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VIA EMAIL ONLY (PLEASE CONFIRM RECEIPT

County of Humboldt
Humboldt County Planning Commission
Attn: Hon. Alan Bongio, Chair
Email: Planningclerk@co.humboldt.ca.us

Humboldt County Planning Department
Attn: Michael Richardson, Supervising Planner
Email: mrichardson@co.humboldt.ca.us

Re: **Comments Concerning Proposed Amendments to the Commercial Cannabis Land Use Ordinance and CEQA Addendum to the CCLUO PEIR** (SCH # 2017042022)

Dear Chairman Bongio, Honorable Members of the Humboldt County Planning Commission and Mr. Richardson:

On behalf of Citizens for a Sustainable Humboldt ("CSH"), we respectfully submit these comments and objections to the proposed amendments to the Commercial Cannabis Land Use Ordinance ("CCLUO" or "Ordinance 2") (the "Proposed Amendments"). These comments respond to information presented in the staff report to the County of Humboldt ("County") Planning Commission concerning the Proposed Amendments.

After reviewing the staff report for this meeting, the Program Environmental Impact Report prepared for the CCLUO and the Addendum prepared for the Proposed Amendments to the CCLUO, CSH concludes that the Planning Commission should not approve the Proposed Amendments unless it conducts subsequent environmental review pursuant to the requirements of California Environmental Quality Act ("CEQA").[1] The proposed regulatory changes would themselves cause unanalyzed environmental impacts and do not consider changed circumstances, namely the repeated and foreseeable severe droughts, severe water shortages, and exacerbated risks of potentially catastrophically devastating wildfire.

[1] *See* Public Resources Code, § 21166; *see also* CEQA Guidelines (14 C.C.R.), § 15162 – 15163.

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I. The Inadequate Addendum Cannot be Relied Upon to Satisfy CEQA's Requirements as Applied to this Proposed Amendments.

A. By Proceeding with an Addendum to the CCLUO EIR and Providing Limited Opportunity for Public and Stakeholder Involvement, the County Is Missing a Chance to Fulfill the Informational and Public Participation Purposes of CEQA.

The Proposed Amendments, while superficially simple, have the potential to greatly alter the regulatory program for commercial cannabis under the CCLUO. Because the Proposed Amendments will apply to hundreds and potentially even thousands of individual projects, regulatory changes concerning artificial lighting and enlarged propagation areas have exponential effects. For this reason, this type of regulatory project is distinguishable from individual development projects – changes to the regulatory program must be examined carefully to determine the potential for more severe or new environmental impacts.

The County has an opportunity to fully engage with the public concerning the Proposed Amendments and any other appropriate revisions to the CCLUO. Instead of considering the relatively narrow subset of regulatory changes before the Commission, it should consider reforming the CCLUO in light of lessons learned over the past several years and rapidly changing circumstances. When considering projects for approval, Planning Commissioners regularly point to an applicant's satisfaction of regulatory requirements as justification for a "yes" vote. Here, the Proposed Amendments to the CCLUO provide a unique opportunity for Commissioners to influence the regulatory program as a whole in light of their now rich experience in considering projects for approval. Likewise, this opportunity extends to the public who also should be afforded the opportunity to influence any revisions to the CCLUO and the associated environmental review.

Because a CEQA addendum to a previously certified EIR need not be circulated for public review, reliance on an addendum in this context provides limited opportunity for public involvement and, in this case, a "stymied" environmental analysis. Here, the Addendum was only made available as a buried attachment to a staff report released days before the Planning Commission's consideration of the Proposed Amendments. This process has denied the public a meaningful opportunity to participate in the environmental review process for the proposed changes to the CCLUO. To facilitate meaningful public participation, a subsequent EIR or supplement to the CCLUO PEIR should instead be prepared and circulated for public review.

B. Because the County Lacks Sufficient Resources to Enforce Conditions of Approval, and There is Evidence That Conditions Are Frequently Violated, the County Cannot Rely on Assumptions That Conditions and Restrictions Will be Satisfied to Conclude the Proposed Amendments Will Not Cause Significant Impacts.

Under CEQA, conditions of approval and mitigation measures must be fully enforceable: "A public agency shall provide that measures to mitigate or avoid significant effects on the environment are fully enforceable through permit conditions, agreements, or other measures."[2] "[A] supplemental EIR must be prepared when a public agency determines a previously adopted mitigation measure is infeasible."[3]

We understand from recent Code Enforcement officer testimony to the Board of Supervisors and the recently released Code Enforcement Annual Report (2020)[4] that the County lacks sufficient resources to effectively and timely enforce conditions of approval for projects approved under the CCLUO.[5] Because County staff have acknowledged the lack of sufficient resources to enforce conditions and mitigation measures imposed on commercial cannabis projects, the Planning Commission cannot rely upon conditions and mitigation measures to conclude the Proposed Amendments will not make the environmental impacts of the CCLUO more severe.

C. The Proposed Amendments to the CCLUO and Changes to the Circumstances Surrounding the County's Commercial Cannabis Regulatory Programs Trigger the Requirement for Subsequent Environmental Review.

As is relevant here, a subsequent EIR or a supplement to an EIR is required when (1) substantial changes are proposed in a project which will require major revisions of the previous EIR or (2) substantial changes in the circumstances under which a project is undertaken occur.[6]

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2 Pub. Resources Code, § 21081.6(b); *see also Lincoln Place Tenants Assn. v. City of Los Angeles* (2005) 130 Cal.App.4th 1491, 1508-1509.

3 *Sierra Club v. County of San Diego* (2014) 231 Cal.App.4th 1152, 1173.

4 Available at: https://lostcoastoutpost.com/loco-media/loco-media/blog/post/31160/1.%2B2020%2BAnnual%2BReport.pdf.

5 *See* Board of Supervisors proceedings for April 13, 2021, starting at hour mark 1:00, available at: http://humboldt.granicus.com/MediaPlayer.php?view_id=5&clip_id=1486 [at approximately hour mark 1:09, staff reports the number of open cases and acknowledges that there is more code enforcement work than staff can currently handle]; *see id.* at approximate hour mark 1:17 to 1:25 [staff presentation re Humboldt Environmental Impact Reduction ("HEIR") Team enforcement activities concerning CCLUO]; *see also* Times-Standard, Humboldt County code enforcement staff inundated (April 13, 2021), available at: https://www.times-standard.com/2021/04/13/humboldt-county-code-enforcement-staff-inundated/.

6 *See* CEQA Guidelines, § 15162(a)(1)-(2).

Here, both of these criteria independently trigger the requirement for more robust environmental impact analysis.

1. The Proposed Amendments to CCLUO Require Major Revisions to the CCLUO EIR.

Because the Addendum purports to incorporate by reference the Program EIR prepared for the CCLUO ("CCLUO PEIR"), the definitions, descriptions and analyses in the first-tier EIR take precedence.[7] According to the CCLUO PEIR, "outdoor" grow operations involve no artificial light.[8]

The CCLUO PEIR also assumed that each cultivation site would be associated with an "ancillary nursery" between 200 and 400 sq. ft. in size.[9] Rather than adhere to this modest propagation area, it has become standard practice for the County to allow a "bonus" area of 10% of a project's permitted cultivation area to be utilized *in addition to* the cultivation area.[10] This has been allowed routinely without conducting any subsequent environmental review for the significant project size increase and associated increased direct, indirect, and cumulative impacts. The Proposed Amendments include the proposal to formalize this practice (which until now has operated informally), but increase this "bonus" propagation area from 10% to 25%.

The Addendum prepared for the Proposed Amendment is internally inconsistent. In some sections, the Addendum inaccurately assumes that propagation areas will be substituted for cultivation areas, such that there would be no net increase in the square footage of the permitted cultivation area for each commercial cannabis project.[11] Conservatively, and in light

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7 *See* Staff Report to Planning Commission for August 5, 2021 meeting ("Staff Report"), pp. 100-102, Addendum to CCLUO EIR ("Addendum"). The Addendum page numbers are not numbered, making them more difficult to reference. Proper tiering under CEQA requires specific reference to the incorporated analysis and a "roadmap." *See* In *Vineyard Area Citizens for Responsible Growth, Inc. v. City of Rancho Cordova* (2007) 40 Cal.4th 412, 443 (*Vineyard Area Citizens*). The omission of page numbers and lack of specific cross-referencing citations in the Addendum should be corrected and not repeated in future environmental review documents. Due to the lack of page numbers in the Staff Report and Addendum, we refer herein to the .pdf page number of the Staff Report and its attachments.

8 *See* CCLUO Draft PEIR, pp. 2-2, 2-6 [Table 2-1], 3.1-17 – 3.1-18.

9 *See* CCLUO Draft PEIR, p. 2-29.

10 *See* Staff Report, p. 4.

11 *See* Addendum, p. 101 ["The amendments to allow the substitution of an area for propagation rather than cultivation will not result in impacts outside those considered by the EIR because propagation simply involves cultivation of immature plants, which is nearly identical in physical effects as the cultivation of mature plants"], emphasis added; *but see id.* at p. 104 ["The ordinance specifically allows the Planning Director or Hearing Officer to consider the propagation area to be in addition to and not a substitute for a cultivation area. That decision to consider the propagation area to be in addition to and not a substitute for a cultivation area would be a discretionary action and subject to project level environmental review where any environmental effects of

of industry input to the Planning Commission on this item, the revised analysis should assume that propagation areas will be in addition to permitted cultivation areas.

By granting cannabis permittees propagation areas that do not count toward the permitted cultivation areas, the County is in fact enlarging and intensifying the commercial cannabis projects that it regulates through the CCLUO. Through a separate propagation area, growers can bring one crop to the flowering stage while germinating or planting clones in a separate uncounted propagation area that is 10 percent to 25 percent of the permitted cultivation area. (Under the proposed 25% standard, with some large projects, this propagation area could exceed 50,000 square feet in size.)

This process, which was not analyzed in the CCLUO PEIR or any other prior environmental review document, facilitates multiple growing cycles per year, thereby substantially enlarging and intensifying the CCLUO "project." For an outdoor grow, for example, this process could potentially transform a one- or two-cycle-per-year process into a two- or three-cycle operation (exponentially increase water and other environmental impacts); for a mixed-light or indoor operation, this process could potentially transform a three-cycle-per year operation into a four-cycle operation. In other words, by allowing ever enlarging "bonus" areas for propagation, the County is changing the definition of the CEQA "project" as described and analyzed in the CCLUO PEIR.

The required subsequent or supplemental EIR must analyze the environmental impacts associated with the policy change to allow enlarged propagation areas that do not count towards permitted cultivation areas. This policy change, applied across thousands of potential commercial cannabis projects, has the potential to greatly increase the significant environmental impacts of the industry as a whole.

One of the stated objectives of the CCLUO PEIR was to "provide consistency with state agency regulations associated with commercial cannabis operations." Allowing artificial light sources to extend the vegetative phase of the cultivation process is inconsistent with state regulations that prohibit any form of artificial light with outdoor operations. The Addendum fails to address this fundamental inconsistency with a key objective of the CCLUO PEIR upon which it relies for its impact analysis.

Not only is the policy change to allow artificial light with so-called "outdoor" grow operations inconsistent with state licensing categories and requirements, but, as described below, this fundamental change also has the potential to increase significant direct, indirect, and cumulative environmental impacts of the CCLUO permitting regime. The Addendum

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expanding the area used for cultivation would need to be evaluated and mitigated through subsequent environmental review."].

proposed for this proposed policy change provided scant analysis of these potentially significant impacts or overlooked them altogether.

2. Changed Circumstances Warrant Subsequent Environmental Review Under CEQA.

The Addendum to the CCLUO EIR summarily concludes, without any substantial analysis and supporting evidence, that "No substantial change in circumstances has occurred since the Commercial Cannabis PEIR was certified in 2017 that would trigger new or more severe significant environmental effects. Therefore, no new EIR is warranted on the grounds of changed circumstances."[12] Of course, as the Planning Commission is well aware, since 2017 one severe drought ended, record-breaking fire seasons ensued, and another severe drought began and has intensified.[13]

The 2012 to 2016 drought was severe, resulting in widespread effects to water supplies, forest resources, and wildlife.[14] Last year was the worst wildfire season on record.[15] Currently, extreme drought conditions characterize most of Humboldt County.[16] In this context of repeated severe droughts, the cumulative impacts of commercial cannabis projects are even more significant. The ongoing drought, and the likely scenario that droughts of increased severity and duration will occur in the future due to climate change, is a change in circumstance that independently warrants subsequent environmental review concerning the County's entire regulatory program for commercial cannabis.

D. The Industry Presentation by Margro Advisors Concerning Propagation Presents an Incomplete, Inaccurate, and Unsupported Picture of the Proposed Amendments' Potential to Cause Significant Environmental Impacts.

The presentation slides from Margro Advisors attached at the beginning of the "Public Comment" portion of the staff report attempt to dispel so-called "myths" without any

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[12] *See* Staff Report to Planning Commission, p. 106, Addendum.

[13] *See* Sierra, The Great Western Drought, Explained (Aug. 2, 2021), available at: https://www.sierraclub.org/sierra/great-western-drought-explained; *see also* L.A. Times, 'Running out of options': California resorts to water cutoffs as drought worsens (Aug. 4, 2021), available at: https://www.latimes.com/california/story/2021-08-04/california-drought-water-restrictions-how-bad-is-it.

[14] *See* Dept. of Water Resources, Report to the Legislature on the 2012–2016 Drought (March 2021), available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Water-Basics/Drought/Files/Publications-And-Reports/CNRA-Drought-Report-final-March-2021.pdf.

[15] *See* CalFire, 2020 Fire Season summary ["As of the end of the year, nearly 10,000 fires had burned over 4.2 million acres, more than 4% of the state's roughly 100 million acres of land, making 2020 the largest wildfire season recorded in California's modern history"], available at: https://www.fire.ca.gov/incidents/2020/.

[16] *See* NOAA, National Integrated Drought Information System [data summary re current drought conditions in Humboldt County], available at: https://www.drought.gov/states/california/county/humboldt, accessed August 3, 2021.

supporting evidence or analysis. The conclusory and unsupported statements in the slides, which downplay the potential for the Proposed Amendments to increase commercial cannabis impacts, do not constitute substantial evidence upon which the Planning Commission can rely to support a decision to approve the changes to the CCLUO.

The presentation does not acknowledge that allowing artificial light for "outdoor" grows and not counting "bonus" propagation areas toward the cultivation area has the potential to increase the number of growing cycles across the industry, and thus magnify project impacts.

E. The Proposed Amendments to the CCLUO Have the Potential to Cause Significant Environmental Impacts, and to Exacerbate Significant Impacts that Were Identified in the CCLUO EIR.

The Addendum brushes aside the potentially substantial increase in numerus areas of environmental effect, with scant analysis and only passing reference to the analysis in the CCLUO PEIR upon which it purports to rely. The Addendum and CCLUO PEIR, read together, do not accurately disclose the Proposed Amendments' potential to worsen environmental impacts. CEQA requires more.

1. <u>Multiplied Air Quality Impacts</u>

The Proposed Amendments have the potential to increase the already significant and unavoidable impacts to air quality with respect to PM_{10}. The CCLUO PEIR concluded that air quality impacts of commercial cannabis during the harvest season would be significant and unavoidable.[17] Allowing a propagation area as a "bonus" area over the permitted cultivation areas could facilitate multiple cultivation cycles per year where previously only one cycle was possible. Similarly, allowing artificial lighting to extend the vegetative phase of cannabis growth could facilitate additional cultivation cycles (i.e., by extending the growing season beyond what would be feasible with strictly "outdoor" cultivation), thereby increasing the number of harvest seasons where air quality impacts are most severe. The Addendum ignored these implications of the Proposed Amendments with respect to air quality impacts.

2. <u>Expanded Energy Impacts</u>

The CCLUO EIR assumed that "Existing outdoor or mixed-light cultivation operations that are not on the grid would be required to obtain at least 80 percent of their energy demand from renewable sources."[18]

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[17] *See* CCLUO Draft PEIR, 3.3-20.

[18] *See* CCLUO Draft PEIR, p. ES-34 [Table summary of Impact 3.14-1 and 3.14-2].

Energy would be supplied through one of the following:

- On-grid power from 100 percent renewable energy source (PG&E Solar Choice, RCEA Community Choice Aggregation, etc.).
- On-grid power with purchase of carbon offset from an accredited source.
- On-site zero net energy provided by a renewable energy source.

> Existing sites may be allowed to use 20 percent generator/80 percent renewable energy supplies, upon issuance of a Zoning Clearance Certificate and compliance with other energy and generator noise performance standards.[19]

According to the CCLUO PEIR, "Cannabis can be grown outdoors, either on natural soil or in pots of pre-made or commercial soil with no artificial light."[20] Because no artificial light is used in outdoor cultivation, operations with this type of state license can typically produce only one crop per year.[21]

Under state licensing standards, outdoor cultivation does not involve any artificial light, so the associated energy impacts should be minimal. Mixed-light cultivation on the other hand intensively relies on artificial light, thereby causing greater energy impacts. Despite this critical distinction, the CCLUO PEIR often treated the two types of cultivation as equivalent with respect to their environmental impacts.

Before considering the proposal to allow an undetermined number of 60-watt bulbs to be used across thousands of square feet of supposedly "outdoor" grow areas, extend the growing season for this type of cultivation, the County should confirm that the CCLUO PEIR's numerous assumptions regarding energy impacts are accurate. CSH has surveyed the approvals granted for a number of commercial cannabis projects and have confirmed that the vast majority do not include ANY requirement for renewable energy sources, much less a requirement that a minimum 80 percent of their energy demand be met with renewables.

The CCLUO PEIR describes the use of artificial light during the nursery and germination phases of cultivation as follows:

> Artificial light used during the germination/nursery phase is not considered to be a mixed-light cultivation operation (further described below), but can represent

[19] *See id.* at p. 2-21.

[20] *See ibid.*; *see also id.* at p. 2-6 [describing state license types and acknowledging that all "outdoor" state licenses do not allow artificial light].

[21] *See id.* at p. 2-3.

> substantial energy demand. Nurseries are frequently located on the same site as an ancillary component of cultivation operations. For remote off-the-grid cultivation sites, maintenance of a nursery often requires off-grid energy sources.[22]

The Addendum fails to consider the increased energy impacts that would result from (1) adding "bonus" propagation areas that add to the already intensive energy requirements for cultivation areas for mixed-light and indoor grow operations. The Addendum also downplays the increased energy impacts associated with allowing artificial lighting for "outdoor" grow operations[23]. These changes to the regulatory program, which have the potential to increase the number of growing cycles and the amount of energy consumed for both propagation and cultivation, have the potential to substantially increase the amount of energy required for commercial cannabis industry as a whole. The supplemental environmental review required for the Proposed Amendments must analyze the associated increased energy demands.

3. <u>Increased Greenhouse Gas Emissions</u>

The Addendum assumes, without any evidentiary support, that "existing cultivation sites would be required to use at least 80 percent renewable energy sources."[24] This assumption must be supported by evidence or citation to an official regulatory requirement. Over the past few years, CSH has observed multiple project approvals where no conditions requiring renewable energy sources have been imposed. As discussed above, even if such conditions were adopted, the County's ability to effectively enforce this condition is limited.

As previously explained, the Proposed Amendments have the potential to increase the number growing cycles annually for potentially hundreds or even several thousand commercial cannabis projects. This increase in cultivation intensity and duration has the potential to increase greenhouse gas emissions associated with traffic, new artificial lighting used for extending the vegetative phase of cannabis plant development, and additional harvest seasons.

4. <u>Elevated Risk of Wildfire</u>

In remote areas that are not connected to the electricity grid, the introduction of lights to outdoor grow operations have the potential to introduce generators. Generators are a

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[22] *See* CCLUO Draft PEIR, p. 2-2.

[23] *See* Staff Report to Planning Commission, p. 109, Addendum. The Addendum fails to consider the cumulative amount of energy that would be required to (1) power enough 60-watt bulbs required to keep acres of cannabis plants in a vegetative phase in the fall growing season and (2) allow up to 25% bonus propagation area which could increase the number of growing cycles across potentially hundreds or even thousands of cannabis operations.

[24] *See ibid.*

known source of wildfire ignition.[25] Despite the increased risk of wildfire associated with adding artificial lighting to outdoor cultivation operations that previously did not rely on electricity, the Addendum is silent with respect to the introduction of generators in remote rural settings surrounded by bone dry forests impacted by repeated severe droughts.

The Addendum also fails to consider the County's pattern and practice of approving commercial cannabis projects in remote rural settings with access roads that do not strictly adhere to minimum access road requirements under the County's Fire Safe Regulations. CSH has observed an unfortunate pattern of bending the Fire Safe requirements with respect to narrow access roads that would not allow the simultaneous emergency response and evacuation of civilians, as required. The CCLUO PEIR incorrectly assumed that projects would comply with Fire Safe Regulations to conclude that the regulatory program would not exacerbate fire risk.[26] The required supplemental analysis must squarely address this false assumption.

5. Added Water Supply Impacts

Commercial cannabis operations reliant on surface water diversions have already had deleterious effects on streams, rivers, and wetlands. Further, mounting evidence demonstrates that the commercial cannabis industry heavily relies upon unregulated groundwater and that withdrawal of hydrologically connected groundwater also have the potential to adversely impact surface water and related aquatic resources.[27] As with the CCLUO PEIR, the Addendum is completely silent with respect to this critically important factual context.

The CCLUO PEIR assumes that diversionary sources of water used for cannabis would be subject to a forbearance period, but no such forbearance period applies to groundwater pumping, despite the potential for such pumping to cause streamflow depletion.[28] If the County is opening up the CCLUO to regulatory changes, why not also propose a forbearance period for potentially hydrologically connected groundwater wells? Such a change to the regulatory program would be especially appropriate given the current extreme drought situation (and foreseeable drought conditions).

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[25] *See* S.F. Chronical, During PG&E outages, generators caused fires, carbon monoxide poisoning (Nov. 13, 2019), available at: https://www.sfchronicle.com/california-wildfires/article/During-PG-E-outages-generators-caused-fires-14833601.php; *see also* SF Gate, Overloaded generator likely cause of fire that burned 2 homes in Oakland hills , available at: https://www.sfgate.com/california-wildfires/article/Oakland-Hills-fire-homes-red-flag-warning-15678536.php; *see also* CalOSHA, FactSheet: Using Portable Generators Safely, available at: https://www.osha.gov/sites/default/files/publications/OSHA3286.pdf.

[26] *See* CCLUO Draft PEIR, p. 3.3-23.

[27] *See* Exh. A - UC Paper, Dillis, et al., Cannabis farms in California rely on wells outside of regulated GW basins, 2021.

[28] *See* CCLUO PEIR, p. 2-25.

The CCLUO PEIR did not analyze the potential for groundwater use for commercial cannabis to adversely affect surface water features due to hydrologic connectivity.[29] The Addendum does not do anything to correct this glaring omission in the necessary analysis.

In many areas of Humboldt County outside of the main groundwater basins, there are limited alluvial deposits – in mountainous areas groundwater is likely to either drain to streams or rivers or otherwise be hydrologically connected to surface waters. Indeed, according to the most recent comprehensive update to Bulletin 118, prepared by the Department of Water Resources ("DWR"):

> Groundwater development in the inland coastal valleys north of the divide between the Russian and Eel Rivers is generally of limited extent. Most problems stemming from reliance on groundwater in these areas is a lack of alluvial aquifer storage capacity. Many groundwater wells rely on hydrologic connection to the rivers and streams of the valleys.[30]

According to the thorough report on groundwater resources in the Eureka area (including within the Project area) prepared by the United States Geological Survey ("USGS") in 1959, the fractured sandstone formations underlying the mountainous areas of southern Humboldt County are likely to bear relatively little groundwater.[31] Indeed,

> The oldest rocks exposed [within the Eureka area] are undifferentiated sedimentary and metamorphic rocks of the Franciscan and Yager formations of Jurassic and Cretaceous age. These rocks crop out in the hills and mountains along the east and south edges of the area and underlie most of the mountainous drainage area. However, they do not yield appreciable amounts of water to wells.[32]

The USGS further found what relatively little groundwater there is to be found in Franciscan formations "occurs along fault zones, in landslide debris, and in joints" and that this water is "discharged in springs or through seepage zones."[33] This finding, while admittedly dated, constitutes substantial evidence that (1) groundwater in many areas of the County is hydrologically connected to surface waters and (2) extracting this groundwater may reduce the

[29] *See* CCLUO Draft PEIR, pp. 3.3-88 – 3.3-89 [discussion of Impact 3.8-3].

[30] DWR's Bulletin 118 Update (2003), p. 123, emphasis added, available at: https://cawaterlibrary.net/wp-content/uploads/2003/10/Bulletin_118_Update_2003.pdf, accessed Aug. 4, 2021.

[31] *See generally* USGS (prepared in cooperation with the California Department of Water Resources), Water-Supply Paper 1470, Geology and Ground-Water Features of the Eureka Area Humboldt County, California (1959), pp. 1, 3-4, 7, 11-12, available at: https://pubs.usgs.gov/wsp/1470/report.pdf, accessed 10/01/20.

[32] *See id.* at p. 12; *see also id.* at p. 13 [Table 1, stating Franciscan Sandstone of the Jurassic age is "Consolidated; not tapped by wells, probably contains *some* water in fractures and in deeply weathered rocks," emphasis added].

[33] *See* USGS Water Supply Paper 1470, *supra*, p. 14.

discharge of groundwater underlying the three Project well sites to nearby "springs and seepage zones." The County's geology has not changed appreciably since the USGS report was written in 1959. Further, given increased water demand, prolonged droughts, and the effects of climate change, groundwater availability in cannot possibly have improved.

The above information, together with more recent scientific studies and government reports, further reinforces the conclusion that widespread use of groundwater outside of the alluvial plains (i.e., the primary groundwater basins) has the potential to deplete streams and other surface waters. Furthermore, to the extent groundwater use depletes surface waters (wetlands, streams, tributaries, and rivers), commercial cannabis groundwater wells may also cause significant impacts to biological resources (e.g., fish, birds, and other wildlife) that depend upon those impacted surface waters.

The County can use available modelling tools and field techniques to determine or estimate whether and to what degree proposed groundwater wells can potentially impact surface waters. For example, USGS Circular 1376 addresses situations where groundwater pumping from wells having a hydrological connection to surface waters may cause a decline in those surface waters.[34] The circular recommends several modeling and field techniques that can be used to determine whether groundwater pumping from a specific well can potentially impact nearby surface waters.[35] The analysis of impacts to surface waters from groundwater use should employ modeling and investigation, not rely on speculation or the unsupported conclusions from unqualified staff, consultants, and well drilling companies.

USGS Circular 1376 summarizes the "Components of streamflow depletion" as follows:

> Both captured groundwater discharge and induced infiltration of streamflow result in reductions in the total rate of streamflow. Streamflow depletion, therefore, is the sum of captured groundwater discharge and induced infiltration. Captured groundwater discharge is often the primary component of streamflow depletion, but if pumping rates are relatively large or the locations of withdrawal relatively close to a stream, then induced infiltration may become an important component of streamflow depletion.[36]

The required supplemental or subsequent environmental review concerning the Proposed Amendments must carefully examine all the ways in which the associated intensification of the commercial cannabis industry can cause increased streamflow depletion.

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[34] *See generally* USGS Circular 1376, Streamflow Depletion by Wells—Understanding and Managing the Effects of Groundwater Pumping on Streamflow, available at: https://pubs.usgs.gov/circ/1376/pdf/circ1376_barlow_report_508.pdf, accessed Sept. 24, 2020.

[35] *See id.* at p. 35, 50, 54.

[36] USGS Circular 1376, p. 76 [Conclusion].

The Proposed Amendments to the CCLUO to allow a "bonus" propagation area equal to as much as 25% of the approved cultivation area has the potential to substantially increase water demand on both an individual project basis as well as cumulatively. Under this change, large propagation areas can be added to project facilities, where juvenile plants can be raised while more mature plants develop within the permitted cultivation areas. In light of substantial evidence that the Proposed Amendments may significantly impact water supplies, the required supplemental or subsequent EIR should analyze the impacts associated with utilizing groundwater that has the potential to be hydrologically connected to surface waters and must support the analysis with substantial evidence.

At the July 15th Planning Commission meeting, in response to a question from Commissioner Levy, Director Ford suggested that the County's cannabis permitting program somehow limits the amount of water that a commercial cannabis project can use annually.[37] This is not accurate. The conditions of approval that we have reviewed do not include any limit or cap on the annual water consumption of any commercial cannabis project. Instead, the staff reports, environmental review documents, and approval resolutions simply report each respective project's *estimated* water demand. The *actual* water demand for each project may be much higher than estimated, and nothing in the County's permitting program prevents projects from consuming more water than estimated (this is especially true for unregulated groundwater pumping).[38] This means that adding "bonus" areas for propagation and allowing artificial lighting to extend outdoor growing seasons will necessarily increase any given project's estimated water demand and County permits currently do not do anything to restrict this increase.

Before considering the proposed changes to the CCLUO for approval, the County must conduct a thorough review of the environmental impacts associated with all "bonus" propagation areas, whether those areas be 10% of the permitted project's cultivation area or 25%. The same is true for the proposal to allow artificial lighting for outdoor grows. Further, due to the ongoing drought conditions, and the increased potential for water scarcity as the effects of climate change increase, the County should consider imposing absolute caps on water consumption based upon sound water-use efficiency standards for cannabis cultivation.

6. Exacerbated Biological Resources Impacts

Enlargement and intensification of commercial cannabis projects associated with the Proposed Amendments have the potential to increase significant impacts to biological

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[37] *See* video of Planning Commission meeting for July 15, 2021, at hour mark: 3:13 through 3:15; available at: http://humboldt.granicus.com/MediaPlayer.php?view_id=5&clip_id=1522, accessed 07/29/21.

[38] *See*, *e.g.*, Planning Commission Resolution 21-11 [approval for Rolling Meadow Ranch project], p. 13 [finding re performance standard for project water use]; *see also*, *e.g.*, Board of Supervisors Resolution 21-26 [approval on appeal for Rolling Meadow Ranch project], Conditions of Approval #24, #40 and Ongoing Requirements/ Development Restrictions Which Must be Satisfied for the Life of the Project, #26.

resources. Such impacts will result from the increased number of growing seasons associated with the introduction of artificial light to outdoor grows and formalizing the process for awarding "bonus" propagation areas.

F. Allowing Artificial Light for Outdoor Cultivation and Extra Space for Propagation on Top of Approved Cultivation Space Will Result in Unanalyzed Cumulative Impacts.

The expansion and intensification of the commercial cannabis industry associated with the Proposed Amendments have the potential to exponentially increase cumulative impacts (both acknowledged in the CCLUO PEIR and not acknowledged). The County responded to CDFW comments on CCLUO Draft PEIR by setting cultivation acreage caps by watershed. The Proposed Amendments will indirectly expand commercial cannabis operation areas beyond the established caps.[39] The required subsequent or supplemental environmental review must specifically and thoroughly analyze the cumulative impacts associated with changes to the regulatory program.

II. Conclusion: The Planning Commission Should Not Approve the Proposed Amendments and, if the Project is Pursued, it Should Require the Preparation of a Supplemental EIR for the CCLUO.

As CSH's above comments demonstrate, substantial revisions to the environmental impact analysis for the CCLUO would be necessary to satisfy CEQA's requirements with respect to the proposed amendments. Supplemental environmental review must be conducted pursuant to Public Resources Code, section 21166 before the proposed amendments can be considered for approval. The Planning Commision should recommend revisions to the CCLUO to address ongoing severe drought conditions and the effects of climate change.

Very Truly Yours,

Jason Holder

[39] Allowing "bonus" areas for propagation on top of approved cultivation space also constitutes an end run around the established caps on cultivation.

cc: (via e-mail only)
Citizens for a Sustainable Humboldt, Board
Greg O'Connell and Scott Bauer, CDFW

Exhibits:

Exh. A. UC Paper, Dillis, et al., Cannabis farms in California rely on wells outside of regulated GW basins, 2021.

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Cannabis farms in California rely on wells outside of regulated groundwater basins

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Abstract

As permitted cannabis farming in California continues to expand statewide, including in ecologically sensitive watersheds, an improved understanding of water-use practices is needed. Existing evidence suggests widespread reliance on groundwater wells for cannabis irrigation may result in streamflow depletion, yet our understanding of where and why well use for cannabis is most prevalent is currently limited. Here, we use California state cannabis permitting data to address four important information gaps regarding well use by cannabis farming: (1) the prevalence of groundwater wells as an irrigation source for regulated cannabis farms statewide, (2) the extent to which groundwater use occurs outside of regulated groundwater basins, (3) the most useful predictors of whether a farm will rely on groundwater for irrigation, and (4) the potential well use from cannabis farms that are currently unpermitted. Well use by cannabis farms is common statewide, with percentages in excess of 75% among permitted farms in nine of the 11 top cannabis producing counties. In eight of these 11 counties, more than one quarter of farms using wells are located outside of groundwater basins subject to state groundwater use regulations. We found that cultivation area size was a positive predictor of well use, while annual precipitation and on-farm stream network density were negative predictors, highlighting the influences of water demand and surface water availability. The output of a machine learning model trained with data from permitted farms in Northern California suggests that the majority (60%) of unpermitted farms are likely to use groundwater wells if they follow the same patterns as the regulated industry. Our results suggest that proactive steps be taken to address groundwater use in cannabis regulations in California and call for further research into the effects of groundwater use on streamflow, especially outside of large groundwater basins.

Introduction

Irrigated agriculture is the largest consumer of freshwater globally, using up to 70% of all water withdrawals worldwide (Gruère *et al* 2020). Reliance on irrigation has allowed agriculture and food production to develop in regions that would otherwise be challenging for farming, such as arid regions of the Western United States. However, water withdrawals to satisfy irrigation demands can have negative environmental impacts by depleting groundwater (Konikow 2015, Ojha *et al* 2018), altering streamflow (Foglia *et al* 2013, de Graaf *et al* 2019), and harming fish and wildlife (Perkin *et al* 2017, Gleeson and Richter 2017). Limiting environmental impacts from irrigated agriculture while providing food, fiber, and other crop commodities for 8 billion people remains one of the greatest challenges for the 21st century.

This challenge is exemplified in California, which supports a $50 billion (USD) agricultural economy that heavily relies on irrigation water supplied by federal and state surface water storage and conveyance projects and by extraction from large groundwater aquifers (Johnson and Cody 2015). Cannabis, however, is unique in

California because it generally occurs outside of valley and low-land areas typical of other agricultural crops and often does not have access to centralized water conveyance systems or regulated groundwater basins upon which the state's traditional agricultural sector relies (Butsic and Brenner 2016, Dillis *et al* in press). This pattern is a result of a history of enforcement-avoidance leading to the development of cannabis farms in remote areas, especially in Northern California (Corva 2014, Butsic and Brenner 2016). Although this industry is currently transitioning from an unpermitted to formalized statewide economy following implementation of a statewide regulatory framework in 2018, the geographic distribution of cannabis farms in California remains linked to a legacy of prohibition and exclusion from traditional agricultural lands (Dillis *et al* 2021).

The high density of farms in remote Northern California watersheds has raised concerns over the environmental impacts of cannabis cultivation (Carah *et al* 2015). In particular, previous work has demonstrated the potential for cannabis surface water diversions to reduce flows or dewater streams that support salmon and other threatened and endangered species (Bauer *et al* 2015). However, there is also growing evidence that cannabis farms in the regulated industry may rely predominantly on groundwater wells, rather than direct surface water diversions, to meet their irrigation needs (Dillis *et al* 2019). Compared to impacts of direct surface water diversions, the impacts from groundwater wells in the remote locations typical of many California cannabis farms are understudied and largely unregulated (Zipper *et al* 2019b). In these locations, well extraction by cannabis farms in upland areas may stress surface water resources and associated aquatic ecosystems by capturing groundwater that otherwise would have flowed into streams (Zipper *et al* 2019b), via a process known as streamflow depletion (Barlow and Leake 2012, Barlow *et al* 2018). Although the environmental impacts of groundwater use within large groundwater basins in California are addressed in the Sustainable Groundwater Management Act (SGMA, State of California 2014), these regulations do not extend to groundwater wells outside of these basins.

State cannabis cultivation policy and water use regulations, in particular, have been responsive to potential environmental threats (State of California 2019a, Bodwitch *et al* 2019), yet so far they have been focused largely on the diversion of surface water. For example, permitted cannabis farms are prohibited from extracting water from springs or streams for the duration of the outdoor growing season (April–October), necessitating that farms relying on these water sources have the storage capacity to collect and store all irrigation water in offseason months to sufficiently meet crop demands during California's dry season (State of California 2019a). Initial data from permitted farms in Northern California suggest there are challenges associated with developing the capacity to store this amount of water (often in excess of 400,000 liters for the typical farm size) in irrigation ponds or above ground storage tanks (Dillis *et al* 2020). While irrigation ponds typically provide sufficient storage, roughly only 10% of farms use ponds, as they are subject to many restrictions on siting and use (State of California 2019a, Dillis *et al* 2020). Thus, many growers may seek to access groundwater, which is not subject to the same seasonal use restrictions as surface water sources. There is also evidence that well use among cannabis farms is more common in drier regions, suggesting that farmers may be more likely to dig wells where the availability of surface water is less reliable (Dillis *et al* 2019). As a consequence, the geographic expansion of cannabis production to drier parts of the state (Dillis *et al* 2021), coupled with transition of cannabis farms to the regulated market, suggest that groundwater may be the primary source of water for cannabis irrigation throughout California, although no formal analysis of these trends have been conducted to date.

In Northern California, up to 80% of cannabis farms in the region have not received permits and remain in the illicit market (Butsic *et al* 2018). These unpermitted farms represent a large pool of prospective entrants to the regulated industry and regulatory agencies are actively engaging unpermitted farmers to incentivize their participation through enforcement actions, civil penalties, and targeted outreach (Bodwitch *et al* 2021). While data on farming practices of unpermitted farms in California remains limited (but see Wilson *et al* 2019), farms that have already become permitted may serve as a model for prospective new entrants to the regulated cannabis industry and provide insights into operations on currently unpermitted farms and how the growth of the regulated industry may influence water use practices and the environment.

In this study, we analyze cannabis cultivation permit data from 2018 and 2019 to understand well use among permitted cannabis farms in California. We explore drivers of well use and apply our findings to both the development of new permitted cannabis farms statewide, as well as the potential transition of a multitude of farms currently operating without permits. The overall goal of the study was to document the statewide prevalence of well use by cannabis farms and assess trends in well use by the regulated industry that warrant attention by local and state policymakers. Specifically, we addressed the following questions:

How prevalent is well use among permitted cannabis farms statewide?

How commonly does well use occur outside of regulated groundwater basins?

What are the most important predictors of well use among permitted cannabis farms?

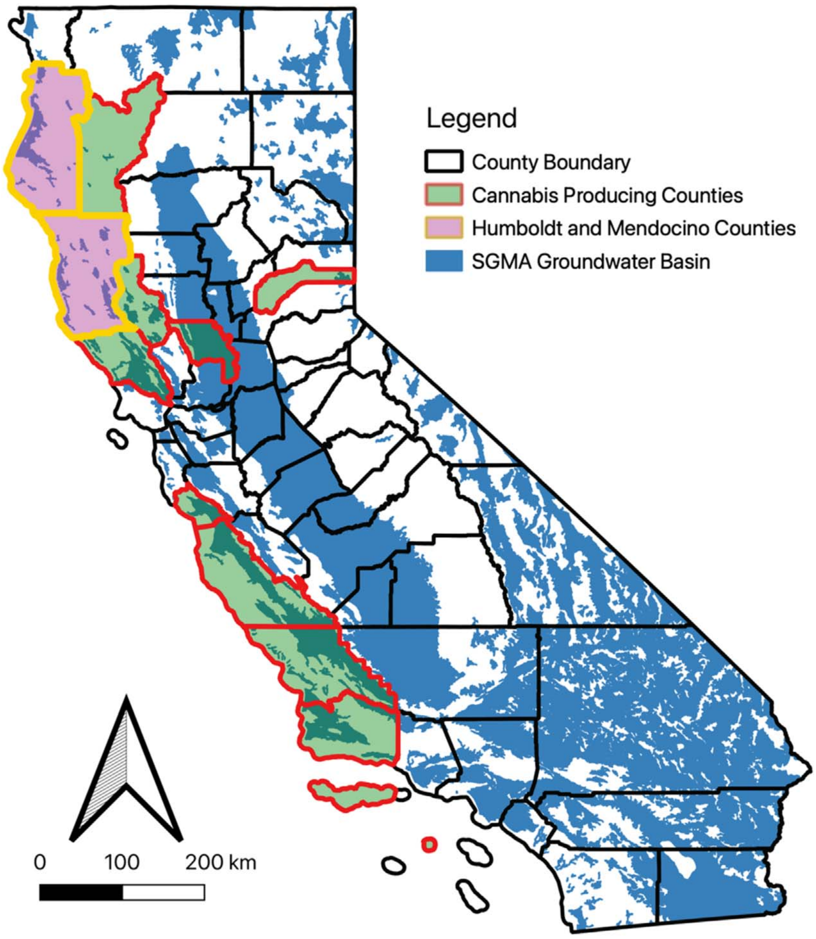

Figure 1. Study Area Map. The full extent of California is displayed for context, along with mapped groundwater basins statewide. The 11 cannabis producing counties included in this study represent those comprising at least 2% of CWB permits statewide with Humboldt and Mendocino counties containing the most permits (26.4% and 25.6%, respectively).

What proportion of farms that are currently operating outside of the regulatory framework are expected to use wells if they follow the same patterns as farms in the regulated industry?

Methods

Data

Cannabis cultivation permit data were obtained via a Public Records Act request to the California Water Boards (CWB). We focused on enrollments from 11 counties, referred to hereafter as *cannabis producing counties* (figure 1), which collectively account for 98% of all CWB permits in California. Permit data included both enrollment forms and annual monitoring reports for the 2018 and 2019 cultivation seasons, each of which indicated the water sources used for irrigation. Enrollment data included geospatial coordinates of farms, which were overlaid on parcel data obtained from the National Parcelmap Data Portal (Boundary Solutions 2020). Data for location and size of unpermitted cannabis farms was collected through digitization of 2018 imagery from the National Agricultural Imagery Program (NAIP; Butsic and Brenner 2016). The data for unpermitted cannabis farms was collected for a representative sample (50%) of the watersheds (HUC12) in Humboldt and Mendocino Counties (Butsic *et al* 2018). Spatial data for statewide SGMA groundwater basins were downloaded from the California State Geoportal (State of California 2019b). GIS data used to quantify farm characteristics for model parameterization included Digital Elevation Models (DEMs) from the National Elevation Dataset (USGS 2018), vector watershed boundary and stream network data from the National Hydrography Dataset (USGS 2019), and land cover raster layers from the National Land Cover Dataset (Dewitz 2019). Finally, precipitation data (30-year annual averages) were downloaded from the PRISM Climate Group (PRISM Climate Group 2018).

Predictors of well use in Humboldt and Mendocino Counties

Our analysis of factors predicting the likelihood of wells as an irrigation water source employed a multilevel logistic regression model, fit using the lme4 package in R Statistical Computing Software (Bates *et al* 2014, R Core Development Team 2018). This analysis was restricted to two of the 11 cannabis producing counties, Humboldt and Mendocino (figure 1), which comprised the majority of permitted cannabis farms statewide (55%) and are the only counties where accessible, reliable maps of non-permitted cannabis farms exist (Butsic *et al* 2018). We calculated several continuous and categorical predictor variables for each permitted farm in these counties (Table S1 (available online at stacks.iop.org/ERC/3/075005/mmedia)) using the spatialEco package within R Statistical Computing Software (Evans 2020, R Core Development Team (2018)). Continuous predictors included: the density of stream networks on the farmed parcel (*Stream Density*; *d*), the average annual precipitation (*Watershed Precipitation*; *t*), catchment size of streams on parcel (*Watershed Size*; *z*) in which they were located, and the square footage of cultivation area (*Cultivation Area*; *c*) obtained from annual reports. Because cannabis is grown almost exclusively via irrigation from natural sources, *Stream Density* and *Watershed Precipitation* were intended to capture the amount of available surface water on a given parcel. *Cultivation Area* was used as a measure of water demand. All continuous variables were scaled (to *Z*-score) to improve model fit. Categorical predictors included: whether a USGS-mapped spring was located on the parcel (*Onsite Spring*; *o*), whether there were any streams on the parcel (*Stream Present*; *s*), whether there was a mapped groundwater basin underlying the parcel (*Groundwater Basin*; *g*), and whether the farm used an irrigation pond for water storage (*Pond*; *p*). As alternative water sources, *Onsite Spring* and *Stream Present* were hypothesized to decrease the likelihood a farm would need to use a well, while the presence of an underlying *Groundwater Basin* was expected to increase this likelihood, given that groundwater should be reliably accessible on these parcels. Previous work has found that the presence of an irrigation *Pond* significantly increased the likelihood a cannabis farm would have sufficient storage capacity to meet regulatory requirements (Dillis *et al* 2020), and thus herein, would reduce the likelihood a farm would use a well.

The generalized linear model (GLM) used a logit link function, predicting the likelihood of well as an irrigation source (P_i) using the following equation:

$$logit(P_i) = \alpha + \alpha_y + \alpha_w + \beta_d d + \beta_t t + \beta_z z + \beta_c C + \beta_p p + \beta_o o + \beta_s s + \beta_g g + \varepsilon \cdot \quad (1)$$

Fixed-effects terms for Stream Density (β_d), Watershed Precipitation (β_t), Watershed Size (β_z), Cultivation Area (β_c), Onsite Spring (β_o), Stream Present (β_s), Groundwater Basin (β_g), and Pond (β_p) were accompanied by random intercepts for County (α_y) and Watershed (HUC12; α_w) and added to the overall intercept (α). All slope and intercept terms were summed to produce an estimate of log-odds, which was then converted to likelihood values (L) for purposes of plotting model predictions:

$$L = \frac{1}{1 + e^{\hat{p}}} \quad (2)$$

Model predictors were considered reliable if 95% confidence intervals, constructed from the standard errors, did not overlap zero.

Prospective well use and scenario modeling

Enrollment data was used to distinguish permitted cannabis farms (n = 1,237) from those operating without permits (n = 6,010), as of December 2019, for all mapped farms in Humboldt and Mendocino County (Butsic *et al* 2018). Predictions (well/no well) for unpermitted farms were generated using training data from current CWB permit holders and the same set of spatial variables (Table S1). Initial performance evaluation of the logistic regression model (based on k-fold cross validation) demonstrated an unacceptable level of bias (+8.74% toward predicting wells), thus motivating the use of machine learning models with more flexibility in structure and optimization.

The classification algorithm used for prediction (well/no well) employed an ensemble of random forest and gradient boosting models (Table S2), using the randomForest and xgboost packages (respectively) within R Statistical Computing Software (Liaw and Wiener 2002, Chen and Guestrin 2016, R Core Development Team (2018)). This ensemble model was evaluated using 1,000 iterations of k-fold cross validation sets (Figure S1) and the top performing model yielded a mean predictive accuracy of 72.13% (std dev = 1.73) and mean bias of −0.01% (std dev = 3.70).

The trained classifier was applied to mapped unpermitted farms and summarized at the HUC12 subwatershed scale to depict the potential extent and location of well use among unpermitted farms. Additionally, we made adjustments to farm characteristics to simulate three industry growth and regulatory scenarios. The first (*Minimum Farm Size Scenario*) is a scenario in which all unpermitted farms in the region increase their cultivation area to match the median size (929 m^2) of those farms currently operating in the

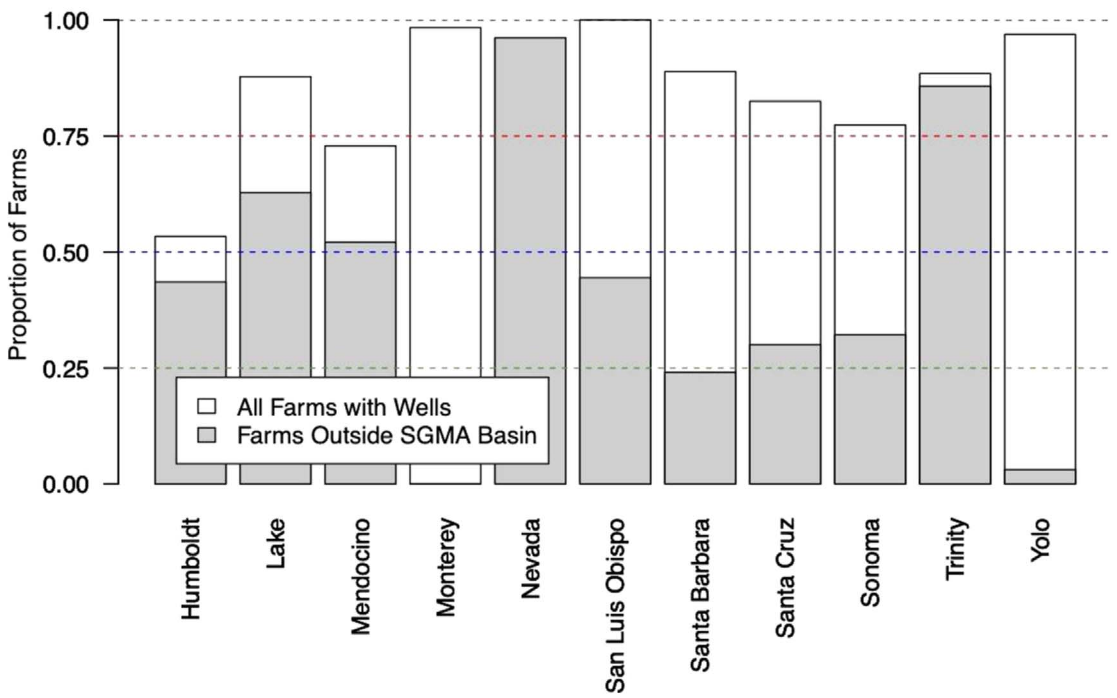

Figure 2. Summary of Well Use Statewide. The proportion of farms in each county reporting well use is displayed (white), as is the proportion of farms both using wells and located outside of a groundwater basin (grey).

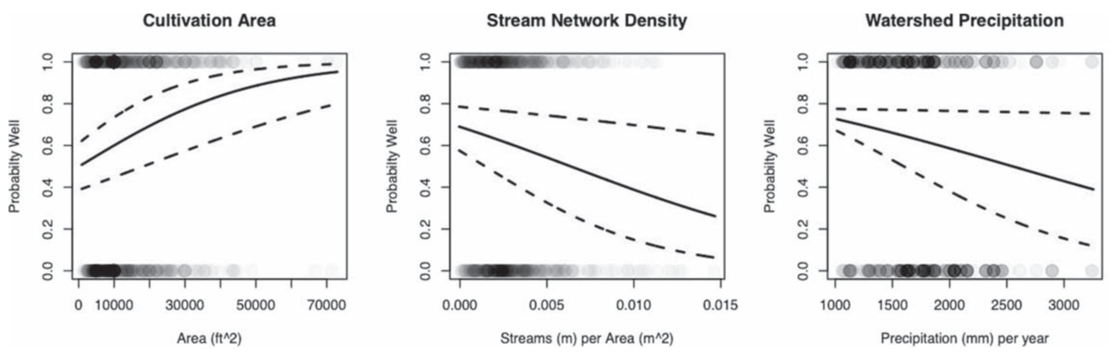

Figure 3. Predictors of Well Use. Statistically reliable continuous fixed-effects are displayed: *Cultivation Area*, *Stream Density*, and *Watershed Precipitation*. Raw binary data for each corresponding variable are plotted at 1 and 0, with the maximum likelihood estimates depicted over the range of observed values with a solid line. Dashed lines depict the 95% confidence interval for the maximum likelihood estimates.

regulated cannabis industry. The second scenario (*Restricted Pond Use Scenario*) considers how the use of irrigation ponds may be restricted as unpermitted farms enter the regulated industry. We identified all unpermitted farms with ponds located on steep terrain and/or near streams that would be prohibited under current regulations and assigned them to the 'no pond' class for model simulations. The suitability threshold was determined using values of average slope and stream network density from data on permitted farms with ponds. The third scenario (*Combination Scenario*) combined the first two scenarios, including an increase in minimum farm size and restrictions on pond use. Outputs of the three scenario simulations were summarized at the HUC12 watershed scale.

Results

Statewide patterns of well use

Well use was common, with an overall reported percentage of 76% among all permitted cannabis farms and percentages universally above 50% (figure 2) in all cannabis producing counties. Only two counties had reported percentages below 75% (Humboldt: 53%; Mendocino: 73%), while four counties were above 95% (Monterey: 98%; Nevada: 96%; San Luis Obispo: 100%; Yolo: 97%). There was more variation between counties in the

Table 1. Model coefficients. Results of logistic regression model predicting well presence. Rows in bold indicate coefficients for which 95% CIs did not overlap zero.

Coefficient	Estimate	Std. error
Intercept	0.54	0.34
Pond	−2.75	0.29
Onsite Spring	0.40	0.36
Stream Present	0.10	0.20
Groundwater Basin	0.48	0.25
Cultivation Area	0.40	0.08
Watershed Precipitation	−0.27	0.12
Watershed Size	−0.05	0.07
Stream Density	−0.28	0.09

percentage of farms using wells that were outside of SGMA groundwater basins. In three counties, fewer than 25% of the farms using wells were located outside of groundwater basins (Monterey: 0%; Santa Barbara: 24%; Yolo: 3%), whereas four counties recorded more than half of all farms using wells outside of groundwater basins (Lake: 63%; Mendocino: 52%; Nevada: 96%; Trinity: 86%; figure 2).

Predictors of well use in Humboldt and Mendocino County

The logistic regression model indicated that the most influential predictor of well use was the presence of an irrigation *Pond*, which had a reliable negative effect on the likelihood of well use (MLE $= -2.75$, SE $= 0.29$). This Maximum Likelihood Estimate translates to a reduction from a 63.18% baseline likelihood of well use to just 9.85% for farms with irrigation ponds (table 1). Three of the four continuous predictors had reliable effects on the likelihood of well use (figure 3). The effect of *Cultivation Area* was reliably positive (MLE $= 0.40$, SE $= 0.08$), whereas *Watershed Precipitation* (MLE $= -0.27$, SE $= 0.12$) and *Stream Density* (MLE $= -0.28$, SE $= 0.09$) had reliably negative effects on the likelihood of well use. The random intercept estimates for Humboldt (MLE $= -0.39$) and Mendocino (MLE $= 0.32$) counties diverged in opposite directions from the overall intercept, following the pattern of observed well use (figure 2), indicating a higher likelihood of well use in Mendocino compared to Humboldt County, all else equal.

Prospective well use and scenario modeling

Based on the characteristics of permitted farms that influenced well use in our model, we estimated that over half of unpermitted farms (60%) in Humboldt and Mendocino counties are likely to use wells if they follow patterns of farms in the regulated industry. The majority of farms predicted to use wells in these counties (73% in Mendocino County; 77% in Humboldt County) were located outside of a SGMA groundwater basin, and thus not subject to SGMA regulations. The results of the scenario modeling showed dramatic increases in well use overall relative to the baseline predictions, but there appear to be divergent causes of predicted increases in either county (figure 4, table 2). In Humboldt County there was a proportional increase in predicted well use of 23% for the *Minimum Farm Size Scenario* relative to the baseline prediction, while in Mendocino this increase was 6%. In contrast, the increase for *Pond Restriction Scenario* relative to baseline was only 3% for Humboldt, but 11% for Mendocino.

The distribution of potential baseline well use among unpermitted farms, summarized at the subwatershed level demonstrated a slight tendency for clustering at high and low values (figure 5(A)). Median values of well use in each watershed increased relative to the baseline (56%) under the *Minimum Farm Size Scenario* (69%) and *Pond Restriction Scenario* (70%) and were highest in the *Combination Scenario* (86%; figure 5(B)−(D)).

Discussion

We found that groundwater wells appear to be the primary water source for cannabis irrigation across the state, but that many wells occur outside of SGMA-regulated groundwater basins. This suggests that many cannabis farms rely on wells that are subject to limited regulatory oversight and highlights a potentially significant gap in cannabis cultivation policy. In particular, current water-use regulations are designed to avoid impacts to sensitive stream habitats from surface water diversions via a summer forbearance period prohibiting surface diversions for the length of the dry season (contemporary with the growing season) (State of California 2019a). However, the use of wells, especially outside of SGMA basins, is not subject to the same restrictions, despite the potential for groundwater withdrawals to deplete streamflow.

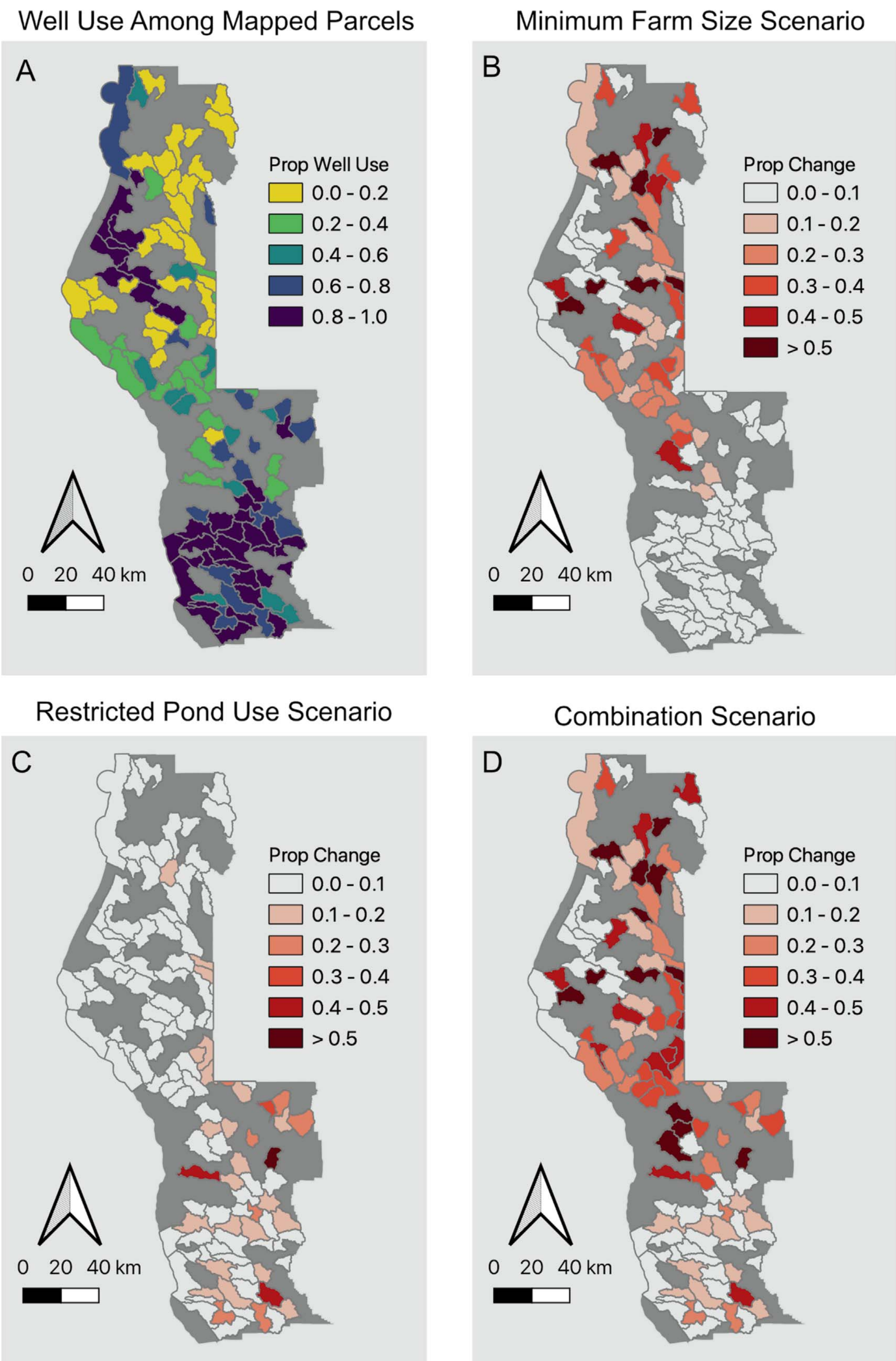

Figure 4. Geospatial Well Use and Scenario Outcomes. (A) Predicted well use among unpermitted farms is displayed at the sub watershed scale (HUC12). Watersheds containing less than five observations are omitted in this and all other subplots. (B) Predicted proportional increases in well use by watershed under the Minimum Farm Size Scenario. (C) Predicted proportional increases in well use by watershed under the Restricted Pond Use Scenario. (D) Predicted proportional increases in well use by watershed under the Combination Scenario.

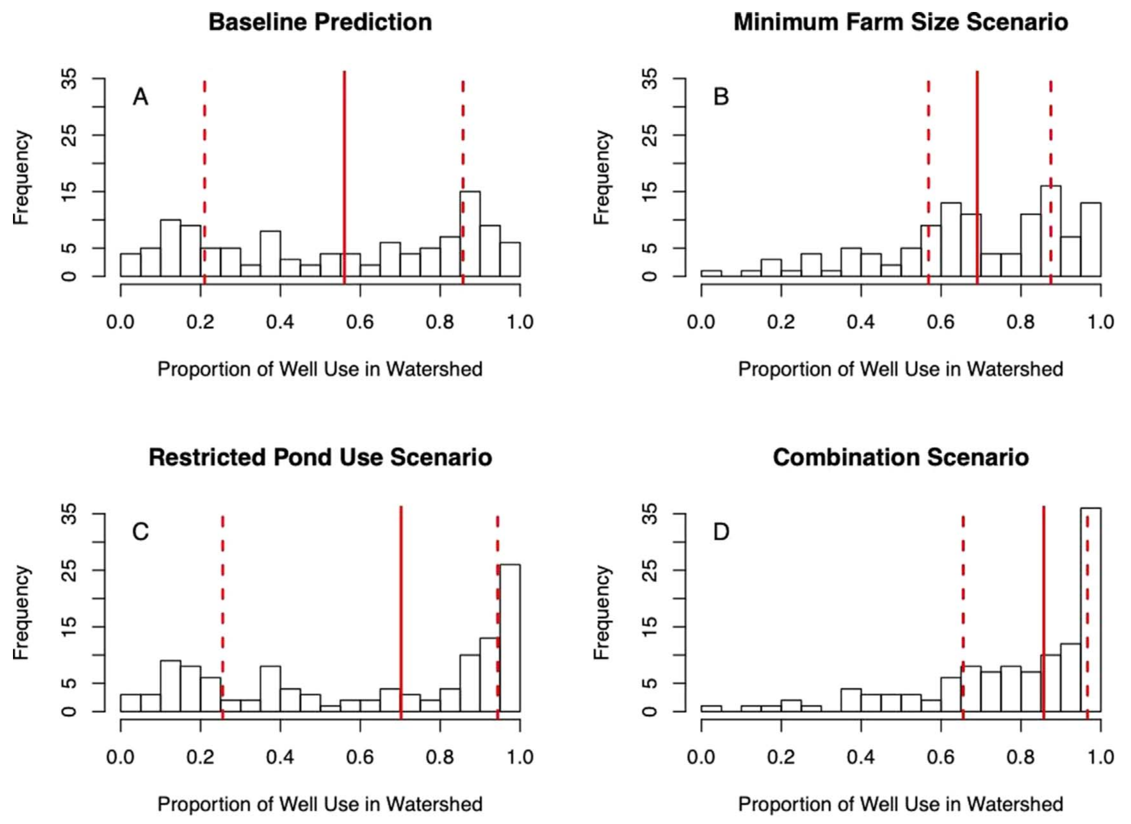

Figure 5. Tabular Summary of Well Use and Scenario Outcomes. Histograms depict predicted values for well use proportions summarized at the subwatershed scale for (A) the baseline prediction, (B) Minimum Farm Size Scenario, (C) Restricted Pond Use Scenario, and (D) Combination Scenario. Solid red lines depict the median value, while dashed redlines depict the interquartile range (25th–75th percentile of values).

Table 2. Ensemble model predictions. Predicted proportions of well use, overall, and summarized by county.

	Baseline well use prediction	Minimum farm size scenario prediction	Pond restriction scenario prediction	Combination scenario prediction
Overall	0.60	0.72	0.67	0.82
Humboldt County	0.38	0.61	0.41	0.66
Mendocino County	0.71	0.77	0.82	0.90

We also found that well use was not uniform across the landscape and that environmental factors can play an important role in influencing farmer decisions to use groundwater wells. Based on our analysis of well use in Humboldt and Mendocino Counties, we found that farms with less access to streams and lower annual precipitation increased the likelihood of groundwater wells. Model results also indicated that farm size had a positive effect on well use. These findings are consistent with patterns observed in the rest of the state, where high rates of well use correspond to regions of lower annual precipitation and larger farm sizes (Dillis *et al* 2021). In Humboldt and Mendocino Counties, farms with ponds had a significantly lower likelihood of well use, consistent with findings reported by Dillis *et al* (2020), who found that irrigation ponds in the region were consistently large enough to meet dry season irrigation demands, thereby precluding the need for using groundwater. However, similar to those findings, only a small fraction (14%) of farms in the current dataset actually had irrigation ponds, while the majority of farms used wells.

As the cannabis industry in California continues to transition from unpermitted production to a regulated agricultural sector, groundwater is likely to remain the primary water source for cannabis irrigation. Although the current use of wells by unpermitted farms is unknown, the proportion of farms is likely similar to permitted farms if it is assumed that the environmental factors that lead permitted farms to use wells - such as the lack of surface water and low rainfall - have the same effect on unpermitted farms. The well use models for Humboldt and Mendocino Counties further suggest that the transition of unpermitted farms to the regulated market will increase the prevalence of well use, especially if unpermitted farms increase in size and change water use practices to avoid surface water diversion and storage requirements. In particular, unpermitted farms currently using wells may face fewer obstacles in obtaining permits than those currently relying on surface sources that are either unable or unwilling to build water storage infrastructure.

A central question and major source of uncertainty related to reliance on groundwater by cannabis farms in California is the extent to which well use threatens streamflow and sensitive species. While most studies of streamflow depletion have focused on heavily-extracted aquifers with substantial row-crop agriculture (i.e., Foglia *et al* 2013, Tolley *et al* 2019, Zipper *et al* 2021), pumping in upland settings more characteristic of cannabis cultivation has also been shown to cause potentially significant streamflow depletion (Zipper *et al* 2019a, 2019b). In areas such as California with a seasonally dry climate, groundwater sustains summer baseflow in streams and provides crucial cold water habitat for aquatic species, including salmon and steelhead protected under the federal Endangered Species Act (Burns *et al* 2017, Larsen and Woelfle-Erskine 2018, Lovill *et al* 2018). Naturally low dry-season flows are highly vulnerable to surface water diversions, when even small water withdrawals can cause stream drying (Gasith and Resh 1999). Groundwater withdrawals can have similar effects as surface water diversions, but unlike direct surface water withdrawals, streamflow depletion is typically lagged and dampened relative to the time at which pumping occurred due to the slow movement of water through the subsurface, making it difficult to predict impacts (Reeves *et al* 2009, Barlow and Leake 2012, Konikow and Leake 2014, Zipper *et al* 2018). The lagged and damping effects will typically be greatest when wells are far from streams or in materials with lower hydraulic conductivity, and lags between pumping and streamflow depletion range widely, from hours to years (Barlow and Leake 2012). Generally, however, depletion will be greater for wells with larger pumping rates, located closer to streams, and situated in hydrogeological substrates with greater hydraulic conductivity (Bredehoeft 2011). Although well location data are exceptionally sparse, limited records from Northern California indicate that wells are preferentially located close to streams (Table S3). The tendency for wells to be drilled near streams, where they have the potential to cause rapid streamflow depletion similar to direct surface water diversions, warrants greater attention and should be addressed in policies that regulate both cannabis and non-cannabis water users.

The difficulty of addressing streamflow impacts from wells is exacerbated by a legacy of California water policy that has limited the state's authority to regulate groundwater use compared to the regulation of surface water resources (Owen *et al* 2019). Furthermore, given the context dependency of groundwater pumping impacts, a universal standard for streamflow protection remains elusive, making it more difficult to craft reasonable and effective statewide policy (Gleeson and Richter 2017). It is important to acknowledge that within groundwater basins, especially large basins regulated under SGMA, the relative demand (and potential impact) from cannabis farms is and will remain small relative to other agricultural sectors, given the much smaller footprint of cannabis farms (Butsic *et al* 2018). However, the use of unregulated groundwater wells for cannabis cultivation outside of groundwater basins, especially where wells are located near streams (Zipper *et al* 2019a), and where farms are clustered (Butsic *et al* 2017), distinguish this form of groundwater use as a potential concern for streamflow depletion, particularly for streams that harbor sensitive species.

Concerns over streamflow depletion are exacerbated by projections of future climate change in California. The prospect of reduced precipitation or changes in precipitation seasonality and variability may have foreseeable consequences for irrigation sources used by cannabis farms. California experienced record drought from 2012–2016 and is currently entering another historically severe drought event (Luković *et al* 2021). Climate projections for California indicate that annual precipitation extremes are likely to become more common (Swain *et al* 2018). While the occurrence of wet years would be welcomed by farms relying on surface water, the potential for increased frequency of drought years raises the threat of annual water insecurity. In other agricultural sectors, drought is known to significantly increase the frequency of well installations in subsequent years (Zipper *et al* 2017). Among cannabis agriculture in California, new evidence suggests that the likelihood of cannabis farms receiving enough precipitation to fill their allotted water rights will decline in the future (Morgan *et al* 2021), further incentivizing wells as a more consistently reliable water source.

The results presented herein could benefit from additional sources of data that are currently unavailable. First, the lack of data on unpermitted cannabis farms precludes our ability to directly evaluate their water use practices. Therefore, we are unable to determine the current extent to which unpermitted farms are using groundwater. Second, given the nascency of California's cannabis water policy, there is only a brief period of permitting record with which to examine how drought and projected increases in climate variability may affect irrigation practices by cannabis farms, as has been explored in other crops (e.g., Ajaz *et al* 2019, Saddique *et al* 2020). However, as the collection of water use data on cannabis farms continues, such analyses should be possible in the future.

Conclusions

Reliable access to irrigation water for cannabis is critical for farms participating in the regulated cannabis industry in California. Yet, methods to obtain water should also seek to avoid streamflow depletion and associated negative effects on aquatic ecosystems, particularly in remote natural areas that harbor sensitive species. While the prospect of regulating groundwater wells in upland areas outside of basins is fraught with legal and technical challenges, researchers and policymakers must engage what is likely to be an emerging issue in the regulated cannabis industry in California. In particular, more research is needed to understand where wells are located relative to streams and the contexts in which groundwater withdrawals cause streamflow depletion. Policies that address groundwater use should also be sensitive to regional variation in water availability and wherever possible, incentivize and facilitate water storage instead of or in conjunction with well use, as even modest storage capacity has the potential to reduce surface water diversions by almost 50% in the dry season (Dillis *et al* 2020). Finally, it should be recognized that, for some farms, wells may be the only viable water source available and therefore approaches to regulate groundwater use must balance concerns of streamflow impacts with the potential benefits of transitioning unpermitted farms to the regulated industry. Cannabis farming will continue to be challenged by water scarcity in California for the foreseeable future and it is important that steps be taken now to guide the development of a viable and environmentally sustainable legal cannabis industry.

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Data availability statement

The data that support the findings of this study are available upon reasonable request from the authors.

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