Economic Impact Analysis of Medical Cannabis Cultivation Program Regulations

Standardized Regulatory Impact Assessment (SRIA)

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1. Introduction

The California Department of Food and Agriculture (CDFA) is moving forward with the rulemaking process for nurseries, indoor, outdoor, and mixed-light medical cannabis cultivation in California. This technical report describes the data, methods, assumptions, and findings of the economic impact analysis of medical cannabis cultivator regulations developed by the Medical Cannabis Cultivation Program (MCCP) in compliance with the Medical Cannabis Regulation and Safety Act (MCRSA). The economic impact analysis follows best economic practice and has been prepared in compliance with the requirements of the Standardized Regulatory Impact Assessment (SRIA) for major regulations set forth in SB 617.

This analysis is based on the best available data on the cannabis market and information about MCCP regulations as of the publication date (1/27/2017). Many factors are still uncertain and every attempt has been made to highlight uncertainties and how they might affect the outcome of the analysis. The analysis is purposefully conservative in that regulations that could be attributed to other factors are included in the MCCP economic impact analysis if they are related to licensing requirements. For example, local permits are included as a MCCP regulatory cost because cultivators are required to have these permits to obtain an MCCP cultivation license. All regulatory costs are itemized so that the reader can understand the relative impacts and magnitude of each component.

The market for medical cannabis is different than other conventional agriculture industries, or more generally, the market for any other established product because cannabis has historically been produced and sold on an unregulated illegal market. This affects the economic impact analysis in two key ways. First, the medical cannabis industry is a new (legal) industry that is still evolving. Medical cannabis businesses—from cultivation through final retail—operate in a market where consumer demand is partially met through the informal black/grey market for non-medical cannabis. In addition, there are no official statewide production statistics, financial data, and limited information about important economic parameters that characterize the market for medical and non-medical cannabis. The second significant factor in the economic impact analysis is that Proposition 64, the adult Use of Marijuana Act (AUMA), passed by California voters on November 8, 2016, fundamentally changes the baseline for the medical cannabis industry by introducing an adult use cannabis market that is a direct substitute for the medical market for many consumers. Accordingly, some current medical cannabis consumers will substitute to the adult use market as it becomes legal, which will decrease for the size of the medical cannabis market and cause some medical cannabis businesses to shift to the adult use sector. That is, legalizing adult use cannabis has an effect on the medical cannabis industry that is separate from the impact of medical cannabis regulations. This significant change in the market structure must be analyzed as part of the baseline medical cannabis industry in order to isolate the effect of legalizing adult use cannabis and hold this separate from the impact of medical cannabis regulations.

1.1 Statement of need for the proposed regulation

These regulations are intended to address the obligation of the California Department of Food and Agriculture (CDFA) to regulate the cultivation of commercial medical cannabis pursuant to Assembly Bill 243 (Chapter 688), Assembly Bill 266 (Chapter 689) and Senate Bill 264 (Chapter 719) enacted by the California Legislature and signed by Governor Brown on October 9, 2015. The laws form the Medical Cannabis Regulation and Safety Act (MCRSA) and became effective January 1, 2016. MCRSA mandates that CDFA create the Medical Cannabis Cultivation Program within CDFA to promulgate commercial medical cultivation regulations and to develop and manage a cannabis track and trace system. The overall purpose of CDFA's Program is to establish a regulatory licensing program that would ensure that medical cannabis cultivation operations would be performed in a manner that protects the environment, cannabis cultivation workers, and the general public from the individual and cumulative effects of these operations, and fully complies with all applicable laws.

One of the largest impacts of unregulated cannabis cultivation has been serious adverse impacts to the environment. The State Water Resources Control Board, the North Coast Regional Water Quality Control Board, and the State Department of Fish and Wildlife (FGC 12029 Findings) have documented a dramatic increase in the number of marijuana cultivation sites, corresponding increases in impacts to water supply and water quality, including the discharge of sediments, pesticides, fertilizers, petroleum hydrocarbons, trash and human waste. These impacts result from the widespread unpermitted, unmitigated, and unregulated impacts of land grading, road development, vegetation removal, timber clearance, erosion of disturbed surfaces and stream banks, stream diversion for irrigation, and temporary human occupancy without proper sanitary or waste disposal facilities which threaten the survival of endangered fish species as well as public safety. In addition, the actions of some marijuana growers, either directly or through irresponsible practices, result in the killing of wildlife, including the endangered Pacific Fisher.

In the absence of a formal regulatory framework the negative impacts associated with cannabis cultivation are expected to increase, resulting in an unregulated, unstudied and potentially permanent negative impact on the environment and upon the peace, health and safety of Californians.

At the federal level cannabis remains on the list of Schedule I controlled substance under the Controlled Substances Act. Thus even with legalization and regulation in California, cannabis businesses still face some uncertainty and risk. The current federal attitude toward medical cannabis was formalized in August 2013 when the United States Department of Justice updated their stance on cannabis policy and decided not to challenge the legalization laws of Colorado and Washington. A subsequent memo drafted by Deputy Attorney General James Cole outlined the priorities for federal enforcement of cannabis prohibition under the Controlled Substances Act. Currently, the federal approach to cannabis under the Cole Memo encourages state laws and regulations that prevent sale to minors, minimize criminal enterprises and related drug

trafficking, prevent interstate transport of cannabis, prevent violence, ban cultivation on public lands, and prevent adverse public health and safety outcomes. MCCP cultivation regulations generally adhere to these basic principles.

1.2 Major Regulation Determination

The MCCP regulations would exceed the $50 million threshold for annual economic impact. For the purposes of this analysis the 12 month period in which the economic impact of the proposed regulation would exceed $50 million is defined as the calendar year January 2018 – December 2018. This period is used because it represents the 12 months following implementation of the proposed regulations (1/1/2018). The total 12-month output value economic impact of regulatory costs to cultivators alone would equal $70.2 million. There are additional costs and benefits to government agencies and ancillary businesses that are also quantified in this SRIA.

1.3 Public Outreach and Input

Concurrent with the SRIA, the MCCP team is preparing an Environmental Impact Report (EIR) in compliance with the California Environmental Quality Act (CEQA). As part of the combined effort, the MCCP has engaged in extensive outreach to the medical cannabis community in preparing the regulations. Scoping workshop information and notices for the EIR process were mailed to potentially interested parties, published in local newspapers, and posted on the MCCP website before the workshops, to invite attendees.

The scoping workshop dates, times, and locations were as follows:

- Sacramento, California: September 13, 2016, 4:00–7:00 p.m., Sacramento Convention Center (1400 J Street, Sacramento, CA 95814)
- San Luis Obispo, California: September 21, 2016, 4:00–7:00 p.m., Courtyard by Marriott (1605 Calle Joaquin, San Luis Obispo, CA 93405)
- Redding, California: September 14, 2016, 4:00–7:00 p.m., Red Lion Hotel (1830 Hilltop Drive, Redding, CA 96002)
- Coalinga, California: September 22, 2016, 4:00–7:00 p.m., Harris Ranch (24505 West Dorris Ave, Coalinga, CA 93210)
- Eureka, California: September 15, 2016, 4:00–7:00 p.m., Red Lion Hotel (Pacific Room, 1929 4th Street, Eureka, CA 95501)
- Pasadena, California: September 27, 2016, 4:00–7:00 p.m., Pasadena Convention Center (300 East Green Street, Pasadena, CA 91101)
- Oakland, California: September 20, 2016, 4:00–7:00 p.m., Oakland Marriott (1001 Broadway, Oakland, CA 94607)
- Desert Hot Springs, California: September 28 2016, 4:00–7:00 p.m. Miracle Springs Resort and Spa (10625 Palm Drive, Desert Hot Springs, CA 92240

All the scoping workshops used the same open format, and interested parties were invited to attend one or all of the workshops. At each workshop, a certified court reporter was available to

take oral comments. In addition to oral comments, MCCP accepted written comments during the workshops, as well as during the scoping period that concluded on September 30, 2016. Comment forms were distributed at the scoping workshops for submission of written comments during or after the workshop.

In addition to the scoping workshops to solicit feedback on draft regulations, the economic analysis for the SRIA included extensive public outreach and input from medical cannabis cultivators. This outreach took place between October 1, 2016 and January 26, 2017. During this time over 60 cultivators were surveyed on the phone or in person. In addition, officials at all 58 local county offices were contacted, as well as state and federal code enforcement. Interviews with various cannabis alliances, dispensaries, and cannabis investor groups were also conducted. The data from this outreach is summarized in the following sections of the SRIA.

1.4 Background

California was the first state to allow medicinal cannabis use with the passage of the Compassionate Use Act (Proposition 215) in 1996. Senate Bill 420 in 2003 established guidelines for issuing a cannabis patient identification cards and regulations for the amount of cannabis cardholders can grow and possess. With other states following suit to decriminalize cannabis possession, legalize medical use, and legalize adult use, the economic activity generated by the industry has grown significantly.

The California Medical Marijuana Regulation and Safety Act[1] (AB 266, AB 243, and SB 643) establishes the Bureau of Medical Marijuana Regulation[2] and gives authority to the Department of Consumer Affairs, the Department of Food and Agriculture (CDFA), the State Department of Public Health, and other agencies, to regulate the medical cannabis industry from cultivation to distribution and final retail sales. AB 243 requires the CDFA, along with the Department of Pesticide Regulation, State Department of Public Health, Department of Fish and Wildlife, and the State Water Resources Control Board to establish regulations for medical cannabis cultivation. SB 837 and AB 2516 make additional changes to the laws, most importantly adding a Type 1C "specialty cottage" cultivator license type and renaming the various agencies.

This analysis considers regulations that apply only to the medical cannabis industry. However, AUMA legalizes cannabis for adult use, fundamentally changing the entire cannabis industry in California, and as such, it changes the industry baseline for evaluating the incremental impact of the medical cannabis regulations. Because this analysis satisfies the requirements of the SRIA for the MCCP, the AUMA regulations—which are still being developed—are not included in the analysis.

[1] The Bureau of Medical Marijuana Regulation is now known as the Medical Cannabis Regulation and Safety Act (MCRSA) under SB 837.
[2] Bureau of Medical Marijuana Regulation is now known as the Bureau of Medical Cannabis Regulation under SB 837.

1.5 MCCP Licenses and Regulatory Costs

Regulations for medical cannabis cultivators broadly fall into two categories: cultivation and operational requirements. A third category of economic impacts caused by the regulations—but not directly part of the regulations—includes changes in expenditures in other local or state agencies.. As the cultivator licensing authority the MCCP will approve applications, issue and renew licenses, conduct inspections, develop and maintain required technology, and administer the medical cannabis track and trace system. This section summarizes the license types, cultivation regulations, and operational requirements for medical cannabis cultivators.

The MCCP issues 14 different license types. License types are classified based on the farm size and cultural practices (production technology), including indoor, outdoor, and mixed light cultural practices for cottage, specialty, small, and medium size operations. Cultural practices are defined based on the use of natural light (outdoor), any light manipulation such that artificial use shall not exceed twenty-five (25) watts per square-foot (mixed-light), or pure artificial light (indoor). The size of the operation is defined by total canopy square footage. [3] Table 1 summarizes the cultivator license types. In addition to indoor, outdoor, and mixed-light cultivation licenses, the MCCP issues a nursery license (Type 4), and a processing license (Type 1P). The Type 4 nursery license is for cultivators who focus on propagative material but do not sell flower or trim directly for retail demand, and the Type 1P processing license is for post-harvest handling (trimming and drying) of medical cannabis.

[3] The term canopy is defined in the proposed regulations.

Table 1 Summary of Cannabis Cultivator Types

License Type	Technology	Min. Canopy (sq ft)	Max. Canopy (sq ft)	Max plants
Type 1	Outdoor	0	5,000	50 plants
Type 1A	Indoor	501	5,000	n/a
Type 1B	Mixed Light	2,501	5,000	n/a
Type 1C	Cottage - Mixed Light	0	2,500	n/a
Type 1C	Cottage - Indoor	0	500	n/a
Type 1C	Cottage - Outdoor	0	n/a	50 plants
Type 2	Outdoor	5,001	10,000	n/a
Type 2A	Indoor	5,001	10,000	n/a
Type 2B	Mixed Light	5,001	10,000	n/a
Type 3	Outdoor	10,001	43,560	n/a
Type 3A	Indoor	10,001	22,000	n/a
Type 3B	Mixed Light	10,001	22,000	n/a
Type 4	Nursery	n/a	n/a	n/a
Type 1P	Processing	n/a	n/a	n/a

Notes: Cultivators may hold multiple license types subject to the following limitations; the MCCP will set a total acreage cap annually.
- Type 1 plants can be non-contiguous up to 50 plants or 5,000 square feet of canopy.
- Cultivator may hold only one Type 3, Type 3a, or Type 3b license.
- Type 1, 1a, 1b and Type 2, 2a, 2b licensees can hold one manufacturing license.
- Type 1 and 2 licensees can hold a dispensary license.
- Producing dispensary licensees can hold any combination of cultivation licenses up to a total canopy of 4 acres.
- Cultivator licensees may hold a transporter license.
- If a licensee holds a transporter license, they may only transport product to a licensed manufacturer or distributor.
- Type 4 licensee also holding a transporter license may transport live plants to a licensed cultivator or distributor.

1.5.1 Cultural Practice Regulations

A cultivator must comply with certain cultural practices on the farm to be eligible for a license. This includes, but is not limited to, complying with State Water Resources Control Board (SWRCB) requirements, Department of Pesticide Regulation (DPR) requirements, Department of Fish and Wildlife (DFW) requirements, all local regulations, and any other mitigation requirements specified in the Environmental Impact Report (EIR).[4]

The cultivator prepares a Cultivation Plan summarizing cultural practices and certifying that the farm is in compliance with various aspects of the regulations. The Cultivation Plan is submitted with the license application materials and updated annually by the cultivator. Some of the key changes to cultural practices under the regulations include the following:

- Maintain commercially clean and organized cultivation site, with designated areas for key production processes
- Maintain records on total wattage and floor plans for indoor and mixed light operations
- Only apply legal pesticides as specified by DPR, per cultivator pest management plan
- Comply with SWRCB requirements

[4] The EIR was not complete at the time this economic impact analysis was finalized.

- Comply with DFW requirements
- Maintain area for batches that are subject to an administrative hold
- Farm size and production technology must comply with license type
- Post-harvest handling requirements and linked businesses in the supply chain must comply with licensing requirements
- Notification and proper disposal of product to be destroyed
- Composting of post-harvest materials
- Any other requirements specified in the EIR

Changing cultural practices to comply with MCCP regulations may result in changes in revenues or costs at the farm. The economic impact analysis is concerned with any incremental changes that are caused by the regulations. For example, if DPR regulations prohibit certain chemical applications this may result in lower yields, lower quality, or higher labor time for pest management. Changes in farm costs can either be direct (e.g., from changing the pesticide application to an Integrated Pest Management regime that requires more labor) or indirect (e.g., the opportunity cost of staff and owner time to learn and comply with requirements).

1.5.2 Farm Operation Regulations

Other MCCP regulations affect medical cannabis cultivator operations. These include administrative requirements, track and trace system operation, record keeping, reporting, fees, taxes, and a range of other paperwork. Changes in operations as a result of the regulations also cause direct and indirect cost and benefits. Some of the key changes to farm operations under the regulations include the following:

- License application submission, fee, and annual licensing fee
- Development and maintenance of a Cultivation Plan
- Farm record maintenance
- Securing a $5,000 surety bond to cover the state's costs of destruction of medical cannabis if necessitated by a violation of licensing requirements.
- Obtaining a Board of Equalization license and generally operating as a legal business entity, including payroll, insurance, and taxes
- Complying with all local regulations, obtain and maintain relevant permits
- Paying DPR, SWRCB, DFW, and any other agency fees
- Declaration of operation as an agricultural employer and compliance with applicable requirements
- Installation of a track and trace system, employee training, system maintenance, purchase of track and trace system components
- Adherence to weight and measurement standards, secure relevant permits
- Compliance with pesticide requirements, obtain relevant permits
- Development of an approved composting program

- Any other administrative requirements included in the EIR

Changes in farm operations typically result in a direct cost to the cultivator as a one-time outlay, capital purchase, or variable (annual) farm expenses. For example, the additional staff time required to manage a track and trace system will increase annual operating costs of the farm. For example, purchasing scanners for a track and trace system and paying one-time application fees are examples of capital expenses and one-time outlays, respectively. Note that the track and trace system is not defined at this time, thus the additional equipment purchases are assumed in this economic impact analysis, but could change. Ongoing costs are included as annual expenses and upfront capital costs are amortized so that they can be included with annual regulatory costs. [5] Operational costs to the cultivator can result in increased sales to other sectors of the economy, and included as such in the economic impact analysis.

1.5.3 Enforcement, Local Agency, and MCCP Costs

Regulating medical cannabis will increase expenditures by state and local agencies and these fiscal costs are included in the economic impact analysis. The MCCP is in charge of all aspects of the medical cannabis cultivator licensing, enforcement, and administration. In addition, various other state agencies (e.g., DPR, DFW, and SWRCB) will increase expenditures to regulate aspects of medical cannabis cultivation. Local agencies including code enforcement may increase enforcement expenditures. The MCCP will be responsible for enforcing compliance for licensed cultivators, the enforcement of non-licensed cannabis cultivators is expected to require collaboration with state and local agencies including law enforcement. The fiscal cost of operating the MCCP, and any local agencies that help enforce the regulations, is included as an economic cost attributable to the regulations. Key agency costs include:

- MCCP operating budget including administration, enforcement, and technology
- Issuing and reviewing permits and licenses (MCCP and local agencies)
- Enforcement of non-licensed cannabis farms (primarily local law enforcement)
- Any other requirements specified in the EIR

The most significant costs to the MCCP are for maintaining the track and trace technology and issuing and enforcing license requirements. The MCCP will also handle reports of cultivators that are not in compliance with the law, and liaise with local law enforcement who will decide whether to investigate the farm in question. The cost of the MCCP and other local agencies for medical cannabis cultivation compliance is included in the economic impact assessment. Increases in agency expenditures can generate economic activity in ancillary industries, and these benefits are quantified in the economic impact analysis.

[5] This analysis assumes that cultivators will have access to capital and formal or informal lending. It is important to note that most financial institutions will not deal with cannabis-related businesses since it is illegal at the federal level. However, the cultivator survey finds that there are informal credit arrangements that currently exist. This is an uncertainty in the analysis that can be investigated in future studies.

Regulations do not require additional expenditures by local governments. Local agencies are able to set fees, taxes, and other rules independent of medical cannabis regulations. Cultivators will be required to comply with any local regulations, and as such, the cost of complying with these local regulations is included in the economic impact analysis. In short, there are no fiscal impacts to local agencies as part of the medical cannabis regulations, but the economic impact analysis does include local fees/costs that cultivators must pay to obtain a medical cannabis license.

1.6 Regulatory Benefits

Regulating the medical cannabis industry also provides direct and indirect benefits to cultivators, local economies, consumers, and the state. When feasible, these benefits are quantified for the economic impact analysis. The net benefit (or cost) of the regulations can be calculated by comparing the average annual benefits with the average annual costs.

The primary economic benefit that regulation provides to cultivators is the reduction in the "risk premium." The risk premium is a measure of the financial risk to cultivators that operate in a black (or grey) market. For example, local law enforcement may eradicate a farm if it is not in compliance with county laws—or for other reasons—and there is some risk of theft from operating as an all cash business. Any reduction in the risk premium is a direct economic benefit to cultivators.

Track and trace and other management requirements of the MCCP may provide benefits to cultivators. For example, track and trace systems can help improve supply chain efficiency at the farm level (Sparling et al. 2011). Track and trace is effectively a real-time inventory management system that allows managers to flexibly manage supply in response to changes in market conditions or inventory. In addition, track and trace allows cultivators to identify the origin of their product. Cannabis appellations are in their infancy (compared to wine, for example) but these appellations may become important marketing tools in the future as important qualities are identified in specific cannabis strains, which are in turn demanded by consumers.

Regulations (particularly testing requirements) signal to consumers that medical cannabis is a reliable product that is free from harmful chemicals. This may increase consumer demand. If the regulated medical cannabis is in fact "healthier" in the sense that certain chemicals are no longer applied, then there may be positive health outcomes for consumers.[6] Some of these benefits can be quantified, others are more speculative, and where possible they are addressed in this economic impact analysis.

The primary statewide economic benefit from medical cannabis regulation is a reduction in environmental externalities associated with current (illegal) production methods. Illegal outdoor cultivators can negatively impact stream flow, water quality, erosion, and chemical runoff. To the extent that regulations limit some of these externalities there is a direct benefit to the state.

[6] Note: a positive health outcome does not suggest that cannabis is healthy to use. However, conditional on deciding to consume cannabis, it is arguably better to consume cannabis that does not have additional harmful chemicals.

There are also potential benefits from reductions in crime and local law enforcement expenditures on cannabis enforcement as agencies are able to more efficiently identify illegal cultivators. In general, these changes are difficult to measure. However, it is reasonable to hypothesize that even if no additional money is spent on illegal cannabis enforcement, the effectiveness per enforcement dollar will increase by allowing law enforcement to more quickly identify illegal cultivators once medical cannabis regulations are in place.

1.7 Organization of the Report

The report is structured as follows. Section 2 provides an overview of the data and analytic approach. Section 3 summarizes the medical cannabis market and the production costs and cultural practices of indoor, outdoor, and mixed-light cultivators. It also includes the baseline used for the SRIA. Section 4 describes the risk premium and regulatory risk premium. Section 5 presents the direct economic cost of the regulation to cultivators, the broader market, and state and local agencies. Section 6 summarizes the indirect and induced, and fiscal impacts of the regulations. Section 7 summarizes alternative regulations that were considered for the analysis and why they were not selected. Section 8 offers some summary remarks.

2. Analytic Approach and Data

The economic impact analysis proceeds in three phases: (i) a cultivator-level trade-off analysis of the costs and benefits of participating in the regulated market, (ii) a market-level analysis of the effect of legalization, and regulation, on the market clearing prices and quantities in the industry, and (iii) a regional (multiplier) analysis of the macroeconomic and fiscal impacts of the direct impacts of the MCCP regulations.

The economic impact of MCCP regulations is evaluated at a single future point-in-time (12 month period) which is interpreted as the medical cannabis market "in equilibrium" after the MCCP regulations are in place (and the adult use market exists). This approach was chosen instead of analyzing adjustments to MCCP regulations over time because the MCCP regulations are not being phased in. The regulations take effect on January 1, 2018. The equilibrium market in this analysis is interpreted as the 12 month period following the implementation of MCCP regulations. In practice, there will be some time for the industry to adjust, but insufficient data exist to analyze this transition, and it would not change the fundamental findings of the analysis.

There are limited data available on legal and illegal cannabis cultivation in California. A range of studies—with varying degrees of credibility—attempting to quantify the "cannabis market" in California have been published over the last several years. The ERA team engaged in a comprehensive literature review, primary survey, interviews, site visits, and broader data gathering effort to compile the information necessary to conduct this analysis. This section summarizes some of the key data sources, additional details and references can be found in the sections of this report that describe the results in greater detail. Much of the information gathered for this analysis required the ERA team to ensure that the underlying data would be kept

confidential, and the ERA team has taken this promise seriously. All of the confidential data used in this analysis has been aggregated such that that no one entity can be identified, but the reader is able to validate all of the conclusions of the economic impact analysis.

The cultivator surveys were completed in person, by phone, or by email, over a span of approximately three months. Unfortunately, the timing of the surveys conflicted with the fall cannabis harvest season, and it was difficult to schedule time to meet with cultivators. The ERA team is continuing the survey effort to expand the dataset as these data are essential for correctly estimating economic multiplier effects and the market response to regulation. Even with harvest constraints, the ERA team was able to create a cultivator dataset that includes outdoor, indoor, and mixed light production, as well as nurseries, and processing, with variation in farm size and production methods. Currently, 61 cannabis cultivation surveys have been completed. Other primary data sources include local agencies, code enforcement, federal agencies, grower groups, industry experts, and various policy officials. Table 2 summarizes the various data.

Table 2 Summary of Key Input Data

Data Description	Source
Cultivation Eradications	Federal Drug Enforcement Agency
Cultivation Locations and Eradications	Various state, federal, local code enforcement and political groups
Cultivation Locations and Operations	Regional Water Quality Control Boards, various local agencies
Consumption Data	SAMSHA, various government reports
Manufacturing/processing	Various industry experts
Local County Ordinances	County agencies, code enforcement, voter guides
Dispensary Sales Tax	Board of Equalization
Market Parameters	Various published studies
Dispensary Locations	Various counties/law enforcement
Cultivation Practices	Cultivator surveys (phone, online, in-person)
Farm financial data	Cultivator surveys, published reports
State socioeconomic data	Department of Finance
Cultural practices, supplemental data	Multiple cannabis alliances and grower groups

2.1 Analytic Approach

The production, distribution, and consumption of cannabis in California will undergo two major shifts: legalization of adult use cannabis, and regulation of medical cannabis. This SRIA estimates the economic impact of proposed MCCP regulations by evaluating the incremental costs and benefits of these regulations. As such, the SRIA baseline, described under Section 3.6, includes the adult use market. The following sections summarize the analytic approach, followed

by a summary of cannabis production, cannabis production budgets, cannabis consumption, and the explicit definition of the SRIA baseline.

2.1.1 Fundamental Trade-Off Analysis

The fundamental decision facing a cannabis cultivator is whether to become regulated or stay in the illegal market. There are three factors that the representative grower considers:

First, the **risk premium**. The risk premium is defined as the estimated loss attributable to the adverse consequences of involvement in an illicit market activity (arrested, raided, robbed, etc.) multiplied by the probability of this adverse outcome being realized. This represents the risk to the grower from staying in the illegal market.

Second, the **direct cost of regulations**. This is the direct cost to the cultivator of complying with the regulations reflected in staff time, owner time, fees, license, and general administrative requirements. In particular, this includes fixed and variable costs from changes in cultural practices and operations requirements.

Third, the **regulatory risk premium**. The regulatory risk premium is the risk of being found to be out of compliance with the regulations, whether on purpose or not, and fined. There are two factors underlying the regulatory risk premium. First, it is possible that an honest, well-intentioned cultivator could fail to meet some component of the regulations. For example, if residual pesticide testing requirements are strict, a cultivator may fail batch testing. Second, cultivators are required to submit an application for Live Scan Service (fingerprinting) in order to get a license. Once a cultivator registers as a legal cultivator and enters into the database, it becomes difficult to leave the legal medical cannabis market in favor of the illegal market in the future.

A simple break-even analysis is developed to illustrate how the various components of the risk premium and regulatory compliance cost vary under current and regulated market conditions, across different classes of cultivators. This simple trade-off analysis acknowledges differences in the production costs, returns, economies of scale, and regulatory environment across indoor, outdoor, and mixed light cultivators. It also allows for evaluating the central trade-off that will affect the total market supply and, importantly, the distribution of market supply across different classes of cultivators. The methodology calculates the net return of a representative cultivator (*n*) of production technology i **(license type)** $\in \{$**1, 1A, 1B, 1C, 2, 2A, 2B, 3, 3A, 3B, 4, 1P**$\}$ producing in either the legal or illegal market, $j \in \{$**legal, illegal**$\}$, as:

$$\pi_{ij} = p_{ij} y_{ij} - c_{ij} - RP_{ij} - RRP_{ij} - RC_{ij} - \phi_{nij}, \quad (1)$$

where π_{ij} is net income, defined as price, p_{ij} ,multiplied by the annual yield, y_{ij}, net of production costs, c_{ij}. The parameter ϕ_{nij} describes a set of cultivator (*i* and *j*) specific parameters that also

vary by individual (*n*), reflecting unobservable factors that affect cultivator profitability and risk preferences. The risk premium, regulatory risk premium, and regulatory (direct) cost are defined as RP_{ij}, RRP_{ij}, and RC_{ij}, respectively. The risk premium is calculated as the probability (ρ) of getting caught multiplied by the cost of getting caught (F), thus $RP_{ij} = \rho_{ij}^{RP} F_{ij}^{RP}$ and $RRP_{ij} = \rho_{ij}^{RRP} F_{ij}^{RRP}$. Grower i shifts from market j to market $-j$ (e.g., illegal to legal) if $\pi_{ij} > \pi_{i-j}$, where any switching premium associated with the decision is implicitly embedded in the various risk premiums.

A representative cultivator stays in the legal market if $\pi_{i,\mathbf{legal}} > \pi_{i,\mathbf{illegal}}$. Assuming that the risk premium is zero in the legal market, the regulatory compliance cost is zero in the illegal market, the regulatory risk premium is zero in the illegal market, and the production costs and returns are the same in both markets, the fundamental trade-off can be written as:

$$\rho_{i,\mathbf{illegal}}^{RP} F_{i,\mathbf{illegal}}^{RP} + \phi_{ni,\mathbf{illegal}} > RC_{i,\mathbf{legal}} + \rho_{i,\mathbf{legal}}^{RRP} F_{i,\mathbf{legal}}^{RRP} + \phi_{ni,\mathbf{legal}} \quad (2)$$

Unobservable factors described in ϕ_{nij} can be thought of as an error term. Setting these components aside, Equation (2) demonstrates there are three fundamental elements that affect the decision to participate in the legal market: (i) the standard risk premium of staying in the illegal market, (ii) the direct cost of regulatory compliance, and (iii) the regulatory risk premium in the legal market. If the risk premium in the illegal market is greater than the direct cost of complying with the regulations, and the additional regulatory risk premium, then the cultivator would choose to enter the legal market.

The risk premium is a function of the level of enforcement in the regulated market. If there is no increase in enforcement for the illegal sector it is likely that the risk premium will actually decrease under regulations, in turn making it more likely that the representative cultivator will decide to stay in the illegal market. The regulatory risk premium depends on the strictness of the medical cannabis cultivation regulations and the penalty for being out of compliance with the regulations. Strict regulations with steep fines are more likely to push cultivators into the illegal unregulated market.

Note that the tradeoff analysis illustrates the decision to participate in the market but does not directly affect the economic impacts estimated for the SRIA. The market analysis, described below, is used to estimate the resulting market equilibrium, and corresponding direct economic impacts, under MCCP regulations.

2.1.2 Market Analysis

The purpose of the market analysis is to estimate the effects on supply and demand of different types of cannabis when subject to additional regulation, particularly on the production sector. The driving force of these regulations on the cannabis sector can be characterized as shifts in

demand in four different sectors of the cannabis market, as well as shifts in supply for different types of production systems and suppliers.

Since the effects of regulation will be manifest in terms of relatively small shifts in market demand, marketing costs, production costs, and production systems, this analysis uses an Equilibrium Displacement Modeling (EDM) approach. EDM has a well-documented history in analyzing the effects of changes in trade policies, advertising, taxes, and regulation of primary production systems. It has been extensively applied to livestock systems such as the dairy sector, beef production, sheep production, marketing, and research and development (Alston et al., 2006, Alston et al., 1995). An EDM model is a mathematical representation of the supply and demand for an aggregate market and underlying market segments that is used to assess the new system equilibrium in response to an exogenous policy shock (in this case, regulations). Various own and cross-price elasticities are used to characterize the various market segments. Given the limited empirical studies on the cannabis market, some of these parameters have a solid empirical foundation based on survey data, however other parameters such as the elasticity of supply, are more tenuous and have been adapted from other agricultural products with similar supply characteristics.

Gardner (1975) further developed the initial EDM specified by Muth (1964). The EDM model is a set of logarithmic differential equations that characterize the comparative economic statics of the system and measures shifts from one equilibrium to another caused by exogenous effects on supply and demand such as would result from new regulations. Since it uses elasticities to measure the change in comparative static equilibria, it can be readily applied to new empirical situations since all the essential relationships are expressed in percentage terms and are not changed by different empirical scales that are required by a more structural modeling approach.

This analysis models the total cannabis market as an aggregate of four market segments: within-California medicinal (MED), within-California adult use (REC), within-California illegal (ILL), and export illegal (EXP). The model reflects a two-stage budgeting process where consumers consider cannabis (C) as an individual group and the MED, REC, ILL, and EXP segments as subgroups of the overall cannabis market. That is, in this analysis the overall cannabis market is weakly separable from all other goods and the cannabis group market segments are weakly separable within the cannabis group. The analysis assumes that the within-California market segments—MED, REC, and ILL (subscript j = 1, 2, and 3, respectively)—are related in consumption, such that the quantity demanded in each within-California market segment is a function of the prices in all three segments. Accordingly, demand for EXP (subscript j = 4) is only a function of the price in the EXP segment.

Three cultivator (producer types), each with their own production processes (technologies) and marginal costs, supply the four market segments. The cannabis market is supplied by outdoor (OUT), mixed-light (MXL), and indoor (IND) operations (subscript i = 1, 2, and 3, respectively).

Each producer type can supply each market segment and bases production decisions on the prices in that market segment.

The cannabis market equilibrium is specified as follows. Consumer demand is defined as:

$$Q_j^D = g_j\left(P_1, P_2, P_3, A_j\right) \; i = 1,2,3 \tag{3}$$

$$Q_4^D = g_4\left(P_4, A_4\right) \tag{4}$$

The cultivator supply-side of the market is defined as:

$$Q_{ij}^S = f_i\left(P_j, B_i\right) \; i = 1,2,3 \; and \; j = 1,2,3,4 \tag{5}$$

The market clearing conditions require total market segment supply to equal total market segment demand:

$$Q_j^D = \sum_{i=1}^{3} Q_{ij}^S \;\; j = 1,2,3,4 \tag{6}$$

Equation (3) is consumer market demand in each of the three within-California market segments, *j*=1,2,3, and Equation (4) describes consumer demand in the illegal export market, *j*=4. Equation (5) is cannabis market supply from producer/cultivator type i to each of the four consumer market segments. Equation (6) is a market clearing condition that requires that the total market segment demand is satisfied or supplied by the aggregate quantities produced by each supplier type for that segment. The parameters A_j and B_i are exogenous market segment demand and supply price shocks (shifters).

Endogenous variables in the model are cultivator output to each market segment, Q_{ij}^S, and the price in each market segement, P_i. Totally differentiating equations (3) – (6) to convert to log-differntial form yields the following system of equations expressed in terms of relative changes in equilibrium prices, quantities, and elasticities. Consumer demand is modeled as:

$$EQ_j^D = \eta_{j1}EP_1 + \eta_{j2}EP_2 + \eta_{j3}EP_3 + \alpha_j\eta_{jj} \;\; j = 1,2,3 \tag{7}$$

$$EQ_4^D = \eta_{44}EP_4 + \eta_{44}\alpha_4 \tag{8}$$

Cultivator supply is modeled as:

$$EQ_{ij}^S = \varepsilon_i EP_j + \varepsilon_i\beta_i \;\; i = 1,2,3 \; and \;\; j = 1,2,3,4 \tag{9}$$

Finally, the market clearing condition is:

$$EQ_j^D = \sum_{i=1}^{3} ss_i Q_{ij}^S \tag{10}$$

Where α_j are the relative increases in market segment *j* demand (i.e., a vertical shift up in the price direction) and β_i is the relative increase in the supply from producer *i* (vertical shift down in the price direction). Substituting Equation (10) into (7) and (8) reduces the system to 16 equations and 16 unknowns.

This analysis assumes that the cannabis groups is weakly separable from other (non-cannabis) consumption, therefore the cross price demand elasticities in (7) and (8) can be decomposed into functions of the overall cannabis group demand elasticity, h, market segment expenditure shares, ds_j, elasticities of substitution between market segments, $s_{j,k}$, and the expenditure elasticity of segment *j*, $h_{j,Y}$ (Edgerton 1997). The analysis assumes that $s_{j,k} = s_{k,j}$. The cross price elasticities are given by:

$$\eta_{11} = -ds_2\sigma_{12} - ds_3\sigma_{12} - \eta_{1Y}ds_1(1+\eta) - \eta_{1Y}ds_1\eta_Y ds_Y \tag{11}$$

$$\eta_{11} = -ds_2\sigma_{12} - ds_3\sigma_{12} - \eta_{1Y}ds_1(1+\eta) - \eta_{1Y}ds_1\eta_Y ds_Y \tag{12}$$

$$\eta_{22} = -ds_1\sigma_{12} - ds_3\sigma_{32} - \eta_{2Y}ds_2(1+\eta) - \eta_{2Y}ds_2\eta_Y ds_Y \tag{13}$$

$$\eta_{33} = -ds_1\sigma_{13} - ds_2\sigma_{23} - \eta_{3Y}ds_3(1+\eta) - \eta_{3Y}ds_3\eta_Y ds_Y \tag{14}$$

$$\eta_{j,k} = ds_k\left(\sigma_{j,k} - \eta_{j,Y}\right) \tag{15}$$

The total change in cannabis output (pounds produced) and price in each market segment can be calculated as:

$$dQ_i = ss_i \sum_{j=1}^{4} Q_j^0 EQ_{i,j}, \quad i = 1,2,3 \tag{16}$$

$$dP_j = P_j EP_j, \quad j = 1,2,3,4 \tag{17}$$

Given that total revenue (*TR*) for producer *i* equals,

$$TR_i = \sum_{j=1}^{4} P_j Q_{i,j} \tag{18}$$

Then it can be shown that,

$$ETR_i = \sum_{j=1}^{4} EP_j + \sum_{j=1}^{4} EQ_{ij} \tag{19}$$

Changes in consumer (CS), producer (PS), and total (TS) surplus can be measured as:

$$\Delta CS_j = -P_j Q_j \left[EP_j - \alpha_j \right] \left[1 + 0.5 EQ_j \right] \quad (20)$$

$$\Delta PS_i = PQ_i \left[EP + \beta_i \right] \left[1 + 0.5 EQ_i \right] \quad (21)$$

$$\Delta TS = \sum_{i=1}^{3} \Delta PS_i + \sum_{j=1}^{4} \Delta CS_j \quad (22)$$

Producer surplus (PS) is a measure of the benefits producers receive from participating in the market and is measured as the difference between the market price and the minimum amount a producer would accept for a given quantity of a good, as defined by the supply curve. Similarly, consumer surplus (CS) is the benefit consumers receive from participating in the market and is measured as the difference between what consumers are willing to pay (as defined by the demand curve) for a given quantity of a good and the price of the good. Total surplus is simply the sum of PS and CS, or the total surplus for agents participating in the market.

There is a different supply response for each of the three production technologies (indoor, outdoor, mixed light). Outdoor small-scale production system is assumed to have a relatively inelastic supply of 0.75 as a result of the relatively small scale of production and the infrequent harvest (usually only once per year). Mixed light production is estimated to have a unit elasticity (1.0) that reflects more frequent harvests and medium scale for this type of production. Indoor production is modeled as being slightly elastic with a supply elasticity of 1.25 because of the greater frequency of production (up to four harvests per year based on cultivator surveys) and a larger scale of production that allows growers to amortize fixed regulatory costs over significantly larger volumes of production. Note that this analysis considers an average annual operation. Similar to conventional agriculture rotations (e.g. intensive lettuce rotations of 2-3 crops per year in the Salinas Valley), cultivators can rotate production through various grow stages, but the average annual production per square foot of canopy depends on the total number of full production cycles (approximately 4 per year based on cultivator surveys). Other parameters that are fixed in the EDM are established from published studies where available, summarized here, and discussed in the following sections.

Table 3 Equilibrium Displacement Model Parameters

Parameters	Value
Supply elasticities	
ε_1	0.75
ε_2	1
ε_3	1.25
Producer type supply shares	
ss_1	0.6
ss_2	0.24
ss_3	0.16
Cannabis group demand parameters	
ds_Y	0.01
η	-0.2
η_Y	1
Elasticities of substitution between market segments	
$\sigma_{12}(\sigma_{21})$	7
$\sigma_{13}(\sigma_{31})$	3
$\sigma_{23}(\sigma_{32})$	7
Conditional expenditure elasticities	
$\eta_{1,Y}$	1
$\eta_{2,Y}$	1
$\eta_{3,Y}$	1
Conditional segment expenditure shares	
ds_1	0.1
ds_2	0.4
ds_3	0.5

Marginal shifts in supply and demand resulting from the MCCP regulations are inputs to the EDM. These are expressed as percentage change in marginal cost of production for each cultivator type, where the change in production cost is equivalent to the direct cost of the MCCP regulations to each cultivator type. The EDM model output includes the percent change in quantity demand and supply resulting from the MCCP regulations, across market segments and cultivator types. These shifts are discussed in subsequent sections. It is important to note that this analysis for MCCP does not explicitly consider any AUMA regulations. AUMA regulations have not been developed, and as of the publication date of this analysis, MCCP regulations were moving forward separately. Future analyses will address this gap in the logic.

2.1.3 Macroeconomic and Fiscal Impact Analysis

The final phase in the analysis is to use the changes in market clearing price and quantities from the market analysis, plus the direct changes in agency and other regulatory costs, to evaluate the

total effect of the regulation on jobs, taxes, value-added across the state. The total economic impact is expressed as the sum of direct, indirect, and induced changes in the economy. The direct effect is a change in primary production value in the medical cannabis cultivation industry. The indirect effect captures changes in intermediate input purchase by the primary industry from other sectors of the economy. For example, medical cannabis cultivators purchase inputs from local lighting supply stores and other farm supply stores. Finally, induced impacts capture the change in expenditures by employees in the primary industry and all linked industries. The net effect of these changes is interpreted as the total economic impact.

This analysis uses the Impacts for Planning and Analysis (IMPLAN) v3.1 model (MIG. Inc, 2016) with a California county-level 2014 dataset as the baseline year for the analysis.[7] The IMPLAN software is an input-output economic model, which estimates the effects of exogenous changes in final demand within a specified geographic region (California). The model leverages a robust data set of national and regional economic accounts that document purchasing relationships between industries through multiple rounds of spending. The software also incorporates institutional demand and inter-institutional transfers which reflect purchases made by households and government agencies.

A critical limitation to the IMPLAN model (or any input-output model) is that the default IMPLAN model data does not include the medical cannabis industry. Three medical cannabis cultivation sectors (indoor, outdoor, mixed-light) are created using the financial data from the cultivator surveys and various secondary sources. An evaluation of cultivator survey data, industry benchmarks, and published articles shows that conventional agricultural sectors in the IMPLAN model are not representative of cannabis cultivation in California. This includes differences in costs of production, employment, and value added. For example, the IMPLAN model offers a detailed spending profile for intermediate expenditures of agricultural commodities; however, the coefficients of inputs purchased are generally held constant over several sectors. Modifying the model to specifically capture cannabis producer characteristics using alternative data sources makes it possible to leverage the robust systematic methods associated with the IMPLAN software while also improving the accuracy of the resulting multipliers.

The primary cultivator survey data are supplemented with production cost reports from Hawkins (2013) and Caulkins (2010) to create cannabis industry sectors in IMPLAN. The survey data is separated into outdoor, mixed-light, and indoor sectors to capture the different production characteristics and intermediate expenditure coefficients across these three sectors. The North American Industry Classification System (NAICS) codes are used to categorize each cost and link with the IMPLAN sector definitions.

[7] The IMPLAN 2015 data for California counties were released after the 2014 dataset was purchased for this analysis.

Industry production function coefficients vary by cannabis cultivation method as a result of variation in cultural practices and production processes. For example, electricity input purchases are a much larger share of total production costs for indoor cultivators than outdoor cultivators. Outdoor production requires minimal electricity, while indoor and mixed-light cultivators rely more heavily on the resource during each harvest cycle. In contrast, the wholesale trade distribution services sector, which includes most of the soil amendment purchases, represents a relatively higher share of input purchases for outdoor cultivators. The following table summarizes the output value and employment multipliers for the custom sectors created in the IMPLAN model. Output value multipliers are generally similar to conventional agriculture industries for outdoor, indoor, and mixed light production. Cannabis industry employment SAM multipliers are generally lower than comparable conventional agriculture industries. However, the direct effect (not shown in the table) of employment is significantly higher than conventional agriculture industries, consistent with significant direct labor inputs for cannabis production and harvesting. The multiplier effects on employment are lower because there are fewer intermediate inputs purchased, and thus less ancillary economic activity.

Table 4 Output Value and Employment SAM Multipliers

IMPLAN Sector	Description	Output Value (SAM)	Employment (SAM)
1	Oilseed farming	1.451	5.633
2	Grain farming	2.132	6.430
3	Vegetable and melon farming	1.615	2.126
4	Fruit farming	1.583	1.452
5	Tree nut farming	1.531	1.875
6	Greenhouse, nursery, and floriculture production	1.671	1.780
8	Cotton farming	1.782	2.817
9	Sugarcane and sugar beet farming	1.719	2.626
10	All other crop farming	1.733	1.631
7	Outdoor Cannabis Production	1.929	1.400
25	Indoor Cannabis Cultivation	1.796	1.814
28	Mixed Light Cannabis Cultivation	1.775	1.345

3. The Cannabis Market and SRIA Baseline

This section describes the market for medical and illegal cannabis production and consumption in California. The Cannabis Supply section presents a comprehensive estimate of total cannabis production in California (as of 2016), using the best available data from a variety of confidential sources. This section also presents the cost of production information for indoor, outdoor, and mixed-light cultivators. The Cannabis Demand section includes a literature review of important

demand elasticity parameters that characterize consumer demand for cannabis, as well as an estimate of total within-California consumption in California. In short, the information in this section summarizes total within-California and export production of California cannabis, within-California consumption, and consumer responsiveness to changes in medical cannabis price, and the price of related goods.

3.1 Cannabis Supply

This study presents a comprehensive data-based estimate of statewide production. This estimate is validated against other aggregated sources of information. For example, an early study by Gettman (2006) estimates approximately 8.6 million pounds of cannabis were produced in California in 2006. Current the DEA (2016) records show that more than 2.6 million plants were eradicated in 2015 alone. Even using conservative estimates of the share of plants that are eradicated and the yield per plant, 8.6 million pounds is a significant underestimate of the total quantity of cannabis produced in California. This analysis relies on three fundamental sources of information to establish total production quantities in each county: registered farms, eradications, and mapped but unregistered farms.

The three sources of data are combined to estimate total cannabis production in a three-stage estimation procedure. First, the total known production in each county is established.[8] If a farm record does not have production information available, it is assumed that each plant yields an annual average of 2 pounds of cannabis. Second, the data are adjusted for under-reporting. Finally, production in areas with missing observations were interpolated from counties with observations based on a simple statistical analysis of production per square mile normalized by the population of the county. County officials in various local agencies in all areas were contacted to review the estimated production, and validate with other anecdotal evidence. Other studies that map grow sites, such as Bauer *et al.* (2015) were also reviewed.

Using this method, total known production in California equals 9.8 million lb per year. That is, with no adjustments to the raw data that covers only 39 out of 58 counties and applying conservative yield assumptions to farms with limited information, California produces nearly 10 million pounds of cannabis per year. After adjusting for under-reporting and extrapolating to the missing 19 counties, this analysis estimates total statewide production equals 13.5 million pounds. This is likely conservative estimate, but it the first comprehensive, data-based estimate of total production in the state. There are two important things to note: (i) as more data on cannabis cultivation in California is compiled this estimate will be refined, and (ii) the total cannabis market does not have a significant effect on the economic impact of proposed MCCP regulations summarized in this SRIA.

Table 5 summarizes the total quantity of cannabis produced in California by region. The nine production regions in California follow the definition used by the University of California

[8] Eradications, permitted farms, or unregistered farm data is available for 39 out of 58counties.

Cooperative Extension for conventional agricultural production regions. Data are aggregated into these regions that represent the minimum unit of analysis. As expected, the primary production regions include the North Coast and Intermountain regions, followed by the Central Coast. At a conservative wholesale value of $1,500 per pound, the farm-gate value of California's cannabis industry exceeds $20 billion annually. It is noteworthy that recent trends indicate a shift in production—particularly larger commercial operations—towards regions in the Central Valley. Production has also been expanding in most of the traditional production regions (Emerald Triangle) for some time.

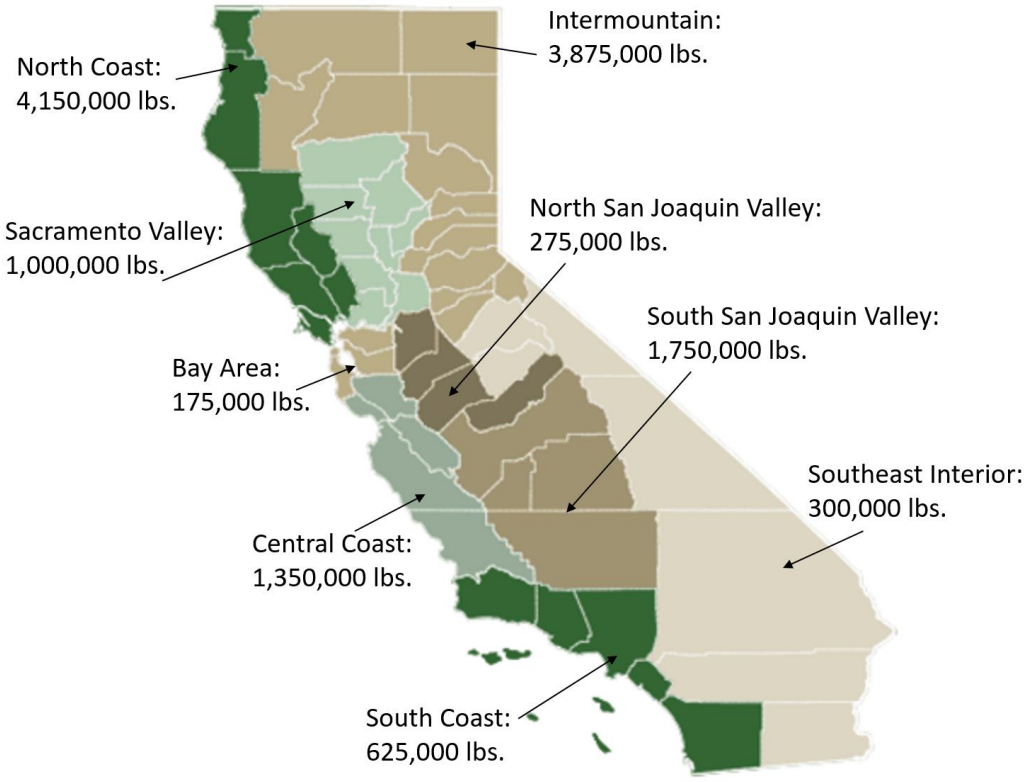
Table 5 California Cannabis Production by Region, 2016

Area	Total Production (lbs.)
Bay Area	175,000
North Coast	4,150,000
Southeast Interior	300,000
North San Joaquin	275,000
Central Coast	1,350,000
Intermountain	3,875,000
South San Joaquin	1,750,000
South Coast	625,000
Sacramento Valley	1,000,000
State Total	**13,500,000**

Notes: All numbers rounded.

The total production estimate of 13.5 million pounds is based primarily on commercial cannabis activity and likely excludes some independent production by home growers. At this time, the data are not available to include personal production of cannabis. In addition, the data do not include an estimate of imported cannabis from Mexico or other regions, but it is likely this is a small share (see subsequent sections). Figure 1 illustrates the distribution across the standard production regions in the state.

Figure 1 Map of Estimated California Production (Pounds) by Region



A second relevant parameter for the economic analysis is the distribution of production technology across the state. Table 6 summarizes the estimated share of production technology by region. It is not possible to isolate the share of production by market segment at this time, thus these proportions are applied uniformly for all scenarios analyzed. The current statewide distribution of production technology is 60 percent outdoor, 24 percent mixed light, and 16 percent indoor. Based on anecdotal feedback from surveys, it is likely that medical cannabis has a smaller share from outdoor cultivation, but there are no data available to support this assertion. These market share parameters are used in the EDM model summarized in the previous section.

Table 6 Share of Production Technology by Region

Region	Indoor	Outdoor	Mixed Light
Bay Area	61%	26%	13%
North Coast	6%	51%	43%
Southeast Interior	8%	83%	8%
North San Joaquin	17%	74%	9%
Central Coast	6%	74%	20%
Intermountain	9%	63%	27%
South San Joaquin	3%	43%	54%
South Coast	30%	48%	22%
Sacramento Valley	8%	77%	15%
Total	**16%**	**60%**	**24%**

3.1.1 Current Medical Cannabis Production

The quantity of medical cannabis produced can be calculated from the production data summarized in the previous section and the total (retail) sales of medical cannabis in California, summarized here. The Board of Equalization (BOE) provided confidential data to the ERA team on the total retail tax receipts from medical cannabis dispensaries in California for 2014 and 2015. The BOE reported tax receipts equaled $58 million in 2015. The average state tax rate is about 8.48 percent (Tax Foundation 2016), thus the implied annual gross receipts are approximately $650 million. However, BOE also reports that since dispensaries operate as a cash business, approximately 30 percent of total revenues are reported. In addition, the BOE cannot perfectly identify all cannabis businesses because there is no NAICS code associated with these entities, thus approximately 90 percent of the businesses are included in the BOE data. Adjusting the gross sales for this underreporting, the total retail sales value of the industry is estimated to equal $2.4 billion as of 2016.

The quantity of medical cannabis produced to serve the $2.4 billion market is calculated as follows. First, a share of the $2.4 billion in retail sales goes to manufactured product including edibles, concentrates, extracts, and topicals. These products are typically derived from trim, a byproduct of processing flower for retail, which fetches a lower price on the market, however some higher-quality products are derived directly from flower. The analysis assumes that approximately 70 percent of the medical cannabis retail market is flower sales, and 30 percent is from manufactured products. The manufactured products are broken down by market share between edibles, concentrates, extracts, and topicals. These categories are further broken into sub-sectors (hash, rosen, keif, tinctures, CO2 oil, lotions, etc.) and each sub-category has a ratio input of oil (from trim and flower) to retail sales value. Each sub-category is assigned a gross sales value based on interviews with dispensary owners.

Using this approach the $2.4 billion cannabis market—currently, prior to AUMA and MCCP regulations—produces and sells between 575,000 and 800,000 pounds of flower equivalent annually in California. This analysis sets the current production for the medical cannabis market equal to 650,000 pounds.

3.2 Cannabis Production Costs and Returns

This section summarizes standard production practices and parameters for cannabis cultivation, nurseries, and processing. There are three types of cultivation considered in this analysis: outdoor, mixed light, and indoor. Cultivation survey responses and anecdotal industry contact information is used in conjunction with the limited research from past studies to establish production budgets. The components of each production method are outlined in the following sections.

Table 7 summarizes the cost of cannabis production, averaged across three cultivator types. The cost of production data for each cultivator is standardized to a per plant/pound basis. The average across the cultivation license type is used to establish the average costs of production per plant. As a reference, sources including Hawkins (2013) and Caulkins (2010) are used to identify inconsistencies across survey respondents. In addition, registration, local law enforcement, and water quality data is utilized to evaluate the canopy areas, spacing of plants, pounds produced, and inputs such as fertilizers used for production. It is important to note that Table 7 represents average production parameters and costs for each cultivation method based on the cultivator survey. That is, there is variation within each cultivation method. For instance, in indoor there is an identified average of four harvests per year. Some cultivators may have only two harvests per year, while others may get five to six harvests per year. Additionally, there is also variation in yields, quality, price, square-feet per plant, and other expense characteristics depending on individual cultivator practices and efficiencies. This variability does not change the fundamental results of this analysis.

Table 7 Sample Average Production Parameters and Costs for Outdoor, Indoor, and Mixed-Light Cultivation

Production Method	Outdoor	Indoor	Mixed Light
Canopy square-feet (sample average)	8132	4869	2058
Yield Per Plant (lb)	2.484	0.588	0.875
Price Per pound ($/lb)	1402	2275	1575
Revenue			
Flower Revenue	$221,860	$574,932	$234,000
Trimmings Revenue	$1,757	$3,737	$1,481
Total Revenue	**$223,617**	**$578,669**	**$235,481**
Expenses (net of mgmt and risk)	**$104,989**	**$157,438**	**$122,398**
Net return to management and risk	**$118,628**	**$421,231**	**$159,658**

3.2.1 Outdoor Cultivation

Outdoor cultivation is the most common production method, especially in areas with open land and mountainous topography. This includes the Emerald Triangle composed of Humboldt, Mendocino, and Trinity counties. Other counties across the state also have excellent conditions for growing outdoors; however, some of the practices and growing conditions may vary based on location. Outdoor cultivation is limited to one annual season, starting around February and running through harvest in October and November. Earlier planting results in larger plants, while planting later in the season results in lower yields. Outdoor cannabis can be grown directly in soil or in pots that allow the cultivator to move plants if necessary. Plants are grown in varying outdoor settings with hoop structures utilized occasionally to prevent mold and mildew if the site experiences unexpected precipitation.

Since outdoor plants are permitted more time and space to grow, outdoor cultivators realize higher average yields per harvest. Average yields range from two to eight pounds per plant. Yield depends on spacing, shaping, harvest time, weather conditions, and additional methods practiced by each cultivators. Of the outdoor cultivators surveyed, the average canopy size is 8,000 square feet. There are roughly 73 plants, each of which yields approximately 2.5 pounds of cannabis. Using these parameters there is approximately 175 pounds of cannabis per harvest. Outdoor production sites range from 800 to 45,000 square feet and plants per operation vary from 20 to over 500.

Since quality and availability of outdoor cannabis fluctuates, the reported wholesale price is slightly lower than for cannabis produced by indoor and mixed light production. The market price ranges from $1,000 to $3,000 per pound with a consistent average of $1,200 to $1,400 per pound. This average considers the higher market prices in early summer before the market is flooded with product during fall harvest. Trim is typically sold for $80 to $100 per pound, although recent reports indicate trim prices are lower.

Outdoor cannabis cultivation has the lowest annual production costs. There are minimal startup costs, simple soil amendments added to the plants, and smaller additional costs associated with production. However, costs vary greatly by cultivator practices, regional climate, and distributor requirements. Startup costs can range from $5,000 to $10,000. This includes initial fencing, pots, security, soil, plant clones or seeds, irrigation systems, and potential hoop structures depending on location and climate. Soil amendments account for an additional $5,000 to mix essential nutrients into the soils. Most growers establish a foundation of worm casting, composts, bat guano, and other products to provide initial nutrients for their plant clones and seeds. Clone prices range from $5 to $25, while seeds can run in packs of 100 for $10 to $25. The grow- and bloom-stages of outdoor production generate average expenses of $2,000 and $1,500, respectively. The application of nitrogen, phosphorus, and potassium in addition to necessary soil amendments promote prime growing and flowering conditions to generate a quality product for consumption. Occasional costs associated with mite and mildew protection can be incurred

depending on climate and infestations. Additional expenses include irrigation and miscellaneous supplies needed for production. Water is typically drawn from a well, but in some cases cultivators depend on municipal, stream, or trucked in water. Other supplies include fuel, equipment costs, trimming machines, trimming materials, storage materials, and other miscellaneous supplies. The largest share of production cost is labor. Full time employees earn an hourly rate ranging from $15 to $30 per hour. Seasonal trimmers are, on average, paid $150 per pound of dry bud completed. It can take four to twelve hours to trim a pound of dry bud depending on the skill level of the trimmer.

3.2.2 Mixed Light Cultivation

Mixed light- means the cultivation of cannabis using light manipulation. Artificial light use shall not exceed twenty-five (25) watts per square foot. In general, mixed light greenhouses use artificial light and dark periods to transition the plants into growing and flowering more efficiently.

Greenhouses allow year round production and up to quarterly harvests. The natural light passing through the enclosed structures raises the temperature inside greenhouse facilities and generates enough heat for the plants to produce in the late winter and early spring. This heat, in conjunction with artificial light, enables more regulated crop cycles. Most operations are small, but anecdotal industry evidence suggests mixed light operations are expanding. In the cultivator survey sample, the average greenhouse is 2,000 square feet, although some cultivators have greenhouses over 30,000 square feet. Cultivators interviewed located in coastal regions that previously had extensive greenhouse operations are now transitioning into large-scale indoor cannabis production operations.

Shorter greenhouse seasons generate an average yield of 0.75 pounds per plant. Yield range varies from a 0.5 pound to 2 pounds per plant depending on the operation. A cultivator can get three to four harvests per year. In addition, mixed light producers also collect revenues from trim similar to outdoor operations. The average price for mixed light cannabis sits around $1,500 per pound, ranging from $1,200 to $2,400 per pound. This average price for mixed light is between that of outdoor and indoor cannabis products. Trim is also sold for a maximum of $100 per pound.

Mixed light production is more costly than outdoor cultivation. The higher costs are associated with startup, electricity, and labor. Greenhouse structures, depending on the size, can cost between $18,000 and $200,000, which is significantly higher than the costs of purchasing fencing, security, and soil for an outdoor operation. Some greenhouses also invest in pots and watering systems that add additional fixed costs. Electricity is a significant cost for artificial light and heat, especially during winter months. To produce light and maintain a constant temperature, cultivators can spend an average of $5,000 annually on electricity. Labor prices are also higher due to the greater volume of workers needed to run a year-round operation with multiple harvest cycles.

3.2.3 Indoor Cultivation

Indoor cultivation has expanded, particularly in urban areas, over the past several years. When done properly, Indoor production allows for an extremely controlled environment. The cultivator can control the artificial light, dark periods, grow mediums, moisture, temperature, and harvest cycles within each grow room. However, the controlled environment of indoor production does not come without risks and additional costs. Indoor production is very energy intensive and requires perfect replication of outdoor conditions. Based on cultivator surveys, the total cost of energy is the largest share of production cost. In addition, producing indoors increases the risk of mold, mildew, and pests. Just as indoor settings create a controlled, ideal environment for the plants to grow, it also creates a prime atmosphere for pests and parasites to infest the grow room. Cultivator diligence of biosecurity is required to maintain healthy crops.

The plant spacing indoors is more limited than that of outdoors or mixed light due to the confined nature of the canopy space. On average, plants may use between one and fifteen square feet. Closer spacing limits plant size and yield to a few ounces up to two pounds, averaging around a half pound per plant with multiple harvests per year. By controlling the light and dark periods of the plants, cultivators can average four harvests per year and up to six harvests maximum.[9] The average reported price across indoor cultivators surveyed equals $2,200 per pound, however it is important to note that many indoor cultivators produce direct-to-retail medical cannabis, thus this price may partially conflate retail margins and wholesale price. Trimming byproduct is also sold for manufacturing.

The cost to produce cannabis indoors is higher than outdoor or mixed light production. Additional costs include creating an indoor grow room, maintaining a stable environment, and year-round extensive labor and energy. In the event of a pest, mildew infestation, or lighting complication, entire crops can be lost. There is a significant upfront cost associated with creating an indoor grow room. These costs can entail building a facility or converting a storage area into a cultivation friendly environment. Costs to gather building supplies, ducting, light bulbs, installation, irrigation systems, security systems, soil, and miscellaneous supplies may exceed $400,000. Electrical costs vary greatly, yet are necessary for an indoor cultivation operation. The sample average of indoor cultivators shows that the average 4,800 square foot facility with four harvest cycles has an annual electrical cost of $14,000. The monthly electrical bills vary based on the grow stage of the plants (dark periods vs. light periods) and the duration of harvest. Cultivators indicate spending between $500 and upwards of $5,000 monthly depending on size of operation and requirements of light being used each month. As with mixed light, indoor cultivation requires extensive labor for the multiple annual harvest cycles and the trimming needed at the end of each cycle.

[9] Note this refers to average annual harvests per square-foot of canopy, allowing for intensive rotation of plants between grow rooms/grow stages, as practiced by many cultivators.

3.3 Nursery Costs and Returns

Nurseries provide cannabis seeds and clones to cultivators and dispensaries for home growers. Depending on production technology and harvest rotation schedules, cultivators can require hundreds of clones at a time. In general, mixed-light and indoor cultivators with multiple cycles need more clones or seeds for each harvest, while an outdoor grow will only require one set of clones or seeds at the beginning of the season. Many cultivators rely on clippings to transplant their own clones and do not purchase regular rootstock from a nursery.

Cultivators will rely on nurseries for various strains of cannabis. It is hard to estimate exactly how many cultivators produce their own clones/seeds and how many purchase from the nursery market. Based on cultivator and nursery surveys, this analysis assumes that the percentage of production from nurseries is 75% for outdoor cultivators, 60% for indoor cultivators, and 60% for mixed-light cultivators.

The use of seeds and clones is split within the industry. Anecdotally, cultivators prefer clones to seeds due to ease of use, zero risk of male plants, and a faster flowering process. This results in a quick harvest with healthier, larger plants with reliable yields. However, some cultivators focus on the quality of product and use seeds as their sole source of plants. Some cultivators who use seeds believe that a cannabis plant is not meant to live more than a year, and by taking clones, the process might be impacting the quality and longevity of the plant product. These cultivators prefer the use of seeds so that a new plant is used during each harvest. Some cultivators even take it upon themselves to experiment with different seeds to create a plant that meets the needs of their market niche. This study assumes that of the cultivators relying on nurseries, 75 percent of cultivators use clones and 25 percent of cultivators use seeds.

Seed and clone prices vary by strain, reputation of nursery, genetic qualities, and quantity purchased. The price of clones ranges from $5 to $25 per clone, with an average around $20. The cost of seeds depends on the product genetics and the quantity of seeds sold. Seeds can come in packs of five, ten, twenty, thirty, and over five hundred seeds in a wholesale pack. The price for a pack of ten seeds can range from $10 to $105 dollars, averaging around $25. However, there is wide price variation.

Nurseries provide clones and seed to industry cultivators and for dispensary retail sale, therefore their production costs are different from that of a cannabis cultivator. It is common for nurseries to have several mother plants in different strains to generate clones. Other rooms mix male and female plants to encourage fertilization, leading to seed production. The clones are cut from new growth on a mother plant, dipped in a cloning gel or powder, and then placed into a foam block or other growing substrate. The roots grow and the snipping becomes an independent young plant. Proper lighting must be provided to the plants for the first two days of the cloning process. On average, nurseries administer some form of 18/6 (light/dark) periods to the clones.

The operating costs of a nursery are similar to that of a transplant nursery for conventional agricultural products. One difference is the additional materials needed specifically for cannabis production. The clone gel and powder is purchased in cans for roughly $7 to $12 and rapid rooting foam containers run about $0.97 each. One of the main costs of a nursery is electricity. Since it is important to have the appropriate dark and light time, electrical bills can exceed $3,000 a month. Additionally, full and part time labor is needed to conduct the cloning, seed collection, and maintenance of the operation. Based on estimates from other nurseries and limited input from cannabis nurseries, it is estimated that an average size nursery requires roughly two full time employees and four part time employees per year.

3.4 Cultivator Processing Costs and Returns

The Processing (Type 1P) license is for post-harvest processing. These entities will take possession of cannabis plants from cultivators to conduct some or all of the following: trimming, drying, curing, grading and packaging of medical. Type 1P licensees may only transport to licensed manufacturers and licensed distributors. This segment of the supply chain does not formally exist in the current market. Some cultivators contract with labor groups to help with trimming and harvesting, however, cultivators do not typically send product out to complete the harvesting process. This is primarily due to security concerns.

The processing licenses are loosely comparable to conventional agricultural labor contractors. For example, in the California strawberry industry, many growers will contract labor to pick and harvest the berries so they do not have to hire labor directly. In the case of cannabis, a service will be offered, but it will take place at a location licensed to the processing site owner. Under a processing licensing, the hired labor will not be permitted to conduct the service at the cultivator's grow location, but will be required to trim, dry, and cure the product at the designated processing location.

The processer will be a new addition to the cannabis supply chain. It is difficult to estimate the potential size of this sector post-MCCP regulation. Survey participants expressed concern about outsourcing cannabis processing activities. This analysis assumes that 20 percent of production will be processed using a Type 1P processor license. It is further assumed that the reduction in harvest labor cost to the cultivator is equivalent to the processor sales. In practice, the processor will make a margin, but given limited information about this sector, this analysis does not attempt to quantify the amount.

The Type 1P processor budget is assumed to be similar to a farm labor contractor, with the exception of having a permanent location to complete work. Major expenses include labor, overhead building expenses, electricity, transportation, and insurance.

3.5 Cannabis Demand

The Substance Abuse and Mental Health Services Administration (SAMHSA) works to minimize substance abuse and mental health issues across the nation. As part of their data

collection, SAMHSA administers an annual National Survey on Drug Use and Health (NSDUH). This survey targets households across the United States with respondents ages twelve and older. The data are a primary source of information for the agency to determine patterns and prevalence of substance abuse and mental health disorders. SAMSHA data are organized by regions containing multiple counties. Table 8 lists the 21 regions in California. Figure 2 displays a graphical representation of the SAMHSA regions.

Table 8 Included Counties by Region

Region	Description
Region 1R	Butte, Colusa, Del Notre, Glenn, Humboldt, Lake, Lassen, Mendocino, Modoc, Plumas, Shasta, Sierra, Siskiyou, Tehama, Trinity
Region 2R	El Dorado, Nevada, Placer, Sutter, Yolo, , Yuba
Region 3R	Sacramento
Region 4R	Marin, Napa, Solano, Sonoma
Region 5R	San Francisco
Region 6	Santa Clara
Region 7R	Contra Costa
Region 8R	Alameda
Region 9R	San Mateo
Region 10	Santa Barbara, Ventura
Region 11	Los Angeles
Region 12 R	Alpine, Amador, Calaveras, Mono, San Joaquin, Tuolumne
Region 13 and 19R	Imperial, Riverside
Region 14	Orange
Region 15R	Fresno
Region 16R	San Diego
Region 17R	Inyo, Kern, Kings, Tulare
Region 18R	San Bernardino
Region 20R	Madera, Mariposa, Merced, Stanislaus
Region 21R	Monterey, San Benito, San Luis Obispo, Santa Cruz

Figure 2 Map of SAMHSA Regions

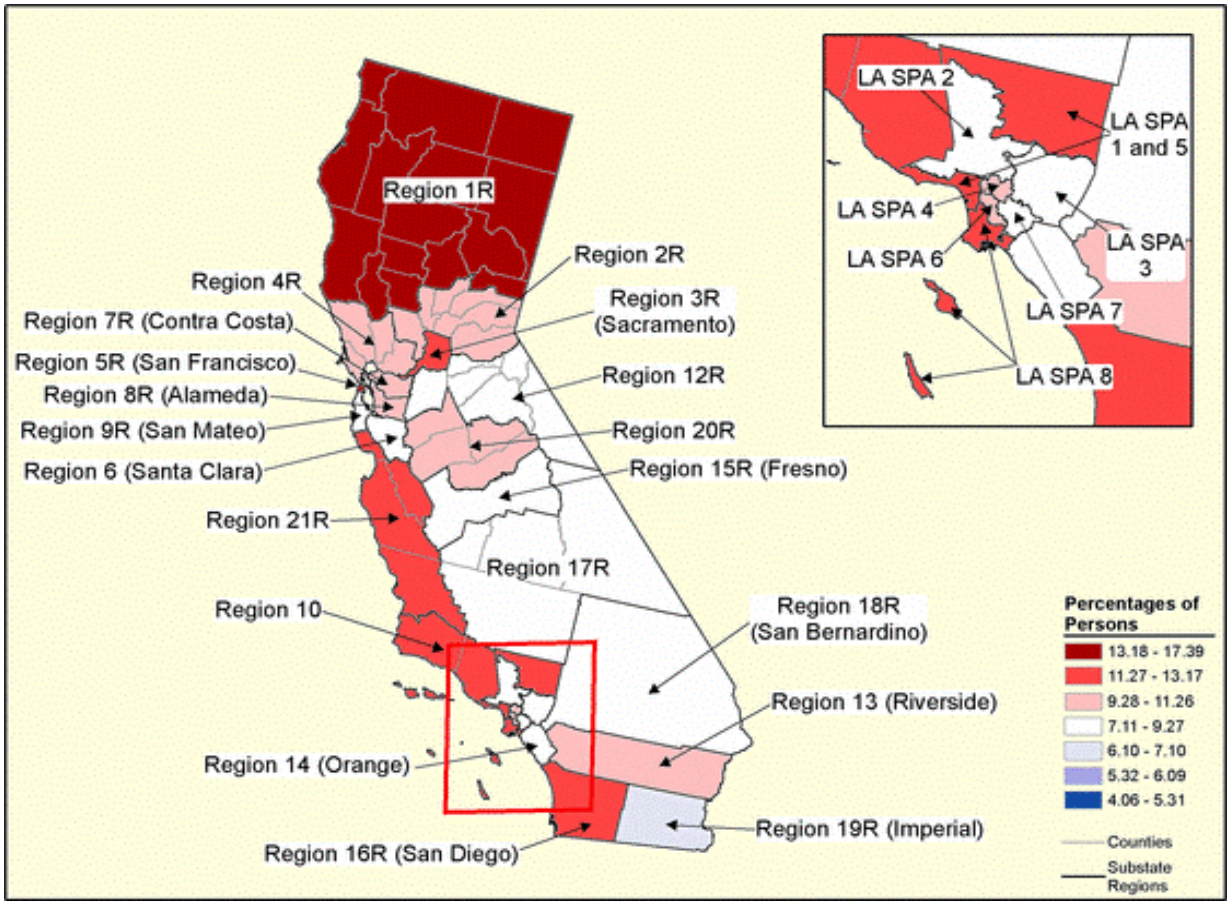


Table 9 shows the total population of each region using data collected from the Department of Finance (DOF) and the cannabis consuming population in each region from SAMSHA. For example, region 1R has a total population of 954,260 with 185,148 people consuming cannabis in the past year (just over 18 percent of the population).

Table 9 Population and Cannabis Use by Region, 2012–2014

Region	Total Population	Any Drug Use Past Month	Cannabis Use Past Year	Cannabis Use Past Month	First Use
Region 1R	954,260	150,735	185,148	133,351	23,753
Region 2R	1,041,849	145,449	172,003	115,549	25,958
Region 3R	1,495,297	182,256	234,809	152,375	37,736
Region 4R	1,337,759	185,429	235,450	151,766	33,477
Region 5R	866,583	168,676	195,474	133,983	16,878
Region 6	1,927,888	180,193	237,383	150,041	36,376
Region 7R	1,123,429	131,391	167,438	107,239	26,663
Region 8R	1,627,865	219,033	240,444	173,630	34,222
Region 9R	766,041	85,835	104,248	69,490	15,458
Region 10	1,303,225	156,237	204,506	133,258	38,625
Region 11	10,241,335	1,118,680	1,387,196	864,814	208,471
Region 12 R	886,084	103,559	119,283	82,238	21,207
Region 13 and 19R	2,533,659	258,268	302,353	202,427	49,516
Region 14	3,183,011	310,763	406,143	257,387	60,521
Region 15R	984,541	105,605	129,969	79,794	24,507
Region 16R	3,288,612	383,060	519,943	309,750	72,417
Region 17R	1,521,869	146,679	172,614	115,532	30,881
Region 18R	2,139,570	212,211	266,456	163,049	50,205
Region 20R	985,301	115,841	135,573	86,330	21,904
Region 21R	1,047,705	138,629	191,844	117,303	29,231
State Population	**39,255,883**	**4,508,894**	**5,622,171**	**3,608,938**	**852,653**

This analysis follows the approach Jacobi and Sovinsky (2016) applied to similar Australian cannabis consumption data. Namely, it is assumed that regular cannabis consumers have consumed within the past month, and casual consumers have consumed cannabis within the past year (difference between use in last month and use in last year). Assuming casual users purchase one-eighth of an ounce (3.5 grams) per month and regular users purchase three-quarters of an ounce (21 grams) per month, total annual cannabis consumption in California is between 2.2 and 2.6 million pounds. This analysis assumes that the quantity consumed equals 2.5 million pounds annually in California. Recall that the medical market is currently approximately 650,000 pounds. The residual is purchased within state in the illegal market.

3.5.1 Demand Elasticity

The economic impact analysis considers the demand for cannabis across four related market sectors: medical cannabis, in-state adult use, in-state illegal, and out-of-state illegal. The economic impact analysis is solely concerned with the medical cannabis market, but it is necessary to consider all cannabis markets simultaneously because consumers have the ability to substitute between different markets. That is, some consumers would consider purchasing

cannabis for medical use from the adult use or other illegal markets. As such, the resulting market price for medical cannabis depends on the demand for cannabis in the other markets and consumers' propensity to substitute between markets.

The own price elasticity shows the change in quantity demanded from a change in cannabis price. Cross-price elasticity of demand measures the demand responsiveness for a product given a change in the price of a compliment or substitute product. Income elasticity of demand measures the change in quantity demanded for a good from a change in consumer income level. Finally, a substitution elasticity measures consumers' propensity to substitute between different market segments. Thirty-six published articles attempting to estimate various cannabis demand elasticities were reviewed. The articles primarily cover American and Australian consumers across the time horizon of 1972 to 2015. This analysis puts greater weight on more recent studies. In particular, the article by Jacobi and Sovinsky (2016) is a recent publication in the *American Economic Review*, widely considered to be one of the top peer-reviewed economic journals, and this analysis uses the demand elasticitiy from that study.

Own price elasticity of demand ranges from -0.125 to -1.013. Most estimates fall into the range of -0.2 to -0.7 for primary consumers while new consumers of cannabis are considerably less price sensitive (Pacula et al 2001, Pacula 2010, Davis and Nichols 2013). This analysis uses a price elasticity of -0.2, consistent with Jacobi and Sovinsky (2016).The cross-price elasticity plays a significant role in consumer demand, but this analysis did not identify any defensible estimates. Consumers' willingness to purchase medical cannabis depends on the product price and on the prices of available substitutes and complements. Cross-price elasticity estimates vary considerably as some articles consider alcohol and drug substitutes to cannabis, while others claim the same products are complements. This is not a central parameter in this analysis.

3.6 Medical Cannabis Industry Baseline for SRIA

The current medical cannabis industry structure is one where medical cannabis is legal, but not regulated at the state level, and adult use adult use of cannabis is legal (as of November 8, 2016), but unregulated at the state level. As such, the cannabis industry is currently adjusting to significant changes in market structure. Currently, the economic cluster of medical cannabis producers, distributors, and ancillary businesses operate within a set of limited state and local regulations. For example, the current two-tier permit system requires distribution businesses to obtain local clearance and then state clearance. Distributors (dispensaries) are often structured as cooperatives where the members (patients) may purchase medical cannabis from the dispensary. These members may also grow some medical cannabis, some of which may be sold back to the dispensary. It is necessary to analyze the current state of the industry, and how the industry might adjust under adult use legalization, so that the effect of legalization can be separated from the effect of regulation.

This section establishes the baseline for the medical cannabis industry. With the legalization of adult use cannabis, the aggregate cannabis market has four market segments: medical, adult use,

within-California illegal, and export. Three producer types (indoor, outdoor, mixed light) supply the aggregate market with linked input from nurseries and processors. It is assumed that the share of any producer's supply to an individual market segment is equal their share of aggregate supply. That is, if outdoor producers supply 60% of total aggregate cannabis, then they supply 60% of the medical, adult use, illegal, and export markets. This is a simplifying assumption that can be relaxed in future analyses as additional data are gathered and cleaned by the ERA team, but it does not change the central conclusions of this analysis.

Legalization of adult use causes three adjustments across cannabis market segments. First, legalization of adult use is likely to result in an increase in aggregate cannabis demand. This is in response to bringing new consumers to the market, increased cannabis tourism, and related effects. It is likely this is a small shift. Adult use legalization also causes significant substitution by cannabis consumers between market segments. It is likely that some current illegal within-California market segment consumers and medical consumers will shift to the adult use market. This is likely to be a sizeable shift, however due to consumer tax savings (e.g. exemption from the AUMA sales tax) it is likely that some medical cannabis consumers will remain in the medical market segment. Finally, there will be a simultaneous increase in supply as new cultivators enter the adult use market and in response to a decrease in the risk premium (effectively, a decrease in production cost). The net effect considered in this analysis is that the price falls across all market segments, quantity consumed in the medical cannabis market shrinks, and total quantity consumed across all within-California market segments increases.

Starting with the pre-AUMA market equilibrium, there is an equilibrium wholesale price of approximately $1,600/lb and a gross within-California consumption of 2.3 million lbs per year. The export market price is higher, averaging closer to $2,000 per lb. The net effect of adult use legalization, following the adjustments described above, is an increase in within-California consumption to 2.5 million lbs per year and a reduction in the average wholesale price to $1,500/lb. Total quantity consumed in the medical market decreases from 0.65 to 0.25 million pounds per year. Adult use market consumption equals 1 million pounds annually. Illegal within-California consumption decreases from 1.65 to 1.25 million pounds, and the export quantity is assumed constant at 11 million lbs per year. In short, the SRIA baseline for proposed MCCP regulations assumes total medical cannabis equals 0.25 million pounds per year at an average wholesale price of $1,500 per pound.[10] The baseline 12 month period is defined as January 2018 – December 2018, reflecting implementation of the proposed regulations.

[10] Note: it is unconventional to establish new market equilibrium, where an entirely new market segment has been introduced, and then layer on the incremental effect of regulations. However, this analysis is specifically focused on MCRSA regulations, and not AUMA regulations, thus this unconventional approach is necessary. It is likely that MCRSA and AUMA regulations will be considered simultaneously in future analyses, and this inconsistency can be explicitly addressed.

4. Cannabis Cultivation Risk Premium

Cannabis cultivation is characterized by production, safety, and legal business risks. Every business accepts some level of risk as part of their standard business model. The cannabis business is unique because it has historically been an illegal market. Even with a trend towards decriminalization at the state level, it remains illegal at the federal level, and businesses typically operate in cash. Because of these risks cannabis businesses require a premium above the standard gross margin for a comparable legal business. This is known as the risk premium. Under legalization and regulation, the risk premium decreases making cultivators more likely to participate in the regulated market.

Using federal eradication data, Gettman (2006) estimates that eradication programs (prior to 2005) resulted in the seizure of 8 percent of all outdoor cultivated cannabis plants and 2 percent of all indoor cultivated plants. This study assumes the eradication rate is 8 percent for outdoor cultivators, 2 percent for indoor cultivators, and uses a mid-point of 5 percent for mixed-light cultivators. These estimates are largely in-line with results of the in-person and online cultivator survey conducted for this analysis, which found that approximately 2% to 3% of participants had experienced loss of production due to eradication, but approximately 10% reported that they knew of someone that had been eradicated.

The cannabis market is characterized by relatively low barriers to entry, where cultivators produce a (relatively) homogenous product, consumers have access to product information, and no one producer has a large share of total production. In this type of perfectly competitive market under full legalization, the long-run profit margins must decrease up to the point that cultivators are earning a normal return on investment. The short-run profit margins that have characterized the industry for the last several decades are attributable to other factors that will be affected by new regulations.

A defining feature of cannabis cultivation—historically and currently—is significant security, legal, and production risks. Cultivators risk jail time and fines if they are caught, and have other security risks from managing a cash business. Economists and financial analysts use the concept of a risk premium to explain the difference between the expected value of a risky asset and the return on a risk-free asset. In the context of cannabis cultivation, the risk premium is the difference between the rate of return on the risky (current) market structure and the (hypothetical) return on risk-free production.

All of the cultivators surveyed and interviewed for this analysis indicated there are significant production risks. The premium is most pronounced for the illegal export market, where most respondents who serve this market indicated there is a significant mark-up. The additional costs included paying for transportation, drivers, safe houses for the driver and product to be secure while driving cross country, and at least $25,000 to $50,000 on standby for bail and lawyer fees if the shipment was intercepted by law enforcement and the driver arrested. When shipments are

intercepted, the costs can exceed $10,000 to $30,000 per incident on bail and lawyer fees for the drivers involved, plus loss of product and loss of future business.

In addition to risks from moving cannabis across state lines, there are production risks to cultivators that participate in the current legal medicinal market. Losses due to theft (or general "leakage") can average 2 percent of harvest costs, according to several cultivators interviewed for this analysis. More experienced cultivators (especially indoor/greenhouse cultivators), who reported having more established and trustworthy networks of distribution, appeared to have more cautious approaches to their business relationships, and more security given the higher investment and operating costs for their cultivation sites and that these cultivation sites were their primary sources of income. There is also a risk of being raided by law enforcement. Medical cannabis cultivators in El Dorado, Mariposa, Butte, and Yolo Counties reported that they were subject to multi-agency raids within the past 24 months, although all were in compliance with local permits. Most reported that the raids were the result of being reported to authorities by neighbors, and that even if local authorities decline to investigate because the cultivators are properly licensed, other agencies can initiate the raid.

Legalization and regulation can result in a decrease in the risk premium. Cultivators with operations in Butte and El Dorado counties that also manage farms in southern Oregon reported that the industry has seen a decrease in law enforcement raids (for legal cultivators) and a decrease in theft as a result of tighter security measures.

4.1 Regulatory Risk Premium

The reduction in risk premium to legal cultivators in the regulated market is partially offset by the high costs of compliance within the regulated market. Concurrent with the increase in regulatory costs for cultivators, the price in the market is falling as more businesses enter and production increases. This effectively squeezes cultivators on costs and revenues, and makes the regulated market less attractive. Cultivators that are unable to afford compliance standards in a saturated market (particularly as legal adult use cannabis comes online) may consider staying in the illegal market. This decision is an example of the regulatory risk premium.

An additional component of the regulatory risk premium is the probability of being out of compliance, fined, jailed, or losing a cultivation license. For example, failing to properly track and trace product, having a batch that fails testing, failing to meet water quality or pesticide requirements, or failing Division of Occupational Safety and Health (DOSH or Cal/OSHA) requirements can result in costly loss of business and fines. Even well-intentioned cultivators risk being out of compliance and facing a fine. The regulatory risk premium is jointly determined by the risk of being out of compliance with regulatory requirements and the cost of being found to be out of compliance.

It is difficult to calculate the regulatory risk premium for a historically illegal industry for which limited data are available. This analysis assumes that the regulatory risk premium is equal to the

probability of being out of compliance multiplied by the violation fine, $100 to $5,000. It is not possible at this time to estimate the probability of being out of compliance with medical cannabis cultivation regulations directly. Instead, this analysis considers non-compliance by conventional agricultural producers with Cal/OSHA and other agricultural employer requirements. These requirements also apply to medical cannabis cultivators, and as such, represent a component of the regulatory risk premium.

The Labor Enforcement Task Force (LETF), which operates under the direction of the Department of Industrial Relations, is a coalition of California State government enforcement agencies that work together and in partnership with local agencies to enforce labor compliance, including on agricultural employers. LETF reports that 42 percent of site inspections result in a violation and fine, meaning the business is out of compliance with labor regulations.[11] However, most of these violations are minor in nature. The probability of a major violation, resulting in a significant fine, criminal charges, or shut down of the business, is less than 10 percent.

5. Direct Costs and Benefits of MCCP Regulations

This section summarizes the direct costs and benefits of medical cannabis regulations to cultivators and ancillary industries. As discussed previously, direct costs to cultivators to comply with MCCP regulations result in purchases from other sectors of the economy. These benefits and costs accrue to different businesses.

The cost of MCCP regulations to cultivators summarized in this section represents the additional incremental costs of the regulations. For example, if an MCCP regulation is already part of standard industry production practices, then there is no incremental cost attributable to the regulations. This ensures that the analysis evaluates the incremental additional cost of MCCP regulations, as required in a standard economic impact analysis. Also, as stated before, this economic impact analysis considers a point-in-time (annual, 12 month) comparison of the baseline to the with-MCCP regulations market. Following presentation of direct regulatory costs, the EDM model is used to estimate the effect of MCCP regulations on the medical cannabis industry.

5.1 MCCP Agency Fiscal Cost

The MCCP is tasked with issuing medical cannabis cultivation licenses and administering all aspects of the medical cannabis cultivation regulations. The total annual agency budget of approximately $16 million includes both medical cannabis and adult use. Medical cannabis-specific program costs are summarized in Table 10.

[11] https://www.dir.ca.gov/letf/letf.html

Table 10 MCCP Annual Operating Budget ($ thousands)

Item	Annual Program Cost
Total MCCP Personnel Services	$982
Operating Expenses	
External services	1,706
Equipment and Vehicle	27
All other	378
Total Operating Expenses	2,111
Total Annual Operating Cost	$3,093

The budget detail is broken-down by MCCP staff costs, other MCCP costs, and external consulting and technical services costs (including the track and trace program). The total operating of the MCCP and AUMA programs are estimated to equal $16.1 million once regulations are in place and licensees are being issued. This analysis assumes the MCCP budget represents the market in equilibrium post-MCCP regulations. The MCCP share of the total operating budget is equal to the proportion of the medical cannabis to the total (legal) market. The total annual operating budget equals $3.1 million and these costs are recovered through application and licensing fees charged to cultivators.

5.2 Other Agency Costs: Enforcement

The MCCP is tasked with enforcing MCCP regulations for licensed cultivators. This includes site inspections and ensuring compliance with all licensing requirements including the track and trace system. In addition, MCCP has the authority to enter into cooperative agreements with agricultural commissioners to carry out the provisions of MCRSA, including, administration, investigations, inspections, licensing and assistance pertaining to the cultivation of medical cannabis. MCCP enforcement staff will also be responsible for forwarding complaints about unlicensed operations to appropriate state and local law enforcement. MCCP staff will not independently investigate these claims, but will liaise as appropriate with law enforcement to help them identify and follow up on illegal grows. This may result in an increased cost to local law enforcement, however getting licensed cultivators to report unlicensed operations, thereby decreasing industry supply and keeping the price high, is critical to prevent the expansion of illegal cultivation.

There are significant enforcement costs that will fall to various local agencies. It is not clear at this time how they will be affected, but some increase in fiscal cost to local agencies must be factored into the analysis. A survey of the literature on enforcement costs generates some parameters. Gieringer (2009) and Caulkins et al. (2010) estimate the cost of cannabis enforcement in California under recent historical conditions.[12] The Drug Enforcement Agency

[12] Proposition 64 decriminalizes cannabis in California, the enforcement costs available are for historical years only.

(DEA) reported expenditures in California of $5,368,410 in 2015, resulting in the eradication of 2,643,708 plants (DEA 2016). This includes expenditures on some local law enforcement, although other agencies incur additional costs not included in the DEA budget. The cost per plant equals $2.03. Local eradication and enforcement can include federal agents from the U.S. Forest Service, the Bureau of Land Management (BLM), the National Park Service, the Drug Enforcement Administration, the Department of Homeland Security, and the U.S. Fish and Wildlife Service. California state and local law enforcement officers also participate in eradication, including sheriffs, California National Guard, and local agencies. Boehm (2011) testified that the average annual site cleanup for an illegal outdoor grow exceeds $15,000, or $1 to $2 per plant.

It is likely that more illegal grow sites will be reported and local agencies will need to allocate more resources to eradication. However, because legal cultivators will be licensed by the MCCP it will be easier for local agencies to identify illegal grow sites and the cost per eradication will likely decrease. In summary, this economic impact analysis assumes that the total compliance cost will increase, but the effectiveness of enforcement per dollar spent will also increase. The net effect on local expenditures due to the MCCP is indeterminate, but likely small. This analysis uses a mid-point cost of eradication equal to $3 per plant, which is assumed to be inclusive of all incremental eradication/enforcement costs, and assumes that eradications increase by 15 percent over 2015 levels (2.6 million plants) under a regulated market. The total increase in enforcement costs equals $1.189 million. This cost is borne by local law enforcement agencies, but this analysis does not attempt to identify which agencies or the likely geographic location. These questions are beyond the scope of the current analysis, but can be addressed in future studies.

5.3 Medical Cannabis Regulations

Table 11 summarizes the expected, average, regulatory compliance costs for indoor, outdoor, cottage, mixed-light, nursery, and processing license types. The following sub-sections describe the regulatory compliance costs in detail, how they are calculated, and any regulatory components that were still under development at the time this analysis was finalized. For readability, Table 11 summarizes the average regulatory cost across all cultivator license types (sizes). The economic analysis considers each license type individually to account for economies of scale and to accurately estimate incentives to participate in the legal market. All reported costs are an incremental cost over standard production practices.

Table 11 Average Regulatory Costs ($/lb) by MCCP License Type

Industry	Outdoor	Indoor	Mixed Light	Nursery*	Processing
Amortized fixed costs ($/lb)					
Cultivation Plan	1.31	0.22	0.37	0.03	0.11
$5,000 Bond	0.08	0.01	0.02	0.00	0.01
BOE License	0.02	0.00	0.00	0.00	0.00
T&T Training	0.20	0.03	0.06	0.00	0.02
Local Permit / Business License	0.53	0.09	0.15	0.01	0.05
Cultivator application fee	0.13	0.13	0.13	0.00	0.01
Label printer	1.05	0.17	0.29	0.00	0.00
Weights and measures application fee	0.04	0.01	0.01	0.00	0.00
Operating expenses ($/lb)					
Cultivator License Fee (MCCP)	9.46	9.46	9.46	0.05	0.93
Local license fee	157.44	16.10	28.52	1.10	5.00
Cultivation Plan Update	3.30	0.55	0.92	0.08	0.32
Local Taxes*	10.60	15.83	11.89	0.17	1.73
T&T Annual Cost	1.65	0.27	0.46	0.04	0.16
T&T Tag and Bag Cost	0.21	0.78	0.54	0.45	0.18
T&T Labor Cost	10.59	3.54	4.15	1.06	1.22
Labor Compliance	12.10	2.01	3.39	0.29	1.17
Pesticide Compliance (training)	6.55	1.02	1.73	0.14	0.57
WQCB and DFW water compliance	13.64	2.05	3.49	0.34	1.35
Labeling requirements	6.49	6.49	6.49	0.05	6.49
Composting cost	0.37	0.28	0.33	0.00	0.14
Weights and measures annual cost	1.08	0.18	0.30	0.00	0.11
Environmental Compliance (EIR)	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Total regulatory cost ($/lb)	**$240**	**$60**	**$75**	**$4**	**$20**

*****Nursery costs are in dollars per plant.

Average annual regulatory compliance costs for cultivators range from $60 to $240 dollars per pound of medical cannabis produced. Outdoor cultivators experience the highest regulatory costs due to lower productivity per square-foot of canopy. This is because fixed regulatory costs—such as training time, paperwork, securing permits, and other local compliance costs—are spread over a lower quantity of total production. In contrast, indoor and mixed-light cultivators realizing up to four harvest cycles per year are able to spread regulatory costs over a greater quantity of production on an annual basis. The following sections summarize the regulatory compliance costs.

5.3.1 Surety Bond, BOE License, and Track and Trace Training

This section summarizes the regulatory costs for obtaining a surety bond, obtaining a Board of Equalization (BOE) license and general business license, and time spent completing the track and trace system training costs. These are one-time expenses that are directly or indirectly paid by the cultivator when establishing a legal business or applying for an MCCP license. These expenses are then amortized for inclusion in the annualized regulatory cost.

Cultivators must post a surety bond in the amount of $5,000. It cost the cultivator $30 to file the bond with the Secretary of State. Per the United States Small Business Administration, surety bond fees vary with creditworthiness. A surety bond can cost between 1% and 4% of the total bond amount depending on the creditworthiness of the bond holder (Weltman, 2016). This analysis assumes that mixed light, combination, and indoor have better credit and are assessed a fee of $150. Outdoor cultivators are considered riskier and pay a fee of $250. This is based on higher production risks outdoors from a less controlled environment.

The Board of Equalization does not charge a fee for registering a new business. It is assumed that this takes a cultivator owner one hour to comply with this requirement to prepare and file the requisite forms. This also includes time to fill out and file paperwork for securing a State of California business license.

Most track and trace systems require one full day of training for new users. It is assumed that the owner and one employee participate in the training. The opportunity cost of the training equals $640. The direct costs of the training are typically covered by the technology company, and are included under the annual expenses category. Annual operating expense compliance costs for the track and track system are included under the Track and Trace section below.

5.3.2 Local Permits

Another significant one-time expense is the local permit.[13] Local agencies are updating current ordinances pertaining to the regulation of medical cannabis cultivation and consumption. Cultivators are required to comply with local ordinances to obtain a MCCP license. Counties listed in Table 12 are registering medical cannabis cultivators through an application process. Each county has different regulations, application requirements, and processing fees. The data compiled for this table comes from county websites, ordinances, personal communication, and application forms.

Table 12 summarizes the current fees for each production type within each county ranging from $100 to over $9,000. These costs can include additional addressing, inspection, and processing fees. The average cost to register as a personal ($2,235), caregiver ($2,247), and commercial ($3,348) cultivator are also identified.

[13] In some counties this is an annual expense.

Table 12 Registration Fees by County, 2016/2017

County	Personal	Caregiver	Commercial
Calaveras	$100	$200	$5,000
Humboldt	$2,154	$2,154	$5,162
Mendocino	$180	$180	$180
San Luis Obispo	$380	$380	$380
Santa Cruz	$500	$500	$500
Sutter	$320	$320	$320
Trinity	$5,000	$5,000	$6,000
Yolo	$9,242	$9,242	$9,242
Average	**$2,235**	**$2,250**	**$3,350**

In addition to application or registration costs, some counties charge an additional fee based on gross receipts or square footage. Businesses are also required to hold a business license and pay local taxes. Any charge per square foot of production area varies by county, as shown in Table 13. The fee for outdoor production ranges from $1 to $25 per square foot with an average cost of $6.12. Indoor has the highest average square foot fee of $8 while mixed light is $7 per square foot. These collected fees are distributed to different county funds as indicated in each ballot measure, ordinance, or application form.

Table 13 Per Square Foot Cultivation Charges by County

County	Outdoor	Indoor	Mixed Light
Calaveras	$2	$5	$2
Humboldt	$1	$3	$2
Lake	$1	$3	$2
Monterey	$25	$25	$25
Yolo	$2	$2	$2
Average	**$6**	**$8**	**$7**

Local fees will be levied in addition to any fees levied by the state. Cultivators will be required to pay local business taxes (and additional taxes) in the counties where their farms are located. As described in the previous section, counties are still deciding on local taxation policy. A flat rate of 0.75% is used in this analysis. This analysis additionally assumes that the local cultivator fee is equal to 3 dollars per square foot of canopy, although as noted, some counties are considering significantly higher fees.

5.3.3 Application and Licensing Fee

Cultivators are required to pay a license application fee as well as a license fee if their application is approved by the MCCP. The application fee is a one-time expense due upon submission of the application, and the license fee is an annual expense for initiating/renewing the

cultivator license due before the license is issued. The MCRSA allows the MCCP to collect application and licensing fees that are sufficient to cover MCCP costs. The MCCP has the authority to periodically update the application fee and licensing fee schedules.

The structure of the application and licensing fees affects the incentive for cultivators to apply for different license types, and the corresponding economic impact of the regulations. For example, a flat fee per square foot of canopy does not acknowledge important differences in production technology and productivity. Outdoor cultivators typically harvest once per year, whereas indoor and mixed-light cultivators can realize three to five harvests per year. Higher productivity per square foot of canopy dilutes the cost of the application and licensing fees. Simply put, a flat fee structure would incentivize large-scale indoor and mixed-light cultivators with higher productivity per square foot of canopy, and provide a strong disincentive to small-scale and outdoor cultivators. However, at the opposite extreme, charging cultivators a licensing and application fee based on their realized total production would stifle innovation and productivity growth by penalizing the most efficient businesses. An efficient and equitable fee structure must consider these incentives to cultivators.

This economic impact analysis sets the licensing and application fees using a two-step procedure. First, the total cost of the MCCP program is calculated from the estimated MCCP program budget and divided by the total estimated medical cannabis market size (in lbs) under the industry baseline. Conditional on the MCCP budget and amount of medical cannabis produced on the market, this represents the average cost of the MCCP program per pound of medical cannabis that must be collected from cultivators in order for the MCCP to cover program costs. Next, the average productivity for each license type is used to calculate the total application and license fee for each cultivator license type.[14] This fee structure favors small and large cultivators equally.

It is assumed that a significant number of applicants will apply for a cultivator license in the first few years of the MCCP licensing program. Once the industry settles into the new market structure, it is likely that the number of new applications will drop (or reach some steady-state trend) and most of the MCCP operating fees will be recovered from the annual license (renewal) fee. The impact analysis is only concerned with the regulated market in equilibrium. This analysis assumes that there will be 10 percent annual turnover in the medical cannabis market once the market has reached a post-regulation equilibrium.

The MCCP also issues nursery and processing license types. Nurseries and processors serve different markets and have different production practices than standard cultivation license types. Since it is not possible to charge nurseries and processors per pound of medical cannabis "produced," application and license fees are allocated based on the share of nursery and processors in the industry. It is assumed that processers will handle 20 percent of the total

[14] Productivity is equal to the average annual yield per square foot of canopy multiplied by the maximum allowable canopy space for each license type.

average annual harvest, consistent with custom harvesting services for fresh fruit and berries. It is assumed that nurseries supply dispensary retail sales and approximately 60 percent of the total commercial cultivation market, of which 25 percent is seed and 75 percent is clones. This implies that nurseries (T4) and processors (T1P) comprise approximately 5 and 10 percent of the total market by value, respectively

The total operating budget of the MCCP that will be covered by the license and application fees equals $3.1 million dollars annually. The total size of the medical cannabis market—after accounting for adult use legalization—equals approximately 250,000 lb per year (see Section 3.6). It follows that the MCCP licensing and application fees must recoup costs equal to $10.55 per pound from Type 1, 2, and 3 license types (excluding Type 1P). This total cost will be split between one-time application fees and annual licensing fees. Following the assumption of 10 percent annual turnover in the market once the market is in equilibrium, this analysis sets the application fee equal to 10 percent of the total per pound cost. That is, the application fee equals $1.05 per pound and the licensing fee equals $9.50 per pound. Note that this fee is charged on the basis of average pounds produced for that license type, not on annual actual production. Table 14 summarizes the one-time application fee and the annual licensing fee for each license type, and the annual license fee expressed as a percentage of annual operating costs.

Table 14 License and Application Fee Summary

Cost	Type 1	Type 1A	Type 1B	Type 1C*	Type 2	Type 2A
Application fee	$130	$1,065	$550	$150	$265	$1,930
License fee	$1,185	$9,600	$4,970	$1,350	$2,370	$17,390
(License fee as % of total cost)	1.2%	1.3%	1.2%	$0	1.2%	1.3%

Cost	Type 2B	Type 3	Type 3A	Type 3B	Type 4	Type 1P
Application fee	$1,105	$760	$4,250	$2,430	$60	$310
License fee	$9,940	$6,870	$38,260	$21,860	$560	$2,785
(License fee as % of total cost)	1.3%	1.6%	1.5%	1.9%	0.3%	0.5%

Note: all numbers rounded.

* Type 1C is averaged over indoor, outdoor, and mixed-light options.

The number of licenses issued annually can be approximated for a total market size of 250,000 pounds by dividing the average annual yield of each cultivator license type into the total market quantity.[15] Using an average annual yield across all cultivator license types, 212 businesses would be able to supply the entire market. If only small cultivators enter the market then the total number of licenses would equal 2,000. The minimum number of large-scale cultivators required to supply the medical cannabis market is 62. All of these calculations assume that each cultivator

[15] Note that the total quantity on the market of 250,000 pounds is in terms of flower equivalent and includes manufactured (oils, edibles, concentrates, and other derived products).

produces up to the maximum total canopy size allowed for each license type. These calculations have not considered the potential for businesses specializing in supplying different segments of the market (e.g., manufactured products), operating at less than the maximum capacity of the farm, or for turnover in the industry (assumed at 10%). As such, a plausible range for total number of MCCP licenses once the market is in equilibrium is 500 – 2,500.

5.3.4 Cultivation Plan

Cultivators are required to develop and submit a cultivation plan that must be approved by the MCCP. The cultivation plan is essentially a business plan that outlines key elements of the cultivators operation. It must summarize specific production practices, hazardous material handling, layout of the facility including canopy space, and general business practices. This analysis approximates the regulatory compliance cost of the cultivation plan based on the cost of preparing a standard business plan. The cost of preparing the plan equals $3,240 for Type 1 license types, $2,592 for Type 2 licenses, and $4,050 for Type 3 licenses. The cost to prepare the cultivation plan for nurseries and processing licenses is equal to the small/Type 1 cultivator cost. This is a one-time cost to the cultivator.

The cultivator is required to keep the cultivation plan up to date and resubmit to the MCCP as part of an annual renewal process. The cost of maintaining the cultivation plan to stay in compliance equals $640 per year for all cultivator types. This includes 16 hours of owner time valued at $40 per hour. If business practices change throughout the course of the year, this update cost will be higher. It is also important to note that these costs are additive. That is, if a cultivator holds multiple license types they will be required to prepare separate cultivation plans, each with a cost as described above.

The cultivation plan compliance costs used in this economic impact analysis were compared to standard business plan costs. The cost of creating a business plan for a small farming operation varies with the time, money, and outside resources utilized by the principal owners. In general, services for a basic business plan can cost $500 to $1,000 (SBA, 2016). A cultivation plan requires more details about day-to-day operations of the farm than a standard business plan, and as such costs more to prepare and maintain.

5.3.5 Track and Trace

Licensed cultivators are required to comply with track and trace system requirements. Traceability requirements include full transparency of all commercial cannabis activities. In general, a cultivator is required to track each plant from seed/clone to final transfer to a distributor, manufacturer, or retailer. Tracing is expected to start by the seed or clone immature lot of no more than 100 plants receiving a lot unique identifier (UID). Once the plant becomes mature, an individual UID is allocated to each plant throughout the remainder of the growth and bloom cycle. When the plant goes to flower and post-harvest handling occurs (trimming and drying), a new UID is created for the harvest batch which includes the plant(s) UID(s) as well as

the immature lot UID(s) for all product included in the final bag. The track and trace program includes all plant material eventually consumed, including flower, leaf, and shake that go for manufactured product.

There is support for current precedent of traceability in agricultural systems. In response to tomato, pepper, cantaloupe, lettuce, and pistachio food borne illness outbreaks, the United States Food and Drug Administration (FDA) has increased focus on tracing food products from cultivation to final distribution (Pouliot and Sumner 2010). More recently, Section 204 of the Food Safety Modernization Act (FSMA) includes requirements for improved food traceability and the FDA is investigating the economic feasibility of alternative systems. There are some supply chain similarities and differences between conventional agricultural product tracing and cannabis product tracing that affect the costs and benefits of implementing a traceability system. However, this analysis will focus primarily on the cultivator requirements.

The Metrc system is being used in Colorado, Oregon, and Alaska (Metrc 2016). Other systems include BioTrackTHC and Leaf Data Systems. The central concept is similar across all systems — cultivators are required to tag individual plants and/or batches and record information in an online tracking system. This analysis bases the direct cost of cultivator compliance on the Metrc system. Although not currently determined by MCCP, for the purposes of this analysis, this assumes that Radio Frequency Identification (RFID) technology is used (Denholm, 2016). Cultivators are required to track and trace every lot of seeds and propagative materials, and every individual plant. The cost of the monthly service fee is approximately $40, generating a $480 annual expense. The cost of a plant tag is $0.45 and the cost of a lot/bag tag is $0.25. The tags are not reusable.

There are two main RFID types utilized that differ based on the level of tracking need. The first, passive RDIF, harnesses the ability to store and transmit data without a power source (Coustasse *et al.* 2013). This RFID technology allows for groups of product and tags to be ready from approximately 18 inches to 30 feet away (Coustasse *et al.* 2013, Sparling *et al.* 2011). The lack of power source makes the chips cheaper when used to identify product. The second, active tag, transmits information up to 300 meters using an integrated battery. This is useful when having to track a product in real time and monitor production progress, as in the cattle industry. Battery operated RFID read range can be up to 300 feet. Both active and passive read ranges can be significantly less if attached to products with water or metal (RFID Journal, 2016).

Track and trace system implementation cost can be broken down into capital and variable expenses. Capital expenses are upfront (or periodic) capital outlays on software, computers, scanners, and other equipment. Variable expenses include management of the system, record keeping, repairs, and general day-to-day operations. Following Metrc (2016) up front capital expenses for a representative track and trace system include a full day of system training for an administrator and second employee as well as office hardware (computers, internet access, scanners and other electronics). Mejia et al. (2010) reported hardware costs of $2,750 (computer

and hand held scanners) for implementation of traceability systems in the food production-packing-shipping sector, a sector that has some similarities to cannabis production. Variable expenses include the opportunity cost of employees' time for managing the tracking system, employee requirements to complete continuing education on the program (in-person training or webinars) and the cost of plant and bag tags with RFID technology. It is noteworthy that, unlike in conventional agriculture and other industries, there is no precedent for track and trace systems in California cannabis production.[16]

The administrator of each designated track and trace system will enter data into the system that fully accounts for all commercial cannabis activities. This includes documenting the removal of plants from production, product that fails testing, and the transportation of product between locations and licensees. Additionally, cultivators will be required to reconcile all cannabis when it is moved. .

Track and trace systems may have other potential economic benefits for cultivators. Alfaro and Rabade (2009) show the potential for optimizing supply chain management in a case study of a fresh vegetable packer-shipper through increased efficiency, capacity utilization, and warehouse space selection. Mainette *et al.* (2013) also investigate the improved business process and consumer education of production history for fresh vegetable industry through the use of RFID. In addition, and of particular importance to the young and growing cannabis industry, track and trace systems offer the potential to identify the origin of medical cannabis. Much like the wine industry, areas which are known to have specific production conditions or strains with favorable qualities can demonstrate this to consumers. If consumers are willing to pay for these attributes, as some anecdotal evidence suggests, then the track and trace system offers a marketing benefit. More generally, investment in track and trace assures consumers of a safe and reliable product across the industry (Sparling et al. 2011).

It is critical to carefully balance capital and operational costs with the benefits of a track and trace system. In contrast to conventional agricultural industries where food safety is the primary concern, the purpose of track and track in medical cannabis is to limit leakage into the illegal market. If successful, this is another benefit to producers by lowering the supply of illegal cannabis on the market and, all else equal, increasing the price of medical cannabis. Labeling Compliance

Cultivators will be required to follow labeling and packaging provisions for non-manufactured cannabis that is packaged for retail sale at the cultivation site . Any product that will be transferred between the supply chain for further processing, manufacturing or packing will not be subject to these regulations.

[16] One notable exception is a pilot system that is being implemented in Humboldt County, with early positive feedback from the county and industry stakeholders, see: https://www.humboldtorigin.org/.

The general labeling provisions have several components similar to those of other conventional agriculture and food products. First, labels are to be clear, listed in English, in relation to the size of the container, apply requirements of Business and Professions Code §19347, and provide the net weight and UID assigned by the track and trace system. In addition, the label shall not include claims that the cannabis was grown in California if it has not been produced within the state and the name of the California county will not be listed unless grown within the county. Lastly, immature plants and seed packed for retail sale will need to include a statement saying "this product has not been tested for pesticide residue in accordance with BPC §19344."

In addition to labels, cultivators will need to follow the guidelines on the packaging of non-manufactured cannabis products. The packed must protect the product from contamination and exposure to harmful substances. It will also need to be tamper-evident so the contents cannot be opened without obvious destruction of the seal. Packaging must be childproof and not imitate or resemble any package typically used for children marketed products.

It is assumed that cultivators must purchase a label printing machine for a one-time cost of $2,500. Labels cost $0.05 cents per label inclusive of staff time to operate the machine. It is assumed that the average sales size is one-half of an ounce (14 grams) and that the average cultivator labels 25 percent of production on site. Nurseries must label each plant as "non-tested" at a similar cost.

5.3.6. Weights and Measures

Cultivators that sell cannabis directly from the farm are required to comply with California Department of Measurement Standards (DMS) requirements. Cultivators are required to use a Class II license to weigh medical cannabis for retail. This ensures that the quantity sold is reported accurately and that both seller and buyer are confident in the accuracy of the transaction. For weighing larger amounts of medical cannabis—potentially as a cultivator at the farm—it may be necessary to purchase a different class of scale. Cultivators are required to purchase and register licenses with their local county agricultural commissioner office. Scale registration fees vary by county and by the size of the scale. A small scale may cost $20 to register, and larger scales can cost over $200. The business location fee of $100 covers the cost of each business location. It is assumed that a cultivator registers a small and large scale at a total annual cost of $220, and that the business location fee equals $100. Thus the total cost of compliance with this requirement equals $320 in the first year, and $220 every year thereafter. The owner time to prepare and submit a registration request is included in the economic cost of this regulation.

In addition to scale requirements, cultivators may need to register as weighmasters.[17] A weighmaster measures bulk commodities and issues a statement of quantity for purchase or sale of a commodity. The cost of registering a business is $75 for the owner and principal place of

[17] https://www.cdfa.ca.gov/dms/programs/wm/wmlicapp.pdf.

business, plus $30 for each additional location, and $20 for each deputy weighmaster. It is assumed that the owner and one employee are registered for one principal place of business at a total annual cost of $95. The owner time to prepare and submit a license is included in the economic cost of this regulation.

5.3.7 Labor Compliance

Labor compliance costs are the most significant direct regulatory cost (pesticide and water regulations are covered in a subsequent section). California regulations require cultivators to register as agricultural employers and comply with various existing regulations for conventional agriculture. This means cultivators must adhere to pesticide and water use requirements, in addition to arrange of other regulations that agricultural employers currently face. For example, compliance with California laws for agricultural worker safety, overtime, shade, water, and other safety requirements.

The current industry structure allows many employers and seasonal trimmers to work under the table, limiting exposure to taxes, social security, and other regulations. In some cases, annual employees are paid under another business entity, while most seasonal trimmers only receive cash for their services.

It can take up to twelve hours to trim a pound of dry cannabis, depending on the skill and ability of the trimmer. To regulate workflow and reward effort, many cultivators currently pay trimmers based on completed pounds of dried bud. This can range from $120 to $250 per pound. Monetary bonuses or final product are sometimes given to employees when quality and quantity are exceptional. Additionally, wages can be deducted with diminishing quality of work.

Regulations will require employers to report employees and pay applicable taxes. Table 15 summarizes average labor needs by cultivation method. These averages are heavily based on collected surveys and industry contacts. There is assumed variation within each production method in that the total FTE equivalent required ranges depending on size of operation, cultivator practices, number of harvests each year, and total product produced.

Table 15 Employment Requirements and Parameters for Each Production Method

Parameter	Outdoor	Indoor	Mixed Light
SQFT of Operation	8,132	4,869	2,058
Average Pounds Produced	211	346	238
Average Full Time Employees	2.3	2.6	2
Average Yield Per Full Time Employee	110	183	105
Average Hours per lb	9.6	9.9	9.8
Total Hours to Trim Pound of Cannabis	2023	3416	2332
Trimming Hours Full Time Equivalent	1	1.6	1.1
Additional Total Hours Needed for Set-Up and Production	183.2	96.1	96.2
Total Full Time Equivalent Jobs	**3.3**	**4.3**	**3.2**

5.3.8 Agricultural Employer

Cultivators are required to certify that they are an agricultural employer to receive a cultivation license. Operating as an agricultural employer means that there are additional record keeping requirements, labor requirements, wages, and other regulatory costs. At this time, it is not entirely clear how this requirement will affect cultivators. Cannabis cultivators will be required to comply with state and federal regulations relating to employee labor wage and health and safety.

The agricultural employer requirements, if applicable, will result in a direct economic cost to cannabis cultivators. For example, agricultural employers must conduct safety and heat illness prevention training for workers, provide adequate shade, provide single-use drinking cups for drinking water, and hand-washing facilities. Agricultural employers are required to hold team training meetings on regulatory compliance, as well as trainings for hazardous material handling, pesticide handling, and water quality compliance. Agricultural employers are also required to meet air quality management (e.g., dust control and limits on burning) and water quality requirements (e.g., water quality coalition fees and testing), as well as general record keeping for broader environmental compliance.

Employee health and safety requirements are often cited by conventional agriculture growers as a significant direct regulatory cost of being an agricultural employer. For example, the Heat Illness Prevention standard is mandated by the Cal/OSHA, and requires specific training and access to shade and water for outside workers. The requirements also cover an acclimatization period for new workers, high heat and emergency procedures, and require employers to develop written procedures and train employees in how to apply them. In 2010, the Cal/OSHA conducted a three-year campaign to publicize heat illness awareness, which highlights the compliance costs of this provision. The results of the campaign were summarized in a report by Teran (2013) to the California Department of Industrial Relations. The report identified several barriers that prevent workers from consistently following heat illness prevention practices. The main obstacle was the conflict between the recommended rest periods and the piece rate compensation structure, with workers being unwilling to stop for water or rest because they would be earning less. Both employees and employers reported that workers are less likely to stop for rest if they are working for piece-rate compensation. In some cases, workers paid by the hour reported not getting permission from supervisors to stop, drink water, and rest. In turn, the employers reported compliance with these regulations is costly, especially for employers with smaller operations.

Since cannabis is a new industry, a comprehensive study of the effect of agricultural employer labor regulations on cannabis cultivators has yet to be completed. Hamilton (2008) estimates that California citrus growers (farm managers/owners) spend an average of 100 hours per year attending meetings, educational workshops, and conducting safety training for employees. This primarily includes time to meet Cal/OSHA requirements. At an opportunity cost of $40 per hour, this equals a compliance cost of $4,000 per farm per year. These estimates are generally

consistent with labor compliance equal to approximately 3% of operating costs for conventional agriculture in California (Paggi et al. 2009, Noel and Paggi 2012, Noel et al. 2013). In addition to training time, there are direct costs of complying with worker safety laws, such as providing shade, breaks, time keeping, and other requirements. Hamilton (2008) shows these costs equal an additional $4 to $10 per acre, or approximately $500 per farm per year.

A key requirement of the Federal Fair Labor Standards Act is that an agricultural employer must average an employee's piece-rate earnings over all hours worked to determine whether that employee's pay meets the minimum wage requirement. Under this federal law, piece-rate earnings in excess of the minimum wage required to cover piece-producing time (PPT) may be applied to the minimum wage requirement to cover non-piece producing time (non-PPT). However, under California law, employers must fully pay for all hours worked, including non-PPT, at the regular hourly rate. Cannabis cultivators will be required to learn and comply with these requirements. The time spent tracking the different categories of time worked, as well as the uncertainty over what constitutes compliance with labor laws, generates an additional cost for employers and employees.

Overtime laws for California agricultural employers are evolving. AB 1066 phases-in agricultural workers under California wage and hour laws. Starting in 2019, agricultural employees must be paid overtime. Effective January 1, 2017, agricultural employers must adhere to meal and rest periods for employees specified in California Labor Code Sections 500 et seq. The law phases in the requirement between 2017 and 2025, at which point all agricultural employers will be subject to the changes in the law. Agricultural employers are required to carry workers' compensation coverage. These rates vary depending on the job classification (DOI 2016). This analysis uses classification code 0005 as a proxy, which includes nurseries for propagation and cultivation of nursery stock. The Department of Insurance (DOI) reports manual base rates between $5.13 and $15.15 per $100 in payroll (effectively, 5.13% to 15.15%). Actual rates charged will vary depending on safety record of the company and provider-specific adjustments. Agricultural rates are typically between 15% and 20% (Hamilton 2006). A rate of 15% is used for this analysis.

5.3.9 Employee Wages

Cannabis harvest labor is typically paid in cash under the table. Under MCRSA, cultivators will be required to have employees on payroll. Given the relatively elastic supply of cannabis farm workers, it is likely that cultivators will pass through a majority of these costs to employees, resulting in a lower wage.

This study assumes that cannabis farm workers for licensed cultivators receive the same pay as conventional farm workers, which currently equals $10.36 per hour (BLS 2016).[18] Direct overhead charges to the cultivator include workers compensation (15%), in addition to the employer's share of federal and California state payroll taxes (13.48%) and miscellaneous

additional benefits (11.52%) for a total overhead charge of 40% (UCCE 2016, BLS 2016, EDD 2016). Thus, the fully-loaded hourly rate for a licensed cultivator equals $14.48 per hour, slightly below the current cash (and not fully-loaded) wage rate paid to seasonal workers. This cost will escalate under the recently enacted labor laws described previously. Given specialization in trimming, and a potentially limited labor supply, it is likely that wages will be closer to vineyard harvest rates. These are closer to the cash wage currently paid in the industry of $20 per hour. This analysis assumes that the wage rate paid to cannabis workers is approximately equal to the current cash wage in the market. Thus the only regulatory impact is from working more (or fewer) hours, and owner time to comply with payroll and other taxes.

5.3.10 Pesticide Compliance

Cannabis cultivators are required to comply with pesticide application rules. In California, pesticides must be registered by both the U.S. Environmental Protection Agency (U.S. EPA) and the California Department of Pesticide Regulation (DPR) before they can be sold and used in California. DPR is tasked with developing guidelines for the use of pesticides in the cultivation of cannabis and residue in harvested cannabis. In general, the rules that cannabis cultivators will be required to follow for pesticide use and application are still being developed. Based on the federal limitations applied to cannabis, it is expected that the range of allowable active ingredients will be greatly limited.

Cultivators surveyed reported a range of pest management procedures. In general, there are some commonalities, but there is no current industry standard for pest management or chemical application programs. Cultivators will be required to comply with pesticide laws and regulations and DPR guidelines. In general there are three costs to cultivators from complying with pesticide requirements: (i) the indirect cost of time and materials to comply with paperwork, training, and other administrative requirements, (ii) the direct labor and operational costs of changing the chemical application program and (iii) the direct cost from yield and revenue impacts on cannabis production from chemical application changes.

The indirect cost of time and materials is defined as the employee and employer time for complying with pesticide requirements. For example, cultivators will be required to become educated on allowable practices, register with the local county agricultural commissioner, and eventually report their annual pesticide applications. Hamilton (2008) estimates these requirements amount to 8 hours of staff time in record keeping, reporting, and tracking requirements per month, or 96 hours per year, per farm. Owners must learn application requirements, train employees in safe handling, provide safety equipment, and comply with other local regulations. It is assumed that owners will spend an additional 40 hours per year managing compliance.

Changing pesticide management procedures also causes changes in operational costs resulting in a direct cost to cultivators. As noted previously, many cultivators use similar pest management approaches, but the application quantity and frequency vary by region due to varying production

technology, practices, climate, strains, and markets. It is likely that the direct cost of materials will decrease under the MCCP regulations because many chemicals cannot be applied. However, it is also likely that cultivators will need to invest more time in pest management, thus labor costs may increase. At this time, it is unclear if a change in standardization of production will result in a net increase or decrease of operational costs for cultivators.

It is likely that allowable chemicals will be less effective than the current chemicals that are being applied to cannabis. Less effective chemicals may cause lower yields or lower quality unless alternative pest management approaches are effective. Given cannabis pest and disease pressure, it is likely that the current (undefined) rules will result in a direct cost to cultivators from lower yields (or quality, or rejected batches). However, there is no way to assess these costs at this time.

It is important to note that conventional agriculture has experienced changes to the allowable chemicals through regulation. For example, strawberries have used the fumigant methyl bromide for over 20 years, and this is now being phased out and banned across the nation. Industries using methyl bromide, including berries, are working to identify other alternative fumigants, targeted injections, and alternative non-fumigant options that reduce costs and emissions (Meadows, 2013). Restricting methyl bromide resulted in a direct economic cost to the industry (Goodhue *et al.*, 2007).

5.3.11 Water Compliance

Cultivators are required to comply with regional and State Water Quality Control Board (SWQCB) requirements in order to obtain a MCCP cultivator license. The SWQCB is developing additional regulatory programs to address potential water quality and quantity issues related to cannabis cultivation. The concerns associated with cannabis cultivation include water supply issues (water rights), erosion and sediment, wetland and riparian impacts, soil additives, trash and human domestic waste, and unpermitted timer conversion (SWQCB, 2016). However, these regulations are not known at this time. The North Coast Regional Water Quality Control Board and the Central Valley Regional Water Quality Control Board have started issuing permits for cultivators under Order R1-2015-0023 and Order R5-2015-0113, respectively.[19,20] The cost of these permits is $1,000, $2,500, and $10,000 for Tier 1, 2, and 3 threats to water quality, respectively. If the cultivator joins a water quality coalition, the fee is reduced, but the cultivator pays the cost of joining the water quality coalition. This analysis assumes a cost of water quality compliance of $1,000 for each cultivator with 5,000 square-feet or less of canopy, and $2,500 for cultivators with greater than 5,000 square feet of canopy.

The Water Boards use a progressive enforcement system that allows for efficient use of available resources. For instance, minor violations may require verbal contact between SWQCB staff and

[19] http://www.waterboards.ca.gov/northcoast/water_issues/programs/cannabis/
[20] http://www.waterboards.ca.gov/centralvalley/water_issues/cannabis/index.shtml

a landowner where more serious violations, or lack of responding to previous violations, can lead to a Notice of Violation (NCRWQCB, 2016). According to the State Water Quality Control Board, the formal enforcement actions can include, but are not limited to, a Notice to Comply, required submission of technical reports, Cleanup and Abatement Orders, time schedule orders, or cease and desist orders (NCRWQCB, 2016). As of the publication of this report, no fines have been set.

Additional water quality regulations that apply to conventional agriculture, including the Irrigated Lands Regulatory Program, Central Valley Salinity Alternatives for Long-Term Sustainability, and other pending regulatory programs, may affect cannabis cultivators. The impact of these programs and the potential effect on licensing requirements is not known at this time.

Cultivators may additionally be required to obtain a 1602 permit from the Department of Fish and Game (DFG). The 1602 Streambed Alternation Agreement is required for production activities that modify a stream or affect the fish and wildlife resources around that stream. Cannabis cultivation—particularly outdoor cultivators in the northern part of the state—may be required to obtain a permit. If necessary, a cultivator will be required to survey the cultivation area, prepare an assessment, prepare a project summary, document CEQA compliance and provide documents, demonstrate RWQCB and United States Army Corps of Engineers (USACE) compliance, and submit all of these materials in an application. If required, the cost of the fee is tied to the cost of the proposed cultivation site development and the length of the agreement. In general, a short-term agreement for a standard cultivation site would cost between $561 and $704. A cost of $600 is used in this analysis.

5.3.12 Other Cultural Practice Compliance

Cultivators are required to comply with other miscellaneous cultural practices that result in a direct economic cost. These include other requirements that will be specified in the Environmental Impact Report that were unknown at the time this report was finalized.

One cultural requirement that is specified in the MCCP regulations is that cultivators must properly compost or dispose of post-harvest materials. Composting/disposal costs are calculated at 5 cents per pound of composting mixing materials plus 4 hours of staff labor time per harvest based on a phone survey of mushroom farms in California.

5.3.13 Administrative and License Violations

If a cultivator is in violation of provisions of the license they may have to pay a fine, forfeit a non-compliant batch of cannabis or could have their license, revoked, suspended or conditioned. It is important to evaluate the likelihood that cultivators will comply with the regulations, which will in turn depend on the probability of being caught and the severity of the fine or administrative action. If a cultivator is out of compliance or violates state law, corresponding penalties will be administered. There are three violation classes that define the severity and

corresponding cost of the fine: minor, moderate, and serious. Evaluation of violation class depends primarily on the severity of offense and potential public or environmental harm, but also considers repeat violations.

The penalties vary accordingly with the severity of the misconduct. Minor violations are a result of failure or refusal to comply with regulations that have minimal adverse effects on public safety or environmental health with a fine ranging from $100 to $500. Moderate penalties range from $501 to $1,000 for a violation that undermines enforcement, enables potential public and environmental harm, or is a repeat minor violation that occurred within a two-year period. Serious violations hold the highest penalties of $1,001 to $5,000 from significant enforcement interference, deceptive business practices, potentially high public or environmental harm, or a repeat moderate violation within a two-year time period. Fines for cultivators that are out of compliance are still being developed in the MCCP regulations. This analysis assumes the cost of a license violation is equal to $1,000 on average. Some of the violations used to determine the level of violation and penalty range include, but are not limited to:

- Failure to maintain safe conditions for inspection by the MCCP
- Failure or refusal to comply with Cultivation Plan submitted to the Department
- Failure or refusal to send all medical cannabis and medical cannabis products cultivated or manufactured to a distributor for laboratory testing
- Failure to maintain records for a minimum of seven years
- Failure or refusal to provide records to CDFA
- Failure or refusal to provide records identified by CDFA on the premise of licensed location
- Refusal to comply with an inspection of the premises or records

License holders maintain the right to request an informal hearing to contest the violation. If the licensee does not file a hearing request within 10 days of receiving the notice, the right to a hearing is considered waived. Informal hearings will take place within forty-five days of the licensee's request for the hearing.

5.4 Trade-Off Analysis

The cultivator-level trade-off analysis evaluates the costs and benefits to the each license type for participating in the regulated market. As described previously, this decision is fundamentally driven by the cost of complying with the regulations, the risk of being out of compliance with the regulations, and the risk of staying in the illegal market. All of these costs (benefits) adjust in response to changes in the regulations, enforcement, and regulations in other markets. This analysis is presented so that the reader can get a feel for the relative costs and benefits to each cultivator type resulting from the MCCP regulations. The market analysis, presented in the following section, describes the net economic impact of all of these factors.

Table 16 summarizes the results of the cultivator-level trade-off analysis. The regulatory risk premium, risk premium, and direct regulatory cost to each license type is shown. The net effect shows the risk premium in the illegal market under MCCP regulations (assumed at 10 percent higher than the current level), net of the regulatory cost and regulatory risk premium from participating in the legal medical market. As shown, the regulations are most costly for outdoor cultivators (Type 1, 2, 3, and a portion of Type 1C), and all else equal, they are least likely to participate in the regulated market. The analysis also shows that larger scale operations are able to spread regulatory costs over a greater quantity of production, making these entities more likely to participate in the regulated market.

Table 16 Trade-Off Analysis Results, Dollars per Pound

Cost	Type 1	Type 1A	Type 1B	Type 1C**	Type 2	Type 2A
Regulatory Cost ($/lb)	$248	$62	$83	$209	$207	$59
Illegal risk premium ($/lb)	$124	$62	$58	$81	$124	$62
Regulatory risk premium ($/lb)	$3	$0	$1	$4	$2	$0
Net ($/lb)	($127)	($0)	($25)	($132)	($84)	$3

Cost	Type 2B	Type 3	Type 3A	Type 3B	Type 4*	Type 1P
Regulatory Cost ($/lb)	$73	$233	$55	$66	$4	$19
Illegal risk premium ($/lb)	$58	$124	$62	$58	$2	$25
Regulatory risk premium ($/lb)	$0	$1	$0	$0	$0	$0
Net ($/lb)	($15)	($109)	$7	($8)	($1)	$6

*Nurseries are expressed in $/plant
** Type 1C is averaged over indoor, outdoor, and mixed-light options.

6. Economic Impact Analysis

This section summarizes the direct, indirect, and induced effects by industry sector, and the corresponding fiscal impacts to the state. This section also summarizes the impact of the MCCP regulations on jobs, businesses, and specific socioeconomic sectors of the economy, as required in the SRIA. The economic impacts of the MCCP regulations include:

- The change in medical cannabis market quantity and price caused by the marginal cost of the regulations across different cultivators
- The direct cost of the regulations to cultivators, including purchases from other sectors of the economy and a decrease in cultivator proprietor income
- The MCCP program expenditures on program staff and administration, and consulting service expenditures

6.1 Market Impacts of the MCCP Regulations

This section summarizes the impact of the MCCP on the medical cannabis market. As discussed at several points in this report, the relevant baseline for establishing the incremental impact of the MCCP regulations is the situation where there is an established adult use market. This analysis does not explicitly consider the effect of adult use regulations because they have not been defined and it is outside of the scope of this economic impact analysis to support the MCCP SRIA. It is important to acknowledge that regulating one market segment (medical cannabis) without regulating a close substitute (adult use) is likely to overstate substitution from the medical to the adult use market. In practice, the adult use market will be regulated at the same time as the medical market and this will be considered in future analyses.

The EDM described in Section 3.4 is used to establish the baseline for the total cannabis market, which is described under Section 6.1. The regulatory costs summarized in the sub-sections of Section 6.3 represent the incremental marginal costs to each cultivator license type. These are the costs incurred under the MCCP regulations. In addition, licensed cultivators realize a reduction in the risk premium. This analysis assumes a full reduction in the reduction in the risk premium for license cultivators and an increase in the risk premium of 10 percent for unlicensed cultivators. Finally, licensed cultivators realize an increase in the regulatory risk premium. The net effect of these three factors is the change in marginal production cost to the cultivator; it is expressed in terms of percent of operating costs and modeled using the EDM model described in Section 3.4. summarizes the regulatory costs for each cultivator license type.

Table 17 Regulatory Costs by Cultivator License Type

Cost	Type 1	Type 1A	Type 1B	Type 1C**	Type 2	Type 2A
Regulatory Cost ($/lb)	$248	$62	$83	$209	$207	$59
Base risk premium ($/lb)	$113	$56	$53	$74	$113	$56
Regulatory risk premium ($/lb)	$3.20	$0.39	$0.76	$4.03	$1.60	$0.22
Production cost ($/lb)	$810	$702	$809	$736	$786	$749

Cost	Type 2B	Type 3	Type 3A	Type 3B	Type 4*	Type 1P
Regulatory Cost ($/lb)	$73	$233	$55	$66	$4	$19
Base risk premium ($/lb)	$53	$113	$56	$53	$2	$23
Regulatory risk premium ($/lb)	$0.38	$0.55	$0.10	$0.17	$0.03	$0.13
Production cost ($/lb)	$749	$607	$628	$506	$18	$191

* Nurseries are in dollars per plant.

** Type 1C is averaged over indoor, outdoor, and mixed-light options.

Each cultivator license class is modeled individually and then averaged across production technology (indoor, outdoor, and mixed light) to be consistent with the aggregate segments included in the EDM. Processing and nursery producers are modeled as industries that are linked to medical cannabis production and are not explicitly included in the EDM. Table 18 summarizes

the β_{ij} cost shift parameters used in the equilibrium displacement model. The medical column summarizes the net effect of the MCCP regulations on the licensed cultivators expressed as a percent change in production costs. The adult use market segment is assumed to be unaffected, although it will be regulated in the future, and this inconsistency has been addressed at various points in this report. The within-California (illegal) market and export market realize higher production costs due to the increase in the risk premium. This analysis assumes the risk premium increase is the same to both of these segments.

Table 18 Equilibrium Displacement Model Cost Shift Parameters

	Medical	Adult use	Within-California	Export
Indoor	3.7%	0.0%	0.8%	0.8%
Outdoor	19.6%	0.0%	1.5%	1.5%
Mixed-light	5.0%	0.0%	0.9%	0.9%

The MCCP regulations also increase demand for medical cannabis because the product is generally safer and of higher quality (e.g. no chemicals). It is assumed that the increase in demand equals 2 percent in the medical market segment, and zero in all other market segments. That is, $\alpha_1 = 0.02$ and $\alpha_{i\neq 1} = 0$.

The net effect of the MCCP regulations follows from substitution between market segments, a small increase in medical cannabis demand, and the heterogeneous impact of MCCP regulations on cultivator types (production technology). Table 19 summarizes the net effect of the MCCP regulations across market segments expressed as the percentage change from the initial market equilibrium. The effects of the MCCP on the medical market—the focus of this economic impact analysis—are shown in the medical column. The net effect of MCCP regulations is a decrease in the total quantity of medical cannabis, equal to 6.88 percent, and an increase in the market price equal to 4.4 percent. As discussed previously, the reduction in the risk premium is less than the direct regulatory cost for most cultivators, and the supply shift is greater than the small demand shift. Underlying the total change in output quantity, outdoor cultivator production falls by 11.4 percent, mixed light production decreases slightly by 0.6 percent, and indoor production increases by 0.8 percent.[21] In summary, the MCCP regulations are most costly for smaller scale and outdoor cultivators because these cultivators have fewer economies of scale and lower productivity, respectively. It follows that the decrease in total quantity produced by outdoor cultivators is the most significant in percentage terms.

[21] It is important to note, again, that this analysis assumes that there are no AUMA regulations in place. In practice, the AUMA regulations, once developed, will affect the production costs of cultivators and this will affect the substitution between markets and in turn the economic impacts of the MCCP. However, that is explicitly beyond the scope of this economic impact analysis for MCCP.

Table 19 Percentage Change in Quantity Produced and Market Price

	Medical	Adult use	Within-California	Export
Quantity - Outdoor	-11.4%	0.8%	-0.4%	-0.8%
Quantity - Mixed Light	-0.6%	1.0%	0.1%	-0.4%
Quantity - Indoor	0.8%	1.3%	0.3%	-0.3%
Quantity - Market	-6.88%	0.93%	-0.15%	-0.60%
Price - Market	4.4%	1.0%	1.0%	0.5%

The gross impact of the MCCP regulations on the medical cannabis market is calculated as the change in cultivator revenues. Table 20 summarizes the farm-gate impact of the MCCP regulations. For completeness, the effect across all market segments is shown. After accounting for adjustment between market segments and production technology, the direct economic impact on cannabis farm-gate revenues of the MCCP regulations equals $1.1 million, with most of the direct cost to outdoor cultivators. All else equal, the incremental effect of the MCCP regulations is to decrease the market size from 250,000 to 230,000 pounds, and price increases from $1,500 to $1,590 per pound.

Table 20 Market Equilibrium Impact of MCCP Regulations ($)

	Medical	Adult use	Within-California	Export
Outdoor	-$1,123,200	$73,300	-$42,450	-$507,350
Mixed Light	-$25,150	$39,100	$5,700	-$99,200
Indoor	$21,150	$32,600	$8,900	-$57,600
Total	-$1,127,200	$145,000	-$27,850	-$664,150

Processing (Type 1P) licenses are a new industry and are assumed to process 20 percent of the regulated medical cannabis market. Under this assumption, the processing industry creates gross annual sales of $13.8 million. These are sales to the cultivation industry (e.g. instead of processing on-farm the cultivator pays a processor license holder). The nursery industry is assumed to supply approximately 60 percent of commercial cannabis cultivation, with 25 percent from seed and 75 percent from clones. It follows that the incremental effect of MCCP regulations on the nursery sector is a decrease in seed and clone inputs equal to 6.88 percent (the change in the medical cannabis cultivation industry), totaling $106,250.

In summary, MCCP regulations cause a small reduction in the total medical cannabis market as the reduction in the risk premium does not, in aggregate, offset the direct cost of complying with the regulations. The relative share of medical cannabis production shifts to indoor and mixed light technology. It is likely that these operations will be located away from the traditional outdoor growing areas. The nursery industry provides inputs to the cultivator sector and the processing industry handle a share of post-harvest activities. These sectors change proportionally

to the cultivation sectors. The ERA cultivator survey and cultivation data show that a large share of cannabis is produced by small-scale outdoor growers, including a significant share of the illegal (within-California and export) production. The share of indoor and mixed light production for medical cannabis may be slightly higher than the statewide average across all market segments. The general conclusion of this analysis in which the supply response to legalization exceeds the demand response, resulting in lower price post-legalization, seems to be consistent with trends that have been observed in the Oregon, Washington, and Colorado cannabis markets. Under regulation, the supply response is negative and greater than the demand response, resulting in a higher price and lower quantity post-regulation.

The illegal within-California and export markets are explicitly considered in the EDM analysis, but are not the central focus of this economic impact analysis. It is likely that California's dominance of the export market to other states will continue because of California's reputation for high quality product and well established supply chains. In addition, strict MCCP or adult use regulations—or burdensome local taxes, fees, and regulations—in the absence of increased enforcement for illegal cultivation, will push cultivators into the illegal markets. It is also noteworthy that there will also be a regional shift in cannabis production not explicitly modeled in this analysis. In particular, the shift in legal and regulated production to new regions will have region-specific socioeconomic impacts.

6.2 Direct, Indirect, and Induced Economic Impacts

The direct economic impacts of the MCCP include the direct regulatory cost to cultivators, change in the medical cannabis market, MCCP program expenditures, and expenditures by state and local agencies. These are considered in the following subsections. A customized IMPLAN model is used to quantify these impacts.

6.2.1 Medical Cannabis Market Impacts

The change in the medical cannabis market results from the change in marginal production cost to each cultivator type, and any demand shifts, as described previously. The EDM analysis demonstrated that gross revenues for cultivators decrease in response to a contraction in the medical cannabis market and increase in medical cannabis price. These direct effects create indirect (intermediate purchases) and induced (employee purchases) in related sectors of the economy.

As shown previously, the total direct impact on gross output value of the medical cannabis cultivation industry equals $1.127 million. This includes a decrease of $1.123 million in outdoor production, and $25,150 in mixed light production, and an increase of $21,150 in indoor production. Changes in the nursery and processing sectors follow from the changes in the primary cultivation sectors. Nursery output value falls by $106,250. The $13.8 million in output value in the new processing industry comes from cultivators who use the processor in lieu of on-farm labor for post-harvest handling. It is assumed that the net effect of this transfer is negligible.

In practice, the processing sector will provide value added, but there is limited data upon which to base any defensible analysis of this effect. The following IMPLAN model sectors are used in the analysis:

- The custom Outdoor Cannabis Cultivation sector, developed using cultivator financial survey data, is used to analyze the effect of changes in outdoor production value.
- The custom Indoor Cannabis Cultivation sector, developed using cultivator financial survey data, is used to analyze the effect of changes in indoor production value.
- The custom Mixed Light Cannabis Cultivation sector, developed using cultivator financial survey data, is used to analyze the effect of changes in mixed light production value.
- The Greenhouse, Nursery, and Floriculture IMPLAN sector is used to analyze the impact of changes in cannabis nursery production. Based on limited cannabis nursery surveys (insufficient to create a custom expenditure profile), this IMPLAN sector most closely approximates cannabis nursery production. The default IMPLAN sector includes transplant and wholesale nurseries, where the former is most similar to cannabis nurseries.

Table 21 summarizes the total economic impact of these changes. The model scope includes all California counties because the scope of the analysis is statewide economic impacts, and cannabis production occurs in most regions in California. Impacts are summarized in terms of jobs, value added, output value, and employee compensation. The statewide net effect across the three cultivator types and nurseries equals a decrease of 22 jobs, $1.6 million in value added, $2.37 million in total output value, and $1.17 million in total labor income.

Table 21 Total Economic Impact of Market Adjustments by Sector

Sector *(IMPLAN Definition)*	Impact	Employment (jobs)	Value Added ($)	Output ($)	labor Income ($)
Outdoor *(custom sector: Outdoor Cannabis)*	**Direct**	(15.0)	(839,280)	(1,123,200)	(737,560)
	Indirect	(1.4)	(193,210)	(319,570)	(107,510)
	Induced	(4.6)	(444,280)	(747,050)	(250,780)
	Total	**(21.0)**	**(1,476,760)**	**(2,189,830)**	**(1,095,860)**
Indoor *(custom sector: Indoor Cannabis)*	**Direct**	0.1	18,840	21,150	16,930
	Indirect	0	1,140	2,080	630
	Induced	0.1	9,020	15,150	5,090
	Total	**0.2**	**29,000**	**38,390**	**22,650**
Mixed Light *(custom sector: Mixed light Cannabis)*	**Direct**	(0.3)	(19,860)	(25,150)	(17,590)
	Indirect	0	(1,800)	(3,490)	(1,090)
	Induced	(0.1)	(9,800)	(16,480)	(5,530)
	Total	**(0.5)**	**(31,460)**	**(45,120)**	**(24,210)**
Nursery *(Greenhouse, nursery, floriculture production)*	**Direct**	(0.6)	(86,810)	(106,250)	(50,360)
	Indirect	(0.1)	(13,860)	(21,540)	(8,550)
	Induced	(0.3)	(30,520)	(51,320)	(17,240)
	Total	**(1.1)**	**(131,190)**	**(179,100)**	**(76,150)**

Outdoor cultivation is most significantly affected by the regulations. This is a result of the assumption of 60 percent medical market share (consistent with the statewide average) for outdoor cultivators, and the fact that the marginal cost of MCCP regulations are higher for outdoor cultivators. The indoor sector expands slightly under the MCCP regulations, although the change is negligible as a share of the total industry output. The overall decrease in value-added ($1.6 million) is small as a share of California's $2.4 trillion dollar economy.[22]

6.2.2 Medical Cannabis Direct Regulatory Costs

The direct cost of complying with the MCCP regulations equals $38 million, excluding MCCP application and licensing fees. The MCCP license and application fee is included under the MCCP program expenditures. The itemized regulatory costs for each cultivator, nursery, and processor that were summarized in detail in Section 6 are aggregated into 5 broader sectors so that the indirect and induced impacts can be analyzed. These sectors include: labor costs, equipment purchases, consulting services, farm inputs, and local agency expenditures (fees).

- Increased labor costs are modeled as a change in employee compensation. In practice, part of the change in labor cost due to the MCCP regulations is a change in proprietor

[22] http://www.dof.ca.gov/Forecasting/Economics/Indicators/Gross_State_Product/

(owner) income. However, data for cannabis proprietor income are limited, and it is difficult to identify which costs will be incurred by employees or owners, thus all labor cost changes are modeled as a change in employee compensation.

- Equipment purchases, including miscellaneous supplies for the track and trace system, composting, and other miscellaneous equipment are associated with NAICS codes in the Wholesale Trade IMPLAN model sector.
- Consulting services may include preparation of Cultivation Plans and other business management. This is modeled as the Management Consulting Services sector of the IMPLAN model for the purposes of assessing the statewide economic impact. In practice, some cultivators may prepare their own cultivation plan.
- Increased farm input purchases to comply with MCCP regulations are included under the IMPLAN sector Support Activities for Agriculture. This is a broad agricultural inputs category in the IMPLAN model including NAICS codes representing farm labor contractors to various agricultural input supplies and farm management services. This includes expenditures on composting and track and trace-related expenses.
- Local agency expenditures include fees paid by cultivators to local governments for business license or cultivation permits. The corresponding IMPLAN model sector is Other Local Government Enterprises. It is likely that these additional fees will support increased enforcement of illegal cultivators.

Table 22 summarizes the direct regulatory costs to cultivators and the corresponding sector of the economy. These are the same costs described in Section 6, but are aggregated into IMPLAN.

Table 22 Direct Economic Impacts to Cultivators, Nursery, and Processing

Industry	IMPLAN Sector	Outdoor	Indoor	Mixed Light	Nursery	Processing
Labor Cost	**Employee Compensation**	$4,115,390	$246,600	$521,470	$10,180	$140,100
Equipment	**Wholesale Trade**	$1,053,000	$248,280	$379,070	$340	$304,830
Consulting	**Management Consulting Services**	$886,290	$39,350	$99,270	$1,010	$27,980
Farm inputs	**Support Activities for Agriculture**	$80,850	$39,380	$48,740	$3,060	$14,840
Local agency	**Other Local Government Enterprises**	$25,632,700	$1,277,030	$2,480,810	$11,000	$387,320
Total		$31,768,230	$1,850,640	$3,529,360	$25,590	$875,070

The IMPLAN model is used to evaluate the indirect and induced impact of these direct changes. Table 23 summarizes the statewide total economic impact. Purchases in other industries resulting from the MCCP regulations generate a total of $77.9 million in output value, $37.5 million in value added, 383 jobs, and $28 million in employee compensation across the state. Most of these impacts are the result of increased local agency fees. These impacts do not include the MCCP program. The regional impacts are not explicitly modeled in this analysis, although Figure 2 can be used to get a qualitative sense of where impacts will be most significant. Future analyses can explicitly link the IMPLAN analysis to the regional distribution of production in California.

Table 23 Total Economic Impact of Direct Regulatory Costs

Sector Name (*IMPLAN definition*)	**Impact**	**Employment (jobs)**	**Value Added ($)**	**Output ($)**	**Labor Income ($)**
Labor *(Employee Compensation)*	**Direct**	0.0	0	0	0
	Indirect	0.0	0	0	0
	Induced	27.7	2,659,900	4,472,880	1,501,090
	Total	**27.7**	2,659,900	4,472,880	1,501,090
Equipment (*Wholesale Trade*)	**Direct**	1.3	232,980	343,500	116,570
	Indirect	0.9	90,570	150,300	58,660
	Induced	1	92,190	155,020	52,040
	Total	**3.2**	415,730	648,810	227,270
Consulting *(Business Consulting Services)*	**Direct**	7.5	674,780	1,053,900	660,040
	Indirect	3	281,450	460,800	190,000
	Induced	4.6	445,780	749,560	251,660
	Total	**15.1**	1,402,010	2,264,270	1,101,700
Farm Inputs *(Support Industries for Agriculture)*	**Direct**	3.2	146,490	186,870	117,380
	Indirect	0.1	15,050	31,070	8,910
	Induced	0.7	66,430	111,710	37,500
	Total	**4**	227,970	329,650	163,790
Local Government *(Local Government)*	**Direct**	96.1	10,080,200	29,788,850	10,605,500
	Indirect	130.4	12,519,520	23,300,800	8,725,480
	Induced	106	10,178,240	17,115,090	5,744,940
	Total	**332.5**	32,777,960	70,204,740	25,075,920

Increased production costs are primarily paid out of cultivator owner (proprietor) income. That is, the MCCP regulations increase cultivator production costs. This is modeled in IMPLAN as a $38 million decrease in proprietor income. Table 24 demonstrates the total effect of this change. There is a statewide decrease of 201 jobs, loss of $32.3 million in output value, $19.2 million in value added, and $10.8 million in labor income.

Table 24 Total Economic Impact of Change in Proprietor Income

Sector Name (*IMPLAN definition*)	**Impact**	**Employment (jobs)**	**Value Added ($)**	**Output ($)**	**Labor Income ($)**
Cultivator Income *(Proprietor Income)*	**Direct**	0	0	0	0
	Indirect	0	0	0	0
	Induced	(201)	(19,241,230)	(32,341,640)	(10,880,240)
	Total	**(201)**	**(19,241,230)**	**(32,341,640)**	**(10,880,240)**

6.2.3 MCCP Program Economic Impacts

The MCCP program expenditures are considered in the economic impact analysis. As discussed previously, the total MCCP program annual operating budget equals $3.09 million once the medical cannabis industry has reached an equilibrium. The annual operating budget is covered with application and annual cultivator licensing fees. This includes the MCCP share of $1.71 million in external consulting services. The remaining budget ($1.38 million) is for MCCP personnel, equipment, and operating expenses. These direct impacts result in different multiplier effects, and thus are separated in the direct economic impact. The following IMPLAN model sectors are used in this analysis:

- Changes in MCCP program expenditures are modeled in the Other State Government Enterprises sector of IMPLAN. This represents general changes in state government expenditures.
- Changes in MCCP consulting services (primarily track and trace technology) are modeled in IMPLAN sector Environmental and Technical Consulting Services, which includes NAICS codes associated with technology and environmental consulting service companies that will provide services to the MCCP.

Table 25 summarizes the impact of the MCCP program expenditures. The MCCP program creates 55 jobs, $7.2 in total output value, $3.6 million in labor income, and $4.1 million in value added in California.

Table 25 Total Economic Impact of MCCP Agency Costs

Sector Name (*IMPLAN definition*)	Impact	Employment (jobs)	Value Added ($)	Output ($)	Labor Income ($)
MCCP Program *(State Government)*	**Direct**	8.5	598,520	1,380,000	710,300
	Indirect	5.1	493,110	917,760	343,670
	Induced	5.8	555,500	934,100	313,530
	Total	**19.4**	1,647,120	3,231,850	1,367,500
MCCP Support *(Environmental and Technical Consulting Services)*	**Direct**	20.3	1,054,840	1,710,000	1,411,500
	Indirect	5.6	488,860	792,510	353,330
	Induced	9.6	922,160	1,550,520	520,670
	Total	**35.5**	2,465,860	4,053,040	2,285,500

The direct effect on jobs created by the MCCP is greater for the consulting services sector than the MCCP agency, as these businesses typically have employees that directly work on any MCCP projects. Statewide labor income increases by $3.6 million, with approximately 40 percent attributable to the MCCP support expenditures.

6.3 Other Benefits

Other benefits include the reduction in the risk premium and a range of other environmental and public health benefits that are not explicitly considered in this analysis.

In addition to the benefits to cultivators, nurseries, and processors, there is a reduction in the risk premium and other intangible economic benefits. The reduction in the risk premium to cultivators is included in this economic impact analysis because it is part of cannabis cultivation marginal production costs. The risk reduction benefits depend on the level of federal enforcement. If the Trump administration decides to crack down on cannabis production then any reduction in the risk premium at the state-level will be largely offset by increased federal risks. Assuming that the federal government does not change its stance on cannabis, and that there is a full reduction in risks to cultivators, the risk premium benefit equals $22.4 million dollars.

Table 26 Reduction in Risk Premium Benefits of MCCP

Sector	Risk premium ($/lb)	Total Benefit
Outdoor	$113	$15,791,810
Mixed Light	$53	$2,954,440
Indoor	$56	$2,090,720
Nursery*	$2	$528,750
Processing	$23	$1,081,000
Total		$22,446,720

*Note: Nursery is reported in dollars per plant
Numbers rounded

There are a range of other economic benefits that are beyond the scope of this analysis. Other benefits that are not explicitly quantified in the economic impact analysis include:

- Reduced environmental externalities (from water quality to GHG emissions)
- Improved cannabis product (reduced pesticides)
- Reduced crime resulting from more effective enforcement
- Any changes to the illegal market segments
- Reduced rates of incarceration from decriminalization

As better industry data become available it will be possible to quantify some of these economic costs and benefits. Data are not available to analyze these benefits as part of this analysis.

6.4 Economic Impact Summary

In summary, the MCCP regulations impose significant costs on cannabis cultivators, increasing the cost of production. The increased costs are proportionally greater for outdoor cultivators. The net effect is a reduction in the medical cannabis market quantity and small increase in price. The gross output value of outdoor, mixed light, and nurseries decreases, and indoor production increases slightly.

The increase in the marginal cost of production has two effects: a decrease in cultivator proprietor income, and an increase in purchases from other sectors of the economy that supply the inputs to comply with MCCP regulations. This includes material purchases as well as employee labor and local government agency fees. In addition, MCCP program expenditures generate economic activity through direct MCCP activities and contracting for technical consulting services. This includes staff to issue licenses and conduct license enforcement, as well as track and trace and other consulting services.

Finally, some benefits are explicitly quantified, such as the reduction in the risk premium, but many cannot be analyzed until better industry data are available. These might be considered in future impact analyses.

Table 27 summarizes the total impact of all changes considered in this analysis of MCCP regulations. This table provides a snapshot of the required SRIA elements, namely change in employment, value added (gross domestic product), output value (business activity), and labor income (employee wages). It also summarizes each of these impacts by sector. The net effect is an increase of 214 jobs, $20.7 million in value added, $50.4 million in output value, and $19.6 in labor income. The following subsections provide a narrative describing key impacts.

Table 27 Total Economic Impact Summary Table

Sector	Employment (jobs)	Value Added ($)	Output ($)	Labor Income ($)
Outdoor Production	(21)	(1,476,760)	(2,189,830)	(1,095,860)
Indoor Production	0	29,000	38,390	22,650
Mixed Light Production	(1)	(31,460)	(45,120)	(24,210)
Nursery Production	(1)	(131,190)	(179,100)	(76,150)
Employee Labor	28	2,659,900	4,472,880	1,501,090
Equipment Purchases	3	415,730	648,810	227,270
Farm Services	15	1,402,010	2,264,270	1,101,700
Farm Input Purchases	4	227,970	329,650	163,790
Local Government Expenditures	333	32,777,960	70,204,740	25,075,920
MCCP Expenditures	19	1,647,120	3,231,850	1,367,500
MCCP Support Expenditures	36	2,465,860	4,053,040	2,285,500
Proprietor Income Change	(201)	(19,241,230)	(32,341,640)	(10,880,240)
Net Effect	**214**	20,744,910	50,487,930	19,668,960
Net increase (benefits)	*438*	*41,625,550*	*85,243,620*	*31,745,420*
Net decrease (costs)	*(224)*	*(20,880,640)*	*(34,755,690)*	*(12,076,460)*

These impacts do not include the effect of changes in expenditure in other related industries, namely adult use cannabis, within-California illegal cannabis, and export illegal cannabis production. These impacts also do not include the change in the processing sector, which given the uncertainty about this new business type, is treated as a transfer of cultivator harvest labor cost. As stated previously, this analysis takes a conservative approach to estimating MCCP economic impacts. Local fees and permits for other state agencies that are explicitly required by the MCCP regulations are all included in the economic impact analysis.

6.4.1 New Businesses and Gross State Product

The MCCP regulations are intended to encourage what are currently illegal cannabis cultivation businesses to become legal (at the state level) and regulated. There may be some new businesses that did not pay taxes before the MCCP regulations, and therefore are “new” in this sense. However, California is a known exporter of cannabis, so it is likely that the new businesses will mostly consist of current operators that decide to join the regulated market. This is the desired outcome of the regulations. In summary, the MCCP regulations will increase the number of legal

medical cannabis cultivation businesses paying taxes in California. The analysis of medical cannabis production and licensing fees estimates that an upper-bound for the number of MCCP licenses issued is 2,000. The regulations would also create a new business sector, processors, that would handle cannabis trimming, drying, and packaging activities. This analysis has assumed that these businesses could be 20 percent of total medical cannabis harvest, based on comparable fresh fruit and berry industries.

The investment in California's gross domestic product is the value added contribution for each industry, shown in Table 27. The net effect on total value added is positive, but varies by sector. As a share of total gross domestic product, these changes represent a small shift. However, as a share of the total medical cannabis market, the impacts are more significant. The net impact on statewide value added equals $29.1 million dollars annually. Most of the increase in value added is due to increased local government expenditures, and the decrease in cultivator proprietor income and outdoor medical cannabis production.

6.4.2 Investment in the state and taxes

The MCCP regulations are likely to spur investment in the California cannabis market. The analysis clearly shows that the MCCP regulations require significant investment in specialty, small, and medium cultivation (and nursery and processing) businesses in California. Again, as noted previously, some of the new investment will be in businesses that have been operating as illegal cultivators for some time, and thus might not be considered "new" investment. In general, there is insufficient data to quantify the increase in new investment, compared to current established illegal businesses, as a result of the MCCP. The economic market analysis estimates that the total size of the medical cannabis market (farm-gate value) equals approximately $365 million (after accounting for adult use legalization and the impact of MCCP regulations). At8.84% average corporate tax rate, this results in $32.2 million dollars in tax revenues.[23]

6.4.3 Incentives for innovation

The MCCP regulations are likely to spur private business innovation for cannabis cultivation. Much like conventional agriculture, cannabis is dependent on land, water, and labor resource inputs. All are in short supply in California, thus there is an incentive to innovate. For example, cannabis production is labor intensive during the harvest/trimming process. At some level this requires skilled labor inputs, but there is potential for innovation of new mechanical harvesting approaches similar to the wine grape industry. Other areas for innovation might include identifying and labeling particular strains of cannabis with desirable qualities. This type of research is currently being conducted by some cultivators. In general, the medical cannabis cultivation industry is young, evolving, and likely to innovate.

[23] https://www.ftb.ca.gov/businesses/faq/717.shtml

6.4.4 Effects on individuals

6.4.5 The MCCP regulations will have an uncertain impact on individuals. Regulations will increase cannabis product safety (e.g. limited pesticides), but this has uncertain effects on consumer health outcomes. General safety may improve through better regulation, enforcement, and compliance (licensing), but there is limited evidence to support that. A Cato (2015) report finds that in Colorado, Alaska and Oregon, legalization had a negligible effect on unintended outcomes among consumer groups. That is, there is no evidence of adverse health or public health outcomes.Jobs

The net effect of the MCCP regulations analyzed in this economic impact study is an increase of 214 jobs statewide, as shown in Table 27. Also in Table 27, total number of jobs created equals 438, total number of jobs destroyed equals 224 (net = 214). Most of the increase comes from additional labor for local and state (MCCP) government and related programs. Labor income increases with the exception of cultivator proprietor income, with different effects by industry sector. The net impact on wage income equals a decrease of $1.7 million statewide annually. This is driven by the significant decrease in proprietor income to cultivators. Effectively, MCCP regulations reduce cultivator margins by increasing licensing, application, and direct regulatory compliance fees. This results in a decrease in proprietor income and statewide labor income.

6.4.6 Competitive Advantage or Disadvantage

California is an established leader in cannabis production and it is likely that this will continue into the foreseeable future. Regulating and standardizing the industry may improve quality and reliability for (medical) cannabis. This could be beneficial and further solidify a competitive advantage for California cannabis producers. However, it is not possible to quantify these effects at this time.

6.4.7 Statewide Costs and Costs for Typical and Small Business

The total statewide cost is shown in Table 27. The total decrease in output value equals $85.2 million per year, including all multiplier effects.

It is likely that most of the medical cannabis cultivators will be small businesses, however it is not possible to quantify the exact share of the market. For this analysis, costs for a typical small business are defined as the average regulatory costs for cottage cultivator license types (the smallest license type by canopy). The costs for a typical business are defined as the average over all license types excluding the cottage cultivators.

One-time up-front expenses for the representative small business equal $7,400 per year. This includes all of the cultivation plan, surety bond, BOE license, track and trace training, local permits, license application fee, printer for label, and weights and measures fee. The annual

expenses equal $21,800. This includes all of the annual operating expenses, which are itemized in Table11.

One-time up-front expenses for the average representative business equal $9,300 per year. This includes all of the cultivation plan, surety bond, BOE license, track and trace training, local permits, license application fee, printer for label, and weights and measures fee. The annual expenses equal $101,400. This includes all of the annual operating expenses, which are itemized in Table11. Record keeping requirements alone for the representative average business equals $11,900, including cultivation plan, track and trace labor costs for record keeping, and labor costs for recordkeeping and compliance.

6.4.8 Benefits Summary

Benefits include unquantified positive public health, safety, and environmental outcomes. Quantified benefits are summarized in Table 27. These are benefits in the sense that they result from direct regulatory cost to cultivators, which in turn increase purchases, and generate economic activity, in other industries. The net increase in terms of output value equals $85.2 million, as shown in Table 27.

6.4.9 State and Local Government Fiscal Impacts

As described previously, the MCCP is tasked with issuing medical cannabis cultivation licenses and administering all aspects of the medical cannabis cultivation regulations. The total annual agency budget of $16.082 million includes both medical cannabis and adult use. The share allocated to medical cannabis equals approximately 0.195, based on the estimated market share in this SRIA. Thus, the share allocated to medical cannabis equals $3.1 million.

The current fiscal year budget of the agency equals $20.810 million, of which $5.006 million is allocated to medical cannabis. The year 1 and 2 budget equals $16.1 million, of which $3.1 million is allocated to medical cannabis. The three-year total equals $52.9 million for adult use and medical cannabis, and $10.6 million for medical cannabis only.

Table 28 MCCP 3-Year Budget Summary ($ in millions)

Fiscal year	Current **2017**	Year 1 **2018**	Year 2 **2019**	**3-year Total**
Adult use and medical (agency total)	20,810	16,082	16,082	**52,974**
Medical only	5,006	3,136	3,136	**11,278**

The share of expenditures in the current fiscal year that are not reimbursable is 100 percent because the MCCP will not start issuing licenses until January 1, 2018, which is in fiscal year 2019.

Proposed MCCP regulations do not require any additional expenditure by local government. As described throughout the SRIA, local governments can set fees, taxes, and other cannabis regulations independent of the proposed state regulations. Cannabis cultivators are required to comply with these regulations, and this cost to cultivators is included in the economic impact analysis, but there is no direct fiscal cost to local governments as a result of the regulations.

7. Alternative Regulations

This section presents two alternative MCCP regulations where key parameters or uncertainties were considered to establish the effect on the economic outcomes under the regulations. The preferred regulatory alternative analyzed for the economic impact analysis largely follows the statutory requirements of MCRSA. Rather than considering more or less strict regulations, this alternative regulation analysis considers distributional effects of the MCCP licensing and application fees. In particular, the alternatives evaluate the effect of different fees on cultivators with different scale and production technology.

The first alternative considers a revised fee structure where the application and license cost is the same for all license types. It is rejected because it increases regulatory costs to small cultivators and outdoor cultivators, putting them at a disadvantage relative to larger, higher productivity cultivators. Small and outdoor cultivators already shoulder a larger share of MCCP regulatory costs. The second alternative considers MCCP license and application fees that are set based on cottage, specialty, small, and medium operations. That is, the application fee is fixed, and the license fee increases with cultivation size, but does not acknowledge differences in productivity. It is rejected because it penalizes cultivators with lower productivity per square-foot of canopy.

7.1 Alternative 1: Flat MCCP License and Application Fee Structure

The licensing and application fees for the MCCP in the preferred regulatory alternative are structured based on the average productivity of each cultivator license type, taking into account both scale and productivity per square foot of canopy. This acknowledges differences in average productivity without discouraging innovation, and importantly, does not penalize smaller cultivators, or cultivators with lower productivity. In particular, smaller outdoor cultivation license types. It was determined that this is an important factor given the predominance of smaller outdoor cultivators in the traditional cultivation regions in California and the importance of these cultivators to the local economies in these regions.

The first regulatory alternative considers a licensing fee structure that does not acknowledge differences in productivity across cultivator classes and charges a flat application fee of $1,500 to apply, plus an annual licensing fee to cover the operating cost of the MCCP. It is assumed that there will be the same 10% annual turnover in the market. It is further assumed that the MCCP issues 1,500 licenses for medical cannabis cultivation. As discussed previously, the total market size of 200,000 – 250,000 pounds will easily be supplied, in equilibrium, by fewer than 2,000

cultivators. The assumption of 1,500 cultivators is justified on this basis. The cost of the annual licensing fee equals $1,900 per license.

Table 29 summarizes the license and application fees by cultivator license type under the preferred alternative and the alternative 1 fee structure. As shown, the alternative 1 licensing and application fees are significantly higher for small and outdoor cultivators (e.g. Type 1).

Table 29 Comparison of License and Application Fees, Preferred and Alternative 1

Fee	Type 1	Type 1A	Type 1B	Type 1C	Type 2	Type 2A
Preferred - Application	$131	$1,066	$552	$150	$263	$1,932
Alt 1 - Application	$1,500	$1,500	$1,500	$1,500	$1,500	$1,500
Preferred - License	$1,183	$9,597	$4,968	$1,349	$2,366	$17,389
Alt 1 - License	$1,912	$1,912	$1,912	$1,912	$1,912	$1,912

Fee	Type 2B	Type 3	Type 3A	Type 3B	Type 4	Type 1P
Preferred - Application	$1,104	$763	$4,251	$2,429	$62	$309
Alt 1 - Application	$1,500	$1,500	$1,500	$1,500	$1,500	$1,500
Preferred - License	$9,937	$6,870	$38,256	$21,861	$557	$2,783
Alt 1 - License	$1,912	$1,912	$1,912	$1,912	$1,912	$1,912

The alternative fee structure is evaluated using the EDM model to assess the impact on the industry equilibrium under regulations. Table 30 compares the change in outdoor production for medical cannabis under the preferred alternative and the alternative fee structure. As shown, this results in an additional $500,000 decrease in outdoor production, most of which is concentrated in the small outdoor growers because they realize the most significant increase in marginal production cost.

Table 30 Market Impact, Preferred and Alternative 1

	Medical	Medical - Alt 1
Outdoor	-$1,123,200	-$1,606,600
Mixed Light	-$25,150	$200,100
Indoor	$21,150	$215,600
Total	-$1,127,200	-$1,190,900

As expected, larger scale mixed light and indoor cultivation expands relative to the preferred alternative. Although it is not modeled explicitly, it is likely that this shift coincides with increased production away from the traditional production regions in the state, where larger scale operations have been expanding in these new regions in recent years. Smaller scale outdoor

cultivators in the traditional production regions are thus more likely to stay in the illegal within-California or export market, undermining the effectiveness of the MCCP regulations.

The change in total economic impact is shown in Table 31. The IMPLAN model is used to analyze the change in outdoor, mixed light, and indoor production. There is a marginal decrease in statewide jobs, value added, output value, and labor income. However, this change is largely borne by outdoor cultivators, realizing a total (including indirect and induced impacts) decrease of $636,000 in value added, $943,000 in output value, and 9 jobs. The net effect of this alternative regulation is not significantly different from the preferred alternative. The distributional impacts, particularly for smaller-scale and outdoor cultivators is the primary reason this alternative is considered.

Table 31 Net Impact of Alternative 1

Sector	Employment (jobs)	Value Added ($)	Output ($)	Labor Income ($)
Outdoor Production	-30	(2,112,330)	(3,132,280)	(1,567,490)
Indoor Production	2	295,600	391,320	230,900
Mixed Light Production	4	250,290	358,960	192,630
Nursery Production	-1	(131,190)	(179,100)	(76,150)
Employee Labor	28	2,659,900	4,472,880	1,501,090
Equipment Purchases	3	415,730	648,810	227,270
Farm Services	15	1,402,010	2,264,270	1,101,700
Farm Input Purchases	4	227,970	329,650	163,790
Local Government Expenditures	333	32,777,960	70,204,740	25,075,920
MCCP Expenditures	19	1,647,120	3,231,850	1,367,500
MCCP Support Expenditures	36	2,465,860	4,053,040	2,285,500
Proprietor Income Change	-201	(19,241,230)	(32,341,640)	(10,880,240)
Net Effect	**212**	**20,657,700**	**50,302,490**	**19,622,420**
Preferred Alternative	*214*	20,744,910	50,487,930	19,668,960

The flat fee structure alternative 1 is rejected because the flat fee favors larger cultivators, and imposes more costs on small outdoor growers. It is likely that this would incentivize smaller outdoor cultivators in the Northern California production regions to participate in the illegal within-California and export markets rather than the regulated market. Market forces in the long and medium-run may naturally encourage consolidation of the market—similar to conventional agriculture—to capitalize on economies of scale, but the MCCP licensing and application fees in the preferred alternative do not accelerate this trend.

7.2 Alternative 2: Increasing MCCP License and Application Fee Structure

The licensing and application fees for the MCCP in the preferred regulatory alternative are structured based on the average productivity of each cultivator license type. As stated previously, it was determined that this is an important factor given the predominance of smaller outdoor cultivators in the traditional cultivation regions in California and the importance of these cultivators to the local economies in these regions.

This alternative 2 considers a fixed application fee with an increasing fee structure based on the business size of the license type. License type size includes cottage (Type 1C), specialty (Type 1, 1A, 1B), small (Type 2, 2A, 2B), and medium (Type 3, 3A, 3B). Nursery and processing license fees are set equal to the specialty license types. The application fee equals $1,500. It is assumed that there will be the same 10% annual turnover in the market. It is further assumed that the MCCP issues 1,500 licenses for medical cannabis cultivation. As discussed previously, the total market size of 200,000 – 250,000 pounds will easily be supplied, in equilibrium, by fewer than 2,000 cultivators. The assumption of 1,500 cultivators is justified on this basis. The cost of the annual licensing fee equals $1,500 for cottage cultivators, $1,750 for specialty, $1,950 for small, and $2,200 for medium.

Table 32 summarizes the license and application fees by cultivator license type under the preferred alternative and this alternative fee structure. As shown, the alternative 2 licensing and application fees are significantly lower for small cultivators and higher for medium cultivators (e.g. Type 3). However, the fees do not vary by average productivity.

Table 32 Comparison of License and Application Fees, Preferred and Alternative 2

Fee	Type 1	Type 1A	Type 1B	Type 1C	Type 2	Type 2A
Preferred - Application	$131	$1,066	$552	$150	$263	$1,932
Alt 2 - Application	$1,500	$1,500	$1,500	$1,500	$1,500	$1,500
Preferred - License	$1,183	$9,597	$4,968	$1,349	$2,366	$17,389
Alt 1 - License	$1,750	$1,750	$1,750	$1,500	$1,900	$1,900
Fee	**Type 2B**	**Type 3**	**Type 3A**	**Type 3B**	**Type 4**	**Type 1P**
Preferred - Application	$1,104	$763	$4,251	$2,429	$62	$309
Alt 2 - Application	$1,500	$1,500	$1,500	$1,500	$1,500	$1,500
Preferred - License	$9,937	$6,870	$38,256	$21,861	$557	$2,783
Alt 2 - License	$1,900	$2,200	$2,200	$2,200	$1,750	$1,750

The alternative 2 fee structure is evaluated using the EDM model to assess the impact on the industry equilibrium under regulations. Table 33 compares the change in outdoor production for medical cannabis under the preferred alternative and the alternative 2 fee structure. As shown, this results in an additional $450,000 per year decrease in outdoor production, most of which is

concentrated in the small outdoor growers because they realize the most significant increase in marginal production cost.

Table 33 Market Impact, Preferred and Alternative 2

	Medical	Medical - Alt 2
Outdoor	-$1,123,200	-$1,575,650
Mixed Light	-$25,150	$202,550
Indoor	$21,150	$219,400
Total	-$1,127,200	-$1,153,700

Consistent with the findings in the preferred alternative and alternative 1, larger scale mixed light and indoor cultivation expands relative to the preferred alternative. Gross farm revenues for outdoor cultivators decrease by $1.57 million relative to the baseline conditions, compared to a decrease of $1.123 million in the preferred alternative. Outdoor cultivators in the traditional production regions are thus more likely to stay in the illegal within-California or export market, undermining the effectiveness of the MCCP regulations.

The change in total economic impact is shown in Table 34. The IMPLAN model is used to analyze the change in outdoor, mixed light, and indoor production. There is a marginal decrease in statewide jobs, value added, output value, and labor income. However, this change is largely borne by outdoor cultivators, realizing a total (including indirect and induced impacts) decrease of $596,000 in value added, $900,000 in output value, and 9 jobs. The net effect of this alternative regulation is not significantly different from the preferred alternative. The distributional impacts, particularly for smaller-scale and outdoor cultivators is the primary reason this alternative is considered.

Table 34 Net Impact of Alternative 2

Sector	Employment (jobs)	Value Added ($)	Output ($)	Labor Income ($)
Outdoor Production	-30	(2,071,640)	(3,071,940)	(1,537,290)
Indoor Production	2	300,810	398,220	234,970
Mixed Light Production	4	253,360	363,360	194,990
Nursery Production	-1	(131,190)	(179,100)	(76,150)
Employee Labor	28	2,659,900	4,472,880	1,501,090
Equipment Purchases	3	415,730	648,810	227,270
Farm Services	15	1,402,010	2,264,270	1,101,700
Farm Input Purchases	4	227,970	329,650	163,790
Local Government Expenditures	333	32,777,960	70,204,740	25,075,920
MCCP Expenditures	19	1,647,120	3,231,850	1,367,500
MCCP Support Expenditures	36	2,465,860	4,053,040	2,285,500

Proprietor Income Change	-201	(19,241,230)	(32,341,640)	(10,880,240)
Net Effect	**212**	20,706,660	50,374,120	19,659,050
Preferred Alternative	*214*	20,744,910	50,487,930	19,668,960

The increasing fee structure regulatory alternative is rejected because the fees favor higher-productivity mixed-light and indoor cultivators. That is, while the increasing fee structure has partially acknowledged differences in scale, this alternative fee structure does not address differences in productivity. In contrast, the preferred alternative recovers MCCP costs on the basis of both productivity and scale by normalizing licensing fees on a productivity basis. Similar to alternative 1, it is likely that alternative 2 would incentivize outdoor cultivators in the Northern California production regions to participate in the illegal within-California and export markets rather than the regulated market. Market forces in the long and medium-run may naturally encourage consolidation of the market—similar to conventional agriculture—to capitalize on economies of scale, but the MCCP licensing and application fees in the preferred alternative do not accelerate this trend.

8. Summary

This analysis benefited greatly from data and feedback from the cultivators who participated in various confidential surveys conducted for the project, as well as other officials, grower groups, and other cannabis industry experts who reviewed the information and provided input. This study includes a comprehensive review of the published literature as well as a primary data gathering effort. In addition, the ERA team has made a significant effort to reach out to cannabis stakeholder groups to gather data, review assumptions, and appropriately characterize the industry. The data used in this report is based on the best information available, but should be interpreted with caution.

This analysis uses a conservative approach to attribute changes to MCCP regulations. For example, MCRSA requires cultivators to comply with all local agency rules and regulations. One could argue that local rules are not part of the MCCP regulations, however these costs do affect the outcome of the MCCP regulations and cultivators are specifically required to comply with them, thus they are included in the analysis. This is also true for State Water Resources Control Board, Department of Pesticide Regulation, and other state agency requirements.

Finally, it is important to note several shortcomings of this analysis. Data inadequacy was a huge hurdle to successfully completing the analysis, and additional data will need to be gathered in the future to support more careful economic analyses, or more general studies of the industry. This analysis has made best use of the existing data, but there are many components in the analysis where the data is insufficient or entirely absent. Throughout the text it has been noted where the data are less than sufficient. There is significant uncertainty about enforcement and the details of the MCCP regulations. It is likely these will be refined as the industry adjusts to a new

equilibrium. Every attempt has been made to be explicit about assumptions and how they may affect the market outcomes.

References

Alfaro, J. A., & Rábade, L. A. (2009). Traceability as a strategic tool to improve inventory management: a case study in the food industry. International Journal of Production Economics, 118(1), 104-110.

Alston, J. M., Balagtas, J. V., Brunke, H., & Sumner, D. A. (2006). Supply and demand for commodity components: implications of free trade versus the AUSFTA for the US dairy industry. Australian Journal of Agricultural and Resource Economics, 50(2), 131-152.

Alston, J. M., Norton, G. W., & Pardey, P. G. (1995). Science under scarcity. CAB International. Wallingford, Oxon, UK.

Boehm, Chris, (2011), Statement of Chris Boehm Assistant Director- Law Enforcement and Investigations Forest Service Before the United States Department of Agriculture, Marijuana Cultivation and the Environmental Impacts on Public Lands

Bureau of Labor Statistics (BLS). (2016). Employer Costs for Employee Compensations for Regions. Last updated December 09, 2016.

Bureau of Labor Statistics (BLS). (2016). Occupational Employment and Wages, May 2015. Farm workers and Laborers, Crop, Nursery, and Greenhouse. Accessed December 12, 2015. https://www.bls.gov/oes/current/oes452092.htm#st

Bauer S, Olson J, Cockrill A, van Hattem M, Miller L, et al. (2015) Impacts of Surface Water Diversions for Marijuana Cultivation on Aquatic Habitat in Four Northwestern California Watersheds. PLOS ONE 10(9): e0137935. doi: 10.1371/journal.pone.0137935.

California Department of Industrial Relations. (2016) Farm Labor Contractors License Requirements. http://www.dir.ca.gov/dlse/Rules_and_Regulations_for_FLCs.htm

California Department of Industrial Relations. (2016) Farm Labor Contract License Examination Study Guide. Accessed January 11, 2017. https://www.dir.ca.gov/dlse/FLC_stdygd.pdf

California DPR. Accessed December 1, 2016 http://www.waterboards.ca.gov/water_issues/programs/enforcement/docs/cannabis_enfrcmnt/pest_mgmt_practices.pdf.

Caulkins, J. P., Kilmer, B., Kleiman, M. A., MacCoun, R. J., Midgette, G., Oglesby, P., and Reuter, P. H. (2015). *Considering marijuana legalization: insights for Vermont and other jurisdictions*. Rand Corporation.

Caulkins, J. P. (2010). Estimated cost of production for legalized cannabis. *Santa Monica, CA: RAND Corporation*.

Central Valley Regional Water Quality Control Board (CVRWQCB). Cannabis Cultivation Waste Discharge Regulatory Program. Accessed December 11, 2016. http://www.waterboards.ca.gov/centralvalley/water_issues/cannabis/index.shtml

Coustasse A, Tomblin S, Slack C. Impact of Radio-Frequency Identification (RFID) Technologies on the Hospital Supply Chain: A Literature Review. Perspectives in Health Information Management. 2013;10(Fall):1d.

Davis, A. J., & Nichols, M. W. (2013). *The Price Elasticity of Marijuana Demand* (No. 13-004).

Department of Industrial Relations Labor Enforcement Task Force (LETF) 2016. OSHA Compliance Summary.

Denholm, Scott (2016) RDIP Practical Application in the Marijuana Industry. Farnwell.

Department of Insurance. Accessed December 15, 2016. http://www.insurance.ca.gov/01-consumers/105-type/9-compare-prem/wc-rate/

Department of Pesticide Regulation (DPR). (2011). A Guide to Pesticide Regulation in California. http://www.cdpr.ca.gov/docs/pressrls/dprguide/dprguide.pdf

Drug Enforcement Agency, DEA, (2016) Domestic Cannabis Eradication/ Suppression Program Statistical Report.

Edgerton, DL. "Weak separability and the estimation of elasticities in multistage demand systems." AJAE. 79 (February 1997): 62-79.

Employment Development Department (EDD), (2016), State of California, 2016 Federal and State Payroll Taxes. http://www.edd.ca.gov/pdf_pub_ctr/de202.pdf

Employment Development Department (EDD), (2016), State of California, California Withholding Schedules for 2017.

U.S. Food and Drug Administration. Accessed December 5, 2016. http://www.fda.gov/Food/GuidanceRegulation/FSMA/ucm270851.htm.

Gardner, B. L. (1975). The farm-retail price spread in a competitive food industry. American Journal of Agricultural Economics, 57(3), 399-409.

Gettman, J. (2006). Marijuana production in the United States (2006). publisher not identified.

Gieringer, Dale, (2009), Benefits of Marijuana Legalization in California,California NORML,

Goodhue, RE, Fennimore, S and Husein, Awa (2007). The economic importance of Methyl Bromide: Does the California Strawberrry Industry Qualify for critical use exemption from the methyl bromide ban?

Hamilton, L. (2008). Comparing California's Cost of Regulation to Other States: A Case Study Approach for Agriculture. *California Institute for the Study of Specialty Crops*.

Hawken, A., & Prieger, J. (2013). Economies of Scale in the Production of Cannabis. Cambridge: BOTEC Analysis Corporation. liq. wa. gov/publications/Marijuana/

BOTEC% 20reports/5c-Economies-of-Scale-in-the-Production-of-Cannabis-Final-Revised.pdf. Accessed February, 25, 2015.

IMPLAN Economic Impact Modeling Software. MIG Inc. http://implan.com/

Internal Revenue Service (IRS). IRS Social Security and Medicare Withholding Rates, 2016. Accessed. January 8, 2016.

Jacobi, L., and Sovinsky, M. (2016). Marijuana on main street. *American Economic Review*.

Mainetti, L., Francesca Mele, Luigi Patrono, Francesco Simone, Maria Laura Stefanizzi, and Roberto Vergallo, "An RFID-Based Tracing and Tracking System for the Fresh Vegetables Supply Chain," International Journal of Antennas and Propagation, vol. 2013, Article ID 531364, 15 pages, 2013. doi:10.1155/2013/531364

Meadows Richard, (2013), Researchers develop alternatives to methyl bromide fumigation. Calif Agr 67(3):125-127.

Mejia, C., McEntire, J., Keener, K., Muth, M. K., Nganje, W., Stinson, T., & Jensen, H. (2010). Traceability (product tracing) in food systems: an IFT report submitted to the FDA, volume 2: cost considerations and implications. Comprehensive Reviews in Food Science and Food Safety, 9(1), 159-175.

METRC Cannabis tracking. Accessed November 1, 2016. http://www.metrc.com/.

Muth, R. F. (1964). The derived demand curve for a productive factor and the industry supply curve. Oxford Economic Papers, 16(2), 221-234.

Noel, J. and M. Paggi. (2012), Regulatory Compliance Cost Analysis Case Studies of California and Arizona Iceberg Lettuce Production and California and Florida Strawberry Production, Center for Agricultural Business, unpublished report.

Noel, J., M. Paggi, and F. Yamazaki. (2013), The Impact of California Regulatory Compliance Costs on California Orange Producer Profitability, Earlier version of the report is available at: http://globalag.net/wordpress/wp-content/uploads/2012/12/Regulatory-Study-Oranges.pdf.

Noel, J., Paggi, M. S., & Yamazaki, F. (2009). Regulatory Compliance Costs and California Specialty Crop Producers' Profitability. In Journal of Agricultural and Resource Economics (Vol. 34, No. 3, pp. 553-554).

North Coast Regional Water Quality Control Board (NCRWQCB). Cannabis Cultivation Waste Discharge Regulatory Program. Accessed December 11, 2016. http://www.waterboards.ca.gov/northcoast/water_issues/programs/cannabis/ \

Oregon Liquor Control Commission. OLCC. http://www.oregon.gov/olcc/docs/news/news_releases/2016/nr_042916_FirstLicenses.pdf

Pacula RL, (2010), The Impact of Legalization on Harms Associated With Marijuana Use. Santa Monica, Calif: RAND Corporation, WR-769.

Paggi, M., J. Noel, and F. Yamazaki. (2009), Regulatory Compliance Costs and California, Specialty Crop Producers Profitability. Report presented at the Western Agricultural Economics Association Annual Meeting, Available at: http://www.fresnostate.edu/jcast/cab/documents/Regulatory%20Compliance%20Costs.pdf.

Pouliot, S., & Sumner, D. A. (2010). Traceability, product recalls, industry reputation and food safety. Unpublished manuscript.

RFID Journal. Accessed January 3, 2016. https://www.rfidjournal.com

RFID Journal. (2013). How Much Time Is Required to Read an RFID Tag? http://www.rfidjournal.com/blogs/experts/entry?10736

Small Business Administration (SBA). Accessed January 12, 2016. https://www.sba.gov/starting-business/write-your-business-plan

Sparling, D. Laughland, P., Sterling, B. 2011. An Appetite for Traceability: results from OnTraceability. White Paper.

State Water Resources Control Board (SWRCB). California Enviromental Protection Agency. Cannabis Cultivation Regulatory and Enforcement Unit. Accessed January 5th, 2016. http://www.waterboards.ca.gov/water_issues/programs/enforcement/cannabis_enforcement.shtml

Tax Foundation. (2016). State and Local Sales Tax Rates in 2016. Accessed December 1, 2016. http://taxfoundation.org/article/state-and-local-sales-tax-rates-2016

Teran, S. 2013. California Heat Illness Prevention Campaign. Summer 2012. Final Performance and Evaluation. Submited to California Department of Industrial Relations.

United States Bureau of Labor Statistics. (BLS). (2016). Employement Data.

Univeristy of California Cooperative Extension (UCCE). Sample Costs to Establish and Produce Plums San Joaquin Valley – South 2016.

Weltman, Barbara. (2016). Fidelity and Surety Bonds: Do You Need Them in Your Business?. United States Small Business Administration. Accessed December 12,2016. https://www.sba.gov/blogs/fidelity-and-surety-bonds-do-you-need-them-your-business.