



An example of an indoor cannabis cultivation in San Diego County enrolled in the State Water Resources Control Board’s Cannabis Cultivation Program. Indoor facilities such as this are issued a waiver of waste discharge requirements. The photo shows approximately 2,100 cannabis plants. Photo credit: Kyle Castanon, Palomar Craft Cannabis

Two years after legalization: implementing the Cannabis Cultivation Policy in southern coastal California

BRIAN M. COVELLONE^{1*}, CELIA S. PAZOS¹, ERIC T. LINDBERG¹, PAMELA YBARRA¹, AND MAHER A. ZAHER¹

¹*Santa Ana Regional Water Quality Control Board, Santa Ana Regional Water Quality Control Board, 3737 Main Street, Suite 500, Riverside, CA 92501, USA*

**Corresponding Author: brian.covellone@waterboards.ca.gov*

During the first two years of legal recreational cannabis cultivation in California, the State Water Resources Control Board's Cannabis Cultivation Program enrolled 4,391 cultivators into the Cannabis General Order. The South Coast Regional Cannabis Unit, covering approximately 28,500 km² in southern coastal California, account for 519 of those cultivators, 516 of which are indoor cultivations. The observed distribution of commercial recreational cannabis cultivation reflects local government restrictions and, combined with the urban nature of the areas where cultivation is permitted in southern California, results in a majority of cultivation being indoor. Of the active enrollees in the South Coast region with indoor cultivation, 94% of the cultivations are discharging their industrial wastewater to a publicly owned treatment works via a sewer connection. The remaining enrollees in the South Coast region with indoor cultivation haul their industrial wastewater to a permitted wastewater treatment facility. These discharges pose a low threat to water quality, provided that they are compliant with the sewer agency's requirements and/or wastewater treatment facility's requirements. As a result, all but the three outdoor cultivators enrolled with the State Water Resources Control Board in the South Coast region were issued waivers of waste discharge requirements as of 1 January 2020.

Enforcement of illicit cultivation for the purpose of the protection of water quality and habitat also plays an important role in the South Coast Regional Cannabis Unit's Cannabis Cultivation Program. The South Coast Regional Cannabis Unit inspected 143 illicit cultivation sites as of 1 January 2020. Observations from inspections of illicit sites identified threats to Clean Water Act 303(d) waterbodies and Regional Water Quality Control Board priority water systems, and observed illegal and/or unauthorized pesticide use, evidence of and potential for sediment mobilization, and ubiquitous and substantial litter. These illicit cultivation sites pose a threat to water quality, aquatic and riparian habitats, and fish and wildlife, though the effects have not yet been quantified.

Key Words: California Regional Water Quality Control Boards, cannabis, cultivation, environmental impacts, management, water quality

California has a long history of cannabis cultivation with records of cultivation dating back to 1795 when hemp was introduced to Mission San Jose (Bowman 1943, Clarke and Merlin 2013). Hemp plantations supported by the Spanish government in colonies within California were established in Santa Barbara, San Jose, Los Angeles and San Francisco in the early 1800's (Clarke and Merlin 2013).

Enacted by the 91st United States Congress, the Comprehensive Drug Abuse Prevention and Control Act of 1970 (21 United States Code (USC) Chapter 13 §812) established cannabis (“marihuana”) as a Schedule I controlled substance¹. California was the first state to legalize non-hemp cannabis cultivation. Legalization of medical cannabis cultivation in California began in 1996 with the passage of Proposition 215 the Compassionate Use Act of 1996 (Health and Safety Code (HSC) §11362.5; HSC §11358). The Medical Marijuana Regulation and Safety Act of 2016, and later the Medicinal and Adult-Use Cannabis Regulation and Safety Act (MAUCRSA) by initiative Proposition 64, established the general framework for regulation of cannabis in California, including its cultivation (Business and Professions Code (BPC) §26000). MAUCRSA authorized the California Department of Food and Agriculture (CDFA) to administer provisions related to cultivation in the state (BPC §26012). CDFA, while the ultimate licensing board for cultivation, is required to include conditions requested by the California State Water Resources Control Board (SWRCB) and California Department of Fish and Wildlife (CDFW) (BPC §26060.1(b)(1); Water Code §13149). While cultivation for personal use is legal statewide under Proposition 64, restrictions to cultivation within HSC §11362.2 are ultimately in the hands of individual local governments, counties, cities, and special districts.

Extensive literature has been produced documenting cannabis cultivation in northern California (Levy 2014, Carah et al. 2015, Butsic and Brenner 2016, Butsic et al. 2018, Wilson et al. 2019, Levy 2020), especially in Humboldt, Mendocino, and Trinity counties known collectively as the Emerald Triangle, however significantly less has been prepared documenting cannabis cultivation in southern California. What follows is a compilation of data describing cannabis cultivation in southern California based on the initial two years of records with the California Regional Water Quality Control Board's South Coast Regional Cannabis Unit (SCRCU). The data set includes 662 cannabis cultivation sites, both legally and illegally operating in southern California.

Statewide Regulatory Framework

In the decades following the passage of Proposition 215 the Compassionate Use Act, cannabis cultivation in northern California rapidly expanded, resulting in waste discharges to the environment, loss of instream flows, and the diversion of springs and streams (North Coast Regional Water Quality Control Board 2015, Central Valley Regional Water Quality Control Board 2015). To mitigate these environmental impacts, the North Coast Regional Water Quality Control Board (RWQCB) and the Central Valley RWQCB began regulating medicinal cannabis cultivation in 2015 under SWRCB Orders R1-2015-0023 and R5-2015-0113, respectively (North Coast Regional Water Quality Control Board 2015, Central Valley Regional Water Quality Control Board 2015). These orders laid the framework for the statewide cannabis cultivation policy after the passage of MAUCRSA, when recreational cannabis cultivation became legal in the state.

¹ Does not include hemp as defined in 7 USC §1639o

The SWRCB adopted Resolution Number 2017-0063, the Cannabis Cultivation Policy – Principles and Guidelines for Cannabis Cultivation (Cannabis Policy), on 17 October 2017 which became effective on 18 December 2017 (State Water Resources Control Board 2017a). The Cannabis Policy was subsequently updated by Resolution Number 2019-0007 (State Water Resources Control Board 2019a):

“The purpose of [the] Cannabis Policy is to ensure that the diversion of water and discharge of waste associated with cannabis cultivation does not have a negative impact on water quality, aquatic habitat, riparian habitat, wetlands, and springs.” (State Water Resources Control Board 2019a)

The Cannabis Policy achieves this purpose by establishing requirements for cannabis cultivation that address the following 12 treatment or control categories (State Water Resources Control Board 2019a):

- riparian and wetland protection and management;
- water diversion, storage, and use;
- irrigation runoff;
- land development and maintenance, erosion control, and drainage features;
- soil disposal;
- stream crossing installation and maintenance;
- fertilizer and soil use and storage;
- pesticide and herbicide application and storage;
- petroleum products and other chemical use and storage;
- cultivation-related waste disposal;
- refuse and human waste disposal; and
- winterization

The Cannabis Policy applies to commercial recreational cannabis and commercial medical cannabis, and exempts personal use recreational or personal use medical cannabis cultivation, as long as the cultivation complies with applicable conditions including riparian setback requirements and disturbed area limitations (State Water Resources Control Board 2019a). The requirements of the Cannabis Policy are implemented through SWRCB Order WQ 2017-0023-DWQ (State Water Resources Control Board 2017b), General Waste Discharge Requirements and Waiver of Waste Discharge Requirements for Discharges of Waste Associated with Cannabis Cultivation Activities (Cannabis General Order), which was updated by SWRCB Order WQ 2019-0001-DWQ (State Water Resources Control Board 2019b). The Cannabis General Order established a tiered approach based on the potential threat to water quality of cannabis cultivation and related activities. Enrollees in the Cannabis General Order are issued general waste discharge requirements (WDRs) that address issues including the mobilization of sediment, the use of fertilizers, and storm water runoff. The tiers are based on the size of the disturbed area, as defined in the Cannabis Policy, the slope of the disturbed area, and the proximity to a water body. The Cannabis General Order also established two conditional exemptions that are issued conditional waivers of WDRs, an indoor commercial cultivation exemption and an outdoor commercial cultivation exemption if the disturbed area for cultivation is less than 2,000 ft² (~185 m²). Indoor cultivation is defined as activities that occur within a structure with a permanent roof, a permanent relatively impermeable floor, such as concrete or asphalt paved, and either discharges all industrial wastewaters to a permitted wastewater treatment facility that accepts cannabis cultivation wastewater, or collects all industrial wastewater in a storage container and hauls

the wastewater offsite to a permitted wastewater treatment facility (State Water Resources Control Board 2019a).

South Coast Regional Cannabis Unit Regional Setting

The SWRCB consists of nine RWQCBs based on watershed boundaries, shown on Figure 1. To account for California's size and geographical variations, which result in highly variable climate and drainage patterns, the Cannabis Policy defines 14 Cannabis Cultivation Policy regions and identifies nine priority regions that support anadromous salmonids where water flow variability and water quality have the potential to inhibit natural migration, spawning, and rearing (State Water Resources Control Board 2019a). The 14 Cannabis Cultivation Policy regions are divided among six cannabis cultivation regulatory units based on geographic location. The SCRCU's Policy region includes one of the nine priority Cannabis Cultivation Policy regions and is based out of the Santa Ana RWQCB in Riverside, California. The SCRCU implements the SWRCB's Cannabis Regulatory program for the Santa Ana, Los Angeles, and San Diego RWQCBs. The area regulated by the SCRCU and the subject of this study spans approximately 28,500 km² and seven counties in southern coastal California, from Rincon Point, Ventura County in the north to the United States-Mexico border in the south, as shown on Figure 1.

The South Coast region lies within the Transverse and Peninsular Ranges geomorphic provinces. Plate motions between the Pacific Plate and North American Plate shape the region's dramatic landscape, where elevations range from sea level to 3,500 m above sea level. Major mountain ranges bound the South Coast region on the north and east and drain water and sediment into the multiple inland and coastal basins. The South Coast region aligns with the Southern California Coastal (Hydrologic Unit Code [HUC] 1807) Subregion and encompasses the Ventura-San Gabriel Coastal (HUC 180701), Santa Ana (HUC 180702), and Laguna-San Diego Coastal (HUC 180703) Basins, 17 Subbasins (HUC8), 82 Watersheds (HUC10), 308 Subwatersheds (HUC12) (United States Department of Agriculture 2019), and 75 groundwater basins (DWR 2018). Broadly speaking, surface streams drain south-southwestward to the Pacific Ocean or to endorheic inland basins. Average annual precipitation within the South Coast region ranges from less than 10 inches in the inland valleys and near the border with Mexico to 40 inches in parts of the Transverse Ranges (United States Environmental Protection Agency 2019). The majority of surface waters are intermittent or ephemeral streams and are dry for most of the year.

METHODS

This data set is a compilation of records with the SWRCB and SCRCU from December 2017 to 1 January 2020. The SCRCU conducted inspections of cannabis cultivators throughout the South Coast region. This data set includes observations made by SCRCU staff from 24 compliance inspections in 2019 at cannabis cultivators actively enrolled within the SWRCB's Cannabis Policy and 143 inspections of illicit cannabis cultivation sites dating from 29 March 2018 through 1 January 2020. Requirements of the Cannabis Policy and Cannabis General Order are enforceable under the Porter-Cologne Water Quality Control Act (Water Code §13000) and site inspection authority of enrolled cannabis cultivators is provided in the Cannabis Policy. Site inspections of illicit cultivations were conducted

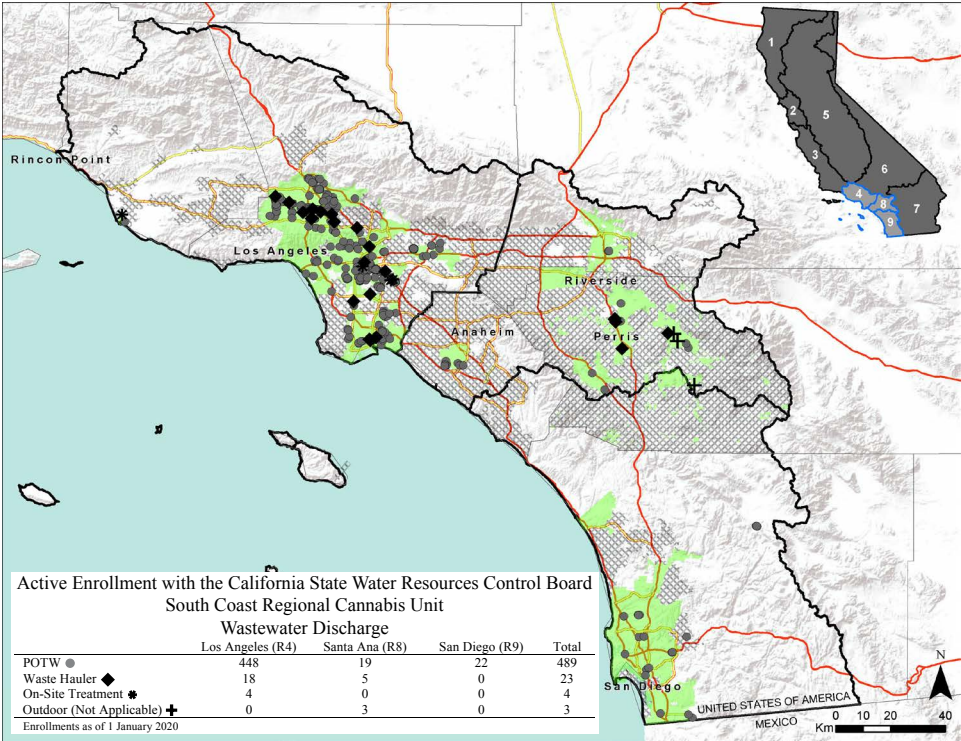


Figure 1. As of 1 January 2020, 519 cultivators are enrolled with the SCRCU into the SWRCB’s Cannabis Policy. The distribution of cultivators is shown throughout the region as a function of their mechanism of wastewater discharge; discharge to the sewer (circles), transport off site via waste hauler (diamonds), and onsite treatment (asterisks) are permitted mechanisms for indoor cultivators to dispose of wastewater. Outdoor cultivators (crosses) are issued waste discharge requirements (WDRs) or a conditional waiver of requirements depending on their potential risk to the environment. The distribution of cultivators throughout the South Coast region is geographically limited by the few local municipalities that allow cultivation (green shaded areas). Throughout most of the South Coast region, commercial cannabis cultivation is prohibited (hatched areas). The areas without shading are either federal lands or do not have ordinances governing cannabis cultivation as of 1 January 2020. The SWRCB’s nine regional waterboards are shown in the inset, 1 – North Coast, 2 – San Francisco Bay, 3 – Central Coast, 4 – Los Angeles, 5 – Central Valley, 6 – Lahontan, 7 – Colorado River, 8 – Santa Ana, and 9 – San Diego.

in coordination with local law enforcement agencies under search warrants and typically included representatives from the CDFW and county code enforcement divisions.

Hereafter, a site refers to a property where a single inspection was performed by SCRCU staff. A site, as defined, may contain more than one address, assessor parcel number, and/or landowner. The observations discussed are only representative of what was noted on the day of each inspection. Sites are dynamic and ever changing. It should be noted that the data set represents only sites where the SCRCU were invited to participate in inspections by enrolled dischargers for permitted facilities or by local law enforcement for illicit cultivation facilities.

RESULTS

Enrollees in the South Coast Cannabis Cultivation Policy Region

As of 1 January 2020, the SCRCU has 519 active enrollees in the SWRCB's Cannabis Policy. Of the permits issued, 516 (99%) are indoor cannabis cultivations. The remaining three enrollees are either Tier 1 – Low risk outdoor cultivations (disturbed area between 2,000 and 43,560 ft²; ~185 and ~4,046 m²) or Tier 2 – Low risk outdoor cultivations (disturbed area greater than 43,560 ft²; ~4,046 m²), as defined by the Cannabis Policy (State Water Resources Control Board 2019a).

The fate of an indoor cannabis cultivation's industrial wastewater, including irrigation tailwater and brines resulting from water treatment or recycling, and the mechanism of that discharge, are important drivers for regulation by the SWRCB. Ultimately, all industrial wastewater from indoor cannabis cultivation activities is intended to end up in a permitted wastewater treatment facility, either by direct discharge to a publicly owned treatment works (POTW) via sewer or by hauling the wastewater off site. Prior to discharging or hauling industrial wastewater, indoor cultivation facilities may also use onsite water treatment systems. However, onsite treatment requires separate regulatory approval and may trigger additional monitoring and reporting requirements. Of active enrollees in the South Coast region with indoor cultivation, 489 (94%) discharge directly to a POTW, 23 (4%) haul wastewater off-site, and 4 (<1%) use some form of onsite treatment and/or water recycling to eliminate or minimize industrial wastewater. Discharge of industrial wastewater, including cannabis wastewater streams from indoor cultivation activities, to a septic system is considered a risk to groundwater quality and is prohibited without separate regulatory approval. Indoor facilities without a sewer connection have industrial wastewater and nonliquid cultivation related waste hauled off site to permitted waste facilities. The distribution of cultivators as a function of their mechanisms of wastewater discharge is shown on Figure 1.

In 2019, the SCRCU inspected 24 enrolled, actively cultivating indoor facilities, where SCRCU staff observed a wide range of cultivation practices and irrigation methods. Inspected indoor facilities ranged in size from a few hundred square feet (tens of square meters) with less than 100 plants to converted warehouses greater than 35,000 ft² (~3,251 m²) with more than 6,500 plants. Twenty-one of the inspected facilities were using some type of hydroponic growing system. The hydroponic growing mediums observed were rockwool, coco fiber/chips, and perlite. All the facilities inspected used a municipal water source for their irrigation water. Observed irrigation methods included drip irrigation system, ebb-flow systems, flood tables, and hand watering. Water use was often not logged by cultivators and is highly variable dependent on the facility size and irrigation method. High efficiency irrigation methods such as drip irrigation systems, flood tables, and ebb-flow systems (Denver Public Health and Environment 2018) were observed at 14 of the inspected facilities. One of the larger facilities inspected, cultivating approximately 6,500 plants, provided the SCRCU with a water bill showing 372 hundred cubic feet or 278,256 gallons (~1 x 10⁶ L) of water usage for one month of operation, though it should be noted that the water bill includes non-cultivation related water use and the cultivator's estimated water usage for cultivation was approximately 2,000 gallons (~7,570 L) per day. The source of the discrepancy between these two numbers is unknown. Of the inspected facilities, cultivators using ebb-flow systems or flood tables recycled their irrigation water. Facilities using automated

drip-irrigation systems have little to no irrigation run-off, limiting their industrial wastewater stream to reverse osmosis brine and HVAC condensate. Indoor cultivation facilities often pretreat municipal source water before augmenting the treated water with nutrients for plant irrigation. Twenty of the 24 facilities treated the municipal source irrigation water prior to nitrification. Irrigation water pretreatment methods included reverse osmosis systems, ultraviolet light treatment, sediment filtration, and carbon filtration.

All inspected facilities were using carbon dioxide augmentation in the grow areas for various reasons including increased growth rates and biomass production (Poudel and Dunn 2017). Carbon dioxide concentrations of the air in the grow areas were observed between 200 and 1,900 parts per million depending on the growing stage, which is near the range typically encountered indoors (350-2,500 parts per million; Seppänen et al. 1999) and well below the Occupational Safety and Health Administration Permissible Exposure Limits of 5,000 parts per million.

Illicit Sites in the South Coast Region

Cultivation of cannabis beyond six plants and without applicable local and state permits or license is illegal in California (HSC §11358) and subject to additional violations, including violations of the California Food and Agriculture Code and California Water Code. The distribution of illicit cannabis cultivation sites inspected by the SCRCU as of 1 January 2020 is shown on Figure 2. The inspected illicit sites ranged in size from small “backyard” style grows to professional, industrial-scale operations. Some smaller sites were observed cultivating fewer than 100 plants in less than 185 m² mixed sunlight and artificial light greenhouses or in full sun outdoor areas. The largest site had greater than 31,000 plants, greater than 200 greenhouses, and disturbed an area of nearly 32,500 m².

Table 1 presents the site characteristics, water source, cultivation style, and irrigation method of 143 illicit cannabis cultivation sites where SCRCU staff performed inspections.

During site inspections the SCRCU documented observations of environmental impacts and potential environmental impacts, including the presence of onsite waterways as indicated in the National Hydrography Dataset (United States Geological Survey 2019), the presence of chemicals, site grading for cannabis cultivation, and substantial litter, and the threat of sediment mobilization. Table 2 presents the frequency of select observed and potential environmental impacts relevant to the 12 treatment and control categories outlined in the Cannabis Policy (State Water Resources Control Board 2019a).

The fate of irrigation tailwater and other cultivation related wastewaters was documented at each of the 143 sites inspected. Wastewater was observed discharged to the ground at 124 sites, to a waterway at 26 sites, to a lake or pond at three sites, and to a sewer at 10 sites. Some sites had multiple points of discharge.

DISCUSSION

Enrolled Cultivation Facilities in the South Coast Region

Distribution and style.—The distribution and style of cultivation, whether indoor, full sun outdoor, or mixed sunlight and artificial light greenhouse, in the South Coast region reflects local government restrictions to cultivation rather than logistic or geographic

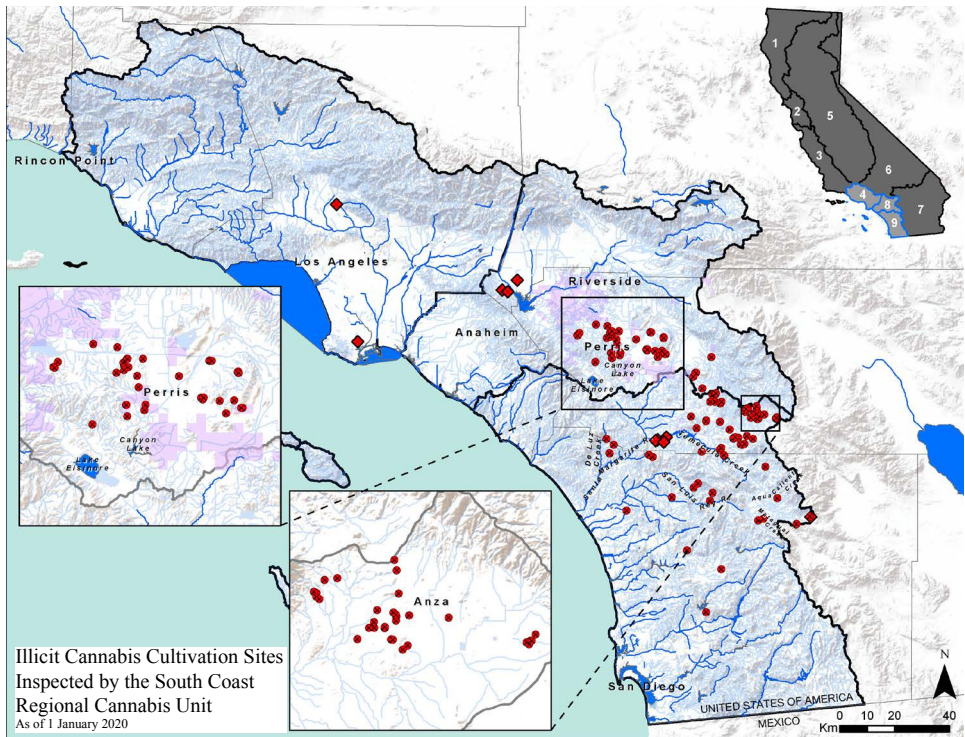


Figure 2. The SCRCU documented environmental impacts at 143 illicit cannabis sites inspected between 29 March 2018 and 1 January 2020. Sites that had outdoor cultivations, either full sun or mixed sunlight and artificial light greenhouses, are shown as red circles. Sites that were exclusively indoor cultivations are shown as red diamonds. Clean Water Act 303(d) (State Water Resources Control Board 2010) impaired waterbodies are indicated as bright blues on the map. National Hydrography Dataset (United States Geological Survey 2019) waterways are shown as light blues. The SCRCU identified 12 Clean Water Act 303(d) waterbodies, listed in Table 3, as having the potential to be threatened by illicit cannabis cultivation activities. In addition, the SCRCU identified 11 sites within Ground Water Protection Areas, shown in pink, as defined by the California Department of Pesticide Regulation (2020). These areas are vulnerable to leaching and runoff pesticide contamination from agricultural use. The SWRCB's nine regional waterboards are shown in the inset as defined in Figure 1.

constraints. Under MAUCRSA, cities and counties (for unincorporated areas) maintain the authority to establish ordinances that allow or prohibit commercial cannabis businesses within their jurisdictions. As of 1 January 2020, legal² commercial cannabis cultivation is limited to the following areas in the South Coast region:

- Santa Barbara County: Not applicable within South Coast region limits
- Ventura County: Port Hueneme
- Los Angeles County: Baldwin Park, Bell, Bellflower, Canoga Park, Carson, Commerce,

² The list of counties and municipalities with ordinances allowing for commercial cultivation and the accompanying map (Figure 1) show the distribution of permitted cannabis cultivation along the southern coast of California as of 1 January 2020. This information is for informational purposes only. The authors make no warranty as to the accuracy of cannabis cultivation legality in the communities listed and shown in Figure 1. Readers are encouraged to contact their local or county government to determine the legality of commercial cannabis cultivation in their community.

Table 1. Characteristics of illicit cannabis cultivation sites inspected by the SCRCU in southern coastal California as of 1 January 2020.

Inspected Site Characteristics						
Water Source	Groundwater Well	Municipal	Diversion	Unknown	Not Applicable	
	84	48	1	11	1 ¹	
	Cultivation Style	Full Sun	Mixed Light ²	Indoor		Not Applicable
	55	105	14		1 ¹	
	Irrigation Method	Drip	Hand			Not Applicable
	77	90			1 ¹	

¹No evidence of past or present cannabis cultivation was observed on the site.

² Mixed sunlight and artificial light greenhouses

Table 2. Select observed and potential environmental impacts relevant to the 12 treatment and control categories outlined in the Cannabis Policy (State Water Resources Control Board 2019a) observed at illicit cannabis cultivation sites inspected by the SCRCU in southern coastal California as of 1 January 2020.

	Select Environmental Impacts		
	Present	Not Present	Not Applicable
Onsite Waterway	42	101	0
Non-EPA Registered Chemical	20	121	2 ¹
Non-Approved Chemical for Cannabis	74	67	2 ¹
Sediment Discharge Risk	133	10	0
Cannabis Cultivation Related Site Grading	71	72	0
Green Waste Litter	83	60	0
Domestic Waste Litter	97	46	0

¹Either unknown due to a limited inspection of the site or no evidence of past or present cannabis cultivation was observed on the site.

Cudahy, Culver City, El Monte, Huntington Park, Long Beach, Los Angeles, Lynwood, Maywood, Montebello, Pasadena, Santa Monica, West Covina

- Orange County: Santa Ana
- San Bernardino County: Colton, San Bernardino
- Riverside County: Jurupa Valley, Lake Elsinore, Moreno Valley, Perris, San Jacinto, Unincorporated County³
- San Diego County: Chula Vista, La Mesa, Lemon Grove, Oceanside, San Diego

Currently, most cities in the South Coast region have ordinances banning commercial cannabis cultivation, but many cities are in various stages of drafting city ordinances that will allow commercial cannabis cultivation or are awaiting outcomes of November 2020

³ Commercial cannabis cultivation in unincorporated Riverside County is limited to specific zoned areas (County of Riverside 2018).

ballot measures to proceed with ordinance drafting. Other cities, such as Jurupa Valley and the City of Commerce have passed ordinances allowing commercial cannabis cultivation and have accepted commercial cannabis cultivation business applications but are in the process of reviewing and approving the businesses.

Of the counties within the South Coast region, only Riverside County has passed an ordinance permitting commercial cannabis cultivation. Riverside County Ordinance No. 348, effective 23 December 2018, allows for commercial cannabis cultivation within specified zones in unincorporated areas of the county (County of Riverside 2018). During the first year of implementation, up to 50 commercial cannabis cultivation businesses will be permitted for indoor artificial light or greenhouse mixed sunlight and artificial light cultivation (County of Riverside 2018). As of 1 January 2020, the county has approved 30 commercial cannabis cultivation facilities to proceed with the licensing process and permits are pending.

Enrollments in the South Coast region are concentrated in the city of Los Angeles, due in part to the preexisting medical cannabis industry permitted in the city since the passage of the Compassionate Use Act in 1996 (Proposition 215). With the passage of Proposition 64 and the adoption of MAUCRSA, the city established a three phase roll out to license commercial cannabis businesses. As of 1 January 2020, the city has rolled out phases 1 and 2, issuing licenses to existing (pre-MAUCRSA) cannabis businesses. Phase 3 of the city's licensing program will open the licensing window for new commercial cannabis businesses, and it is anticipated that the number of enrolled commercial cannabis cultivation facilities in the city will significantly increase after the closing of Phase 3.

The cultivation style of enrollees in the South Coast region reflects the urban nature of the areas where cultivation is permitted in southern California, with 99% of enrollees issued an indoor waiver of WDRs. This is also true of other predominately urban SWRCB regions. Within the San Francisco Bay RWQCB, 151 out of 177 (85%) enrollees were issued indoor waivers as of 1 January 2020. For comparison, statewide, 1,260 out of 4,391 (29%) active enrollments into the SWRCB's Cannabis General Order as of 1 January 2020 are indoor cultivations. Removing the SCRCU, the percentage of indoor cultivations drops to 745 out of 3,873 (19%) statewide. For the purpose of this comparison, we define northern California as the North Coast RWQCB, the San Francisco Bay RWQCB, and the northern geographic regions covered by the Central Valley RWQCB and the Lahontan RWQCB (enrollees with the Central Valley RWQCB's Redding and Rancho Cordova offices and Lahontan RWQCB's South Lake Tahoe office). In northern California, 396 out of 3,251 (12%) of active enrollments are indoor cultivations, and within the Emerald Triangle, less than 3% of nearly 2,500 enrolled cultivations with the North Coast RWQCB are indoor cultivations.

Water use.—Most of the South Coast region receives minimal rainfall and Los Angeles in particular imports approximately 86% of their water from either the Eastern Sierra Nevada via the Los Angeles Aqueduct, the Sacramento Bay Delta via the California Aqueduct, or the Colorado River via the Colorado River Aqueduct (Los Angeles Department of Water and Power 2019). Recent multi-year droughts have led water providers to enact mandatory conservation measures. Water consumption concerns are not unique to the cannabis industry and industry specific water use restrictions are not established (Denver Public Health and Environment 2018). However, efforts to reduce water consumption were observed in many of the inspected permitted facilities. This proactive approach to efficient water use is mutually beneficial to the cultivator, in terms of lower operational costs, and to the environment.

Discharge.—Indoor cannabis cultivations that discharge wastewater to a com-

munity sewer system pose a low threat to water quality, provided that the discharges are compliant with the sewer agency's requirements. Although cannabis cultivation effluent may contain nutrients such as phosphate or nitrate, salinity constituents such as sodium, chloride, potassium, calcium, sulfate, and magnesium, or other constituents such as iron, manganese, molybdenum, boron, and silver (State Water Resources Control Board 2019a), as of 1 January 2020, local POTWs in the South Coast region do not have pollutant limits, pre-treatment requirements, or discharge permits specifically for commercial cannabis operations. In November of 2019, the SCRCU began a cultivation effluent sampling project to characterize wastewater concentrations originating from indoor cannabis cultivations. Preliminary analytical results from two facilities in the city of Los Angeles show pollutant concentrations well below established local limits for industrial wastewater. Full results of the effluent sampling project will be reported at a future date.

Illicit Sites in the South Coast Region

Legalization does not eliminate the need for enforcement of illicit activities, particularly illicit outdoor cannabis cultivations which pose the highest risk to the environment and water quality. Polson and Petersen-Rockney (2019) state that "California's cannabis legalization has enabled a kind of multi-agency neoprohibitionism at the county level, one that reinforces older criminal responses with new civil-administrative strategies and authorities". While this statement accurately identifies the control that local jurisdictions have on the emerging cannabis market, which is particularly limiting for cultivation, it does not consider the economic complexities of a regulated market structure and the pervasive implications of illicit activities, including their environmental impact. An important component to ensure the success of the regulated market structure is prevention of black-market undercutting, not unlike other regulated industries, and the SCRCU has been encouraged to pursue enforcement action against illicit cultivators by licensed cultivators operating within the legal market. However, among the multiple agencies that regulate and/or take part in cannabis related enforcement activities, the primary mission is specifically non-economics based, but rather is meant to directly address environmental impacts. Whereas enrolled/permitted cultivation sites must adhere to requirements that protect water quality to maintain their permitted status, unregulated/unpermitted cannabis cultivation sites are not properly engineered and rarely implement best management practices that would prevent environmental degradation and minimize potential water quality impacts. The SWRCB's strategy for enforcement is to, "ensure that the diversion of water and discharge of waste associated with cannabis cultivation does not have a negative impact on water quality, aquatic habitat, riparian habitat, wetlands, or springs", which includes action for noncompliance with the Cannabis General Order at enrolled sites and enforcement of the California Water Code on illicit cultivation activities (State Water Resources Control Board 2019a). In addition, enforcement action is given to Priority Watersheds which are designated for their "high value water quality, water supply, and habitat factors or current impairments to these factors" (State Water Resources Control Board 2019c). "Priority Watershed are at increased risk of environmental impacts due to the potential of cannabis cultivation activities to severely harm important watershed features and further aggravate existing impairments" and include Clean Water Act 303(d) listed waterbodies (State Water Resources Control Board 2010) and RWQCB priority designations (State Water Resources Control Board 2019c).

Clean Water Act impaired waterbodies.—During the 143 inspections conducted by the SCRCU within the South Coast region, 12 Clean Water Act 303(d) impaired waterbodies were identified as potentially threatened by illicit cannabis cultivation activities. Table 3 identifies these waterbodies and their impairments. Discharges from cannabis cultivation activities have the potential to aggravate existing impairments, particularly impairments from nutrients, nitrogen, phosphorus, and sulfates, total dissolved solids, pH, and toxicity based impairments resulting from harmful algae blooms (State Water Resources Control Board 2019a) which imply a nutrient imbalance.

San Diego RWQCB priority designations.—The semiautonomous RWQCBs designate priority water systems based on the local conditions within their regions. The San Diego RWQCB identified key areas for priority beneficial uses within their Practical Vision strategic plan (San Diego Regional Water Quality Control Board 2013), as well as identified high quality waters through the Clean Water Act 305(b) Report (San Diego Regional Water Quality Control Board 2016). High Quality and High Priority (HQHP) stream systems were identified as areas of special importance for the Habitat and Ecosystem Key Beneficial Uses, most critical to protecting human and environmental health (San Diego Regional Water Quality Control Board 2016, 2017). These HQHP stream systems also include refer-

Table 3. Clean Water Act 303(d) waterbodies identified as having the potential for impact by illicit cannabis cultivation activities at sites inspected by the SCRCU as of 1 January 2020.

Clean Water Act 303(d) Waterbodies and Impairments						
Impaired Waterbody						Other(s)
	Nutrients	Total Nitrogen as N	Nitrogen	Phosphorus	Sulfates	TDS ¹
Canyon Lake	X					Pathogens
Cloverdale Creek				X		X
De Luz Creek			X		X	Iron, Manganese
Gopher Creek						Benthic Community Effects
Keys Creek						Selenium
Rainbow Creek			X	X	X	X
San Dieguito			X	X		X
Santa Gertudis Creek				X		Enterococcus, Fecal Coliform
						Chlorpyrifos, Copper, E. Coli, Fecal Coliform, Iron, Manganese
San Luis Rey River, Upper		X				
Santa Margarita River, Upper				X		
San Vicente Reservoir		X			X	Chloride, Color, pH (High)
Temecula Creek				X		X
						Chlorpyrifos, Copper

¹Total Dissolved Solids (TDS)

ence stream segments identified as being minimally disturbed by human activity (Ode et al. 2016). A total of 10 illicit cannabis cultivation sites were identified and inspected within the following HQHP stream systems, four sites within the De Luz Creek system, one site in Arroyo Seco Creek system, two sites within the Pauma Creek-San Luis Rey River system, one within the Agua Caliente Creek system, and two within the Matagual Creek-San Luis Rey River system.

Santa Ana RWQCB priority designations.—The Santa Ana RWQCB Basin Plan (Santa Ana Regional Water Quality Control Board 2019) incorporates a salt and nutrient management plan that identifies nitrate and salinity concentrations in groundwater and surface water as key metrics for compliance with the state's Antidegradation Policy (Mulligan 1968) in the Santa Ana River and San Jacinto River watersheds. The Basin Plan reports that the most serious threat to water quality in both the Santa Ana River and San Jacinto River watershed basins is the build-up of nutrients and dissolved minerals, or salts, in the groundwater and surface waters (Santa Ana Regional Water Quality Control Board 2019). Likewise, the Basin Plan calls for controls on salt loadings from all water uses including residential, commercial, industrial, and agricultural (Santa Ana Regional Water Quality Control Board 2019). The application of fertilizers and the irrigation of agricultural crops is identified as one of the principal causes of the salt problem in the Santa Ana Region. Implementation of a salt and nutrient management plan requires that discharges of waste be regulated to meet objectives for the concentrations of salinity, expressed as total dissolved solids, and nitrate, expressed as nitrogen, in groundwater Management Zones of the Santa Ana Region shown in Figure 3 (Santa Ana Regional Water Quality Control Board 2019). The Cannabis General Order (State Water Resources Control Board 2019b) requires Tier 2 cultivations with aggregate cultivation areas greater than one acre (~4,046 m²) to provide a Nitrogen Management Plan to minimize discharge and protect water quality. Six illicit cannabis cultivation sites, discharging their irrigation tailwater to the ground, were identified and inspected within a groundwater Management Zone in the San Jacinto River watershed. Without a Nitrogen Management Plan to manage and minimize discharges of total dissolved solids and nitrates, these illicit cannabis sites are likely to contribute to the degradation of the San Jacinto River watershed.

Pesticide use.—Pesticide use on permitted legal cannabis cultivation sites is regulated by the California Department of Pesticide Regulation (DPR 2017), and the Bureau of Cannabis Control established action levels for residual pesticides on cannabis products heading to the market (16 California Code of Regulations (CCR) §5719). Greater than 50% of the inspected illicit cultivation sites had pesticides not approved for use on cannabis. The observed pesticides included Federal Insecticide, Fungicide, and Rodenticide Act Restricted Use Pesticides (7 USC §136 et seq.), California Restricted Materials (3 CCR §6400), pesticides on the California Groundwater Protection List (3 CCR §6800), and pesticides not registered for food use. Pesticides not registered for use by the United States Environmental Protection Agency (US EPA) were observed on 20 (14%) inspected sites. These are pesticides that are not legally allowed for distribution and use in the United States. Active ingredients in those pesticides included carbofuran, methamidophos, zinc phosphide, chlorothalonil, metalaxyl-m, and chlorantraniliprole. On sites with carbofuran, dead wildlife was sometimes observed, typically dead rodents or birds with dead insects nearby that had been exposed to the pesticide. Due to a lack of resources to remove these hazardous materials many of the pesticides are left on site and remain a potential risk to human health and the environment while civil and/or criminal enforcement is pending.

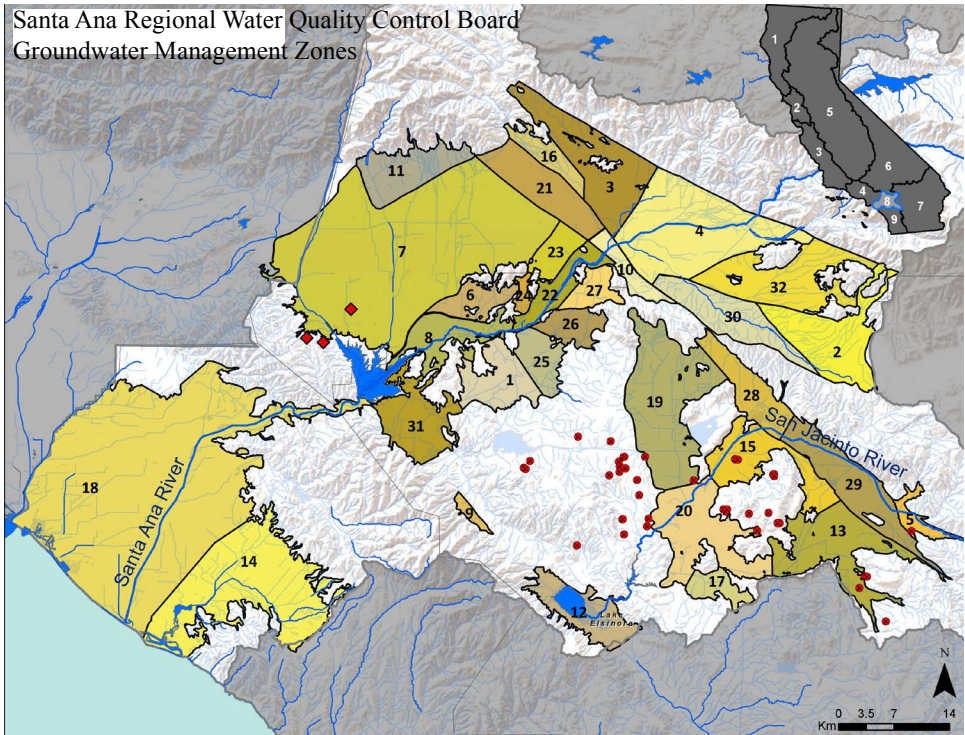


Figure 3. The Santa Ana RWQCB Basin Plan (Santa Ana Regional Water Quality Control Board 2019) identifies 32 groundwater Management Zones in the Santa Ana River and San Jacinto River watersheds where salt and nutrient water quality objectives protect beneficial uses. The SCRCU documented environmental impacts at 47 illicit outdoor cannabis cultivation sites within the Santa Ana Region between 29 March 2018 and 1 January 2020. Sites that had outdoor cultivations, either full sun or mixed sunlight and artificial light greenhouses, are shown as red circles. Sites that were exclusively indoor cultivations are shown as red diamonds. Of those 47 sites, six illicit cannabis cultivation sites were overlying groundwater Management Zones in the San Jacinto River watershed and had discharged irrigation wastewater to the ground. The SWRCB's nine regional waterboards are shown in the inset as defined in Figure 1. The 32 groundwater Management Zones are defined as follows: Arlington – 1, Beaumont – 2, Bunker Hill-A – 3, Bunker Hill-B – 4, Canyon – 5, Chino-East – 6, Chino-North – 7, Chino-South – 8, Coldwater – 9, Colton – 10, Cucamonga – 11, Elsinore – 12, Hemet-South – 13, Irvine – 14, Lakeview/Hemet-North – 15, Lytle – 16, Menifee – 17, Orange County – 18, Perris-North – 19, Perris-South – 20, Rialto – 21, Riverside-A – 22, Riverside-B – 23, Riverside-C – 24, Riverside-D – 25, Riverside-E – 26, Riverside-F – 27, San Jacinto-Lower Pressure – 28, San Jacinto-Upper Pressure – 29, San Timoteo – 30, Temescal – 31, Yucaipa – 32.

The DPR began addressing pesticide contamination in groundwater and drinking water supplies from agricultural use with the passage of the Pesticide Contamination Prevention Act. The DPR established a Groundwater Protection Program (2020) that evaluates use restrictions on pesticides that have been detected in groundwater and have the potential to contaminate groundwater, such as pesticides on the Groundwater Protection List (3 CCR §6800). The DPR also defined Ground Water Protection Areas (GWPA)s which are areas vulnerable to pesticide contamination from agricultural use. The DPR identified leaching and runoff as pathways or mechanisms for pesticides to enter the groundwater system (2020). Illicit cultivation sites without engineering controls and best management practices to prevent discharge to the ground and runoff of pesticides and wastewater containing pesticides,

pose a risk to GWPAs. Of the 74 illicit sites identified as having non-approved chemicals for cannabis cultivation on site, 11 sites were within GWPAs and 44 sites were within 5 kms of a GWPAs (Figure 2).

Sediment mobilization.—Sediment, both clean native soils and impacted soils, can be a significant source of water pollution and degradation of water quality (Santa Ana Regional Water Quality Control Board 2018). The Cannabis General Order (State Water Resources Control Board 2019b) requires Tier 1 and Tier 2 Moderate risk cultivators to provide a Site Erosion and Sediment Control Plan to minimize the discharge of sediment; higher risk sites are also required to provide a Disturbed Area Stabilization Plan prior to approval to begin cultivation. Uncontrolled mobilization of sediment has the potential to alter the landscape, change water flow patterns, and lead to habitat loss and/or fragmentation. Unpermitted site development and grading may not consider or account for the cumulative effects of sediment mobilization. Site grading, for the purpose of illicit cannabis cultivation, was observed at nearly half of the sites inspected. In multiple cases, grading had occurred within waterways and riparian environments. Evidence of sediment mobilization or the potential for sediment mobilization was observed at all mixed sunlight and artificial light greenhouse and full sun outdoor sites inspected, 133 out of 143 sites. Erosion channels and rills and fluid mobilized growing medium and potting soil was ubiquitous. Stockpiles of soil were typically stored on the bare ground without engineering controls and containment to prevent mobilization. Without engineering controls and the application of best management practices, full sun outdoor and mixed sunlight and artificial light greenhouse cultivation sites are potentially significant sources of sediment and threats to water quality. One of the larger and more environmentally egregious inspected sites was located in a HQHP stream system in San Diego County. The site was set on slopes greater than 40 degrees that had been cut and graded for greenhouses, vegetation from the slope side was removed, and no engineering controls or best management practices were present to prevent sediment mobilization or cultivation runoff. The disturbed area was estimated to be approximately 32,500 m². An intermittent stream, tributary to an impaired waterway for nitrogen (State Water Resources Control Board 2010), was located approximately 60 m downslope. Rills and erosion channels were observed throughout the site and discharge of sediment and cultivation runoff was observed downslope toward the stream.

Litter.—Perhaps the most visible impact to the environment from illicit sites is litter. Extensive litter was observed on illicit cultivation sites and included cultivation related litter such as plastic irrigation lines, chemical containers with residue, and plastic sheeting or mesh, and domestic litter such as food containers, fuel and petroleum products, paper, cans and bottles, and miscellaneous household products. Litter was observed intentionally disposed of in ditches, waterways, and excavated pits. Living conditions often resulted in discharges of raw untreated sewage onto the ground, into pits, or directed intentionally into waterways. Pit toilets and intentional discharge of sewage from recreation vehicles via pipes or hoses were also observed. The deleterious effects of litter in waterways impacts beneficial uses and poses a threat to aquatic life, wildlife, and public health (State Water Resources Control Board 2015). The impacts of litter on the marine and terrestrial environment are well documented, and beyond the deterioration of aesthetics, the extensive litter observed threatens ingestion and entanglement by fish and wildlife, habitat alteration and degradation that affects migration, spawning, reproduction, and development of organisms, and poses a threat to human health (State Water Resources Control Board 2015).

Surface water diversion.—Lack of precipitation and reliable surface water make diversion of water rare in the South Coast region. Most of the water ways in the South Coast region are intermittent or ephemeral and dry most of the year. As a result, water diversion was observed on only one site, located on the southern flank of Palomar mountain at an elevation of approximately 1,050 m above sea level.

Conclusions

During the first two years of legal recreational cannabis cultivation in California, the SWRCB's Cannabis Cultivation Program enrolled 4,391 cultivators into the Cannabis General Order. The SCRCU, covering approximately 28,500 km² in southern coastal California, account for 519 of those cultivators, 516 of which are indoor cultivations. The risk to water quality associated with discharges of waste from indoor cultivations is minimal within the guidelines of the Cannabis Policy (State Water Resources Control Board 2019a), especially when considering that those cultivators are discharging their industrial process wastewater to a permitted, and further regulated, POTW or wastewater treatment facility. As a result, all but three outdoor cultivators enrolled with the SWRCB in the SCRCU were issued waivers of WDRs as of 1 January 2020.

Enforcement of illicit cultivation for the purpose of the protection of water quality and habitat also plays an important role in the SCRCU's Cannabis Cultivation Program. The SCRCU inspected 143 illicit cultivation sites as of 1 January 2020. Illicit cultivation sites have the potential to pose a significant risk to the environment. Observations from inspections of illicit sites identified threats to Clean Water Act 303(d) waterbodies and RWQCB priority water systems, and observed illegal and/or unauthorized pesticide use, evidence of and potential for sediment mobilization, and ubiquitous and substantial litter. These illicit cultivation sites pose a threat to water quality, aquatic and riparian habitats, and fish and wildlife, though the effects have not yet been quantified.

Limitations

The authors make no warranty as to the accuracy of cannabis cultivation legality in the communities discussed. Readers are encouraged to contact their local or county government to determine the legality of commercial cannabis cultivation in their community.

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AUTHOR CONTRIBUTIONS

Conceived and designed the study: BMC, CSP, ETL, PY, MAZ

Collected the data: BMC, CSP, ETL, PY, MAZ

Performed the analysis of the data: BMC, CSP, ETL, PY, MAZ

Authored the manuscript: BMC, CSP, ETL

Provided critical revision of the manuscript: BMC, CSP, ETL, PY, MAZ

LITERATURE CITED

- Bowman, J. N. 1943. Notes on hemp culture in provincial California. University of California, Berkeley, USA.
- Butsic, V., and J. C. Brenner. 2016. Cannabis (*Cannabis sativa* or *C. indica*) agriculture and the environment: a systematic, spatially-explicit survey and potential impacts. *Environmental Research Letters* 11:044023.
- Butsic, V., J. K. Carah, M. Baumann, C. Stephens, and J. C. Brenner. 2018. The emergence of cannabis agriculture frontiers as environmental threats. *Environmental Research Letters* 13:124017.
- California Department of Pesticide Regulation (DPR). 2017. Legal Pest Management Practices for Cannabis Growers in California. Available from: <https://www.cdpr.ca.gov/docs/county/cacfltrs/penfltrs/penf2015/2015atch/attach1502.pdf>
- California Department of Pesticide Regulation (DRP). 2020. Groundwater Protection Program. Available from: <https://www.cdpr.ca.gov/docs/emon/grndwtr/>
- California Department of Water Resources (DWR). 2018. Bulletin 118. Sacramento, CA, USA.
- Carah, J. K., J. K. Howard, S. E. Thompson, A. G. Short Gianotti, S. D. Bauer, S. M. Carlson, D. N. Dralle, M. W. Gabriel, L. L. Hulette, and B. J. Johnson. 2015. High time for conservation: adding the environment to the debate on marijuana liberalization. *BioScience* 65:822–829.
- Central Valley Regional Water Quality Control Board. 2015. Waste Discharge Requirements General Order for Discharges of Waste Associated with Medicinal Cannabis Cultivation Activities. Available from: https://www.waterboards.ca.gov/centralvalley/water_issues/cannabis/general_order/r5-2015-0113.pdf
- Clarke, R. C., and M. D. Merlin. 2013. Cannabis: evolution and ethnobotany. University of California Press, Berkeley, CA, USA.
- County of Riverside. 2018. Ordinance No. 348 Providing for Land Use Planning and Zoning Regulations and Related Functions of the County of Riverside.
- Denver Public Health and Environment. 2018. Cannabis Environmental Best Management Practices Guide. Available from: https://www.denvergov.org/content/dam/denvergov/Portals/771/documents/EQ/MJ%20Sustainability/Cannabis_BestManagementPracticesGuide_FINAL.pdf
- Levy, S. 2014. Pot poisons public lands. *BioScience* 64:265–271.

- Levy, S. 2020. Weed and water woes in the legendary Emerald Triangle. Environmental Health News. Available from: <https://www.ehn.org/cannabis-grows-water-california-2641589643.html>
- Los Angeles Department of Water and Power. 2019. Briefing Book 2018-2019. Available from: <https://www.ladwpnews.com/2018-briefing-book/>
- Mulligan, K. W. 1968. Statement of Policy with Respect to Maintaining High Quality of Water in California. State Water Resources Control Board. Available from: https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/1968/rs68_016.pdf
- North Coast Regional Water Quality Control Board. 2015. Waste Discharge Requirements and General Water Quality Certification for Discharges of Waste Resulting from Cannabis Cultivation and Associated Activities or Operations with Similar Environmental Effects in the North Coast Region. Available from: https://www.waterboards.ca.gov/northcoast/board_decisions/adopted_orders/pdf/2015/15_0023_Cannabis_Order.pdf
- Occupational Safety and Health Administration. 2016. Air contaminants, Toxic and Hazardous Substances, Occupational Safety and Health Standards. 1910.1000. U.S. Department of Labor, Code of Federal Regulations.
- Ode, P. R., A. C. Rehn, R. D. Mazor, K. C. Schiff, E. D. Stein, J. T. May, L. R. Brown, D. B. Herbst, D. Gillett, and K. Lunde. 2016. Evaluating the adequacy of a reference-site pool for ecological assessments in environmentally complex regions. *Freshwater Science* 35:237–248.
- Polson, M., and M. Petersen-Rockney. 2019. Cannabis farmers or criminals? Enforcement-first approaches fuel disparity and hinder regulation. *California Agriculture* 73.
- Poudel, M., and B. Dunn. 2017. Greenhouse carbon dioxide supplementation. Oklahoma State University, Stillwater, USA.
- San Diego Regional Water Quality Control Board. 2013. San Diego Water Board Practical Vision. Available from: https://www.waterboards.ca.gov/sandiego/water_issues/programs/practical_vision/docs/PV-WQCC_Version.pdf
- San Diego Regional Water Quality Control Board. 2016. Clean Water Act Sections 305(b) and 303(d) Integrated Report for the San Diego Region. Available from: https://www.waterboards.ca.gov/sandiego/water_issues/programs/303d_list/docs/Staff_Report_101216.pdf
- San Diego Regional Water Quality Control Board. 2017. Focusing on What is Most Important: Key Beneficial Uses and Key Areas; Habitats and Ecosystems: Marine, estuarine, freshwater, riparian. Available from: https://www.waterboards.ca.gov/sandiego/water_issues/programs/key_areas/docs/key_use_habitats_ecosystems_feb_2017.pdf
- Santa Ana Regional Water Quality Control Board. 2018. Erosion and Sediment Control. Available from: https://www.waterboards.ca.gov/santaana/water_issues/programs/nps/docs/erosion.pdf
- Santa Ana Regional Water Quality Control Board. 2019. Water Quality Control Plan for the Santa Ana River Basin. Available from: https://www.waterboards.ca.gov/santaana/water_issues/programs/basin_plan/
- Seppänen, O., W. Fisk, and M. Mendell. 1999. Association of ventilation rates and CO₂ concentrations with health and other responses in commercial and institutional buildings. *Indoor air* 9:226–252.

- State Water Resources Control Board. 2010. 2010 Integrated Report (Clean Water Act Section 303(d) List / 305(b) Report). Available from: https://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml
- State Water Resources Control Board. 2015. Amendment to the Water Quality Control Plan for the Ocean Waters of California to Control Trash and Part 1 Trash Provisions of the Water Quality Control Plan for Inland Surface Waters, Enclosed Bays, and Estuaries of California. Available from: https://www.waterboards.ca.gov/water_issues/programs/trash_control/documentation.html
- State Water Resources Control Board. 2017a. Cannabis Cultivation Policy - Principles and Guidelines for Cannabis Cultivation.
- State Water Resources Control Board. 2017b. General Waste Discharge Requirements and Waiver of Waste Discharge Requirements for Discharges of Waste Associated with Cannabis Cultivation Activities.
- State Water Resources Control Board. 2019a. Cannabis Cultivation Policy - Principles and Guidelines for Cannabis Cultivation.
- State Water Resources Control Board. 2019b. General Waste Discharge Requirements and Waiver of Waste Discharge Requirements for Discharges of Waste Associated with Cannabis Cultivation Activities.
- State Water Resources Control Board. 2019c. Water Boards' Cannabis Cultivation Program Procedures.
- United States Department of Agriculture - Natural Resources Conservation Service USGS, United States Environmental Protection Agency. 2019. Watershed Boundary Dataset for California. Available from: <http://datagateway.nrcs.usda.gov>
- United States Environmental Protection Agency. 2019. EnviroAtlas. Available from: <https://www.epa.gov/enviroatlas>
- United States Geological Survey. 2019. National Hydrography Dataset High-Resolution for Hydrologic Unit 1807.
- Wilson, H., H. Bodwitch, J. Carah, K. Daane, C. Getz, T. Grantham, and V. Butsic. 2019. First known survey of cannabis production practices in California. *California Agriculture* 73:119–127.