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Industrializing Cannabis?

Socio-Ecological Implications of Legalization and Regulation in California

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Introduction

One of the major features of cannabis legalization is its attention to matters of production. In California, the nation's largest cannabis producer (Rea 2015), this is a departure from earlier waves of decriminalization and medicalization, which liberalized consumption and distribution yet left cultivation largely unregulated. With the new shift in regulation toward cultivation itself, new questions are emerging: How will patterns of cannabis production and associated environmental impacts change as the sector becomes visible, regulated, and taxed? Will legalization result in the *industrialization* of cannabis production, following the example of US agriculture in general (Magdoff, Foster, and Buttel 2000)? Or can a different model emerge, one that fosters substantive sustainability for ecosystems, farmers, and producer communities?

Focusing on California, we briefly review the characteristics of industrialized agriculture in general. We then consider the environmental impacts of cannabis production, pre- and post-legalization, as well as the policy factors that shape them. With early evidence that industrialization is already under way in regions of California far from the traditional epicenter of cannabis production, we contemplate what industrialized cannabis agriculture might entail for socio-ecological dynamics in the future. We conclude by discussing obstacles to research and the urgent need for interdisciplinary, mixed-methods collaboration, particularly in the period *prior* to full industrialization and its likely impacts on ecology, industrial structure, and regulation.

Industrial Agriculture

Conventional industrial agriculture in the US displays a number of recognizable characteristics. First, industrial agriculture is *capitalist* agriculture: commercially oriented and profit motivated. This is especially true for California agriculture, which never witnessed any significant history of

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family-scale or "yeoman" farming (Walker 2004). Second, relations among farms are characterized by *competition* to increase market share and return on investment by lowering costs and increasing productivity. Thus, third, industrial agriculture displays a drive to achieve greater *economies of scale* through the development and application of technologies in every dimension of production. Prominent among these are biotechnologies to improve seeds through selective breeding and genetic engineering (Kloppenburg 2004); mechanization to reduce labor per unit output, in the field and in processing, storage, and distribution (Olmsted and Rhode 1988; Valdés 1994); chemical pesticides to manage insects, weeds, diseases, and other pests (Duncan 1996; Romero 2016); application of organic and especially synthetic fertilizers to augment and replenish soil nutrients (Smil 2001); irrigation in areas of limited or irregular rainfall, drawing on groundwater resources and/or large (often public) investments in dams, aqueducts, and canals (Reisner 1986; Worster 1992); and scientific research and development, both publicly and privately funded, to accelerate innovation in all of the aforementioned arenas. California has long been at the forefront in all of these technological frontiers, reflecting its unusually diverse, productive, and profitable agricultural sector.

Acting together, these traits enable and perpetuate a set of complex dynamics that are widely, if unevenly, evident across the agricultural systems of the US and much of the developed world[1] and increasingly evident in the developing world as well (Galt 2014). Market competition in agriculture, as compared with other sectors, tends to be particularly severe due to the large number of farms, their geographical dispersion, limited options for product differentiation, and the perishability of many crops, which inhibits farmers' ability to choose when to sell. Pronounced consolidation among downstream buyers and processors of farm outputs, especially in recent decades, exacerbates these forces further (Hauter 2012). And as a primary component of real wages, the production of cheaper consumption goods is structurally advantageous to capital in general. On farm, the pressure to reduce labor costs is intense, leading to chronic—and often violent—struggles with farm laborers in sectors where mechanization has not (yet) made inroads, including large portions of California's major agricultural regions (McWilliams 1939; Mitchell 1996; Olmsted 2015; Wells 1996). Meanwhile, the imperative to invest in the latest technologies to keep up with ever-increasing productivity induces heavy reliance on credit, even as the aggregate result is chronic production surpluses, which depress prices and narrow profit margins further (Cochrane 2003; Dudley 2000; Henderson 1998). Each boom and bust cycle in market prices thus results in a wave of foreclosures and farmland consolidation (Graddy-Lovelace 2019). In the US, the average farm size increased throughout the 20th century, while mid-sized farms declined and reliance on off-farm income increased for most farm households (Fitchen 1991).

These dynamics give rise to two additional features of industrial agriculture that are particularly relevant to cannabis in California today, as legalization releases producers from the need to hide their operations in remote locations. The first is the tendency toward geographical differentiation, as farmers seek to match the crops they grow to the characteristics of specific places and locations—the soils, hydrology, climatic conditions, water supplies, and access to markets for labor, inputs and outputs, etc. (Walker 2004). Differentiation can manifest at various scales depending on biophysical variation, from large regions such as the Corn and Wheat Belts of the Midwest to micro-regional specialization in California's Central Coast. With micro-regional specialization in the cannabis industry comes the potential for product differentiation via branding to enhance demand for products from particular regions (e.g. through an accredited appellation system). The second relevant feature of industrial agriculture is a chronic tendency, under the pressure of market competition, to overexploit the ecological resources available at any given site, through extensification (e.g. farming "fencerow to fencerow" to maximize the area under production) and intensification (planting more densely, applying excessive quantities of fertilizers or pesticides, or gradually depleting groundwater supplies) (Kloppenburg 2004; Graddy-Lovelace 2019). State processes to govern cannabis production and trade may also create incentives for cannabis farmers to extensify and intensify production to transform the scale, location, and environmental impacts of industry dynamics.

Socio-Ecological Dynamics of Cannabis Prior to Legalization

Until 1996, cannabis production in California occurred outside of legal systems. In 1996, California voters approved the Compassionate Use Act (CUA), decriminalizing use and cultivation of cannabis for medical purposes (State of California 1996). The state implemented the CUA in 2004 legislation[2] but did not thoroughly address cultivation (Butsic et al. 2018), leaving cities and counties to create and enforce guidelines individually and, thereby, unevenly (Short-Gianotti et al. 2017). Illegal under federal law, production in California remained quasi-legal (Carah et al. 2015; Short-Gianotti et al. 2017). Federal enforcement efforts to eradicate cannabis production continued throughout this period for California farms, medical and otherwise, though it increasingly prioritized larger grows, especially ecologically impactful ones on public lands (Corva 2014; Polson 2019). In 2015, California passed a package of bills comprehensively regulating medical cannabis production, distribution, and use, known as the Medical Cannabis Regulation and Safety Act (MCRSA) (State of California 2016a). In 2016, California voters passed the Adult Use of Marijuana Act (AUMA), which legalized adult recreational use and production of cannabis (State of California 2016b), and regulation of recreational production began in January 2018.

Though cannabis cultivation has a long history in the US (Weisheit 2011), countercultural migrants initiated more widespread production in the late 1960s (Potter, Bouchard, and Decorte 2013; Raphael 1985). In line with "back-to-the-land" ethics (and in contrast to California's industrial agricultural dynamics), cannabis cultivation in Northern California at that time was primarily small, off-grid, without chemical inputs, and for non-market consumption. After adopting new horticultural techniques, acquiring seeds suited to US latitudes, and building consumer circuits, cultivators began producing more regularly for markets. Prices steadily increased through the early 1980s but spiked with the intensification of governmental eradication programs (Corva 2014; Leeper 1990; Polson 2018; Weisheit 2011).

Under full-throttle prohibition, rewards for cultivation incentivized risk-taking and more intensive, profit-focused, environmentally impactful production practices (Corva 2014), such as indoor growing, "trespass" and public land cultivation, and increased violation of informal community norms around environmental care (McCubbrey 2007; Polson 2019). Farm siting focused on secrecy to avoid enforcement action, directing cultivation to remote, rural watersheds on both public and private lands where plants were generally grown outdoors and sometimes associated with unpermitted water diversion, native vegetation clearing, pollution from pesticides and herbicides, or trash dumping associated with informal residences for temporary cultivator-guards (Butsic and Brenner 2016; Carah et al. 2015; Gabriel et al. 2012; Gabriel et al. 2013; Thompson et al. 2014; Wang, Butsic, and Brenner 2017). These locations, many of which were concentrated on California's North Coast (particularly Humboldt, Mendocino, and Trinity Counties), overlap with areas of high conservation value, such as forested watersheds (Wang, Butsic, and Brenner 2017) that harbor rare or US Endangered Species Act–listed species like coho salmon, steelhead trout, and Pacific fisher (Butsic et al. 2018; Gabriel et al. 2012).

Fear of detection placed informal limits on farm size, especially on private property where plants could be tied to owners and property seizure and arrest was a real threat (Polson 2019). Further, price inflation due to prohibition (Raphael 2012) allowed some farmers to experiment with labor-intensive, ecologically conscious growing methods, including permacultural, organic, and pesticide-free techniques. Informal self-regulation on private lands also took place during this time, where some farmers abided by local norms surrounding farm size, location, and cultivation techniques to reduce incidence of detection by or conflict with neighbors (Anders 1990; McCubbrey 2007; Polson 2019; Raphael 1985).

The allowance of medical cannabis cultivation after 1996 affected production dynamics. Legal-medical protections, particularly physician recommendations, made it less risky to cultivate, thus fueling an expansion of the number of (patient-)cultivators. Collective gardens enabled multiple patients to grow in one site rather than many or, conversely, for single growers to cultivate for multiple patients and distribute through medical dispensaries and collectives, thus increasing garden size. "Reasonable compensation" (State of California 2003) for medically designated cultivators made medical cultivation economically viable and, for some, made it possible to resist pressures to expand scale. Pressure to produce "medical-grade" cannabis, especially with the growing utilization of quality and safety testing, discouraged use of pesticides and encouraged organic inputs, though agricultural practices were far from uniform (Polson 2019). All this said, there was significant mixing between medical and underground market production during this time period (Short-Gianotti et al. 2017). Often, this meant cultivators used medical recommendations to produce large amounts of cannabis, only a portion of which (if any at all) would go to verified patients, thus alleviating pressure to produce medical-grade product.

Between 2008 and 2010, garden sizes increased, often to 99 plants, the limit at which federal minimum sentencing guidelines activated—an increase at least partly attributable to the *Kelly* decision, which struck down California's efforts to limit plant numbers (Schwab and Butsic 2017). Expanded production placed downward pressure on prices, resulting in price instability that only increased between 2012 and 2016. Characterized as a "green rush," farmers began producing significantly more cannabis in even larger gardens, possibly in anticipation of full legalization and relatively less enforcement (Butsic et al. 2018). For example, between 2012 and 2016 in Humboldt and Mendocino Counties, the number of cannabis farms increased by 56%, the number of plants increased by 183%, and the total area under cultivation increased by 91%, with significant expansion happening in environmentally sensitive areas such as those on steep slopes or near creeks with salmon and steelhead (Butsic et al. 2018). These environmental transformations were a primary focus of state cultivation regulations and county ordinances passed since 2015 (Polson 2019).

In 2015, the state first began targeted regulatory programs of cultivation in Northern California, but comprehensive statewide regulation of production was not implemented until 2018 (Butsic et al. 2018). Prior to 2018, the first farms seeking to enter a regulated cannabis industry in Northern California remained relatively small, largely due to county ordinances that restricted size (e.g. HGA 2010). With implementation of adult-use regulations in 2018, a statewide licensing program implemented by the California Department of Food and Agriculture opened opportunities for localities to develop cannabis ordinances and welcome—or ban—a new regulated cannabis industry.

Socio-Ecological Dynamics of Cannabis Since Legalization

By early 2019, industrial-scale commercial cannabis appears to have arrived in California. A cursory review of cultivation license data from the California Department of Food and Agriculture (CDFA) shows that large-scale operations have already been proposed or initiated in counties representing new frontiers for the cannabis industry (CDFA 2019) (Figure 19.1(A)). The emergence of these farms may have environmental implications, both directly through their local impacts and indirectly as competitors for smaller operations on the North Coast.

In some respects, cannabis cultivation regulations are substantially stricter than are requirements for traditional agriculture. These regulations include mandatory summer water diversion forbearance (State of California 2019a), extensive site maintenance standards, exclusive use of organic amendments, and mandatory product testing with certified laboratories (State of California 2019b). Local regulations, such as zoning restrictions, are highly variable in requirements between jurisdictions and

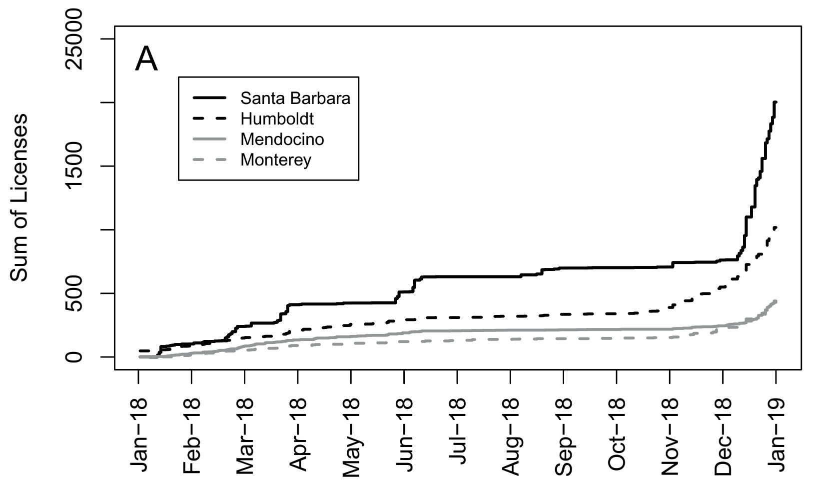

Figure 19.1(A) California Department of Food and Agriculture Cultivation Licenses by County—2018

Cumulative sum of cultivation licenses issued by the California Department of Food and Agriculture in 2018 for the top four counties in licenses issued. Data are restricted to temporary licenses that remained active as of January 2019, excluding specialty and cottage-scale license types.

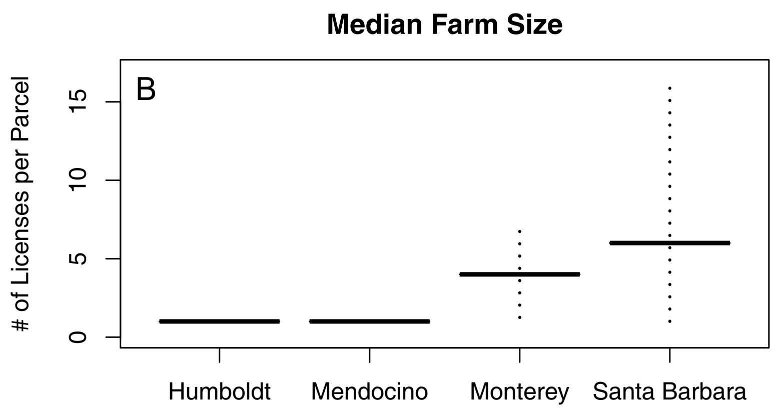

Figure 19.1(B) Typical number of cultivation licenses per parcel, California—2019

Size of cultivation area is limited for a single license, but the number of licenses per parcel is not. Bars depict median values and dashed lines represent the interquartile range (25th–75th percentile).

likely play a significant role in siting decisions for legal and illicit growers in the state (Polson and Petersen-Rockney 2019). In traditional cannabis-producing communities, adherence to new production criteria can require overhaul of existing operations, limit new development, and also incentivize noncompliance (Bodwitch et al. 2019; Polson and Petersen-Rockney 2019). The remote and rugged terrain that once attracted illicit cultivation in attempts to avoid detection may now hinder the ability of farms in these areas to comply with environmental regulatory standards and ultimately become licensed. Multiple environmental permits may be required in order to obtain a CDFA cultivation license if growing outdoors or in greenhouses, and the fees and information requirements may represent significant hurdles to some farmers (Bodwitch et al. 2019).

Initial evidence indicates the first wave of regulated, industrial-scale cannabis has largely begun not in the historical epicenter of Northern California but in the hills and isolated valleys of the Central Coast. Although select counties in the Central Valley have allowed a token number of large cannabis farms (as many as five to ten times larger than their North Coast counterparts; CDFA 2019), licenses for farms of equivalent size have been issued en masse in counties such as Santa Barbara and Monterey (Figure 19.1(A)). In these areas, it is not yet clear if large-scale cannabis farms will more commonly repurpose existing infrastructure (e.g. abandoned facilities from the former cut-flower industry) or stake out new territory farther from existing agriculture and closer to natural spaces.

Understanding the potential environmental impacts of industrialized cannabis requires knowing where and why extensification or intensification occurs, the patterns of natural resource use, and how these dynamics relate to regulatory mandates. For example, regarding the issue of water, the legacy of illegal cannabis cultivation sites and their tendency to divert from streams and springs has led to these sources of water becoming tightly regulated within the legal cannabis industry. In particular, extraction from these sources is prohibited during the growing season, and farms that rely on them must either instead collect and store this water in the off season or use an alternative source. For the majority of regulated cannabis farms, the choice has been to use well water, and this is already the most common source for irrigation (Dillis et al. 2019). Given the hurdle of developing sufficient storage, especially at increasingly larger farm sizes, the use of wells will likely increase in frequency (Dillis et al. 2019b). While the story of groundwater depletion in California is common knowledge (Reisner 1986; Scanlon et al. 2012), the use of wells by commercial cannabis farms is fundamentally different, given their tendency to occur outside of large aquifer basins (Butsic et al. 2018). Such wells that are located adjacent to watercourses, in small alluvial aquifers, or in fractured bedrock have the potential to reduce crucial stream flow during the summer months (Konikow and Leake 2014), although this topic is currently understudied and generally beyond the purview of current California groundwater policy (State of California 2014). This is a concern not only for large-scale farms in the new frontier of the Central Coast, but also for farms on the North Coast that must compete with these operations. The pressure on farms on the North Coast to increase size to compete, while using groundwater extraction to comply, has latent environmental implications, deserving further research.

Research Priorities, Prospects, and Challenges

Characterized by geographically isolated, small farms, the informal cannabis cultivation sector represented a form of agriculture distinct from California's consolidated, credit-supported industrial model. The historic legacy of the cannabis industry in Northern California has differentiated this region and led to worldwide recognition of its products. However, remoteness has now isolated traditional cultivation regions from an emerging legal supply chain and new markets, while obligating farms to navigate high regulatory costs associated with operating in environmentally sensitive locations. How farmers in these remote watersheds respond holds importance for the future of the cannabis industry and its socio-ecological dynamics. Formation of grower cooperatives (allowed at small scales under statewide regulations), appellation systems, caps on farm size and license consolidation (which the state government has not implemented), or a return to medical provisioning collectives (which the state terminated in 2019) may provide tools to overcome steep start-up and licensing costs for small farmers. Due to ongoing federal prohibition, farmers do not have access to traditional supports such as bank loans or crop insurance and instead must rely on private capital, limiting engagement in legal markets by many smaller farmers. Paradoxically, if barriers to capital are reduced, it may invite institutional investment and accelerate further industrial consolidation and upscaling.

More research is needed to understand the socio-ecological dynamics that underpin changes in cannabis cultivation in California and beyond. California's statewide legalization opens some research pathways through regulatory databases, harmonization among institutions and jurisdictions, and new funding mechanisms. Yet, federal prohibition still creates a "quasi-legal challenge" for robust research (Short-Gianotti et al. 2017), with consequences for effective policymaking and environmental health (Carah et al. 2015). Federal prohibition can inhibit institutional funding (since many research and agricultural extension institutions receive federal funds) (Wilson et al. 2019), discourage participation of informants in studies (Short-Gianotti et al. 2017), lead to suspicion of researchers by potential study participants (Polson and Petersen-Rockney 2019), create difficulty for institutional review boards and researchers to estimate and mitigate risks for human subjects, and create asymmetries in data collection and knowledge types. High numbers of producers operating outside of regulatory systems impede the ability for comprehensive and representative studies and projects limited to only "compliant" producers and cannot account for the total socio-ecological dynamics of cultivation. With a lack of robust research, resulting policies cannot be driven by direct research on cannabis, may impair social equity in the transition of informal producers to formal markets (Kelly and Peluso 2015; Putzel et al. 2015), and complicate implementation of strategies to govern common environmental resources (Ostrom 1990). Further, policies that incentivize industrial consolidation and eliminate small producers may have environmental consequences (Guthman 2004; Vásquez-León 1998).

Among cannabis producers, decisions about production can alter ecological and hydrological conditions, requiring attention not just to stream flows, pest management, indicator species, and wildlife movement patterns, but also to the social calculus of decision-making. Analyses of production decisions necessitate the development of qualitative research methods to understand how policy formations, social norms, knowledge access, and enforcement practices, among other variables, shape production practices across different kinds of ecologies and regions. In particular, many farmers are electing to avoid compliance (Bodwitch et al. 2019). Factors influencing noncompliance may derive from prohibition (e.g. distrust or fear of officials) or may only emerge post-legalization (e.g. concern that compliance costs will make it impossible to earn a living; negative interactions with regulatory officials) (Bodwitch et al. 2019). Understanding the perspectives of noncompliant farmers is crucial to researching the social and ecological dynamics of cannabis production. Equally important is a qualitative, political-economic understanding of how and why policies take particular forms in certain jurisdictions at certain times. Which interests and groups are most and least influential in forming policy? Who bears the consequences and rewards of the resulting regulatory regimes?

Rapid transformations in cannabis policy are corresponding to the emergence of new scales, practices, and ecological consequences of cannabis cultivation. Lessons from other legal forms of agriculture suggest that increased market pressures may lead to industrialization, extensification and/or intensification, and increased reliance on credit fueled by debt. Siting patterns described here indicate that all three may already be trending upward in California since legalization of production for recreational use. As changes rapidly occur, research is urgently needed to understand the relations between regulatory change, farm size, location, environmental outcomes, and the geographical distributions of benefits and impacts. Such analyses will aid policymakers' ability to govern and farmers' capacities to participate in this newly regulated industry. If done with an eye toward equitable and just outcomes, it may also point the way toward a cannabis agriculture that incorporates and learns from the lessons and failures of industrialized agricultural production.

Notes

1 Meaning the Organisation for Economic Co-operation and Development (OECD) countries, often glossed as the First World or the Global North.

2 This eight-year gap in legislative implementation can be attributed to legislative fears of federal reprisal, though there were also many forces opposed to implementation altogether.

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