezing all those in process that are located on CA zoned property which abuts or is within 500 feet of a residence until a new ordinance is approved by the Board. (An extension of the moratorium is required for this option and included as an attachment.) This is similar to the way the Board managed an update to the vacation rental ordinance a few years ago. In that case all applications were frozen while a new ordinance was developed and once applications were accepted, “frozen” applicants were given priority processing if they met the criteria under the new ordinance. The advantage of this option is it allows for continued public debate and extensive Board and Planning Commission thoughtful deliberation. The disadvantage of this option is that it puts significant capital investments at risk for those currently awaiting their use permits, potentially opening the County to litigation and could also impact the current fiscal year revenue projections for licensing. Our budgeted tax and licensing revenue for the current fiscal year included an increase based on projects in the pipeline as well as on current licensed operations.

Option 2: Eliminate the moratorium for applications in process but halt the acceptance of any new applications on CA zoned land abutting or within 500 feet of a residence until a new ordinance is approved by the Board. This would allow potential licensees to continue in the process under the conditions as when they first applied while also allowing the use permit process to address neighborhood concerns on a case-by-case basis. It could also preserve potential tax and licensing revenue while eliminating potential litigation threats. The disadvantage of this option is that changing Board thinking on CA zoned properties would not be implemented for applications in process. Staff recommends this option.

Noticing and Community Input Process

Recent changes to the retail cannabis ordinance provided a public notice and appeal procedures for Licensing Official decisions related to the relocation of cannabis retailers seeking a setback waiver. The addition of the proposed language defined the public notification and the appeal process. The public notification process includes a mailer sent to all property owners within 600 feet of the proposed location and all lawful occupants of properties within 100 feet of the proposed location. The public notification also includes the posting of a sign on the proposed location at least 14 days prior to the end of the appeal window. These public notification procedures align with current Planning Department public notification procedures for Level IV proposed development. The new appeal procedure included having an Administrative Hearing Officer review the matter de novo and render a written decision.

Through the use permit process public notification and input procedures within the Planning Department are currently in place when a cannabis applicant seeks a use permit for their cannabis application. It is staff's understanding that the Board wanted the non-retail licensing process to mirror the retail licensing process when setback exceptions are requested. Any time a setback exception is requested this triggers a Level V use permit, which requires public notification and a Zoning Administrator public hearing. It is, therefore, recommended that the current public hearing and notification procedures remain in place rather than having redundant notifications for the same project.

Opportunities for Future Cannabis Operations

At the conclusion of the August 24th meeting, staff was directed to return with ideas that would help grow the cannabis industry and increase the tax base of cannabis operations. The following ideas are presented to encourage future discussions and not intended to be a part of the discussion or direction provided today to staff for ordinance changes on CA-zoned parcels.

Increasing Production to Increase Cannabis Business Tax

Cannabis Business Taxes (CBT) are based on gross sales amounts. An increase to the production of cannabis could increase CBT.

1) Use of greenhouses on CA parcels less than 10 acres. Currently, CA parcels of less than 10 acres are limited in the amount of square footage cultivation to a maximum of 22,000 square feet. However, especially in areas previously devoted to cut flowers, greenhouses may constitute significantly more square footage on the parcel. Greenhouses allow for greater controls, including odor, on cannabis production and the Board should consider allowing for all greenhouses on a CA zoned property to be used for cannabis production. An alternative concept would be to allow excess greenhouse capacity to be devoted to nursey production only with no square footage limitations.

2) Allow parcels zoned A (Agricultural) that are greater than 30 or 40 acres to follow the same guidelines as CA zoned parcels which would allow for increased cultivation area. There are 74 A zone parcels greater than 30 acres and 41 parcels greater than 40 acres, as shown on Exhibit A.

3) Increase the canopy limits in certain zone districts. This would allow operators to expand their existing sites rather than seeking out new land for production. It is suggested that a pilot project that allowed for community input during the project be conducted to assess the interest and impacts of production changes.

Increasing Overall Sales to Increase Cannabis Business Tax

4) Allow retail sales and consumption of non-manufactured cannabis goods grown by a licensed farm, similar to a winery. Again, a pilot project with a limited number of exceptional operators is suggested for assessing and evaluating this option. Limitations such as only the use of existing structures of 120 square feet or less, no new parking or impervious area allowed, limited hours and potential seasonal limitations on such operations could also be imposed.

5) Allow current retail operations the option to have on-site consumption lounges similar to breweries. Use of the model for compliance and human health have been established in San Francisco and should be considered as a best practice when assessing and evaluating this concept through a pilot project. This idea could also create additional jobs.

Financial Impact
Financial impacts vary by potential changes to the Non-Retail Commercial Cannabis Program.

Strategic Plan Element(s)
This item supports the Strategic Plan Element of Comprehensive Health and Safety and Dynamic Economy.

Submitted by:
Carlos J. Palacios, County Administrative Officer

Recommended by:
Carlos J. Palacios, County Administrative Officer

Attachments:

a Extension Ordinance - Moratorium on Cannabis in CA (10-13-21) final
b Map of A zone 30 acres or more

EXHIBIT D

Memorandum

To	:	Cities and Counties Issuing Cannabis Cultivation Permits and Licenses	Date:	June 17, 2019
			Place:	Sacramento
			Phone:	(916) 654-0321

From : **Department of Food and Agriculture -** 1220 N Street, Suite 400
Sacramento, CA 95814

Subject : **Re: CEQA Practice Recommendations from CDFA for Cannabis Cultivation - Categorical Exemptions**

Introduction

The California Department of Food and Agriculture (CDFA) CalCannabis Division (CalCannabis) issues licenses, as required, to cultivate, propagate and process commercial cannabis in the State of California. CDFA issues licenses to outdoor, indoor, and mixed-light cannabis cultivators, cannabis nurseries and cannabis processor facilities where local jurisdictions authorize these activities. This authority is pursuant to the Business and Professions Code, Division 10, Chapter 2, Section 26012(a)(2). For the complete text of CDFA's CalCannabis regulations, please visit: static.cdfa.ca.gov/MCCP/document/CDFA%20Final%20Regulation%20Text_01162019_Clean.pdf.

CDFA understands that most local jurisdictions have an interest in ensuring that cultivation permittees or licensees within their jurisdictions receive their state licenses as efficiently as possible. Pursuant to CDFA's regulations, applicants for an annual license from CDFA are required to provide evidence of exemption from, or compliance with, the California Environmental Quality Act (CEQA). (Cal. Code Regs., tit. 3, § 8102.) CDFA has determined that its action on each annual license application for cannabis cultivation is a discretionary decision. If CDFA receives an application for an annual license for a project where the local Lead Agency has issued a local cultivation permit or license with the determination that a project is categorically exempt from CEQA, CDFA will evaluate the documentation provided by the local jurisdiction or applicant to determine whether it supports CDFA's decision regarding the issuance of a state license for the project. This means that CDFA must have sufficient information to determine whether a categorical exemption is appropriate for a particular project.

CDFA needs supporting information sufficient to determine not only whether the project is eligible for an exemption, but also whether any relevant exceptions specified in the

State CEQA Guidelines may apply, disqualifying the project from an otherwise applicable exemption. (Cal. Code Regs., tit. 14, § 15300 et seq.) CDFA can more efficiently process applications when local jurisdictions provide applicants with the information that CDFA needs to conduct its evaluation.

This memorandum is intended to provide local jurisdictions with information about CDFA's documentation needs for projects approved under categorical exemptions and tools that may be helpful to jurisdictions to ensure that the needed documentation is provided.

Most Likely Classes of Categorical Exemptions

CDFA expects that the following categorical exemptions are the most likely to be applicable to cannabis cultivation projects:

- Class 1: Existing Facilities
- Class 2: Replacement or Reconstruction
- Class 3: New Construction or Conversion of Small Structures
- Class 4: Minor Alterations to Land
- Class 11: Accessory Structures
- Class 32: In-fill Development Projects

If a local Lead Agency finds that a project qualifies under a categorical exemption class not included in the list above, CalCannabis recommends that the Lead Agency provide information that supports that finding, as provided in the CEQA Guidelines. (Cal. Code Regs., tit. 14, § 15300 et seq.) If there is insufficient information to support the finding for the categorical exemption, this could delay processing or issuance of the state annual license.

Information for CDFA's Review of Exemption Applicability

The following information will assist CDFA when it conducts its independent review of applications for annual licenses that are potentially subject to one or more CEQA categorical exemptions.

Notice of Exemption (NOE). CDFA recommends that local Lead Agencies complete a NOE when identifying one or more categorical exemptions for a project. We further recommend that, in addition to notice-filing requirements under Public Resources Code section 21152 and CEQA Guidelines section 15062, local lead agencies file a copy of a NOE with the State Clearinghouse. While CEQA does not require lead agencies to file a NOE, CDFA must have evidence either that CEQA review has been completed or that a project is exempt from CEQA. CDFA recommends local Lead Agencies provide a copy of the signed and dated NOE, and evidence of posting if completed, to cultivation applicants so that applicants may provide this evidence to CDFA as part of their license application packages.

While CDFA prefers that a copy of a NOE be provided with each license application, in the absence of a signed and dated copy of a NOE, a signed and dated local permitting decision document regarding the project, which references the permitting agency's reliance on a categorical exemption may be adequate to document the local jurisdiction's determination that a project is categorically exempt.

Project Description. As noted above, when CDFA receives a license application identifying a project as eligible for a categorical exemption, it must conduct an independent evaluation to determine whether the project qualifies for the categorical exemption class(es) identified by the local jurisdiction. CDFA recognizes that the project description associated with categorical exemptions need not contain the detail required of other CEQA documents. However, CDFA must have sufficient information to make an independent determination whether the project fits within the exemption and whether any of the exceptions to an exemption apply. CDFA has prepared a separate memo "CEQA Practice Recommendations from CDFA for Cannabis Licenses – Project Description Information Requirements," which discusses the requested contents of a project description adequate for CDFA licensure decisions. To the extent that it is available, all of the information discussed in that memo should be provided for projects that may fit within categorical exemptions.

Cumulative Impact Assessment. Of particular importance when evaluating categorical exemption exceptions is that projects may not qualify for any class of categorical exemption if the project contributes, along with successive projects of the same type in the same place, over time, to a significant cumulative impact. (Cal. Code Regs., tit. 14, § 15300.2(b).) Thus, an analysis of cumulative impacts is needed to determine whether a categorical exemption applies. The cumulative impacts analysis required for categorical exemptions is more narrowly defined than that required for initial studies or Environmental Impact Reports. Nevertheless, if the local jurisdiction has prepared a CEQA document for its cannabis program, information from that analysis may be used in the analysis for a subsequent categorical exemption. If a jurisdiction's CEQA document identified significant and unavoidable impacts, applicants in that jurisdiction may need to provide evidence that the proposed project would not make a contribution to those impacts. If a CEQA document has not been prepared for the local jurisdiction's cannabis program, the local General Plan and its environmental analysis might provide the information necessary for the cumulative impacts' analysis. If no cumulative impacts analysis is available for a jurisdiction, information as to other existing or proposed cannabis cultivation sites in the vicinity of the proposed project should be provided. In addition, some evidence that the project would not contribute to cumulative significant impacts is necessary to support a finding that a categorical exemption applies. Such evidence may include: information indicating that the circumstances of the project preclude a contribution to cumulative significant impacts; the absence of other existing or proposed cannabis cultivation sites in the vicinity of the proposed project; the inclusion of measures required by ordinance (e.g., noise or odor control) that reduce or minimize cumulative impacts; or measures adopted by the applicant that reduce or minimize cumulative impacts.

Documentation of Evaluation. The CEQA Guidelines define the types of projects and activities eligible for each class of categorical exemption. As noted above, the Guidelines also list exceptions that apply to all, or certain classes of, exemptions. Consequently, projects normally eligible for an exemption may not be eligible if certain circumstances exist or would exist. In order to ensure the most expedient processing of cultivation license applications, CDFA has prepared some tools to assist local jurisdictions in documenting their decisions regarding the applicability of categorical exemptions for a proposed project. For each of the six categorical exemptions classes listed above, CDFA has prepared two tools to assist local Lead Agencies, including a Categorical Exemption Evaluation Form to document the agency's determination(s), and instructions for completing the Evaluation Form. These tools are provided in Attachments A-F. As a best practice, local agencies may use these tools and provide state annual license applicants a completed Evaluation Form for each categorical exemption that may be applicable to the applicant's proposed project.

Conclusion

CDFA is committed to working with local jurisdictions to streamline the review process for annual cultivation license applications. If you have any questions, or require additional information, please contact Kevin Ponce, Senior Environmental Scientist, at (916) 263-0801 or via e-mail at kevin.ponce@cdfa.ca.gov.

ATTACHMENT A

Tools For Categorical Exemption Class 1

ATTACHMENT B

Tools for Categorical Exemption Class 2

ATTACHMENT C

Tools for Categorical Exemption Class 3

ATTACHMENT D

Tools for Categorical Exemption Class 4

ATTACHMENT E

Tools for Categorical Exemption Class 11

ATTACHMENT F

Tools for Categorical Exemption Class 32