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March 17, 2021

By Electronic Mail

Mendocino County Planning Commission
pbs@mendocinocounty.org

RE: Commercial Cannabis Activity Land Use Development Ordinance OA-2021-0002 (Cannabis Cultivation Phase 3)

Dear Mendocino County Planning Commissioners:

We are legal counsel to Willits Environmental Center ("WEC"), writing on their behalf to inform you of the enormous hidden costs of the proposed Commercial Cannabis Activity Land Use Development Ordinance ("CCAO"). WEC is a member-supported, non-profit organization that has been protecting the natural landscapes and native species of Mendocino County and surrounding areas since 1990. WEC has grave concerns about the escalation in environmental impacts that the proposed ordinance will cause, especially in light of the implementation of the existing Cannabis Cultivation Ordinance codified in Chapters 10A.17 and 20.242 ("2017 Ordinance").

In apparent short-sighted haste and to avoid investing in an appropriate environmental analysis at the front end, the County has elected to use an exemption from CEQA for CCAO which will create an impossible burden for small commercial applicants as well as overworked staff and under-resourced regulators and law enforcement. Worse, because provisions of the CCAO modify the 2017 Ordinance, and because the assumptions of scope of impact of the mitigated negative declaration ("MND") for the 2017 Ordinance will now be hopelessly inaccurate, if the CCAO is adopted, either the County or Phase 1 applications must perform additional CEQA analysis on a project-by-project basis before approving even existing Phase 1 applications, a process that may well bring the County to its knees.The addition of tens of thousands of acres of cannabis cultivation in the Rangeland District is also inconsistent with the General Plan.

In short, this is a classic case of pennywise, pound foolish.

I. Adoption of the CCAO will multiply the County's CEQA Burdens

A. Regulation of by-right, non-commercial cultivation cannot qualify for the Business & Professions Code CEQA exemption.

The CEQA exemption in Business & Professions Code, section 26055, subdivision (h), exclusively applies to regulations that both impose later a "discretionary" process and govern "commercial cannabis activity." Section 13 of the CCAO and the Staff Report offer no other justification for foregoing CEQA. Yet, the CCAO also regulates indoor and outdoor cultivation of medical and adult-use cannabis, which are allowed by-right without any further permitting process and are not commercial activity. (County Code, § 22.18.030(B),(C).) Specifically, the CCAO revises this non-CEQA-exempt activity in at least the following ways:

- Reduces the required adult-use and medical cannabis cultivation setbacks. Neighboring occupied residential structures can now be 100 feet away instead of 200 feet and separately-owned parcels can be 50 feet instead of 100 feet. (Staff Report, p.3; proposed section 22.18.030(G)(2),(4).)

- Eliminates the existing requirement in County Code Section 10A.17.040(J), which is applicable to adult-use and medical cultivation, that "pesticides and concentrated fertilizers, amendments, and similar materials shall be stored in a locked, hard-faced enclosure to prevent unauthorized entry by humans, to exclude large animals that may be attracted by odors, and to ensure that they will not enter or be released into surface or ground waters" and that fuel must be stored to avoid spillage. (Staff Report, pp.2,4.)

Halving setbacks for indoor growing on smaller, residential lots in particular will make cultivation lawful in many areas where it is currently illegal. Numerous members of the public submitted written comments to the Board of Supervisors on January 25, 2021, that cultivation in residential areas would have significant negative consequences.

The scope of these provisions must be examined; staff apparently have done no analysis of how many more lots will satisfy the new conditions for cultivating up to 200 square feet of cannabis and where those lots are located. The County's 2016 Medical Marijuana Cultivation Regulation ordinance ("2016 Ordinance") findings declared:

> "Marijuana that is gown indoors may require excessive use of electricity, which may overload standard electrical systems creating an unreasonable risk of fire. If indoor grow lighting systems are powered by diesel generators, improper maintenance of the generators and fuel lines and improper storage of diesel fuel and waste oil may create an unreasonable risk of fire."

(County Code, § 9.31.030(J).)

This finding was issued before legalization expanded the potential grower population manyfold. The Staff Report does not contain any evaluation of the significance of fire, electricity, greenhouse gas emission, pesticide, water and odor-related impacts of increased adult-use and medical

cannabis cultivation. Moreover, the Sheriff has declared a lack of enforcement resources and expects an increase in illegal cultivation under the guise of adult-use, the impacts of which must be considered as well.[1] These significant changes to current regulations are not exempt from CEQA under the Business & Professions Code and must be addressed in a new or updated CEQA analysis.

B. Phase 3 Applicants and County Staff will be burdened with very expensive, time-consuming, and unpredictable environmental impact analyses.

Born of frustration with the existing ordinance, proposed Chapter 22.18 offers the tantalizing prospect of avoiding CEQA by invoking an exemption found in Business and Professions Code section 26055, subdivision (h). In reality, this provision just kicks the can down the road—over-burdening County Staff and applicants.

The crux of the problem is that under the CCAO, "each site will be reviewed individually for compliance with the California Environmental Quality Act (CEQA)." (Staff Report, p.2.) A glance at the detailed CEQA checklist required by CDFA demonstrates that this would *monumentally* expand the level of individual, project-level analysis required of each applicant, and the review of that analysis by Staff. (See 14 Cal. Code Regs., Appendix G, attached as Exhibit A.) Under state law all potentially significant environmental impacts of commercial cannabis projects must either be mitigated or considered in detail through an EIR. (*Pocket Protectors v. City of Sacramento* (2004) 124 Cal.App.4th 903, 928.) CDFA guidance states: "The best way for local CEQA Lead Agencies to ensure that an environmental document being prepared for a project will meet CDFA's needs when it acts as a Responsible Agency, is to provide CDFA with *several opportunities* to consult with the Lead Agency." (CDFA, *CEQA Practice Recommendations from CDFA for Cannabis Licensing –General Recommendations*, p.4 (May 19, 2019) ("CDFA Memo") (emphasis added), attached as Exhibit B.) Instead of the County preparing a *single* CEQA document evaluating direct and cumulative impacts of all new cannabis cultivation to which individual projects could tier with minimal additional or unique analysis, under the CCAO *each and every* Phase 3 application will generate a new CEQA review. (CDFA Memo, p.5.) And *each of those* will need multiple consultations with the CDFA to ensure compliance with state law. No time or effort is ultimately saved, and the County has insufficient staff to properly process hundreds or thousands of EIRs or negative declarations, which means gridlock is ensured.

Under CDFA guidance, technical studies and expert opinions will be required to establish that a project does not have a significant impact. (CDFA Memo, p.4.) Each permit will need specific, nonuniform, site-specific mitigation because no thresholds of significance have been established for the CCAO. This mitigation will also need to respond to anticipated cumulative impacts from future cultivation allowed by the CCAO.

[1] At the January 25, 2021, Board of Supervisors' meeting, Sheriff Kendall explained that he estimates there are over one million plants in Covelo alone and there is only one, often- diverted, officer assigned there. The Sheriff declared that deputies do not intervene to stop unlawful residential cultivation unless there are additional aggravating factors, such gang involvement. Therefore, he said, "It's kind of a moot point to even discuss that when we don't even have the personnel to deal with it." (https://mendocino.granicus.com/MediaPlayer.php?view_id=2&clip_id=226 (37:00).)

To be valid, mitigations must be realistically enforceable. (Pub. Rec. Code, § 21081.6, subd. (b); *Fed'n of Hillside & Canyon Associations v. City of Los Angeles*, 83 Cal. App. 4th 1252, 1262 (requiring that mitigation measures actually be funded and implemented).) The County has an abysmal enforcement history under the present-day, less extensive regulatory program. It will be difficult to show that project-specific mitigation is enforceable and funded in this context, especially given the variability the broadly discretionary program will inject into not only the CCAO, but also applicants not yet fully processed under the 2017 Ordinance. (See discussion below.)

The demanding, yet transparent detail of the 2017 Ordinance tracks the MND. There is no such road map for applicants or Staff under the CCAO process, even for very small projects. In the event that the Planning Department does produce "a guidance document" (proposed section 22.18.060), it will have to end up looking very similar to the details of the current ordinance. The presence of a "guidance document" will not insulate the County from a CEQA challenge.

In addition to time, the proposed ordinance will expand the collective cost of permitting by orders of magnitude. The millions of dollars that Supervisors worried the County would have to spend on a program-level CEQA analysis will now be borne by applicants hiring biologists, hydrologists, engineers, and CEQA consultants. And the County will *still* spend millions of dollars reviewing and conferring over the applications this effort produces. It is the County that has the duty to comply with CEQA and can be sued over each project determination—each of which will now be unique, creating a thousand potential challenges where before there realistically was one-for which the statute of limitations to challenge it long ago lapsed.

And if an error is made, which is more likely in a customized review, applicants will also face the more likely eventually of indemnifying the County for defending complex CEQA suits, including potentially the fees and costs incurred by the challenging party should they prevail.[2] (County Code, § 10A.17.100(B).) This alone may be enough to dissuade the small growers whom the County has previously tried to protect, or cause them financial ruin. The CCAO opens up rural the Mendocino County to massive corporate growers whose deep pockets and anticipated return on multi-acre farms make the financial gamble imposed by the proposed discretionary ordinance worthwhile. Smaller growers do not have these resources and many will be forced to choose among terrible options: risk the discretionary process, quit, or remain on the black market. (See Bodwitch, et al, *Barriers to Compliance in Cannabis Agriculture*, (Dec. 2020), attached as Exhibit C.)

At the end of the day, the fundamental problem with the current ordinance is not actually the ordinance, but the lack of staff resources to competently process applications and take enforcement action. The CCAO does not solve this problem. Instead, it places *greater* burdens on staff.

[2] If the applicant is financially unable to indemnify the County, then the County will have to foot the bill.

C. Phase 1 applicants will now also need to do site-specific CEQA.

The CCAO misleadingly claims to allow existing Phase 1 applicants to complete processing of their non-discretionary permits under existing Chapter 10A.17 (CCAO, § 2.) In actuality, the CCAO will force each remaining Phase 1 applicant to complete an individualized CEQA review to justify the sufficiency of mitigations in light of the new impacts authorized by the CCAO.

The determination in the 2017 MND that certain activities were below the level of "significance" was based on the 2017 Ordinance's cap on water use, wildlife disruption, soil and water pollution, traffic, light pollution, greenhouse gas emissions, and the extent of site disturbance, and other limitations on cumulative impacts from current and future operations. The CCAO blows the ceiling off these limits, greatly expanding the impact of cannabis cultivation in the County and rendering the MND largely meaningless.

Under the existing ordinance, other than nursery production, cultivation area maximum is capped at 10,000 square feet per parcel. (County Code, § 20.242.060.) New commercial cannabis cultivation is banned in the Rangeland (RL) District, which constitutes roughly one-third of the County at over 700,000 acres. (Id.) The CCAO will open the RL District to new cultivation and, by means of a single footnote in Appendix A, increases allowable cultivated area to up to 10% of parcels over 10 acres in the Agricultural (AG), RL, and Upland Residential (UR) Districts. A simple example highlights the enormity of this change. The *minimum* parcel size in the RL District is 160 acres (County Code, § 20.060.030), allowing an unprecedented 16 acres of cannabis cultivation, or *697 times* as much cultivated area on this minimum lot as would be permitted by the 2017 Ordinance. The CCAO also allows Phase 3 cultivation with trucked water without specific watershed analysis, depleting watersheds already in use for Phase 1 cultivation. (CCAO, § 5.)

Area Subject to New 10% Allowance under the CCAO

Zone	*Approx. County Total*
Rangeland	738,500 ac.
Agriculture	60,000 ac.
Upland Residential	109,000 ac.

As recognized in the MND and numerous studies, widespread, commercial cannabis cultivation without careful regulation results in massive environmental impacts ranging from traffic to solid waste to harm to wildlife. (WEC will also submit comments from the Center for Biological Diversity and others to the Bureau of Cannabis Control in 2017 discussing in greater detail the impacts of cultivation and the impacts of its legalization; the 2017 Center for Biological Diversity comments are incorporated herein by reference.)

As noted in the findings to the 2016 Ordinance:

> The State Water Resources Control Board, the North Coast Regional Water Quality Control Board, and the State Department of Fish and Wildlife have documented a dramatic increase in the number of marijuana cultivation sites, corresponding increases in impacts to water supply and water quality, including the discharge of sediments, pesticides, fertilizers, petroleum hydrocarbons, trash and human waste. These impacts result from the widespread unpermitted, unmitigated, and unregulated impacts of land grading, road development, vegetation removal, timber clearance, erosion of disturbed surfaces and stream banks, stream diversion for irrigation, temporary human occupancy without proper sanitary or waste disposal facilities and threaten the survival of endangered fish species. In addition, the actions of some marijuana growers, either directly or through irresponsible practices, result in the killing of wildlife, including the endangered Pacific Fisher. (County Code, § 9.31.030(Q).)

Moreover, larger operations of the scale to be allowed under the CCAO in the AG, RL and UR Districts, generate qualitatively more intensive impacts than small-scale cultivation. They have fundamentally different infrastructure demands and are more likely to result in increased vehicle traffic, road grading, heavy machinery use, and construction of laborer housing, warehouses and workspaces for on-site processing. Moreover, these impacts will occur in the more rural, ecologically sensitive oak woodlands, grasslands and chaparral of the RL District where presently there are few roads or other infrastructure. Added activity in the RL District also pose new and unstudied fire risk, potentially taxing County resources beyond their capacity. (See Attorney General letters, attached as Exhibit D.)

Clearly, the CCAO constitutes a "substantial change" to cannabis cultivation impacts in the County, and the "involvement of new significant, environmental effects or a substantial increase in the severity of previously identified significant effects." (14 Cal. Code Regs., § 15162.) As a result, the CCAO will invalidate the 2017 CEQA review by substantially changing the context within which the 2017 Ordinance's impacts were considered and undermining every aspect of the impacts analysis. As a result, the County must revisit its analysis of the impacts of the 2017 Ordinance and supplement the MND, prepare an EIR, or require each applicant still in the Phase 1 process to do site-specific CEQA to remedy the gaping insufficiencies that the CCAO will cause in the prior analysis. (See CDFA Memo, p.6.)

II. The CCAO is inconsistent with the County's General Plan

General Plans are statements of development policies. (Gov. Code, § 65302.) They consist of objectives, principles, standards, and plan proposals. (Id.) Projects have to be consistent with the General Plan. (Gov. Code, § 66473.5.) Mendocino County's General Plan requires, *inter alia*:

- That stream corridors and riparian habitat be protected (Policy RM-1);
- That the County have a Riparian System Management plan to facilitate protection and enhancement of aquatic habitat (Action Item RM-4.1.);
- The County must affirmatively protect water Resources (Policy RM-11);

- The County must affirmatively plan for management of water resources (Policy RM-12);
- Existing users of water are given priority over new uses (Policy RM-14);
- Development cannot be allowed absent proof of capability of the available water supply (Policy RM17);
- The county must avoid fragmentation of its natural landscape (Policy RM-24; 25, 30);
- Land and natural resources must be used in a "environmentally sound and sustainable manner" (Policy RM-26);
- Wildlife corridors must be identified and maintained (Action Item RM-27.1);
- Adoption of an ordinance, as a "discretionary public project" requires specific actions be taken to protect species (Policy RM-28);

B. Cannabis cultivation Should not be Allowed in Range Land.

Lands zoned RL in the County are not well-suited to cannabis cultivation. These areas are dry, streams are already taxed and the land particularly vulnerable to wildfire. (See Exhibit F.) The creation of RL District is intended to protect natural and water resources from "fire, pollution, erosion, and other detrimental effects." (County Code, § 20.060.005.) Mendocino General Plan, Policy DE-17, Intent, 3-76, provides that the RL District is to "protect these lands from the pressures of development" and preserve them for "uses determined to be related to and compatible with ranching, conservation, processing and development of natural resources . . . " Massive cannabis cultivation (potentially cultivating over 73,000 acres, not including related infrastructure) is incompatible with the General Plan designation.

Moreover, these remote, rural areas are especially challenging to monitor and protect. While other types of farming are generally in decline, the greenrush is in full swing. One study estimates that each cannabis plant requires 900 gallons per year, nearly twice the water use of grapes. (Bauer, et al., *Impacts of Surface Water Diversions for Marijuana Cultivation on Aquatic Habitat in Four Northwestern California Watersheds* (2015), attached as Exhibit E.) The massive black market, continuing federal legal obstacles, extensive illegal cannabis cultivation, boom-bust risk from the sudden explosion of the legal cannabis market, entrepreneurial culture of new entrants to the industry, and minimal enforcement raises the distinct risk that cannabis cultivations will give rise to unpermitted activities with more prevalence than would occur in other agricultural settings.[3] The County has not been able to successfully regulate cannabis cultivation in other zones yet, so it is inappropriate to stretch thin resources further by opening three quarters of a million additional acres to cultivation.

[3] Illegal, incremental impacts that add to that deteriorating scenario must be considered as potentially cumulative significant impacts. (*See e.g., Los Angeles Unified School Dist. v. City of Los Angeles* (1997) 58 Cal. App. 4th 1019, 1026; *Kings County Farm Bureau v. v. City of Hanford* (1990) 221 Cal. App. 3d 692, 718.)

C. The General Plan Must Be Updated

The General Plan does not discuss cannabis cultivation at all. Before establishing a program across the County allowing large scale grows for the first time, the General Plan must be updated.

III. Adoption of the CCAO Raises Numerous Issues of Compliance with State Resource Laws for which There is No Exemption.

A. Laws Protecting Plants and Animals.

The County can violate the Endangered Species Act by issuing permits that cause injury to species by destroying their habitat or authorizing activities that result in their harm. (16 U.S.C. § 1538(a)(1); *Babbitt v Sweet Home Chapter* (1995) 515 US 687; *Strahan v Coxe* (1st Cir 1997) 127 F.3d 155.) Cultivation threatens "take" of endangered species, including fishers, marbled murrelets, northern spotted owls, and salmonid species, through habitat fragmentation, light and sound pollution and pesticide use. (See Rich, et. al, *Anthropogenic Noise: Potential Influences on Wildlife and Applications to Cannabis Cultivation*, Cal. Fish & Wildlife, Cannabis Special Issue 108-119 (2020), attached as Exhibit F.) Numerous species are placed at risk by the particular use of anticoagulant pesticides in cannabis cultivation. (See Gabriel, et. al, *Anticoagulant Rodenticides on our Public and Community Lands: Spatial Distribution of Exposure and Poisoning of a Rare Forest Carnivore* (2012), attached as Exhibit G.)

B. California Laws Protecting Water Resources

The California Constitution "requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented." (Cal. Const., Art. X, § 2.) Water diversion, sedimentation, and pesticide, fertilizer and chemical pollution already threaten the County's waterways. (See *North Coast Regional Water Quality Control Board Investigative Order* (2020), attached as Exhibit H.) New burdens imposed by industrial-scale cultivation in the drier regions of the County is unreasonable. Moreover, both the Eel and the Russian Rivers are designated as "impaired" pursuant to Section 303 of the Clean Water Act due to excess sedimentation and temperature increase that threaten salmon and steelhead populations, as well as other species.

The Eel River is also designated as a Wild and Scenic River under federal and state law. (Pub. Rec. Code, § 5093.54, subdiv. (d), (f).) The Eel River must be "preserved in [its] free-flowing state, together with [its] immediate environments, for the benefit and enjoyment of the people of the state." (Id., § 5093.50.) It is illegal to divert water from the Eel River for cultivation purposes (Id., § 5093.55.) The Eel River runs through Covelo region and other areas where extensive cannabis cultivation is expected. Expanding cultivation in the area of the Eel River without robust protections and enforcement will result in illegal diversion of the river.

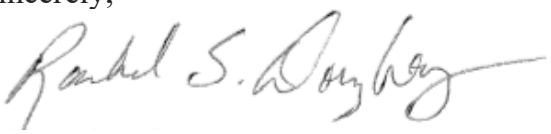
IV. Conclusion

County Supervisors are understandably unhappy with the County's cannabis permitting process. Some blame the 2017 Ordinance for being too complicated and propose the CCAO as the solution for Phase 3. But, the 2017 Ordinance is intricate because the environmental impacts of cannabis cultivation are substantial and wide-ranging. Ultimately, criticism of the 2017 Ordinance is dissatisfaction with CEQA, a state law that the County has no discretion to ignore. Planning Staff will still have to address environmental impacts of the discretionary permits proposed in the CCAO. But, the review at the individual permit level, instead of programmatic level, will result in a nontransparent process and inconsistent and conflicting decisions. The County must focus instead on properly resourcing and managing its own permit workflow to professionally regulate the level of activity that is actually occurring in the County before allowing more cultivation in rural areas.

WEC recognizes that cannabis cultivation plays an important role in Mendocino County and the County government faces difficult resource, regulatory, and policy challenges. However, the County must meet its environmental obligations by evaluating the cumulative environmental impact of its chosen course of action and implement realistic mitigations to prevent environmental harm. To this end, in addition to this letter, we are also submitting into the public record under separate cover, due to file size constraints, the Center for Biological Diversity's July 31, 2017, comments on the CDFA's CalCannabis Cultivator Licensing Program EIR, which extensively documents the environmental impacts of cannabis cultivation. WEC invites the Planning Commission to work with WEC to protect the County's natural resources, develop a workable permit regime and comply with CEQA.

Please contact me if you have any questions or concerns or desire further discussion of this matter.

Sincerely,



Rachel Doughty

CC: Julia Krog, Assistant Planning Director (ackerj@mendocinocounty.org)

Mendocino County Board of Supervisors (bos@mendocinocounty.org)

Matthew Kiedrowski, county counsel, (kiedrowskim@co.mendocino.ca.us)

EXHIBIT A

Memorandum

To : Local Jurisdictions Developing Cannabis Licensing or Permitting Programs

Date: May 13, 2019

Place: Sacramento

Phone: (916) 263-0801

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

Subject : **CEQA Practice Recommendations from CDFA for Cannabis Licensing – General Recommendations**

The California Department of Food and Agriculture's (CDFA's) CalCannabis Cultivation Licensing Division (CalCannabis) has jurisdiction over the issuance of licenses to cultivate, propagate and process commercial cannabis in the State of California. CalCannabis is reaching out to local jurisdictions that are developing cannabis cultivation permitting programs to assist them in structuring their ordinances and permitting programs. This memorandum gives an overview of CDFA's responsibilities for compliance with the California Environmental Quality Act (CEQA) and gives recommendations to local jurisdictions related to incorporating CEQA compliance into their programs in order to facilitate subsequent licensing by CDFA.

CDFA issues licenses for commercial cannabis cultivation (including outdoor, indoor, and mixed-light cultivation), cannabis nurseries, and cannabis processor facilities, where local jurisdictions authorize these activities. All commercial cannabis cultivation within the State of California requires a cultivation license from CDFA, pursuant to the Bus. & Profs. Code § 26012(a)(2).

CDFA certified a Programmatic Environmental Impact Report (PEIR) for the adoption of its cannabis cultivation licensing regulations on November 13, 2017. The PEIR can be found at the following link: https://www.cdfa.ca.gov/calcannabis/PEIR.html.

CEQA Documentation Requirements for CalCannabis Annual Cultivation License Applicants

Pursuant to Cal. Code of Regs., tit. 3, § 8102, CDFA requires an annual license applicant to provide evidence of exemption from, or compliance with, CEQA. The evidence provided must be one of the following:

(1) A signed copy of a project-specific Notice of Determination and a copy of the associated CEQA document, a Notice of Exemption, or reference to where these materials may be located electronically, a project description, and/or

any accompanying permitting documentation from the local jurisdiction used for review in determining site specific environmental compliance;

(2) If an applicant does not have the evidence specified in subsection (1), or if the local jurisdiction did not prepare a CEQA document, the applicant will be responsible for the preparation of an environmental document in compliance with CEQA that can be approved or certified by [CDFA], unless [CDFA] specifies otherwise.

When the project has been evaluated in a site-specific environmental document previously certified or adopted by the local Lead Agency, CDFA will evaluate the project as a Responsible Agency, as provided in section 15096 of the CEQA Guidelines. CDFA will act as the CEQA Lead Agency when the local jurisdiction does not act as the Lead Agency.

For a complete list of all license requirements please visit: static.cdfa.ca.gov/MCCP/document/CDFA Final Regulation Text_01162019_Clean.pdf.

Recommendations

CalCannabis provides the following recommendations to assist local jurisdictions in completing CEQA compliance in ways that will facilitate CDFA's review of applications for licensure.

Recommendation 1: Incorporate Site-Specific CEQA Compliance Into Local Permitting Process

Local jurisdictions that are developing programs for permitting cannabis cultivation should incorporate CEQA compliance into their permitting process. This should involve the preparation of a site-specific CEQA evaluation for every project, regardless of whether a program level CEQA document has been prepared. The documentation required is described in Cal. Code of Regs., tit. 3, § 8102.

While the CalCannabis PEIR evaluated impacts of cannabis cultivation statewide, CDFA determined that some environmental topics generally fell outside of CDFA's regulatory authority because these topics are regulated by local land use authorities better situated to evaluate local and regional impacts (see Attachment A). These include issues such as aesthetics, land use and planning, geology and soils, mineral resources, noise, odors, regional recreational structures and services, compliance with building standards, provisions for police and fire protection, and connections to public utilities (e.g., public water, wastewater, and storm drainage systems).

Additionally, there are other topics for which detailed analysis in the CalCannabis PEIR was not possible because of the statewide nature of the CalCannabis licensure program. The CalCannabis PEIR determined that the evaluation of impacts related to these topics would most appropriately be evaluated in local program-level or site-specific documents. Many of these topics involve the evaluation of site-specific

conditions, the details of which were infeasible to identify and evaluate in a statewide PEIR, and the characteristics of which (e.g., the locations of new cultivation sites) were unknown at the time the PEIR was published.

Environmental protections and significance thresholds appropriate at a local level may be provided in the local jurisdiction's cannabis cultivation ordinance or in a regulatory framework established in the local or regional general plan, land use policies, ordinances, and/or other regional plans. The establishment of environmental protections through ordinance or standard permit terms may allow jurisdictions to streamline CEQA compliance for individual projects by making it easier to demonstrate that the impacts of projects would be less than significant.

If a local jurisdiction prepares site-specific CEQA compliance document for each cannabis cultivation project for which it issues a permit, and those documents contains the information required by CDFA to issue an annual license, it improves the efficiency with which CDFA can issue annual licenses for projects located within that jurisdiction. When CDFA receives an application for a cultivation project that does not include site-specific CEQA compliance documentation, CDFA must act as the CEQA Lead Agency and must either prepare a CEQA document itself or request that the applicant prepare site-specific analysis. In either event this is likely to significantly delay CDFA's issuance of the state license.

Recommendation 2: Consult Early and Often with CDFA

The best way for local CEQA Lead Agencies to ensure that an environmental document being prepared for a project will meet CDFA's needs when it acts as a Responsible Agency, is to provide CDFA with several opportunities to consult with the Lead Agency. The opportunities provided by CEQA include:

- Allowing for informal consultation with CDFA prior to finalizing a decision about the type of environmental document to be prepared for each cannabis project (CEQA Guidelines §15063(g)).

- Ensuring that CDFA is included in the Reviewing Agencies Checklist for all future environmental documents for cannabis cultivation projects so that CDFA has the opportunity to comment on any draft documents.

- Carefully considering any comments made by CDFA regarding environmental documents.

- Providing a copy to all applicants of the CEQA documentation prepared by the Lead Agency so they can include these with their application to CDFA. For categorical exemptions, this includes the filed Notice of Exemption with documentation supporting the exemption determination. For other CEQA documents, this includes a copy of the adopted IS/ND or IS/MND, certified EIR, or Addendum, and a copy of the Notice of Determination.

Recommendation 3: Provide a Robust Project Description

When CDFA receives a CEQA document prepared by a local jurisdiction, it must determine if the CEQA document is adequate for its purposes of issuing an annual license. Similarly, when CDFA receives a Notice of Exemption for a project, it must determine if the project qualifies for an exemption (or exemptions). In order to make these determinations, CDFA must have sufficient information about the construction and operation of the proposed project. When a local jurisdiction provides the project description information the local jurisdiction used when complying with CEQA, it allows CalCannabis to evaluate the project for licensure more quickly. Details regarding the types of information required can be found in the document titled, "*CEQA Practice Recommendations from CDFA for Cannabis Licensing – Project Description Content Requirements*."

Recommendation 4: Document Conclusions with Substantial Evidence

CEQA requires that Lead Agencies evaluate the environmental impacts of proposed projects. "Substantial evidence" should support Agencies' factual conclusions. Substantial evidence includes facts, reasonable assumptions predicated upon facts, and expert opinion supported by facts. When CDFA reviews CEQA compliance documents provided by local Lead Agencies, it will evaluate whether substantial evidence supports Lead Agencies' conclusions. This will apply to all types of CEQA documents (EIRs, IS/NDs, IS/MNDs, addenda), as well as to Notices of Exemption submitted to document the use of categorical exemptions.

Of particular importance are assertions that project circumstances, permit conditions, local regulations, or other factors would prevent a project from resulting in a significant impact. Local Lead Agencies should provide evidence such as the results of technical studies, expert opinion, local ordinances or policies, permit conditions, or specific mitigation measures to support the Agencies' conclusions. When using mitigation measures to reduce the significance of mitigation measures, provide detail as to what is to be done, when it is to be done, and who is responsible for completing each measure. Also, be sure to include a significance determination after mitigation, and describe how the mitigation measure would reduce the impact to less than significant.

Recommendation 5: Take Advantage of Tiering from the CalCannabis PEIR and Other CEQA Streamlining Opportunities

If the local jurisdiction elects to prepare a CEQA document related to cannabis cultivation subject to state licensure, it should give particular attention to topics not specifically covered by the CalCannabis PEIR. These topics are listed in Attachment A, "*Topics Determined by the CalCannabis PEIR to be Most Appropriately Evaluated by Local Jurisdictions*." While the PEIR provides general conclusions regarding the likelihood and types of impacts caused by cannabis cultivation, including the cumulative impacts that would be expected under the statewide CalCannabis Program, the PEIR does not evaluate these impacts in detail.

Although, local jurisdictions are not required to tier from, or incorporate by reference, the CalCannabis PEIR, appropriate streamlining can facilitate CDFA's review of projects. This applies whether the document is a program-level CEQA document for a local cannabis ordinance, or a site-specific CEQA analysis.

Recommendation 6: Use 2019 CEQA Guidelines

CalCannabis recommends that local jurisdictions incorporate the changes to the CEQA Guidelines adopted on December 28, 2018, after the CalCannabis PEIR was certified in their CEQA analysis. The updated CEQA Guidelines can be found at: www.califaep.org/index.php?option=com_content&view=article&id=111&Itemid=258. In particular, CDFA suggests that local jurisdictions utilize the updated Appendix G checklist when completing a CEQA evaluation or tiering from the CalCannabis PEIR. The updated checklist incorporates recent case law and recommends that Initial Studies and EIRs evaluate additional resource topics, including energy impacts (required in EIRs, recommended in Initial Studies) and impacts related to wildfire.

Recommendation 7: Analyze Cumulative Impacts

Site-specific CEQA documents should evaluate the contribution of a project to cumulative impacts. As defined in section 15355 of the CEQA Guidelines, cumulative impacts may be potentially significant when the contribution of an individual project may be less than significant, but where a number of past, present, and reasonably foreseeable individual projects may contribute to a significant cumulative impact. Such analysis is required for projects approved under a categorical exemption (or exemptions), and when an IS/ND, IS/MND, or an EIR is prepared for the project, though a different level of analysis is required for each.

If a local jurisdiction prepares a program-level CEQA document for the adoption of its cannabis cultivation ordinance that includes a cumulative impact analysis, then individual projects need only reference that analysis, and evaluate the contribution of the project to any identified cumulative impacts. Should the program-level document identify significant and unavoidable cumulative impacts, the site-specific document should take special care to analyze whether the project would make a considerable contribution to such impacts. Of particular importance are topics for which the direct impacts of an individual project may be less than significant, but for which it may make a considerable contribution to a significant cumulative impact. These topics may include:

- Impacts of surface water diversions on aquatic species and habitats, including riparian habitats reliant on streamflows;
- Impacts of groundwater diversions on the health of the underlying aquifer, including impacts on other users, and impacts on stream-related resources connected to the aquifer;
- Impacts on terrestrial biological species and habitats, particularly special-status species as defined under CEQA;
- Impacts related to noise;

- Impacts related to air quality and objectionable odors.

When evaluating cumulative impacts, a cumulative analysis should include reasonably foreseeable future projects. For project applicants that propose multiple projects on different parcels, or who apply for multiple state licenses, all such projects are reasonably foreseeable and should be evaluated.

Adequately evaluating these cumulative impacts and incorporating mitigation measures to address them will allow applicants and the local jurisdictions to take advantage of CEQA streamlining opportunities at the site-specific level.

Additional Reference Materials

CDFA is preparing reference materials that will provide additional detail regarding some of the topics discussed above. The topics to be addressed include:

- Project Description
- Categorical Exemptions
- Streamlining Opportunities

Conclusion

CDFA appreciates the cooperation of local jurisdictions in working with CDFA to ensure that applicants have adequate CEQA documentation for CDFA's issuance of annual licenses. Note that applicants who are eligible for annual licenses, except that CEQA has not been completed, but can show that CEQA compliance is underway may receive a provisional license. Following the recommendations contained in this letter will provide the most expedient processing of cultivation license applications and avoid lapses in license coverage between the expiration of provisional or temporary licenses and the issuance of annual licenses.

CDFA welcomes the opportunity to discuss CEQA requirements and the information contained in this document with you. If you require additional information, please contact Kevin Ponce, Senior Environmental Scientist, at (916) 263-0801 or via e-mail at kevin.ponce@cdfa.ca.gov.

Memorandum

To : Local Jurisdictions Developing Cannabis Licensing or Permitting Programs

Date: May 13, 2019

Place: Sacramento

Phone: (916) 263-0801

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

Subject : **CEQA Practice Recommendations from CDFA for Cannabis Licensing – Project Description Content Requirements**

CalCannabis Review of CEQA Documents

Before CalCannabis can grant an annual license for a project permitted by a local jurisdiction, CalCannabis must make an independent evaluation of the document prepared for the project in compliance with the California Environmental Quality Act (CEQA), or documentation provided by the applicant as evidence of exemption from CEQA. To conduct this evaluation, CalCannabis must have a complete description of the proposed project that provides information about the project site, including existing conditions and facilities, proposed facilities and improvements (both on and off site), and the construction methods and operations practices of the proposed project. CalCannabis can complete its review more quickly and efficiently when applicants provide the information needed to complete an independent evaluation of the proposed project. This will translate into faster issuance of licenses for qualified applications.

Project Description Information Required

When submitting an application for a cultivation license to CalCannabis, the local jurisdiction or applicant should provide a project description that contains the following information:

- **Project Location** – Indicate the precise location and boundaries of the proposed project. At a minimum, provide an address and the location of the project on an appropriately scaled map (i.e., one that shows both the specific location of the project and enough surrounding area to allow CDFA to understand its general location). CDFA prefers applicants to provide this information on a topographic map or aerial photograph.
- **Description of Project Site** – Provide a premises map and a property diagram showing the location of all existing structures and facilities, and all proposed structures and facilities, labeled so reviewers can distinguish the existing features from proposed features. Applicants may attach the proposed premises and property diagram submitted with their application to satisfy this

requirement, provided the diagram delineates those details described above. Also provide the following information about the project site:

  - Description of existing topographic conditions on the project site and surrounding areas (is the project site generally flat, gently sloped, or steeply sloped);
  - Description of current land uses on the project site and any existing buildings and structures;
  - Description of any natural features or habitats on the project site (e.g., wetlands, stream channels, forested areas); and
  - Description of land uses surrounding the project site.

- **Required Site Improvements (Construction Activities) –** The project description should include details of all improvements that will be made to the project property as part of the proposed project. This should include the following information, as relevant:
  - Any new small or accessory structures that will be constructed, including the location (on the premises map), dimensions, purpose, how long their construction is expected to last, and what types of equipment will be used for each;
  - Any modifications or improvements to existing buildings or facilities that will be completed, including the nature of the improvements;
  - Any new facilities, including infrastructure improvements or upgrades, whether those improvements are located on the project site or off site (e.g., extension of water line);
  - Any grading that will be required and the anticipated amounts of cut and fill; and
  - Where construction equipment and materials storage (staging) areas will be located, where appropriate.

- **Description of Project Operations** – Provide the following information about project operations:
  - Number of employees;
  - Number of daily trips for delivery of materials or supplies and shipment of product;
  - The source(s) of water for irrigation, processing, and domestic use;
  - The method for treatment of wastewater generated by the project; and

- The source of energy used in operation of the project, and a list of all energy management and efficiency features included in the project.

Should project operation details (e.g., source(s) of water, method(s) for treatment of wastewater, source(s) of energy) be described in other portions of the application and/or attachments, applicants may direct reviewers to where these details have been provided. However, for reviewer efficiency purposes, applicants are encouraged to provide a complete project description that includes those details pertaining to proposed operations.

- **Environmental Commitments** – Describe any environmental commitments regarding project construction or operations that the applicant proposes, including those required by ordinance and any others included voluntarily. Environmental commitments could be related to energy efficiency, water efficiency, noise abatement, lighting, or other aspects of the project that may reduce the impacts of the project on the environment.
- **Other Required Permits and Approvals** - A list of other environmental permits that may be required or have been obtained (e.g., annual cultivation license from CDFA, water right permit from State Water Resources Control Board (SWRCB) for diversion of surface waters, proof of enrollment in enrollment in or exemption from either the SWRCB or Regional Water Quality Control Board program for water quality protection, Lake or Streambed Alteration Agreement from California Department of Fish and Wildlife).

EXHIBIT B

APPENDIX G

ENVIRONMENTAL CHECKLIST FORM

NOTE: The following is a sample form that may be tailored to satisfy individual agencies' needs and project circumstances. It may be used to meet the requirements for an initial study when the criteria set forth in CEQA Guidelines have been met. Substantial evidence of potential impacts that are not listed on this form must also be considered. The sample questions in this form are intended to encourage thoughtful assessment of impacts, and do not necessarily represent thresholds of significance.

1. Project title: _____
2. Lead agency name and address:

_____

_____

3. Contact person and phone number: _____
4. Project location: _____
5. Project sponsor's name and address:

_____

_____

6. General plan designation: _____
7. Zoning: _____
8. Description of project: (Describe the whole action involved, including but not limited to later phases of the project, and any secondary, support, or off-site features necessary for its implementation. Attach additional sheets if necessary.)

_____

_____

_____

_____

_____

_____

_____

9. Surrounding land uses and setting: (Briefly describe the project's surroundings)

_____

_____

_____

10. Other public agencies whose approval is required: (e.g., permits, financing approval, or participation agreement.)

    _____

    _____

11. Have California Native American tribes traditionally and culturally affiliated with the project area requested consultation pursuant to Public Resources Code section 21080.3.1? If so, is there a plan for consultation that includes, for example, the determination of significance of impacts to tribal cultural resources, procedures regarding confidentiality, etc.?

    _____

    _____

NOTE: Conducting consultation early in the CEQA process allows tribal governments, lead agencies, and project proponents to discuss the level of environmental review, identify and address potential adverse impacts to tribal cultural resources, and reduce the potential for delay and conflict in the environmental review process. (See Public Resources Code section 21080.3.2.) Information may also be available from the California Native American Heritage Commission's Sacred Lands File per Public Resources Code section 5097.96 and the California Historical Resources Information System administered by the California Office of Historic Preservation. Please also note that Public Resources Code section 21082.3(c) contains provisions specific to confidentiality.

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED:

The environmental factors checked below would be potentially affected by this project, involving at least one impact that is a "Potentially Significant Impact," as indicated by the checklist on the following pages.

☐ Aesthetics	☐ Agriculture / Forestry Resources	☐ Air Quality
☐ Biological Resources	☐ Cultural Resources	☐ Energy
☐ Geology/Soils	☐ Greenhouse Gas Emissions	☐ Hazards and Hazardous Materials
☐ Hydrology/Water Quality	☐ Land Use / Planning	☐ Mineral Resources
☐ Noise	☐ Population / Housing	☐ Public Services
☐ Recreation	☐ Transportation	☐ Tribal Cultural Resources
☐ Utilities / Service Systems	☐ Wildfire	☐ Mandatory Findings of Significance

DETERMINATION

On the basis of this initial evaluation:

I find that the proposed project COULD NOT have a significant effect on the environment, and a NEGATIVE DECLARATION will be prepared.

I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the project have been made by or agreed to by the project proponent. A MITIGATED NEGATIVE DECLARATION will be prepared.

I find that the proposed project MAY have a significant effect on the environment, and an ENVIRONMENTAL IMPACT REPORT is required.

I find that the proposed project MAY have a "potentially significant impact" or "potentially significant unless mitigated" impact on the environment, but at least one effect 1) has been adequately analyzed in an earlier document pursuant to applicable legal standards, and 2) has been addressed by mitigation measures based on the earlier analysis as described on attached sheets. An ENVIRONMENTAL IMPACT REPORT is required, but it must analyze only the effects that remain to be addressed.

I find that although the proposed project could have a significant effect on the environment, because all potentially significant effects (a) have been analyzed adequately in an earlier EIR or NEGATIVE DECLARATION pursuant to applicable standards, and (b) have been avoided or mitigated pursuant to that earlier EIR or NEGATIVE DECLARATION, including revisions or mitigation measures that are imposed upon the proposed project, nothing further is required.

Signature	*Date*

EVALUATION OF ENVIRONMENTAL IMPACTS

1. A brief explanation is required for all answers except "No Impact" answers that are adequately supported by the information sources a lead agency cites in the parentheses following each question. A "No Impact" answer is adequately supported if the referenced information sources show that the impact simply does not apply to projects like the one involved (e.g., the project falls outside a fault rupture zone). A "No Impact" answer should be explained where it is based on project-specific factors, as well as general standards (e.g., the project would not expose sensitive receptors to pollutants, based on a project-specific screening analysis).
2. All answers must take account of the whole action involved, including off-site as well as on-site, cumulative as well as project-level, indirect as well as direct, and construction as well as operational impacts.
3. Once the lead agency has determined that a particular physical impact may occur, then the checklist answers must indicate whether the impact is potentially significant, less than significant with mitigation, or less than significant. "Potentially Significant Impact" is appropriate if there is substantial evidence that an effect may be significant. If there are one or more "Potentially Significant Impact" entries when the determination is made, an EIR is required.
4. "Negative Declaration: Less Than Significant With Mitigation Incorporated" applies where the incorporation of mitigation measures has reduced an effect from "Potentially Significant Impact" to a "Less Than Significant Impact." The lead agency must describe the mitigation measures, and briefly explain how they reduce the effect to a less than significant level.
5. Earlier analyses may be used where, pursuant to the tiering, program EIR, or other CEQA process, an effect has been adequately analyzed in an earlier EIR or negative declaration. Section 15063(c)(3)(D). In this case, a brief discussion should identify the following:
    a) Earlier Analyses Used. Identify and state where they are available for review.
    b) Impacts Adequately Addressed. Identify which effects from the above checklist were within the scope of and adequately analyzed in an earlier document pursuant to applicable legal standards, and state whether such effects were addressed by mitigation measures based on the earlier analysis.
    c) Mitigation Measures. For effects that are "Less than Significant with Mitigation Measures Incorporated," describe the mitigation measures which were incorporated or refined from the earlier document and the extent to which they address site-specific conditions for the project.
6. Lead agencies are encouraged to incorporate into the checklist references to information sources for potential impacts (e.g., general plans, zoning ordinances). Reference to a previously prepared or outside document should, where appropriate, include a reference to the page or pages where the statement is substantiated.
7. Supporting Information Sources: A source list should be attached, and other sources used or individuals contacted should be cited in the discussion.
8. This is only a suggested form, and lead agencies are free to use different formats; however, lead agencies should normally address the questions from this checklist that are relevant to a project's environmental effects in whatever format is selected.
9. The explanation of each issue should identify:
    a) the significance criteria or threshold, if any, used to evaluate each question; and
    b) the mitigation measure identified, if any, to reduce the impact to less than significance

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
I. AESTHETICS. Except as provided in Public Resources Code Section 21099, would the project:				
a) Have a substantial adverse effect on a scenic vista?	☐	☐	☐	☐
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☐	☐	☐
c) In nonurbanized areas, substantially degrade the existing visual character or quality of public views of the site and its surroundings? (Public views are those that are experienced from publicly accessible vantage point). If the project is in an urbanized area, would the project conflict with applicable zoning and other regulations governing scenic quality?	☐	☐	☐	☐
d) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?	☐	☐	☐	☐
II. AGRICULTURE AND FORESTRY RESOURCES. In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state's inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment project; and forest carbon measurement methodology provided in Forest Protocols adopted by the California Air Resources Board. Would the project:				
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?	☐	☐	☐	☐
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☐	☐
c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code Section 12220(g)), timberland (as defined by Public Resources Code Section 4526), or timberland zoned Timberland Production (as defined by Government Code Section 51104(g))?	☐	☐	☐	☐
d) Result in the loss of forest land or conversion of forest land to non-forest use?	☐	☐	☐	☐
e) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?	☐	☐	☐	☐
III. AIR QUALITY. Where available, the significance criteria established by the applicable air quality management district or air pollution control district may be relied upon to make the following determinations. Would the project:				
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☐	☐
b) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard?	☐	☐	☐	☐
c) Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☐	☐
d) Result in other emissions (such as those leading to odors) adversely affecting a substantial number of people?	☐	☐	☐	☐

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
IV. BIOLOGICAL RESOURCES. Would the project:				
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service?	☐	☐	☐	☐
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service?	☐	☐	☐	☐
c) Have a substantial adverse effect on state or federally protected wetlands (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?	☐	☐	☐	☐
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☐	☐	☐	☐
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☐	☐	☐
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☐	☐
V. CULTURAL RESOURCES. Would the project:				
a) Cause a substantial adverse change in the significance of a historical resource pursuant to § 15064.5?	☐	☐	☐	☐
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to § 15064.5?	☐	☐	☐	☐
c) Disturb any human remains, including those interred outside of dedicated cemeteries?	☐	☐	☐	☐
VI. ENERGY. Would the project:				
a) Result in potentially significant environmental impact due to wasteful, inefficient, or unnecessary consumption of energy resources, during project construction or operation?	☐	☐	☐	☐
b) Conflict with or obstruct a state or local plan for renewable energy or energy efficiency?	☐	☐	☐	☐
VII. GEOLOGY AND SOILS. Would the project:				
a) Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:	☐	☐	☐	☐
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map, issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	☐	☐	☐	☐
ii) Strong seismic ground shaking?	☐	☐	☐	☐
iii) Seismic-related ground failure, including liquefaction?	☐	☐	☐	☐
iv) Landslides?	☐	☐	☐	☐
b) Result in substantial soil erosion or the loss of topsoil?	☐	☐	☐	☐

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?	☐	☐	☐	☐
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property?	☐	☐	☐	☐
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?	☐	☐	☐	☐
f) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☐	☐
VIII. GREENHOUSE GAS EMISSIONS. Would the project:				
a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?	☐	☐	☐	☐
b) Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?	☐	☐	☐	☐
IX. HAZARDS AND HAZARDOUS MATERIALS. Would the project:				
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☐	☐	☐
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☐	☐	☐
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☐	☐	☐
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code § 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☐	☐	☐	☐
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard or excessive noise for people residing or working in the project area?	☐	☐	☐	☐
f) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☐
g) Expose people or structures, either directly or indirectly, to a significant risk of loss, injury or death involving wildland fires?	☐	☐	☐	☐
X. HYDROLOGY AND WATER QUALITY. Would the project:				
a) Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or ground water quality?	☐	☐	☐	☐
b) Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin?	☐	☐	☐	☐
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would:	☐	☐	☐	☐

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
i) result in a substantial erosion or siltation on- or off-site;	☐	☐	☐	☐
ii) substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or offsite;	☐	☐	☐	☐
iii) create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff; or	☐	☐	☐	☐
iv) impede or redirect flood flows?	☐	☐	☐	☐
d) In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation?	☐	☐	☐	☐
e) Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?	☐	☐	☐	☐
XI. LAND USE AND PLANNING. Would the project:				
a) Physically divide an established community?	☐	☐	☐	☐
b) Cause a significant environmental impact due to a conflict with any land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☐	☐
XII. MINERAL RESOURCES. Would the project:				
a) Result in the loss of availability of a known mineral resource that would be a value to the region and the residents of the state?	☐	☐	☐	☐
b) Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?	☐	☐	☐	☐
XIII. NOISE. Would the project result in:				
a) Generation of a substantial temporary or permanent increase in ambient noise levels in the vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☐	☐	☐
b) Generation of excessive groundborne vibration or groundborne noise levels?	☐	☐	☐	☐
c) For a project located within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?	☐	☐	☐	☐
XIV. POPULATION AND HOUSING. Would the project:				
a) Induce substantial unplanned population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	☐	☐	☐	☐
b) Displace substantial numbers of existing people or housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☐
XV. PUBLIC SERVICES. Would the project:				
a) Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the public services:	☐	☐	☐	☐

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
Fire protection?	☐	☐	☐	☐
Police protection?	☐	☐	☐	☐
Schools?	☐	☐	☐	☐
Parks?	☐	☐	☐	☐
Other public facilities?	☐	☐	☐	☐
XVI. RECREATION.				
a) Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☐	☐
b) Does the project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?	☐	☐	☐	☐
XVII. TRANSPORTATION. Would the project:				
a) Conflict with a program, plan, ordinance or policy addressing the circulation system, including transit, roadway, bicycle and pedestrian facilities?	☐	☐	☐	☐
b) Conflict or be inconsistent with CEQA Guidelines § 15064.3, subdivision (b)?	☐	☐	☐	☐
c) Substantially increase hazards due to a geometric design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☐	☐
d) Result in inadequate emergency access?	☐	☐	☐	☐
XVIII. TRIBAL CULTURAL RESOURCES.				
a) Would the project cause a substantial adverse change in the significance of a tribal cultural resource, defined in Public Resources Code § 21074 as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe, and that is:	☐	☐	☐	☐
i) Listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code section 5020.1(k), or	☐	☐	☐	☐
ii) A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code § 5024.1. In applying the criteria set forth in subdivision (c) of Public Resource Code § 5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe.	☐	☐	☐	☐
XIX. UTILITIES AND SERVICE SYSTEMS. Would the project:				
a) Require or result in the relocation or construction of new or expanded water, wastewater treatment or storm water drainage, electric power, natural gas, or telecommunications facilities, the construction or relocation of which could cause significant environmental effects?	☐	☐	☐	☐

	Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
b)	Have sufficient water supplies available to serve the project and reasonably foreseeable future development during normal, dry and multiple dry years?	☐	☐	☐	☐
c)	Result in a determination by the waste water treatment provider, which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☐
d)	Generate solid waste in excess of state or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals?	☐	☐	☐	☐
e)	Comply with federal, state, and local management and reduction statutes and regulations related to solid waste?	☐	☐	☐	☐
XX. WILDFIRE. If located in or near state responsibility areas or lands classified as very high fire hazard severity zones, would the project:					
a)	Substantially impair an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☐
b)	Due to slope, prevailing winds, and other factors, exacerbate wildfire risks, and thereby expose project occupants to pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire?	☐	☐	☐	☐
c)	Require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?	☐	☐	☐	☐
d)	Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?	☐	☐	☐	☐
XXI. MANDATORY FINDINGS OF SIGNIFICANCE.					
a)	Does the project have the potential to substantially degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, substantially reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☐	☐	☐	☐
b)	Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects.)	☐	☐	☐	☐
c)	Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☐	☐	☐

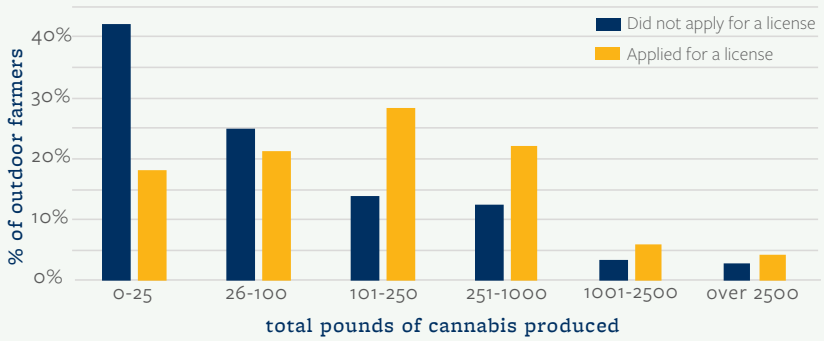
EXHIBIT C

Berkeley UNIVERSITY OF CALIFORNIA Cannabis Research Center

Barriers to Compliance in Cannabis Agriculture

December 2020

In 2019, we surveyed California's cannabis farmers to understand why some were — and others were not — complying with the state's licensing initiative. Over 360 farmers completed the survey from across the state. Approximately 2/3 of the respondents had applied for a license ("applicants") and the remaining 1/3 had not ("non-applicants").



Which farmers apply for licenses?

Larger farms applied more often than small farms. Non-applicants were more likely to be "part-time" farmers, where small cannabis crops were used to supplement their income. Among farmers who grew less than 100 pounds of cannabis, only 43% appllied for permits. The percentage increases to over 70% for farmers who grew over 100 pounds of cannabis.

Why don't cannabis farmers apply for licenses?

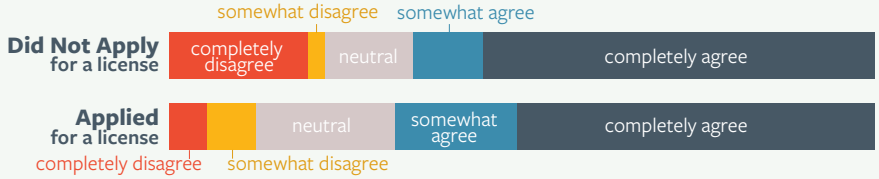
High costs were the most frequently cited reason for not seeking a license. Both the cost of permitting as well as bringing properties into regulatory compliance (e.g. culverts, road grading, building modifications) were substantial.

Frequently, people could not obtain required permits from their local government. A majority of non-applicants were located on properties not zoned for cultivation in their local jurisdiction.

A lack of clear, accurate information posed a barrier to compliance for all farmers. Trusted sources of information on the permitting process varied. Applicants were more likely to view government websites as important sources of information, whereas non-applicants were more likely to rely on neighbors for information.

"A lack of clear, accurate information on regulations has hindered my ability to comply."

The percent of survey respondents according to their agreement with the above statement. The full bar represents 100%.



Few face enforcement actions. A small proportion (<10%) of the respondents had experienced enforcement actions by government agencies, for example visits by the Department of Agriculture or Fish and Wildlife, although non-applicants were more likely to have experienced enforcement than applicants.

Berkeley UNIVERSITY OF CALIFORNIA Cannabis Research Center

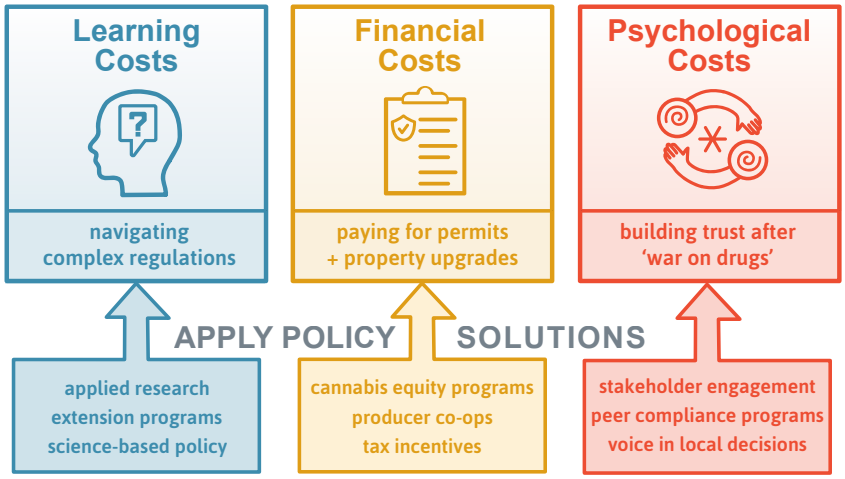
Barriers to Compliance in Cannabis Agriculture

What motivated farmers to apply for a license — or not?

All sought economic security. How to get there was debated. Non-applicants believed they would make a better living on the non-legal market and that risk of enforcement was limited. Applicants also doubted that legal markets would bring economic security. Instead, they were motivated by the idea that licenses would hold future value either to grow cannabis or to later sell.

All farmers supported stewardship, but many questioned the extent to which current regulations improve environmental outcomes. Applicants and non-applicants reported environmentally protective practices including organic and biodynamic methods.

Peer pressure has played a minimal role in encouraging — or discouraging — compliance. Few farmers felt any social pressure.



Survey results revealed barriers to compliance, including learning, financial and psychological costs.

Targeted strategies to reduce each cost represent opportunities to refine policies and practices toward a sustainable, equitable market for cannabis.

What can be done to increase compliance?

Streamline and harmonize county regulations with state permitting requirements to reduce administrative burdens.

Reduce financial costs of permitting by lowering fees and establishing grant programs to incentivize property upgrades needed for compliance.

Develop state outreach programs to deliver reliable information on how to navigate the permitting process and to recognize legal cannabis cultivation as a legitimate economical and social enterprise.

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

Suggested Citation: Bodwitch, H., Polson, M., Biber, E., Butsic, V., Carah, J., Dillis, C., Grantham, T., Parker-Shames, P. 2020. *Barriers to Compliance in Cannabis Agriculture.* Cannabis Research Center, University of California, Berkeley, CA.

EXHIBIT D

XAVIER BECERRA
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March 20, 2019

Planning Commission of Monterey County
Monterey County Resource Management Agency
Attn: Mike Novo
1441 Schilling Place – South, 2nd Floor
Salinas, CA 93901
Sent via email: novom@co.monterey.ca.us

Re: Paraiso Springs Resort, Project No. PLN040183

Dear Mr. Novo and Commissioners,

Our office has reviewed the Final Environmental Impact Report ("FEIR") and the Recirculated Draft Environmental Impact Report ("DEIR") for the proposed Paraiso Springs Resort Development ("Project") and respectfully submits the following comments. We request that you consider our comments prior to certifying the FEIR. We spoke with County Counsel and staff on March 20, 2019 and alerted them we would be submitting comments prior to your consideration of the FEIR at your March 27, 2019 Planning Commission meeting.

The Attorney General's Office submits these comments pursuant to the Attorney General's independent power and duty to protect the environment and natural resources of the State from pollution, impairment, or destruction, and in furtherance of the public interest. (See Cal. Const., art. V, § 13; Gov. Code, §§ 12511, 12600-12612; *D'Amico v. Bd. of Medical Examiners* (1974) 11 Cal.3d 1, 14-15.)[1] In the wake of the State's deadliest wildfires this past year and the increased occurrence of fires anticipated throughout the State in coming years, it is particularly important that local jurisdictions carefully review and consider new developments in fire prone areas. This is particularly important for new developments proposed in the wildland urban interface or in other relatively undeveloped and remote areas, like the area where the Project is proposed.

Paraiso Springs Resort, LLC, proposes to develop a spa resort along the floor of a canyon in the foothills at the end of rural Paraiso Springs Road in a "very high fire sensitivity

[1] This letter is not intended, and should not be construed, as an exhaustive discussion of the FEIR's and DEIR's compliance with the California Environmental Quality Act ("CEQA") or the Project's compliance with other applicable legal requirements.

zone." The Project site is bordered to the east by grazing and farm land, and to the north, south and west by the Santa Lucia Mountains. (DEIR 2-1.) The Project site was previously operated as a commercial hot springs resort beginning in 1874. (DEIR 3-137.) The site has seen several fires over the years that have destroyed various structures on the Property, including a fire in 1891 that destroyed one of the more substantial buildings on the property, a fire in 1928 that destroyed the hotel, the bathhouse, a garage, the dance hall, and some other smaller buildings, and another major fire in 1954 that destroyed the rebuilt hotel and annex. (DEIR 2-15, 3-137-3-138.)

Paraiso Springs Road, the sole ingress and egress to the site,[2] is a narrow, two-lane road varying in width from 16 to 22 feet that dead ends at the Project site. (DEIR 2-45.) The road currently serves approximately 90 vehicles per day associated with single-family residences and local vineyards. (DEIR 3-329.) The Project would include the development of 103 hotel rooms, 77 multi-bedroom timeshare units, three restaurants, entertainment facilities, and various spa amenities at the end of this narrow two-lane rural road. (DEIR 2-17 – 2-18.) It is anticipated that there would be several hundred people at the resort on peak days. With the Project at 100% occupancy, there would be over 400 additional vehicle trips per day on the road. (DEIR 3-336.)[3] Additionally, because of parking limitations at the proposed Project site and limitations with the capacity of the rural access road, the Project proposes to shuttle in many of the guests and 90% of all employees from a parking lot nearly two miles away. (DEIR 3-335 – 3-336.)

Monterey County, as the lead agency, has prepared a FEIR for the proposed Project. Despite the acknowledgment that the Project is located in a "very high fire sensitivity zone," the FEIR fails to adequately address the risk of fire in several important respects.[4]

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[2] In response to CalFire's comments on the DEIR, the FEIR suggests that there is a service road for ingress and egress at the rear of the development. (FEIR, Response to comment letter No. 18, 2-12.) The response cites to maps within the DEIR. (*Ibid.*) These maps show service roads *within* the development, but these roads do not appear to provide ingress and egress *to the Project site.*

[3] We note that several commenters questioned whether the traffic analysis for the Project underestimated the trips that will be associated with the Project. (See, e.g., FEIR, Comment Letter 10 (p 20-23).) While we have not evaluated the adequacy of the traffic analysis, we are concerned that the number of visitors accessing the site may be even higher than anticipated in the FEIR, which would exacerbate our concerns regarding the risks associated with wildfires and the FEIR's inadequate analysis of those risks.

[4] We understand that LandWatch submitted comments to the County on January 15, 2019 raising many of these same issues. The FEIR does not include a response to these comments.

I. THE FEIR MUST ANALYZE THE INCREASED RISK OF WILDFIRE THAT WILL RESULT FROM THE PROJECT.

The FEIR does not, but should, analyze the increased risk of wildfire that will result from siting the proposed development within a high fire sensitivity zone. The DEIR discussed emergency access to the site in the event of fire and onsite measures to provide fire protection.[5] However, the DEIR did not disclose that locating new development in a high fire sensitivity zone will itself increase the risk of fire and, as a result, increase the risk of exposing existing residents in the area as well as guests and employees of the resort to an increased risk of fire. (See CEQA Guidelines Section 15126.2, subd. (a) [requiring the evaluation of potentially significant environmental impacts of locating development in areas susceptible to hazardous conditions such as wildfire risk areas, especially as identified in hazard maps and risk assessments].)[6] It is well-accepted that building in wildland areas increases the risk and severity of fires.[7] The California

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[5] A preliminary fire protection plan was prepared for the Project. (DEIR 2-55.) Fire protection elements include hydrants, sprinkler systems, and the use of fire-resistant building materials. (DEIR 2-55 – 2-56.) The Project also includes vegetation management for defensible space. (See e.g., DEIR 3-81 – 3-80.) Cal Fire's Department of Forestry and Fire Protection commented on, among other issues, the adequacy of the vegetation management discussed in the DEIR. (FEIR Comment Letter 18.) In response to these comments, the FEIR simply refers back to the DEIR and does not provide any additional commitments or project modifications. (FEIR, Responses to Comment Letter 18, 2-12.)

[6] Our comments are based on the CEQA Guidelines in effect prior to the recent 2019 update, but it is worth noting that the update confirms and clarifies the need to consider wildfire risks as part of the environmental review for new developments subject to CEQA.

[7] See, e.g., Rapid Growth of the U.S. Wildland-Urban Interface Raises Wildfire Risk (February 6, 2018) (https://www.pnas.org/content/pnas/115/13/3314.full.pdf); *New York Times*, Climate Change is Fueling Wildfires Nationwide, New Report Warns (November, 2018) (https://www.nytimes.com/interactive/2018/11/27/climate/wildfire-global-warming.html); *Scientific American*, Living on the Edge: Wildfires Pose a Growing Risk to Homes Built Near Wilderness Areas (https://www.scientificamerican.com/article/living-on-the-edge-wildfires-pose-a-growing-risk-to-homes-built-near-wilderness-areas/); *USDA*, Wildfire, Wildlands, and People: Understanding and Preparing for Wildfire in the Wildland-Urban Interface (January 2013) (https://www.fs.fed.us/rm/pubs/rmrs_gtr299.pdf). While these articles and reports largely focus on the risks of locating housing within fire-prone areas, the same risks would appear to apply for commercial establishments offering overnight lodging. The issue with locating development in these areas is that most fires are human induced, so bringing people into wildland areas creates an increased risk that fire will occur. (*Ibid.*) In addition, the risks of fire are exacerbated because development in wildland areas alters the natural environment (e.g., it fragments native vegetation, introduces nonnatives species, and disturbs soils). (See Rapid Growth of the U.S. Wildland-Urban Interface Raises Wildfire Risk (February 6, 2018) (https://www.pnas.org/content/pnas/115/13/3314.full.pdf).) Further, fire management in developed wildland areas is more challenging because it is more difficult to fight fires in these

Supreme Court has confirmed that this kind of risk must be considered as part of the CEQA analysis for a proposed project. (*California Building Industry Assn. v. Bay Area Air Quality Management Dist.* (2015) 62 Cal.4th 369, 388 [holding that while CEQA does not require consideration of the environment's effect on a project, it does require analysis of the project's impacts on the existing environment].)

Concerns regarding the Project's impact on the occurrence of widlfires were raised in public comments on the DEIR. For example, Lois Panziera noted that "[w]hen more people are added to a high severity fire area, the potential for fires will occur." (FEIR, Letter 7, Comment 75.) In response, the FEIR simply refers back to the DEIR. (FEIR 2-58 – 2-59.) However, as explained above, the DEIR did not address the increased risk of fires that will result from locating new development within a high fire sensitivity zone. The County should address these issues prior to certifying the FEIR.

II. THE FEIR SHOULD ADDRESS EVACUATION IN THE EVENT OF FIRE.

Based upon the onsite fire fighting infrastructure (sprinkler systems, etc.) and the Project proponent's commitment to develop a fire protection plan, the DEIR concludes that the "occupants would be protected to the extent possible in the case of fire" such that the potential impacts associated with wildfire hazards would be less than significant. (DEIR 3-215 – 3-216.) The DEIR describes emergency access *to* the site, but does *not* address: (i) the evacuation of employees and guests in the event of a fire, (ii) the increased challenges that existing users of the sole ingress and egress road will face in the event of an evacuation due to the added users on the road, or (iii) the increased challenges that firefighters and emergency responders would face accessing the site and preventing the spread of a wildfire due to the simultaneous evacuation of guests and employees from the Project and neighboring areas. The EIR should include a more robust discussion of the fire hazards and describe the evacuation plan for guests and employees, as well as neighboring residents and existing users of Paraiso Springs Road. (See *Clews Land & Livestock, LLC v. City of San Diego* (2017) 19 Cal.App.5th 161, 194 [discussing whether or not the EIR adequately considered the risk of fire to future users of the project site, including acceptable evacuation plans]; *California Clean Energy Committee v. County of Placer* (Cal. Ct. App., Dec. 22, 2015, No. C072680) 2015 WL 9412772 [concluding that the EIR failed to adequately evaluate evacuation issues associated with the project].)

In response to public comments, including from CalFire's Department of Forestry and Fire Protection, asking about evacuation plans (see Comment Letter 18 starting on FEIR 2-11), the FEIR promises that a final Fire Protection Plan that includes evacuation procedures will be developed. (FEIR 2-12.) Meaningful analysis of the risk of fire and evacuation plans should not be deferred until after the FEIR is certified and the Project is approved. (See CEQA Guidelines

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landscapes and fire management strategies that allow natural fires to burn are not an option. (*Ibid.*; see also *USDA*, Wildfire, Wildlands, and People: Understanding and Preparing for Wildfire in the Wildland-Urban Interface (January 2013) (https://www.fs.fed.us/rm/pubs/rmrs_gtr299.pdf).)

Section 15126.4(a)(1)(B).) While the deferment of mitigation measures may sometimes be appropriate, here no basis has been provided for why the evacuation plan was not already prepared as part of the DEIR or FEIR, nor have any performance standards or potential mitigation measures been identified. (*Ibid*; see also, e.g., *San Joaquin Raptor Rescue Center v. County of Merced* (2007) 149 Cal.App.4th 645, 671 [mitigation measure that included development of a post-FEIR management plan was found to be improperly deferred mitigation where no basis was provided for why the development of mitigation measures needed to be deferred to future plans and, no specific criteria, performance standards, or potential mitigation measures were set forth in the EIR].) In addition, based on the discussion in the DEIR, we are concerned that the Fire Protection Plan, when it is developed, may not adequately address the totality of issues related to evacuation (see above).

III. THE PROJECT MUST COMPLY WITH THE REQUIREMENTS FOR STATE RESPONSIBILITY AREAS.

The Project is located in a State Responsibility Area, which is an area for which the Board of Forestry and Fire Protection has designated the State to be financially responsible for preventing and suppressing fires. (Pub. Resources Code, § 4102.) Local jurisdictions may adopt standards for wildfire protections in State Responsibility Areas, but those standards must be at least as stringent as the State's minimum standards and be certified by the State. (Pub. Resources Code, § 4117.) Monterey County has adopted standards for this purpose. (Monterey County Code, §§ 18.56.010 – 18.56.100.) The proposed Project does not appear to comply with these standards.

First, Paraiso Springs Road is a dead end road that terminates at the proposed Project location. Both the County and State standards limit dead end roads to a cumulative length not to exceed 5,280 feet. (Monterey County Code § 18.56.060(11); Cal. Code. Regs., tit. 14, § 1273.09.) The Paraiso Springs Road that would serve as the sole ingress and egress for the Project is 1.9 miles long or 10,032 feet according to Google maps, nearly double the allowable limit. The FEIR and DEIR do not address the Project's failure to comply with the length limitation for dead end roads in State Responsibility Areas.

Second, the width of Paraiso Springs Road will not comply with the local or State standards. State standards generally require a minimum of two 10-foot traffic lanes. (Cal. Code Regs., tit. 14, § 1273.01.)[8] The Project proposes to widen "*the majority of* Paraiso Springs Road to either 18 or 20 feet wide." (DEIR 3-340.) However, the FEIR explains that the road will only be widened "where feasible". (FEIR 2-10). The Project proponent should commit to widening not just a majority of the road, but the entirety of the road, to a distance that complies with the applicable standards.

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[8] The County requires that all roads have a minimum of two 9-foot traffic lanes. (Monterey County Code, § 18.56.060(3).) Therefore, the State's more stringent requirement would control.

IV. THE PROJECT SHOULD PROVIDE PROXIMAL ACCESS TO A FIRE STATION.

Despite a request from the local fire district, the Project proponent has declined to construct a small fire station onsite, concluding that it would be "incompatible with resort operations." (DEIR 3-307.) The closest fire station is nine miles away, which the program Google Maps reports is an 18-minute drive. The DEIR claims the fire station is within the 15 minutes recommended by the applicable Monterey County General Plan. (DEIR 3-307.) Public comments on the DEIR noted the Project site is not within a 15-minute response time from the Soledad fire station. (See, e.g., Letter 7, Comment 74 starting on FEIR 2-33 and Letter 8, Comment 5 starting on FEIR 2-61). Rather than provide factual support for the DEIR's claim that the fire station is within 15 minutes from the Project site or revise the Project so that it complies with the Monterey County General Plan recommendation, the FEIR simply restates the DEIR's conclusion that "the project would not warrant construction of new or expanded facilities in order to maintain … response times…." (FEIR 2-11). The FEIR should be revised to accurately reflect the distance of the nearest fire station to the Project site and should require compliance with the policy prescribed by the General Plan—preferably with construction of a fire station onsite as requested by the local fire district.

We appreciate your consideration of our comments and respectfully request that you defer certification of the FEIR and approval of the Project until you more fully address the risks of wildfire associated with the Project. If you have any questions or would like to discuss our comments, please feel free to contact us.

Sincerely,

NICOLE U. RINKE
Deputy Attorney General
HEATHER C. LESLIE
Deputy Attorney General

For XAVIER BECERRA
Attorney General

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July 9, 2019

Planning Commission of Monterey County
Monterey County Resource Management Agency
Attn: Mike Novo
1441 Schilling Place – South, 2nd Floor
Salinas, CA 93901
Sent via email: novom@co.monterey.ca.us

Re: Paraiso Springs Resort, Project No. PLN040183

Dear Mr. Novo and Commissioners,

We appreciate your preparation of a Recirculated Draft EIR [June 2019] ("RDEIR") responding to public comments on the previous Recirculated DEIR [February 3, 2018] and Final EIR [March 14, 2019] ("FEIR'), including the comments we submitted on March 20, 2019, regarding wildfire risks associated with the proposed Paraiso Springs Resort Development (the "Project"). We have reviewed the additional information presented and acknowledge and appreciate that you have provided more information regarding wildfire risks associated with the proposed Project than was included in the previous analyses. While we thank you for including that additional information, we remain concerned that the risks of wildfire have not been adequately addressed.[1] Specifically, the Project still does not comply with state requirements for development in State Responsibility Areas. Additionally, the RDEIR does not comply with CEQA's requirement to analyze and mitigate the Project's wildfire impacts.

The Project does not comply with the requirements for State Responsibility Areas.

The Project does not comply with the state's dead end road limitations and road width limitations applicable to State Responsibility Areas (SRA). (Cal. Code. Regs., tit. 14, § 1273.09 and 1273.01; adopted pursuant to Pub. Res. Code. § 4290.) In the RDEIR, the County expresses its view that the dead end road limitation does not apply to the Project because the road, having been built in the 19th century and maintained by the County, is not subject to the SRA regulations. (RDEIR, p. 62.) Neither the regulations nor the statute setting forth the SRA

[1] This letter is not intended, and should not be construed, as an exhaustive discussion of the RDEIR's compliance with the California Environmental Quality Act ("CEQA") or the Project's compliance with other applicable legal requirements.

requirements, however, include an exemption for historic roads or roads maintained by the County. In general, the SRA requirements apply to any application for new construction with only limited exceptions for certain parcel or tentative maps approved before 1991 and roads used solely for agriculture, mining, or timber related purposes. (See Cal. Code. Regs., tit. 14, § 1270.02.)

The RDEIR further states that the Project meets the intent of the dead end road limitation, but does not provide any support for its understanding of that intent, nor a justification for why compliance with the intent would excuse non-compliance with the clear regulatory requirement. (RDEIR, p. 62.) The RDEIR suggests that mitigation measure 3.7-6a (regarding the Fire Protection Plan to be developed) is being applied to the Proposed Project as if the SRA requirements did apply to the Project. (RDEIR, p. 62.) However, the Fire Protection Plan does not propose to modify the dead end nature of the road. CEQA requires mitigation that is triggered by the need to avoid significant environmental impacts; CEQA mitigation may not be used to excuse non-compliance with independent state regulatory requirements.

Likewise the RDEIR suggest that the Project complies with state law requiring two 10-foot travel lands because 98% of the road would comply—only a "small area of 150 feet" due to topographical constraints would be limited to an 18-foot wide road. (RDEIR, p.61.) However, substantial compliance is not the state standard. A small section of inadequate road width could create a bottleneck that would hamper evacuation, particularly where emergency response vehicles are trying access the site at the very same time others are seeking to exit the site. While the SRA regulations provide a process for requesting exceptions to the standards (Cal. Code. Regs., tit. 14, §§ 1270.07 and 1270.08), the RDEIR does not suggest that an exception through this process has been requested or approved.

The RDEIR does not comply with CEQA's requirement to analyze and mitigate the Project's wildfire impacts.

The RDEIR considered the questions identified in section XX of the Updated CEQA Guidelines regarding wildfire risk (RDEIR, pp. 59-72), which we appreciate. The RDEIR did not, however, address the related but separate question in Section IX(g) of Appendix G regarding whether the Project would "expose people or structures, either directly or indirectly, to a significant risk of loss, injury, or death involving wildland fires." This issue should also be addressed. (See CEQA Guidelines § 15126.2, subd. (a) [requiring the evaluation of potentially significant environmental impacts of locating development in areas susceptible to hazardous conditions such as wildfire risk areas, especially as identified in hazard maps and risk assessments]; *California Building Industry Assn. v. Bay Area Air Quality Management Dist.* (2015) 62 Cal.4th 369, 388 [holding that while CEQA does not require consideration of the environment's effect on a project, it does require analysis of the project's impacts on the existing environment].)

In addition, for the wildfire associated risks that the RDEIR did analyze—those in Section XX of Appendix G—the RDEIR concludes that there are potentially significant effects, but that these effects are less than significant after mitigation. The RDEIR proposes additional mitigation measures, but these measures largely rely on development of future fire prevention plans. With respect to this project and the proposed future plans, CEQA prohibits the deferral of mitigation. (See CEQA Guidelines § 15126.4(a)(1)(B).) While the development of mitigation measures may sometimes be appropriate, there is no reason here for this failure to prepare the evacuation plan as part of the DEIR or FEIR, nor have any performance standards or potential mitigation measures been identified. (*Ibid*; see also, e.g., *San Joaquin Raptor Rescue Center v. County of Merced* (2007) 149 Cal.App.4th 645, 671 [mitigation measure that included development of post-FEIR management plan was found to be improperly deferred mitigation where no basis was provided for why development of mitigation measures needed to be deferred to future plans and, no specific criteria, performance standards, or potential mitigation measures were set forth in EIR].)

In our previous comments, we also requested that the FEIR address evacuation in the event of fire. Specifically, we highlighted the need to consider: (i) the evacuation of employees and guests in the event of a fire, (ii) the increased challenges that existing users of the sole ingress and egress point will face in the event of an evacuation due to the added users on the road, and (iii) the increased challenges that firefighters and emergency responders would face accessing the site and preventing the spread of a wildfire due to the simultaneous evacuation of guests and employees from the Project and neighboring areas. (March 20, 2019 letter, pp. 4-5). Again, we appreciate that you have now included an evacuation plan in the RDEIR, but find that it and the supporting analysis it relies upon falls short of addressing the full scope of issues we believe are required for analysis under CEQA in order to provide full information to decision makers and the public about the wildfire risks associated with the Project.

In addition, the RDEIR does not seem to disclose or address the possibility of a fire starting down canyon and potentially blocking Paraiso Springs Road altogether. While the RDEIR describes that the site will be designed to serve as a temporary refuge area during fire, which could conceivably help to mitigate the risk of a down canyon fire occurring that blocks evacuation via Paraiso springs Road, this is not fleshed out in any detail. The RDEIR also does not address the ability of emergency vehicles to efficiently access the site while the sole ingress and egress road is also being utilized for evacuation.[2]

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[2] The letter from Keith Higgins, which is indirectly referenced in the RDEIR, includes just a conclusory comment on this issue—"The one lane on the road going toward the project site would remain open almost exclusively to inbound emergency access. In summary, the road is capable of handling incoming and outgoing traffic in a mass evacuation with no significant conflicts with the surrounding neighbor or incoming emergency vehicles." (March 8, 2019 Letter from Keith Higgins, Traffic Engineer, referenced in Appendix 2 of the RDEIR, p. 140.)

We appreciate your consideration of our comments and respectfully request that you revise the RFEIR accordingly. If you have any questions or would like to discuss our comments, please feel free to contact us.

Sincerely,

Heather Leslie

HEATHER C. LESLIE
Deputy Attorney General
NICOLE U. RINKE
Deputy Attorney General

For XAVIER BECERRA
Attorney General

EXHIBIT E

PLOS | ONE

Impacts of Surface Water Diversions for Marijuana Cultivation on Aquatic Habitat in Four Northwestern California Watersheds

Scott Bauer , Jennifer Olson , Adam Cockrill, Michael van Hattem, Linda Miller, Margaret Tauzer, Gordon Leppig

Published: March 18, 2015 • DOI: 10.1371/journal.pone.0120016

Abstract

Marijuana (*Cannabis sativa* L.) cultivation has proliferated in northwestern California since at least the mid-1990s. The environmental impacts associated with marijuana cultivation appear substantial, yet have been difficult to quantify, in part because cultivation is clandestine and often occurs on private property. To evaluate the impacts of water diversions at a watershed scale, we interpreted high-resolution aerial imagery to estimate the number of marijuana plants being cultivated in four watersheds in northwestern California, USA. Low-altitude aircraft flights and search warrants executed with law enforcement at cultivation sites in the region helped to validate assumptions used in aerial imagery interpretation. We estimated the water demand of marijuana irrigation and the potential effects water diversions could have on stream flow in the study watersheds. Our results indicate that water demand for marijuana cultivation has the potential to divert substantial portions of streamflow in the study watersheds, with an estimated flow reduction of up to 23% of the annual seven-day low flow in the least impacted of the study watersheds. Estimates from the other study watersheds indicate that water demand for marijuana cultivation exceeds streamflow during the low-flow period. In the most impacted study watersheds, diminished streamflow is likely to have lethal or sub-lethal effects on state-and federally-listed salmon and steelhead trout and to cause further decline of sensitive amphibian species.

Citation: Bauer S, Olson J, Cockrill A, van Hattem M, Miller L, et al. (2015) Impacts of Surface Water Diversions for Marijuana Cultivation on Aquatic Habitat in Four Northwestern California Watersheds. PLoS ONE 10(3): e0120016. doi:10.1371/journal.pone.0120016

Academic Editor: Gil Bohrer, The Ohio State University, UNITED STATES

Received: September 3, 2014; **Accepted:** February 3, 2015; **Published:** March 18, 2015

Data Availability: Most data used are available via public sources (USGS gage data, EWRIMS, and Google Earth), but specific spatial locations of marijuana grows cannot be shared due to legal and privacy concerns. Summary data and all methods/information needed to replicate the study are included in the manuscript. Plant counts and greenhouse counts and measurements for all watersheds are included as Supporting Information (excel spreadsheets).

Funding: The authors have no support or funding to report.

Competing interests: The authors have declared that no competing interests exist.

Introduction

Marijuana has been cultivated in the backwoods and backyards of northern California at least since the countercultural movement of the 1960s with few documented environmental impacts [1]. Recent increases in the number and size of marijuana cultivation sites (MCSs) appear to be, in part, a response to ballot Proposition 215, the Compassionate Use Act (1996). This California law provides for the legal use and cultivation of medical marijuana. In 2003, legislation was passed in an attempt to limit the amount of medical marijuana a patient can possess or cultivate (California State Senate Bill 420). However, this legislation was struck down by a 2010 California Supreme Court decision (*People v. Kelly*). As a result of Proposition 215 and the subsequent Supreme Court ruling, the widespread and largely unregulated cultivation of marijuana has increased rapidly since the mid-1990s in remote forested areas throughout California [2]. California is consistently ranked highest of all states for the number of outdoor marijuana plants eradicated by law enforcement: from 2008–2012 the total number of outdoor marijuana plants eradicated in California has ranged from 53% to 74% of the total plants eradicated in the United States [3]. In spite of state-wide prevalence, there is not yet a clear regulatory framework for the cultivation of marijuana, and from an economic viewpoint there is little distinction between plants grown for the black market and those grown for legitimate medical use [4].

Northwestern California has been viewed as an ideal location for marijuana cultivation because it is remote, primarily forested, and sparsely populated. Humboldt, Mendocino, and Trinity Counties, the three major counties known for marijuana cultivation in Northwestern California [5], comprise 7% (26,557 km^2) of the total land area of the state of California. However, their combined population of 235,781 accounts for only 0.62% of the state's total population (United States Census Data 2012). Humboldt County,

with an area of 10,495 km^2, has over 7689 km^2 of forestland comprising more than 70% of its land base. More importantly, Humboldt County has 5,317 km^2 of private lands on over 8,000 parcels zoned for timber production [6]. This makes Humboldt County a feasible place to purchase small remote parcels of forestland for marijuana cultivation.

The broad array of impacts from marijuana cultivation on aquatic and terrestrial wildlife in California has only recently been documented by law enforcement, wildlife agencies, and researchers. These impacts include loss and fragmentation of sensitive habitats via illegal land clearing and logging; grading and burying of streams; delivery of sediment, nutrients, petroleum products, and pesticides into streams; surface water diversions for irrigation resulting in reduced flows and completely dewatered streams [2,7–10]; and mortality of terrestrial wildlife by rodenticide ingestion [11,12]. Though these impacts have been documented by state and federal agencies, the extent to which they affect sensitive fish and wildlife species and their habitat has not been quantified. These impacts have gained attention in recent years [7,9] because of the continuing prevalence of "trespass grows," illicit marijuana cultivation on public land. In comparison, the extent of cultivation and any associated environmental impacts on private lands are poorly understood, primarily because of limited access. In addition, state and local agencies lack the resources to address environmental impacts related to cultivation on private lands. In contrast with many MCSs on public lands, MCSs on private lands appear to be legal under state law, pursuant to Proposition 215. Regardless of the legal status of these MCSs, the water use associated with them has become an increasing concern for resource agencies [13].

California's Mediterranean climate provides negligible precipitation during the May—September growing season. In Northern California, 90–95% of precipitation falls between October and April [14]. Marijuana is a high water-use plant [2,15], consuming up to 22.7 liters of water per day. In comparison, the widely cultivated wine grape, also grown throughout much of Northwestern California, uses approximately 12.64 liters of water per day [16]. Given the lack of precipitation during the growing season, marijuana cultivation generally requires a substantial amount of irrigation water. Consequently, MCSs are often situated on land with reliable year-round surface water sources to provide for irrigation throughout the hot, dry summer growing season [7,8,12]. Diverting springs and headwater streams are some of the most common means for MCSs to acquire irrigation water, though the authors have also documented the use of groundwater wells and importing water by truck.

The impacts to aquatic ecosystems from large hydroelectric projects and other alterations of natural flow regimes have been well documented [17–20], but few studies have attempted to quantify the impacts of low-volume surface water diversions on stream flows [21,22]. A study in the Russian River watershed in Sonoma County, CA, concluded that the demand of registered water diversions exceeded stream flows during certain periods of the year, though this study did not quantify unregistered diversions. In addition, this study indicates that these registered diversions have the potential to depress spring base flows and accelerate summer recession of flows [22]. We postulate that the widespread, increasing, and largely unregulated water demands for marijuana cultivation, in addition to existing domestic demands, are cumulatively considerable in many rural Northern California watersheds.

In northern California, unregulated marijuana cultivation often occurs in close proximity to habitat for sensitive aquatic species. Because of this proximity and the water demands associated with cultivation, we chose to focus on the cumulative impacts of low-volume surface water diversions associated with marijuana cultivation. We evaluate these water demands at a watershed scale to determine whether they could have substantial effects on streamflow during the summer low-flow period. In addition, we discuss which sensitive aquatic species are most likely to be impacted by stream diversions and describe the nature of these impacts.

Methods

Methods are presented for the following components of the study: study area selection, data collection, water use estimates, and hydrologic analysis. For the purposes of this study, a MCS is defined as any area where marijuana is grown, either outdoors or inside a greenhouse, based on our aerial image interpretation. Because marijuana cultivation is federally illegal, its scope and magnitude are difficult to measure precisely [2,4,23]. However, the authors have accompanied law enforcement on search warrants and site inspections to evaluate more than 40 MCSs in the Eel River watershed and other watersheds in northwestern California. During these site inspections the number, size, and arrangement of marijuana plants were recorded, as were the water sources, conveyance and storage methods. These on-the-ground verification data were used as the basis for identifying characteristics of MCSs from aerial images.

Study Areas

Four study watersheds were selected—Upper Redwood Creek, Salmon Creek, and Redwood Creek South, located in Humboldt County; and Outlet Creek, located in Mendocino County (Figs. 1–4). Study watersheds were selected using the following criteria: (1) they are dominated by privately owned forestlands and marijuana cultivation is widespread within their boundaries as verified by low altitude survey flights and aerial imagery. (2) The primary watercourse, or downstream receiving body, has documented populations of sensitive aquatic species, such as coho salmon (*Oncorhynchus kisutch*). (3) Watersheds are of sufficient size so as to allow realistic population-scale and regional ecological relevance, but are not so large that conducting an analysis would be infeasible given limited staffing resources. (4) Streams in the watershed had either a flow gage, or nearby streams were gaged, which would allow proxy modeling of the low-flow period in the study watershed.

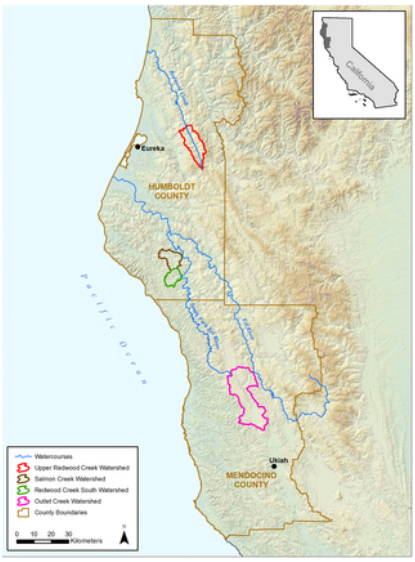

Fig 1. Study Watersheds and Major Watercourses.
doi:10.1371/journal.pone.0120016.g001

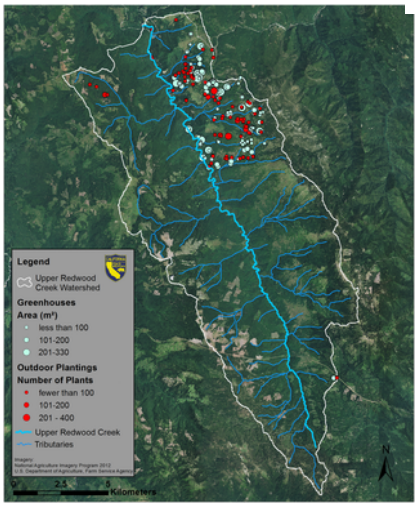

Fig 2. Upper Redwood Creek Watershed.
Outdoor marijuana plantings are marked in red and greenhouses are marked in light green.
doi:10.1371/journal.pone.0120016.g002

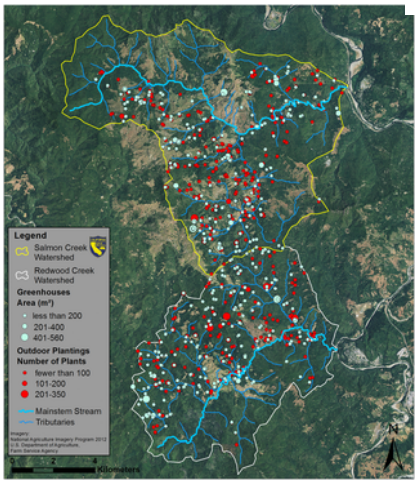

Fig 3. Salmon Creek and Redwood Creek South Watersheds.
Outdoor marijuana plantings are marked in red and greenhouses are marked in light green.
doi:10.1371/journal.pone.0120016.g003

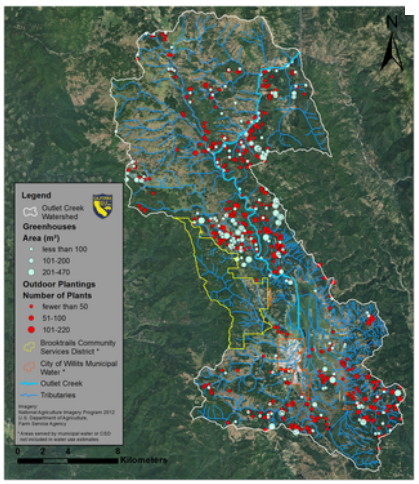

Fig 4. Outlet Creek Watershed.
Outdoor marijuana plantings are marked in red and greenhouses are marked in light green.
doi:10.1371/journal.pone.0120016.g004

Habitat

The study watersheds are dominated by a matrix of open to closed-canopy mixed evergreen and mixed conifer forests with occasional grassland openings. Dominant forest stands include Tanoak (*Notholithocarpus densiflorus*) and Douglas-fir (*Pseudotsuga menziesii*) Forest Alliances ("Alliance" is a vegetation classification unit that identifies one or more diagnostic species in the upper canopy layer that are indicative of habitat conditions) [24]. These forests are dominated by Douglas—fir, tanoak, madrone (*Arbutus menziesii*), big leaf maple (*Acer macrophyllum*), and various oak species (*Quercus* spp.). The Redwood (*Sequoia sempervirens*) Forest Alliance, as described by Sawyer et al. [24] is dominant in areas of Upper Redwood Creek and in lower Salmon Creek and Redwood Creek South and includes many of the same dominant or subdominant species in the Tanoak and Douglas-fir Forest Alliances. These watersheds, a product of recent and on-going seismic uplift, are characterized as steep mountainous terrain dissected by an extensive dendritic stream pattern, with the exception of Upper Redwood Creek, which has a linear trellised stream pattern [25].

Data Collection and Mapping Overview

Study watershed boundaries were modified from the Calwater 2.2.1 watershed map [26] using United States Geological Survey (USGS) 7.5 minute Digital Raster Graphic images to correct for hydrological inconsistencies. These watershed boundaries and a reference grid with one square kilometer (km^2) cells were used in Google Earth mapping program and ArcGIS (version 10.x, ESRI, Redlands, CA). Using Google Earth's high-resolution images of northern California (image dates: 8/17/11, 7/9/12, and 8/23/12) as a reference, features of interest such as greenhouses and marijuana plants were mapped as points in ArcGIS. We identified greenhouses by color, transparency, elongated shape, and/or visible plastic or metal framework. Although we could not confirm the contents of greenhouses, the greenhouses we measured were generally associated with recent land clearing and other development associated with the cultivation of marijuana, as observed in our site inspections with law enforcement. Greenhouses clearly associated with only non-marijuana crop types, such as those in established farms with row crops, were excluded from our analysis. We identified outdoor marijuana plants by their shape, color, size and placement in rows or other regularly spaced configurations. We measured greenhouse lengths and widths using the Google Earth "Ruler" tool to obtain area, and counted and recorded the number of outdoor marijuana plants visible within each MCS. We also examined imagery from previous years using the Google Earth "Historical Imagery" tool to confirm that outdoor plants were not perennial crops, such as orchards.

Plant Abundance and Water Use Estimates

For each watershed, we totaled the number of marijuana plants that were grown outdoors and combined this value with an estimated number of marijuana plants in greenhouses to get a total number of plants per watershed. To develop a basis for estimating the number of marijuana plants in greenhouses, we quantified the spatial arrangement and area of marijuana plants in 32 greenhouses at eight different locations in four watersheds in Humboldt County while accompanying law enforcement in 2013. We calculated 1.115 square meters (m^2) per plant as an average spacing of marijuana plants contained within greenhouses. For the purposes of this study, we assume that the average greenhouse area to plant ratio observed by the authors on law enforcement visits was representative of the average spacing used at MCSs in the study watersheds.

Our water demand estimates were based on calculations from the 2010 Humboldt County Outdoor Medical Cannabis Ordinance draft [27], which states that marijuana plants use an average of 22.7 liters per plant per day during the growing season, which typically extends from June-October (150 days). Water use data for marijuana cultivation are virtually nonexistent in the published literature, and both published and unpublished sources for this information vary greatly, from as low as 3.8 liters up to 56.8 liters per plant per day [7,28]. The 22.7 liter figure falls near the middle of this range, and was based on the soaker hose and emitter line watering methods used almost exclusively by the MCSs we have observed. Because these water demand estimates were used to evaluate impacts of surface water diversion from streams, we also excluded plants and greenhouses in areas served by municipal water districts (Outlet Creek, Fig. 4).

Hydrologic Analyses: Estimating Impacts on Summer Low Flows

The annual seven-day low flow, a metric often used to define the low flow of a stream, is defined as the lowest value of mean discharge computed over any seven consecutive days within a water year. This value varies from year to year. Annual seven-day low flow values for the ungaged watersheds in this study were estimated by correlating to nearby USGS gaged streams. Annual seven-day low flow values for Elder Creek (Fig. 5), a gage used for this correlation, demonstrate the year-to-year variability in the study watersheds. Elder Creek is considered to be the least disturbed of the gaged watersheds, and is also the smallest, with a contributing area of 16.8 square kilometers. The annual seven-day low flow estimates were made by scaling the gaged data by the ratio of average flow of the ungaged and gaged stream, a method that provides better estimates than scaling by watershed area [29]. Regression equations based on average annual precipitation and evapotranspiration were used to estimate average annual flow, providing a more unique flow characterization than using watershed area alone. These methods were developed by Rantz [30]. The gaged data were either from within the watershed of the study area or from a nearby watershed. Correlation with daily average flow data from a gaged stream makes sense when the ungaged watershed is considered to be hydrologically similar to the gaged watershed, i.e. similar geology, vegetation, watershed size and orientation, and atmospheric conditions (precipitation, cloud cover, temperature). The accuracy of gaged data at low flows can be problematic because gaging very low flows is difficult and

limited depending on the location of the gage and the precision in low-flow conditions, but the method can still provide a rough estimate of low flow by taking into account the range of uncertainty. Data were used from the closest most relevant gaged watershed for correlation to the ungaged sites.

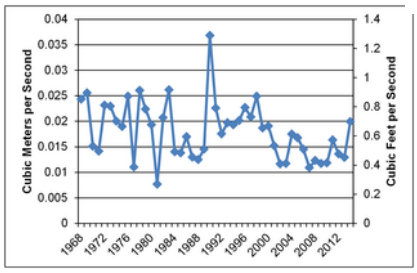

Fig 5. Elder Creek annual seven-day low flow.
Values are shown for the period of record (water years 1968–2014).
doi:10.1371/journal.pone.0120016.g005

Data for the gaged stations are shown in Table 1. This table includes the estimated average annual flow calculated from both the gaged data and also by use of the regression equations for comparison. The annual seven-day low flow for the period of record of each of the gaged stations is shown in Table 2. This table also shows the minimum, average, and maximum seven-day low flow values over the period of record as a way to represent the variability of the low flow from year to year. To estimate the annual seven-day low flow for the ungaged streams, the average annual seven-day low flow of the gaged stream was multiplied by the ratio of the annual average streamflow of the ungaged stream and the annual average streamflow of the gaged stream. A range of values, including the lowest and highest estimate for each location were calculated to represent the annual variability.

Watershed	Gage	Period of Record	Area (km^2)	MAP[a] (cm/yr)	PET[b] (cm/yr)	Mean Annual Runoff (cm/yr)	Q[c]avg (CMS)[d], predicted	Qavg (CMS), gaged	% difference
South Fork Eel River	USGS 11476500	10/1/1930–9/30/2012	1390.8	192.8	101.6	129.0	57.8	52.0	-11.1
Bull Creek	USGS 11478600	10/1/1967–9/30/2012	72.5	166.4	101.6	102.6	2.4	3.3	27.1
Elder Creek	USGS 11475560	10/1/1967–9/30/2012	16.8	215.9	101.6	152.1	0.8	0.7	-14.9
Outlet Creek	USGS 11472200	10/1/1956–9/30/1994	417.0	152.9	101.6	89.2	12.1	11.1	-8.8
Upper Redwood Creek	USGS 11481500	10/01/1953–10/1/2013	175.3	231.1	86.4	173.5	9.6	8.5	-12.6
Redwood Creek South	Ungaged	N/A	64.7	157.2	101.6	93.5	0.46	N/A	N/A
Salmon Creek	Ungaged	N/A	95.1	151.4	101.6	87.6	0.48	N/A	N/A

[a]mean annual precipitation
[b]potential evapotranspiration
[c]flow
[d]cubic meters per second

doi:10.1371/journal.pone.0120016.t001

Table 1. USGS stream gages in or near study watersheds.
doi:10.1371/journal.pone.0120016.t001

Gage	Seven-day low flow for period of record in cubic meters per second		
	Minimum	Average	Maximum
SF Eel Miranda	0.3519	0.8829	1.796
Bull	0.0059	0.0310	0.0853
Elder	0.0076	0.0180	0.0368
Outlet Creek	0.0000	0.0162	0.0498
Upper Redwood Creek	0.0265	0.1064	0.2601
Redwood Creek South (based on Elder Creek)	0.004	0.010	0.021
Salmon Creek (based on Elder Creek)	0.005	0.011	0.022

doi:10.1371/journal.pone.0120016.t002

Table 2. Annual seven-day low flow range for period of record.
doi:10.1371/journal.pone.0120016.t002

The mean annual streamflow of each ungaged stream was estimated using a regression equation, based on estimates of runoff and basin area developed by Rantz [30] (Equation 1). The mean annual runoff was estimated from a second regression equation (Equation 2) based on the relationship between mean annual precipitation and annual potential evapotranspiration for the California northern coastal area [30]. Mean annual precipitation values are from the USGS StreamStat web site (http://water.usgs.gov/osw/streamstats/california.html), which uses the PRISM average area weighted estimates based on data from 1971–2000. The estimates of mean annual evapotranspiration were taken from a chart produced by Kohler [31].

$$Q_{Avg} = 0.07362 = \left(\frac{m^3}{sec} \times yr \times cm \times km^2\right) \times R \times A \quad \text{eq. (1)}$$

With

$$R = MAP - 0.4(PET) - 9.1$$

eq. (2)

Where

$$Q_{Avg} = \text{mean annual discharge}\left(\frac{m^3}{sec}\right)$$

$$R = \text{mean annual runoff}\left(\frac{cm}{yr}\right)$$

$$A = \text{drainage area}\,(km^2)$$

$$MAP = \text{mean annual precipitation}\left(\frac{cm}{yr}\right)$$

$$PET = \text{potential evapotranspiration}\left(\frac{cm}{yr}\right)$$

Estimates of average annual flow made by using these equations range from-15% to +27% below and above the calculated value using the gaged daily average data (Table 1). The Bull Creek gage estimate produced the largest deviation of 27% and may be considered an outlier because of the known disturbances in the watershed due to historic logging practices, and USGS reported "poor" low flow data.

The mean annual flow for each ungaged watershed was calculated using the Rantz method described above. The mean annual precipitation and runoff values are shown in Table 1 with the predicted mean annual flow for the ungaged streams. The annual seven-day low flows for Upper Redwood Creek and Outlet Creek were calculated using data from their respective stream gages. For Redwood Creek South and Salmon Creek, both watersheds with no mainstem gage, the annual seven-day low flow was calculated in the same way by using the data from nearby gaged streams within the South Fork Eel watershed (Bull Creek, Elder Creek, and South Fork Eel near Miranda gage). Fig. 6 shows three different estimates of the duration curves of the annual seven-day low flow for the Redwood Creek South ungaged site based on the three different nearby gages. The variations between these estimated duration curves (Fig. 6) illustrate the relative variability of annual seven-day low flow. Reasons for this variability may include the difference in hydrologic response of the gaged watersheds from the ungaged watersheds, differences in withdrawals or low flow measurement error, differences in the atmospheric patterns over the watershed, or differences in watershed characteristics (watershed size, orientation, land use, slope etc.). The gaged watersheds differed from the study watersheds in several ways, such as size (Miranda gage), disturbance (Bull Creek gage), and distance and orientation from the study watersheds (Elder Creek gage). Despite the differences, the Elder Creek gage most likely represents the best data set for correlation to the ungaged watersheds based on its similar size and relative unimpairment. The estimated values represent the upper limit of low flows for the ungaged streams, thus are conservative values and may be an overestimate.

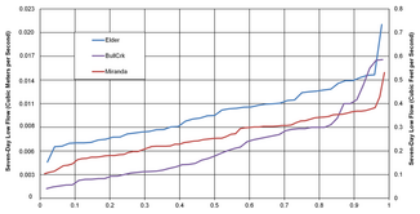

Fig 6. Duration curve of estimates of annual seven-day low flow for Redwood Creek South based on USGS data from nearby streams (Elder Creek, South Fork Eel at Miranda, and Bull Creek).

doi:10.1371/journal.pone.0120016.g006

Results

MCSs were widespread in all four study watersheds. In general, MCSs were clustered and were not evenly distributed throughout the study watersheds (Figs. 2–4). Estimated plant totals ranged from approximately 23,000 plants to approximately 32,000 plants per watershed (Table 3). Using the plant count estimates multiplied by our per plant daily water use estimate of 22.7 liters [27] we determined that water demands for marijuana cultivation range from 523,144 liters per day (LPD) to 724,016 LPD (Table 3). We also calculated the daily water use for each parcel that contained at least one marijuana cultivation site (S1 Table). Histograms showing the frequency distribution of daily water use per parcel are displayed for each watershed in Fig. 7. The majority of parcels in this study use an estimated 900 to 5,000 LPD for marijuana cultivation. These water use estimates are only based on irrigation needs for the marijuana plants counted or the greenhouses measured on that parcel, and do not account for indoor domestic water use, which in Northern California averages about 650 liters per day [32]. Thus, our water use demand estimates for marijuana cultivation are occurring in addition to domestic household uses that may occur and are also likely satisfied by surface water diversions.

Watershed	Outdoor Plants	Green-houses (counted)	Total area, m^2 (Green-houses)	Estimated Plants in Green-houses	Estimated Total Plants in Watershed	Estimated Water Use per Day (Liters)
Upper Redwood Creek	4,434	220	20749.4	18,612	23,046	523,144
Salmon Creek	11,697	302	20557.5	18,440	30,137	684,110
Redwood Creek South	10,475	324	18703.9	16,777	27,252	618,620
Outlet Creek	15,165	266	18651.1	16,730	31,895	724,016

doi:10.1371/journal.pone.0120016.t003

Table 3. Marijuana mapping summary of four watersheds.

Outdoor plants and greenhouses were identified from aerial images of Humboldt and Mendocino Counties. Greenhouse areas were estimated using the Google Earth measuring tool and an average area of 1.11484 m^2 (converted from 12 ft^2) per plant was used to estimate total number of plants in greenhouses.

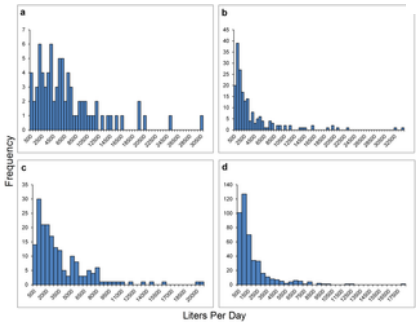

Fig 7. Frequency distribution of the water demand in liters per day (LPD) required per parcel for marijuana cultivation for each study watershed.
(a) Upper Redwood Creek watershed, 79 parcels with marijuana cultivation, average water use 6622 LPD, (b) Salmon Creek watershed, 189 parcels with marijuana cultivation, average water use 3620 LPD, (c) Redwood Creek South watershed, 187 parcels with marijuana cultivation, average water use 3308 LPD, (d) Outlet Creek watershed, 441 parcels with marijuana cultivation, average 1642 LPD. See also S1 Table.

doi:10.1371/journal.pone.0120016.g007

Minimum and maximum annual seven-day low flow values in these watersheds (Table 2) ranged from 0.0–0.05 cubic meters per second (CMS) in Outlet Creek to. 03 -. 26 CMS in Upper Redwood Creek. By comparing daily water demands to minimum and maximum annual seven-day low flow values, we arrived at a range of values that represent water demand for marijuana cultivation as a percentage of stream flow in each watershed (Table 4, S2 Table). In Upper Redwood Creek, which had the greatest summer flows (Table 2), we estimate water demand for marijuana cultivation is the equivalent of 2–23% of the annual seven-day low flow, depending on the water year. In Redwood Creek South, our data indicate that estimated water demand for marijuana cultivation is 34–165% of the annual seven-day low flow, and in Salmon Creek, estimated water demand for marijuana is 36–173% of the annual seven-day low flow. In Outlet Creek, estimated demand was 17% of the maximum annual seven-day low flow. However, the percent of the annual seven-day low flow minimum could not be calculated because this minimum stream flow was undetectable at the gage (flow <0.00 CMS) in nine of 38 years during the period of record (1957–1994). Due to this minimum annual seven-day low flow of almost zero, marijuana water demand is greater than 100% of the minimum annual seven-day low flow, but we cannot determine by how much.

Watershed	Area (km^2)	Plants per km^2	Demand as percent of seven-day low flow	
			Percent of low flow maximum	Percent of low flow minimum
Upper Redwood Creek	175.3	131.6	2%	23%
Salmon Creek	95.1	316.9	36%	173%
Redwood Creek South	64.7	421.2	34%	165%
Outlet Creek	419.1	76.1	17%	>100%*

* The seven-day low flow minimum was measured as 0.0 CMS at the gage.

doi:10.1371/journal.pone.0120016.t004

Table 4. Estimated water demand for marijuana cultivation expressed as a percentage of seven-day low flow in four study watersheds.

We also compared the per-watershed daily water demands to the seven-day low flow values for each year of data available in order to better understand the magnitude and frequency of these water demands (Fig. 8, S2 Table). Although substantial demand for water for marijuana cultivation is a more recent and growing phenomenon, by comparing the water use estimates from our remote sensing exercise to historical stream flow data we can better understand how this demand as a percentage of stream flow may vary over the years. Our results indicate that if the same level of water demand for marijuana cultivation had been present for the period of record of the gages, this demand would have accounted for over 50% of streamflow during the annual seven-day low flow period in the majority of years in the Redwood Creek South and Salmon Creek watersheds (based on Elder Creek gage data that spans from water year 1968–2014). In Outlet Creek, the annual seven-day low flow data varied greatly over the period of record (water year 1957–1994) and was too low to measure in nine of the 38 years. The seven-day low flow value was therefore recorded as zero, which means that the water demand was greater than 100% of streamflow, but we could not calculate the water demand as a percentage of stream flow in those years. In Upper Redwood Creek, water demand was much less pronounced in comparison to stream flow, with water demand never accounting for more than 23% of the annual seven-day low flow, and accounting for 10% or greater of the annual seven-day low flow in only 30% of years during the period of record (water year 1954–2014 with a gap between 1959–1972). To summarize, we estimate that in three of the four watersheds evaluated, water demands for marijuana cultivation exceed streamflow during low-flow periods.

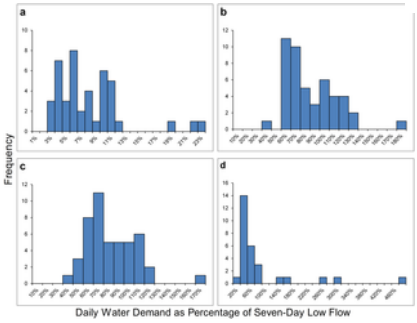

Fig 8. Frequency distribution of the water demand for marijuana cultivation as a percentage of seven-day low flow by year in each study watershed.

Water demand data are from a remote sensing exercise using aerial imagery from 2011–2012 and are compared with each year's annual seven-day low flow value for the period of record in each study watershed: (a) Upper Redwood Creek watershed (USGS gage near Blue Lake, CA, coverage from water year (WY) 1954–1958 and 1973–2014), (b) Salmon Creek watershed (data modeled using USGS gage on Elder Creek, CA, coverage from WY 1968–2014), (c) Redwood Creek South (data modeled using USGS gage on Elder Creek, CA, coverage from WY 1968–2014), and (d) Outlet Creek (USGS gage near Longvale, CA, coverage from WY 1957–1994). Data from WYs 1977, 1981, 1987–1989, and 1991–1994 are excluded from Outlet Creek watershed due to seven-day low flow values of zero at the gage. Water demand as a percentage of seven-day low flow would be >100% in these years, but we cannot determine by how much.

doi:10.1371/journal.pone.0120016.g008

Discussion

Aerial Imagery Limitations and Water Demand Assumptions

Due to a number of factors, it is likely that the plant counts resulting from aerial imagery interpretation (Table 3) are minimum values. The detection of marijuana plants using aerial imagery was found most effective for larger cultivation plots in forest clearings greater than 10 m^2 because forest canopy cover and shadows can obscure individual plants or small plots, preventing detection. Some cultivators plant marijuana on a wide spacing in small forest canopy openings in order to avoid aerial detection [7,8]. The authors have also observed a variety of cultivation practices such as the use of large indoor cultivation facilities that could not be detected via aerial imagery. Moreover, a review of Google Earth historical aerial images after field inspections revealed that all MCSs visited in 2013 were either new or had expanded substantially since the previous year. Therefore, it is likely our results underestimate the total number of plants currently grown in these study watersheds and consequently underestimate the associated water demands.

Marijuana has been described as a high water-use plant [2,15] that thrives in nutrient rich moist soil [33]. Marijuana's area of greatest naturalization in North America is in alluvial bottomlands of the Mississippi and Missouri River valleys where there is typically ample rain during the summer growing season [23,33]. Female inflorescences and intercalated bracts are the harvested portion of the marijuana plant. According to Cervantes [15], marijuana uses high levels of water for floral formation and withholding water stunts floral formation. Cervantes recommends marijuana plants be liberally watered and "allow for up to 10 percent runoff during each watering."

There is uncertainty as to actual average water use of marijuana plants because there are few reliable published reports on marijuana water use requirements. As with the cultivation of any crop, variation in average daily water use would be expected based upon many variables, including the elevation, slope, and aspect of the cultivation site; microclimate and weather; size, age, and variety of the plant; native soil type and the amount and type of soil amendments used and their drainage and water retention characteristics; whether plants are grown outdoors, in greenhouses, or directly in the ground or in containers and the size of the container; and finally, the irrigation system used and how efficiently the system is used and maintained [34–36]. However, our water demand estimate of 22.7 L/day/plant based on the limited industry data available [27] comports with the U.S. Department of Justice 2007 Domestic Cannabis Cultivation Assessment [2], which indicates marijuana plants require up to 18.9 L/day/plant.

In many rural watersheds in Northern California, the primary source for domestic and agricultural water is from small surface water diversions [37]. These diversions must be registered with the State Water Resources Control Board (SWRCB), the agency responsible for administering water rights in California. SWRCB registrations are also subject to conditions set by the California Department of Fish and Wildlife in order to protect fish, wildlife, and their habitats. However, when querying the SWRCB's public database, we found low numbers of registered, active water diversions on file relative to the number of MCSs we counted in the study watersheds. The total number of registered, active diversions on file with the SWRCB accounted less than half of the number of parcels with MCSs that were visible from aerial imagery (Fig. 9). In some watersheds, the number was as low as 6%. Since we do not know if the registered diversions on file with the SWRCB belong to parcels with MCSs, it is uncertain if the registered diversions in a particular watershed are connected with any of the MCSs we counted.

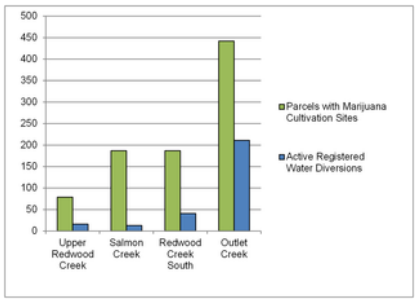

Fig 9. Active water rights in the study watersheds.
Parcels with active registered water diversions (on file with California's Division of Water Rights) compared to parcels with marijuana cultivation sites (MCSs) in the four study watersheds.
doi:10.1371/journal.pone.0120016.g009

Our calculations of water demand as a percentage of stream flow assume that all potential water users are diverting surface water or hydrologically-connected subsurface flow. Historical water use practices and our field inspections with law enforcement support this assumption, although there are few hard data available as there are relatively few active registered water diversions on file with the Division of Water Rights when compared to the potential number of water users in the watersheds (Fig. 9).

Implicit in our calculations is the assumption that all water users are pumping water at the same rate throughout the day, as well as throughout the growing season. In reality, we expect water demand to gradually increase throughout the season as plants mature. This increased water demand would coincide with the natural hydrograph recession through the summer months, creating an even more pronounced impact during the summer low-flow period. In a similar study that monitored flow in relation to surface water abstraction for vineyard heat protection, flows receded abnormally during periods of high maximum daily temperature [21]. These results indicate that water users can have measureable effects on instantaneous flow in periods of high water demand. Our results suggest that similar impacts could occur during the summer low flow period in the study watersheds.

Additionally, our analysis assumes the water withdrawals will impact the entire watershed in an even, consistent way. In reality, we would expect water demand to be more concentrated at certain times of day and certain periods of the growing season, as described above. Furthermore, results of our spatial analysis indicate that MCSs are not evenly distributed on the landscape, thus impacts from water withdrawals are likely concentrated in certain areas within these watersheds. Because of these spatially and temporally clustered impacts, we may expect to see intensification of stream dewatering or temperature elevation in certain tributaries at certain times of year, which could have substantial impacts on sensitive aquatic species. Recent data indicate that peaks in high stream temperatures and annual low-flow events are increasing in synchrony in western North America [38], an effect that would be exacerbated by the surface water withdrawals we describe here. Further modeling and on-the-ground stream flow and temperature observations are needed to elucidate the potential extent of these impacts. The minimum streamflow estimates in Salmon Creek, Redwood Creek South, and Outlet Creek are so low that even a few standard-sized pumps operating at 38 liters per minute (LPM), which is a standard rate approved by the SWRCB for small diversions, could dewater the mainstem stream if more than four pumps ran simultaneously in any one area. It follows that impacts on smaller tributaries would be even more pronounced. In addition, on-site observations of MCS irrigation systems, though anecdotal, indicate many of these water conveyance, storage, and irrigation systems lose a substantial amount of water through leaks and inefficient design. This would significantly increase the amount of surface water diverted from streams beyond what would actually be needed to yield a crop. More study is needed to fully understand the impacts of MCS water demand on instantaneous flow in these watersheds.

Given that marijuana cultivation water demand could outstrip supply during the low flow period, and based on our MCS inspections and surface water diversion and irrigation system observations, we surmise that if a MCS has a perennial water supply, that supply would be used exclusively. However, for MCSs with on-site surface water sources that naturally run dry in summer, or are depleted though diversion, it is likely that direct surface water diversion is used until the source is exhausted, then water stored earlier in the year or imported by truck supplants the depleted surface water. It is difficult to determine to what degree imported water and wet season water storage is occurring. However, our on-site MCS inspections support the assumption that the vast majority of irrigation water used for marijuana cultivation in the study watersheds is obtained from on-site surface water sources and water storage and importation is ancillary to direct surface water diversions.

Comparison of Water Demands to Summer Low Flows

Our results suggest that water demand for marijuana cultivation in three of the study watersheds could exceed what is naturally supplied by surface water alone. However, in Upper Redwood Creek, the data suggest that marijuana cultivation could have a smaller impact on streamflow, with demand taking up approximately 2% to 23% of flow (Table 4). This projected demand of flow contrasts with the 34% to >100% flow demand range in the other watersheds, most likely because Upper Redwood Creek has greater mean annual precipitation, less evapotranspiration, and generally higher stream flow than the other watersheds (Tables 1–2). Furthermore, approximately half of the Upper Redwood Creek watershed is comprised of either large timber company holdings or federal lands. As Fig. 2 illustrates, MCSs in Upper Redwood Creek are concentrated within a relatively small area of privately-owned land that has been subdivided. It stands to reason that if all the land within the Upper Redwood Creek watershed was subject to the subdivision and parcelization that has occurred in Redwood Creek South, Salmon Creek, or Outlet Creek, the potential impacts to stream flow would also be greater.

In Outlet Creek, our results indicate a large range of potential water demand as a percentage of streamflow, from 17% in a "wet" year to greater than 100% when the stream becomes intermittent, as it does during many summers. Our data indicate that impacts to streamflow will vary greatly depending on the individual watershed characteristics, whether the year is wetter or drier than average, and the land use practices taking place.

Environmental Impacts

The extent of potential environmental impacts in these watersheds is especially troubling given the region is a recognized biodiversity hotspot. According to Ricketts et al. [39], the study watersheds occur within the Northern California Coastal Forests Terrestrial Ecoregion. This ecoregion has a biological distinctiveness ranking of "globally outstanding" and a conservation status of "critical" [39]. For example, Redwood National Park, 20 km downstream of the Upper Redwood Creek sub-basin, has approximately 100 km^2 of old-growth redwood forest, which is one of the world's largest remaining old-growth redwood stands. The study watersheds also occur within the Pacific Mid-Coastal Freshwater Ecoregion defined by Abell et al. [40]. This ecoregion has a "Continentally Outstanding" biological distinctiveness ranking, a current conservation status ranking of "Endangered" and its ranking is "Critical" with regards to expected future threats [40]. Not surprisingly, numerous sensitive species, including state- and federally-listed taxa, occur in the study watersheds or directly downstream (Table 5).

Scientific Name	Common Name	Conservation Status in California	Study Watersh
Oncorhynchus kisutch	coho salmon	State and federally-threatened	URC, RCS, SC, OC
Oncorhynchus tshawytscha	Chinook salmon	federally-threatened	URC, RCS, SC, OC
Oncorhynchus clarki clarki	coastal cutthroat trout	SSC[1]	URC
Oncorhynchus mykiss	steelhead trout	federally-threatened	URC, RCS, SC, OC
Rana aurora	northern red-legged frog	SSC	URC, RCS, SC, OC
Rana boylii	foothill yellow-legged frog	SSC	URC, RCS, SC, OC
Rhyacotriton variegatus	southern torrent salamander	SSC	URC, RCS, SC, OC
Ascaphus truei	coastal tailed frog	SSC	URC, RCS, SC
Emys marmorata	western pond turtle	SSC	RCS, SC, OC
Margaritifera falcata	western pearlshell	S1S2[2]	URC

[1]The California Department of Fish and Wildlife designates certain vertebrate species as Species of Special Concern (SSC) because declining population levels, limited ranges, and/or continuing threats have made them vulnerable to extinction. Though not listed pursuant to the Federal Endangered Species Act or the California Endangered Species Act, the goal of designating taxa as SSC is to halt or reverse these species' decline by calling attention to their plight and addressing the issues of conservation concern early enough to secure their long-term viability.

[2] The California Natural Diversity Database (CNDDB) designates conservation status rank based on a one to five scale, one being "Critically Imperiled", five being "Secure". Uncertainty about a rank is expressed by a range of values, thus a status of S1S2 indicates that there is uncertainty about whether *Margaritifera falcata* ranks as state "Critically Imperiled" (S1) or state "Imperiled" (S2).[1-1].

doi:10.1371/journal.pone.0120016.t005

Table 5. Sensitive aquatic species with ranges that overlap the four study watersheds: Upper Redwood Creek (URC), Redwood Creek South (RCS), Salmon Creek (SC), and Outlet Creek (OC).
doi:10.1371/journal.pone.0120016.t005

Our results indicate that the high water demand from marijuana cultivation in these watersheds could significantly impact aquatic- and riparian-dependent species. In the Pacific Coast Ecoregion, 60% of amphibian species, 16% of reptiles, 34% of birds, and 12% of mammals can be classified as riparian obligates, demonstrating the wide range of taxa that potentially would be affected by diminished stream flows [42]. The impacts of streamflow diversions and diminished or eliminated summer streamflow would however disproportionately affect aquatic species, especially those which are already sensitive and declining.

Impacts to Fish

Northern California is home to some of the southernmost native populations of Pacific Coast salmon and trout (i.e., salmonids) and the study area is a stronghold and refugia for their diversity and survival. Every salmonid species in the study watersheds has some conservation status ranking (Table 5). California coho salmon, for example, have undergone at least a 70% decline in abundance since the 1960s, and are currently at 6 to 15% of their abundance during the 1940s [43]. Coho salmon populations in all four study watersheds are listed as threatened under both the California and the Federal Endangered Species Acts, and are designated as key populations to maintain or improve as part of the Recovery Strategy of California Coho Salmon [43].

Of California's 129 native inland fish species, seven (5%) are extinct in the state or globally; 33 (26%) are in immediate danger of becoming extinct (endangered), and 34 (26%) are in decline but not at immediate risk of extinction (vulnerable) [44]. According to Katz et al. [45], if present population trends continue, 25 (78%) of California's 32 native salmonid taxa will likely be extinct or extirpated within the next century.

The diminished flows presented by this study may be particularly damaging to salmonid fishes because they require clean, cold water and suitable flow regimes [44]. In fact, water diversions and altered or diminished in-stream flows due to land use practices have been identified as having a significant impact on coho salmon resulting in juvenile and adult mortality [43].

Additionally, all four study watersheds are already designated as impaired for elevated water temperature and sediment by the U.S. Environmental Protection Agency pursuant to the Clean Water Act Section 303(d). Reduced flow volume has a strong positive correlation with increased water temperature [44]. Increased water temperatures reduce growth rates in salmonids, increase predation risk [46], and increase susceptibility to disease. Warmer water also holds less dissolved oxygen, which can reduce survival in juvenile salmonids [44]. Both water temperature and dissolved oxygen are critically important for salmonid survival and habitat quality [47–50].

Reduced stream flows can also threaten salmonids by diminishing other water quality parameters, decreasing habitat availability, stranding fish, delaying migration, increasing intra and interspecific competition, decreasing food supply, and increasing the likelihood of predation [43]. These impacts can have lethal and sub-lethal effects. Experimental evidence in the study region suggests summer dry-season changes in streamflow can lead to substantial changes in individual growth rates of salmonids [51]. Complete dewatering of stream reaches would result in stranding and outright mortality of salmonids, which has been observed by the authors at a number of MCSs just downstream of their water diversions.

Impacts to Amphibians

Water diversions and altered stream flows are also a significant threat to amphibians in the northwestern United States [52,53]. The southern torrent salamander (*Rhyacotriton variegatus*) and coastal tailed frog (*Ascaphus truei*) are particularly vulnerable to headwater stream diversions or dewatering, which could lead to mortality of these desiccation-intolerant species [54]. To maximize the compatibility of land use with amphibian conservation, Pilliod and Wind [53], recommend restoration of natural stream flows and use of alternative water sources in lieu of developing headwater springs and seeps.

Numerous studies have documented the extreme sensitivity of headwater stream-dwelling amphibians to changes in water temperature [55,56] as well as amounts of fine sediment and large woody debris [57,58]. Additionally, Kupferberg et al. and others [52,59] have demonstrated the impacts of altered flow regimes on river-dwelling amphibians. However, the threat of water diversion and hydromodification—or outright loss of flow—from headwaters streams has not been well-documented in the amphibian conservation literature. This is likely because illegal and unregulated headwater stream diversions did not exist at this scale until the

recent expansion of marijuana cultivation in the region. In contrast, timber harvesting, which until recently was the primary land use in forested ecoregions in the western United States, does not typically divert headwater streams in the same manner as MCSs. Timber harvesting operations, at least in California, have state regulatory oversight that requires bypass flows to maintain habitat values for surface water diversions. Thus, the results of our study highlight an emerging threat to headwater amphibians not addressed in Lannoo [60], Wake and Vredenburg [61], or more recently in Clipp and Anderson [62]

Future Water Demands and Climate Change

Flow modification is one of the greatest threats to aquatic biodiversity [63]. As in many parts of the world, the freshwater needed to sustain aquatic biodiversity and ecosystem health in our study area is also subject to severe competition for multiple human needs. The threats to human water security and river biodiversity are inextricably linked by increasing human demands for freshwater [64,65]. In California, irrigated agriculture is the single largest consumer of water, taking 70–80% of stored surface water and pumping great volumes of groundwater [44]. In our study area, agricultural demands account for 50–80% of all water withdrawals [66]. Only late in the last century have the impacts of water diversions on aquatic species become well recognized. However, these impacts are most often assessed on large regional scales, e.g. major rivers and alluvial valleys, and the large hydroelectric dams, reservoirs, and flood control and conveyance systems that regulate them [67].

Few studies thus far have assessed the impacts of many small agricultural diversions on zero to third order streams and their cumulative effects on a watershed scale [21,22]. On a localized scale, with regional implications, this study detects an emerging threat to not only aquatic biodiversity but also human water security, since surface water supplies most of the water for domestic uses in watersheds throughout Northwestern California [37]. In these watersheds, the concept of “peak renewable water,” where flow constraints limit total water availability [68], may have already arrived. In other words, the streams in the study watersheds simply cannot supply enough water to meet current demands for marijuana cultivation, other human needs, and the needs of fish and wildlife.

Due to climate change, water scarcity and habitat degradation in northern California is likely to worsen in the future. Regional climate change projections anticipate warmer average air temperatures, increases in prolonged heat waves, decreases in snow pack, earlier snow melt, a greater percentage of precipitation falling as rain rather than snow, a shift in spring and summer runoff to the winter months, and greater hydroclimatic variability and extremes [69–77]. Consequently, future hydrologic scenarios for California anticipate less water for ecosystem services, less reservoir capture, a diminished water supply for human uses, and greater conflict over the allocation of that diminished supply [70,71,75,78,79]. Climate change is expected to result in higher air and surface water temperatures in California’s streams and rivers in the coming decades, which in turn could significantly decrease suitable habitat for freshwater fishes [80–83]. Due to a warming climate, by 2090, 25 to 41% of currently suitable California streams may be too warm to support trout [84].

Already, gage data and climate stations in northwestern California show summer low flow has decreased and summer stream temperatures have increased in many of northern California’s coastal rivers, although these changes cannot yet be ascribed to climate change [85]. In an analysis of gage data from 21 river gaging stations, 10 of the gages showed an overall decrease in seven-day low flow over the period of record. This dataset included Upper Redwood Creek as well as the South Fork Eel River, the receiving water body for Redwood Creek South and Salmon Creek [85].

Our analysis suggests that for some smaller headwater tributaries, marijuana cultivation may be completely dewatering streams, and for the larger fish-bearing streams downslope, the flow diversions are substantial and likely contribute to accelerated summer intermittence and higher stream temperatures. Clearly, water demands for the existing level of marijuana cultivation in many northern California watersheds are unsustainable and are likely contributing to the decline of sensitive aquatic species in the region. Given the specter of climate change induced more severe and prolonged droughts and diminished summer stream flows in the region, continued diversions at a rate necessary to support the current scale of marijuana cultivation in northern California could be catastrophic for aquatic species.

Both monitoring and conservation measures are necessary to address environmental impacts from marijuana cultivation. State and federal agencies will need to develop more comprehensive guidelines for essential bypass flows in order to protect rearing habitat for listed salmonid species and other sensitive aquatic organisms. Installation of additional streamflow gages and other water quality and quantity monitoring will be necessary to fill data gaps in remote watersheds. In addition, increased oversight of water use for existing MCSs and increased enforcement by state and local agencies will be necessary to prevent and remediate illegal grading and forest conversions. Local and state governments will need to provide oversight to ensure that development related to MCSs is permitted and complies with environmental regulations and best management practices. Local and state agencies and nonprofit organizations should also continue to educate marijuana cultivators and the public about the environmental threats, appropriate mitigation measures, and permit requirements to legally develop MCSs and best protect fish and wildlife habitat. Finally, local governments should evaluate their land use planning policies and ordinances to prevent or minimize future forestland conversion to MCSs or other land uses that fragment forestlands and result in stream diversions.

Supporting Information

S1 Table. Number of outdoor plants counted, area of greenhouses measured, and estimated water use in Liters per day for each parcel in the study watersheds.

doi:10.1371/journal.pone.0120016.s001
(XLSX)

S2 Table. Per-watershed daily water demands compared to seven-day low flow by year.

doi:10.1371/journal.pone.0120016.s002
(XLSX)

Acknowledgments

The authors gratefully acknowledge the contributions of two anonymous reviewers who offered meaningful suggestions that greatly improved the manuscript. We thank the California Department of Fish and Wildlife (CDFW)'s Coastal Conservation Planning team, especially Clare Golec, Tony LaBanca, David Manthorne, and Mark Smelser, for their input on study design, manuscript review, and/or fieldwork. We thank CDFW Wildlife Officers and pilots for their invaluable field support during site inspections. Finally, we thank Mourad Gabriel for constructive feedback on the manuscript, and Daniel Barton for helpful input on data analysis and figures.

Author Contributions

Conceived and designed the experiments: SB MVH LM AC JO. Analyzed the data: JO AC MT SB MVH GL. Wrote the paper: GL JO AC MT SB. Collected the data: AC JO SB MVH GL.

References

1. Corva D. Requiem for a CAMP: The life and death of a domestic U.S. drug war institution. Int J Drug Policy. 2014 Jan;25(1):71–80. doi: 10.1016/j.drugpo.2013.02.003. pmid:23561719
View Article • PubMed/NCBI • Google Scholar

2. United States Department of Justice. Domestic cannabis cultivation assessment 2007. Johnstown, PA: National Drug Intelligence Center; 2007.

3. National Drug Control Strategy Data Supplement. Executive Office of the President, Office of National Drug Control Policy; 2013.

4. Arnold JM. Energy Consumption and Environmental Impacts Associated With Cannabis Cultivation. M.Sc. Thesis, Humboldt State University. 2013. Available: http://humboldt-dspace.calstate.edu/handle/2148/1461

5. Leeper JS. Humboldt County: its role in the emerald triangle. Calif Geogr. 1990;30(6):93–109.
View Article • PubMed/NCBI • Google Scholar

6. Humboldt County Planning and Building Department. Forest Resources [Internet]. Humboldt County, CA; 2002 [cited 2014 Feb 24] p. 3.1–3.16. Available: https://co.humboldt.ca.us/gpu/docs/meetings/natl_res/06chapte.pdf

7. Mallery M. Marijuana National Forest: Encroachment on California Public Lands for Cannabis Cultivation. Berkeley Undergrad J. 2011 Jan 1;23(2). Available: http://escholarship.org/uc/item/7r10t66s#page-2

8. Gabriel MW, Wengert GM, Higley J, Krogan S, Sargent W, Clifford DL. Silent Forests? Rodenticides on illegal marijuana crops harm wildlife. Wildl Prof. 2013;7(1):46–50.
View Article • PubMed/NCBI • Google Scholar

9. Milestone JF, Hendricks K, Foster A, Richardson J, Sean D, Demetry A, et al. Continued Cultivation of Illegal Marijuana in U.S. Western National Parks. In: Weber S, editor. Rethinking Protected Areas in a Changing World. Hancock, Michigan: The George Wright Society; 2012.

10. Mills E. The carbon footprint of indoor Cannabis production. Energy Policy. 2012 Jul;46:58–67. doi: 10.1016/j.enpol.2012.03.023
View Article • PubMed/NCBI • Google Scholar

11. Gabriel MW, Woods LW, Poppenga R, Sweitzer RA, Thompson C, Matthews SM, et al. Anticoagulant Rodenticides on our Public and Community Lands: Spatial Distribution of Exposure and Poisoning of a Rare Forest Carnivore. PLoS ONE. 2012 Jul 13;7(7):e40163. doi: 10.1371/journal.pone.0040163. pmid:22808110
View Article • PubMed/NCBI • Google Scholar

12. Thompson C, Sweitzer R, Gabriel M, Purcell K, Barrett R, Poppenga R. Impacts of rodenticide and insecticide toxicants from marijuana cultivation sites on fisher survival rates in the Sierra National Forest, California. Conserv Lett. 2013. Available: http://onlinelibrary.wiley.com/doi/10.11 11/conl.12038/abstract
View Article • PubMed/NCBI • Google Scholar

13. State Water Resources Control Board. Marijuana Cultivation on the North Coast Threatens Water Quality and Wildlife. 2013. Available: http://www.waterboards.ca.gov/northcoast/publications_and_forms/available_documents/pdf/2013/130611_MarijuanFactSheet.pdf

14. Western Regional Climate Center. Cooperative Climatological Data Summary [Internet]. National Oceanic and Atmospheric Administration; 2014. Accessed: http://www.wrcc.dri.edu/summary/Climsmnca.html

15. Cervantes J. Marijuana horticulture: the indoor/outdoor medical grower's bible. Sacramento, CA: Van Patten Pub.; 2006.

16. Williams LE. Irrigation of winegrapes in California. Practical Winery and Vineyard Journal [Internet]. 2001 Dec; Available: http://www.practicalwinery.com/novdec01p42.htm

17. Lytle DA, Poff NL. Adaptation to natural flow regimes. Trends Ecol Evol. 2004;19(2):94–100. pmid:16701235 doi: 10.1016/j.tree.2003.10.002
View Article • PubMed/NCBI • Google Scholar

18. Bunn SE, Arthington AH. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environ Manage. 2002;30(4):492–507. pmid:12481916 doi: 10.1007/s00267-002-2737-0
View Article • PubMed/NCBI • Google Scholar

19. Poff NL, Allan JD, Bain MB, Karr JR, Prestegaard KL, Richter BD, et al. The natural flow regime. BioScience. 1997;47(11):769–84. doi: 10.2307/1313099
View Article • PubMed/NCBI • Google Scholar

20. Power ME, Dietrich WE, Finlay JC. Dams and downstream aquatic biodiversity: Potential food web consequences of hydrologic and geomorphic change. Environ Manage. 1996;20(6):887–95. pmid:8895411 doi: 10.1007/bf01205969
View Article • PubMed/NCBI • Google Scholar

21. Deitch MJ, Kondolf GM, Merenlender AM. Hydrologic impacts of small-scale instream diversions for frost and heat protection in the California wine country. River Res Appl. 2009;25(2):118–34. doi: 10.1002/rra.1100
View Article • PubMed/NCBI • Google Scholar

22. Deitch MJ, Kondolf GM, Merenlender AM. Surface water balance to evaluate the hydrological impacts of small instream diversions and application to the Russian River basin, California, USA. Aquat Conserv Mar Freshw Ecosyst. 2009;19(3):274–84. doi: 10.1002/aqc.1012
View Article • PubMed/NCBI • Google Scholar

23. Starrs PF, Goin P. Field Guide to California Agriculture. University of California Press; 2010. 504 p.

24. Sawyer JO, Keeler-Wolf T, Evens J. A manual of California vegetation. California Native Plant Society Press; 2009. 1316 p.

25. Cashman SM, Kelsey HM, Harden DR. Geology of the Redwood Creek Basin, Humboldt County, California. 1995;U.S. Geological Survey Professional Paper 1454-B. Available: http://www.waterboards.ca.gov/water_issues/programs/tmdl/records/region_1/2003/ref2065.pdf

26. California Interagency Watershed Mapping Committee. California Interagency Watershed Map of 1999 (CalWater2.2.1) [Internet]. 2.2.1 ed. Sacramento, CA: California Interagency Watershed Mapping Committee; 2004. Available: http://www.calfish.org/ProgramsData/Refe renceLayersHydrography/CaliforniaInteragencyWatershedMapof1999.aspx

27. Humboldt Growers Association. Humboldt County Outdoor Medical Cannabis Ordinance Draft [Internet]. 2010. Available: http://library.humboldt.edu/humco/holdings/HGA2.pdf

28. PRWEB. Leading California Marijuana Attorney Says Growers Must Focus on Water Conservation. 2012 Mar 22. Available: http://www.prweb.com/releases/marijuana-attorney/california/prweb9316223.htm. Accessed 22 Jan 2014.

29. Lang M, Love M, Trush W. Improving Stream Crossings for Fish Passage. National Marine Fisheries Service. 2004. Available: http://www.stream.fs.fed.us/fishxing/fplibrary/Lang_2004_Improving_stream_crossing_for_fish_passage_FINAL.pdf

30. Rantz SE. Average annual precipitation and runoff in north coastal California. United States Geological Survey. 1968. Report No.: HA—298. Available: http://pubs.er.usgs.gov/publication/ha298

31. Rantz SE. Surface-water hydrology of coastal basins of northern California. United States Geological Survey. 1964. Report No.: WSP—1758. Available: http://ngmdb.usgs.gov/Prodesc/proddesc_24932.htm

32. DeOreo WB, Mayer P, Martien L, Hayden M, Funk A, Kramer-Duffield M, et al. California Single Family Water Use Efficiency Study [Internet]. Boulder, Colorado: Aquacraft Water Engineering and Management; 2011 Jun. Available: http://www.irwd.com/images/pdf/save-wate r/CaSingleFamilyWaterUseEfficiencyStudyJune2011.pdf

33. Bailey LH. The Standard Cyclopedia of Horticulture: I. A-E. 1935. 1200 p.

34. Journal of Agricultural Research. U.S. Government Printing Office. 1915. 704 p.

35. Howell TA. Enhancing water use efficiency in irrigated agriculture. Agron J. 2001;93(2):281–9. doi: 10.2134/agronj2001.932281x
View Article • PubMed/NCBI • Google Scholar

36. Jensen ME. Water Consumption by Agricultural Plants. In: Kozlowski TT, editor. Water Deficits and Plant Growth, Vol 2. New York: Academic Press Inc; 1968. Available from: http://eprints.nwisrl.ars.usda.gov/742/1/92.pdf

37. North Coast Water Quality Control Board. Water Quality Control Plan for the North Coast Region. Santa Rosa, CA; 2011. Available: http://www.waterboards.ca.gov/northcoast/water_issues/programs/basin_plan/083105-bp/basin_plan.pdf

38. Arismendi I, Safeeq M, Johnson SL, Dunham JB, Haggerty R. Increasing synchrony of high temperature and low flow in western North American streams: double trouble for coldwater biota? Hydrobiologia. 2013 Jul;712(1):61–70. doi: 10.1007/s10750-012-1327-2
View Article • PubMed/NCBI • Google Scholar

39. Ricketts TH. Terrestrial ecoregions of North America: A Conservation Assessment. Washington, D.C.: Island Press; 1999.

40. Abell RA. Freshwater Ecoregions of North America: A Conservation Assessment. Washington, D.C.: Island Press; 2000.

41. Special Animals List [Internet]. California Department of Fish and Wildlife, Natural Diversity Database; 2015. Available: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/SPAnimals.pdf

42. Kelsey KA, West SD. Riparian Wildlife. In: Naiman RJ, Bilby RE, Kantor S, editors. River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. New York, NY: Springer-Verlag; 1998.

43. California Department of Fish and Game. Recovery Strategy for California Coho Salmon: Report to the California Fish and Game Commission. The California Resources Agency; 2004. Available: http://www.dfg.ca.gov/fish/documents/SAL_SH/SAL_Coho_Recovery/ReportToCommission_2004/CohoRecoveryStrategy.pdf

44. Moyle PB. Inland fishes of California. Berkeley: University of California Press; 2002.

45. Katz J, Moyle PB, Quiñones RM, Israel J, Purdy S. Impending extinction of salmon, steelhead, and trout (Salmonidae) in California. Environ Biol Fishes. 2012 Jan 31;96(10–11):1169–86. doi: 10.1007/s10641-012-9974-8
View Article • PubMed/NCBI • Google Scholar

46. Marine KR, Cech JJ. Effects of High Water Temperature on Growth, Smoltification, and Predator Avoidance in Juvenile Sacramento River Chinook Salmon. North Am J Fish Manag. 2004;24(1):198–210. doi: 10.1577/m02-142
View Article • PubMed/NCBI • Google Scholar

47. Suttle KB, Power ME, Levine JM, McNeely C. How fine sediment in riverbeds impairs growth and survival of juvenile salmonids. Ecol Appl. 2004 Aug 1;14(4):969–74. doi: 10.1890/03-5190
View Article • PubMed/NCBI • Google Scholar

48. Silver SJ, Warren CE, Doudoroff P. Dissolved Oxygen Requirements of Developing Steelhead Trout and Chinook Salmon Embryos at Different Water Velocities. Trans Am Fish Soc. 1963;92(4):327–43. doi: 10.1577/1548-8659(1963)92[327:dorods]2.0.co;2
View Article • PubMed/NCBI • Google Scholar

49. Stevens PW, Blewett DA, Casey JP. Short-term effects of a low dissolved oxygen event on estuarine fish assemblages following the passage of hurricane Charley. Estuaries Coasts. 2006 Dec 1;29(6):997–1003. doi: 10.1007/bf02798661
View Article • PubMed/NCBI • Google Scholar

50. Moore MK, Townsend VR. The Interaction of Temperature, Dissolved Oxygen and Predation Pressure in an Aquatic Predator-Prey System. Oikos. 1998 Mar;81(2):329. doi: 10.2307/3547053
View Article • PubMed/NCBI • Google Scholar

51. Harvey BC, Nakamoto RJ, White JL. Reduced Streamflow Lowers Dry-Season Growth of Rainbow Trout in a Small Stream. Trans Am Fish Soc. 2006;135(4):998–1005. doi: 10.1577/t05-233.1
View Article • PubMed/NCBI • Google Scholar

52. Bondi C, Yarnell S, Lind A, Lind A. Transferability of habitat suitability criteria for a stream breeding frog (Rana boylii) in the Sierra Nevada, California. Herpetol Conserv Biol. 2013;8(1):88–103.
View Article • PubMed/NCBI • Google Scholar

53. Pilliod DS, Wind E, editors. Habitat Management Guidelines for Amphibians and Reptiles of the Northwestern United States and Western Canada. Birmingham, AL: Partners in Amphibian and Reptile Conservation; 2008. 139 p.

54. Ray C. Vital Limits and Rates of Desiccation in Salamanders. Ecology. 1958 Jan 1;39(1):75–83. doi: 10.2307/1929968
View Article • PubMed/NCBI • Google Scholar

55. Bury RB. Low thermal tolerances of stream amphibians in the Pacific Northwest: Implications for riparian and forest management. Appl Herpetol. 2008 Jan 1;5(1):63–74. doi: 10.1163/157075408783489211
View Article • PubMed/NCBI • Google Scholar

56. Welsh HH Jr, Lind AJ. Habitat correlates of the southern torrent salamander, Rhyacotriton variegatus (Caudata: Rhyacotritonidae), in northwestern California. J Herpetol. 1996;385–98. doi: 10.2307/1565176
View Article • PubMed/NCBI • Google Scholar

57. Welsh HH, Hodgson GR. Amphibians as metrics of critical biological thresholds in forested headwater streams of the Pacific Northwest, U.S.A. Freshw Biol. 2008;53(7):1470–88. doi: 10.1111/j.1365-2427.2008.01963.x
View Article • PubMed/NCBI • Google Scholar

58. Welsh HH, Ollivier LM. Stream amphibians as indicators of ecosystem stress: a case study from California's redwoods. Ecol Appl. 1998;8(4):1118–32. doi: 10.2307/2640966
View Article • PubMed/NCBI • Google Scholar

59. Kupferberg SJ, Palen WJ, Lind AJ, Bobzien S, Catenazzi A, Drennan J, et al. Effects of flow regimes altered by dams on survival, population declines, and range-wide losses of California river-breeding frogs. Conserv Biol J Soc Conserv Biol. 2012 Jun;26(3):513–24. doi: 10.1111/j.1523-1739.2012.01837.x. pmid:22594596

View Article • PubMed/NCBI • Google Scholar

60. Lannoo MJ, editor. Amphibian Declines: The Conservation Status of United States Species. Berkeley: University of California Press; 2005.

61. Wake DB, Vredenburg VT. Are we in the midst of the sixth mass extinction? A view from the world of amphibians. Proc Natl Acad Sci. 2008 Aug 11;105(Supplement 1):11466–73. doi: 10.1073/pnas.0801921105. pmid:18695221
View Article • PubMed/NCBI • Google Scholar

62. Clipp HL, Anderson JT. Environmental and Anthropogenic Factors Influencing Salamanders in Riparian Forests: A Review. Forests. 2014 Nov 13;5(11):2679–702. doi: 10.3390/f5112679
View Article • PubMed/NCBI • Google Scholar

63. Dudgeon D, Arthington AH, Gessner MO, Kawabata Z-I, Knowler DJ, Lévêque C, et al. Freshwater biodiversity: importance, threats, status and conservation challenges. Biol Rev. 2006;81(2):163–82. pmid:16336747 doi: 10.1017/s1464793105006950
View Article • PubMed/NCBI • Google Scholar

64. Gleick PH. Water Use. Annu Rev Environ Resour. 2003;28(1):275–314. doi: 10.1146/annurev.energy.28.040202.122849
View Article • PubMed/NCBI • Google Scholar

65. Vörösmarty CJ, McIntyre PB, Gessner MO, Dudgeon D, Prusevich A, Green P, et al. Global threats to human water security and river biodiversity. Nature. 2010 Sep 30;467(7315):555–61. doi: 10.1038/nature09440. pmid:20882010
View Article • PubMed/NCBI • Google Scholar

66. Averyt K, Meldrum J, Caldwell P, Sun G, McNulty S, Huber-Lee A, et al. Sectoral contributions to surface water stress in the coterminous United States. Environ Res Lett. 2013 Sep 1;8(3):035046. doi: 10.1088/1748-9326/8/3/035046
View Article • PubMed/NCBI • Google Scholar

67. Tockner K, Bunn S, Gordon C, Naiman RJ, Quinn GP, Stanford JA. Flood plains: Critically threatened ecosystems. 2008. p. 45–61. Available: http://www98.griffith.edu.au/dspace/handle/10072/23618

68. Gleick PH, Palaniappan M. Peak water limits to freshwater withdrawal and use. Proc Natl Acad Sci. 2010 May 24;107(25):11155–62. doi: 10.1073/pnas.1004812107. pmid:20498082
View Article • PubMed/NCBI • Google Scholar

69. Snyder MA, Bell JL, Sloan LC, Duffy PB, Govindasamy B. Climate responses to a doubling of atmospheric carbon dioxide for a climatically vulnerable region. Geophys Res Lett. 2002;29(11):9–1–9–4. doi: 10.1029/2001gl014431
View Article • PubMed/NCBI • Google Scholar

70. Kim J, Kim T-K, Arritt RW, Miller NL. Impacts of Increased Atmospheric CO2 on the Hydroclimate of theWestern United States. J Clim. 2002;15(14):1926–42. doi: 10.1175/1520-0442(2002)015<1926:ioiaco>2.0.co;2
View Article • PubMed/NCBI • Google Scholar

71. Snyder MA, Sloan LC, Bell JL. Modeled Regional Climate Change in the Hydrologic Regions of California: A Co2 Sensitivity Study. JAWRA J Am Water Resour Assoc. 2004;40(3):591–601. doi: 10.1111/j.1752-1688.2004.tb04445.x
View Article • PubMed/NCBI • Google Scholar

72. Snyder MA, Sloan LC. Transient future climate over the western United States using a regional climate model. Earth Interact. 2005;9(11):1–21. doi: 10.1175/ei148.1
View Article • PubMed/NCBI • Google Scholar

73. Leung LR, Qian Y, Bian X, Washington WM, Han J, Roads JO. Mid-Century Ensemble Regional Climate Change Scenarios for the Western United States. Clim Change. 2004 Jan 1;62(1–3):75–113. doi: 10.1023/b:clim.0000013692.50640.55
View Article • PubMed/NCBI • Google Scholar

74. Shaw MR, Pendleton L, Cameron DR, Morris B, Bachelet D, Klausmeyer K, et al. The impact of climate change on California's ecosystem services. Clim Change. 2011 Dec 1;109(1):465–84. doi: 10.1007/s10584-011-0313-4
View Article • PubMed/NCBI • Google Scholar

75. Knowles N, Cayan DR. Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary. Geophys Res Lett. 2002;29(18):38–1–38–4. doi: 10.1029/2001gl014339
View Article • PubMed/NCBI • Google Scholar

76. Miller NL, Bashford KE, Strem E. Potential Impacts of Climate Change on California Hydrology. JAWRA J Am Water Resour Assoc. 2003;39(4):771–84. doi: 10.1111/j.1752-1688.2003.tb04404.x
View Article • PubMed/NCBI • Google Scholar

77. Hayhoe K, Cayan D, Field CB, Frumhoff PC, Maurer EP, Miller NL, et al. Emissions pathways, climate change, and impacts on California. Proc Natl Acad Sci U S A. 2004;101(34):12422–7. pmid:15314227 doi: 10.1073/pnas.0404500101
View Article • PubMed/NCBI • Google Scholar

78. Schlenker W, Hanemann WM, Fisher AC. Water Availability, Degree Days, and the Potential Impact of Climate Change on Irrigated Agriculture in California. Clim Change. 2007 Mar 1;81(1):19–38. pmid:17415585 doi: 10.1007/s10584-005-9008-z
View Article • PubMed/NCBI • Google Scholar

79. Mayer TD, Naman SW. Streamflow Response to Climate as Influenced by Geology and Elevation. JAWRA J Am Water Resour Assoc. 2011 Aug 1;47(4):724–38. doi: 10.1111/j.1752-1688.2011.00537.x
View Article • PubMed/NCBI • Google Scholar

80. Poff NL, Brinson MM, Day JW Jr. Aquatic ecosystems and global climate change. Pew Cent Glob Clim Change Arlingt VA. 2002;44.
View Article • PubMed/NCBI • Google Scholar

81. Mohseni O, Stefan HG, Eaton JG. Global Warming and Potential Changes in Fish Habitat in U.S. Streams. Clim Change. 2003 Aug 1;59(3):389–409.
View Article • PubMed/NCBI • Google Scholar

82. Yates D, Galbraith H, Purkey D, Huber-Lee A, Sieber J, West J, et al. Climate warming, water storage, and Chinook salmon in California's Sacramento Valley. Clim Change. 2008 Jun 4;91(3–4):335–50. doi: 10.1007/s10584-008-9427-8
View Article • PubMed/NCBI • Google Scholar

83. Wenger SJ, Isaak DJ, Luce CH, Neville HM, Fausch KD, Dunham JB, et al. Flow regime, temperature, and biotic interactions drive differential declines of trout species under climate change. Proc Natl Acad Sci. 2011 Aug 15;108(34):14175–80. doi: 10.1073/pnas.1103097108. pmid:21844354
View Article • PubMed/NCBI • Google Scholar

84. O'Neal K. Effects of Global Warming on Trout and Salmon in U.S. Streams [Internet]. The Natural Resources Defense Council; 2002. Available: http://www.defenders.org/publications/effects_of_global_warming_on_trout_and_salmon.pdf

85. Madej MA. Analysis of Trends in Climate, Streamflow, and Stream Temperature in North Coastal California. Proceedings of the Fourth Interagency Conference on Research in the Watersheds. United States Geological Survey; 2011.

EXHIBIT F

Generators such as this are common at cannabis cultivation sites, particularly those in remote forested regions like the Emerald Triangle (Humboldt, Mendocino, and Trinity Counties), CA. Photo Credit: CDFW staff

Example of a large outdoor cultivation in Humboldt County. Photo Credit: Scott Bauer, CDFW

California Fish and Wildlife, Cannabis Special Issue; 108-119; 2020

Anthropogenic noise: potential influences on wildlife and applications to cannabis cultivation

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Biological sounds play an important role in activities ranging from territory defense to mate choice to predator avoidance to foraging. Anthropogenic noise can mask these sounds, potentially altering the habitat selection, activity patterns, phenology, and physiology of wildlife species. For example, cannabis (Cannabis sativa or C. indica) cultivation may increase levels of anthropogenic noise given the use of diesel generators, irrigation pumps, and landscaping equipment. To predict how noises associated with cannabis cultivation may influence wildlife in California, we review scientific literature assessing the influences of anthropogenic noise on various species of mammals, birds, herpetofauna, and invertebrates. We then outline potential noises associated with cannabis cultivation and why they may be unique on the landscape and provide recommendations on future research needs.

Key words: activity patterns, anthropogenic noise, cannabis, habitat selection, phenology, physiology, wildlife

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The acoustic environment is more than just a collection of auditory signals between individuals, it is an interconnected landscape of information networks consisting of many signalers, receivers, and sounds vital to the fitness of a species (Templeton and Greene 2007; Barber et al. 2010; Read et al. 2013). For example, sounds pertaining to territory defense, mate attraction, or family cohesion (i.e., contact calls) promote reproductive success (Halfwerk et al. 2011a, b; Allen et al. 2016). In songbirds, these sounds are used to assess numerous individuals simultaneously for mate choice, extra-pair copulations, and rival assessment (Barber et al. 2010). Alternatively, sounds announcing the approach of predators (i.e., alarm calls) promote survival of both conspecifics to whom the calls were directed and other species that capitalize on the alarms (Templeton and Greene 2007; Sloan and Hare 2008; Magrath et al. 2015).

Successful acoustic communication requires sounds to 1) move through the environment from senders to receivers and 2) be detectable through background noise (Patricelli and Blickley 2006). There is mounting evidence that noise produced by humans, whether from vehicles, construction equipment, or humming power sources (e.g., generators, power lines,

wind turbines), dramatically increases the amount of background noise, in turn impeding detectability of acoustic signals and negatively impacting the ability of a species to communicate (Fernández-Juricic et al. 2005; Gillam and McCracken 2007; Barber et al. 2010; Kite and Swaddle 2011; Francis and Barber 2013). Masking of biologically relevant sounds can limit mate choice, cause species to abandon territories or potential habitat, negatively impact species' ability to locate food, or cause deleterious physiological effects like hearing loss, raised blood pressure, and increased production of stress hormones (Rabin et al. 2006; Wright et al. 2007; Schaub et al. 2008; Shannon et al. 2014; Ware et al. 2015). In a rural to suburban area where ambient noise levels are 45 – 55 decibels (dB), new sources of anthropogenic noise can begin having deleterious effects when they increase overall noise by just 5 – 10 dB (Dooling and Popper 2007). The specific noise level at which impacts begin to appear, however, depends on the amount of ambient noise and the temporal and spectral overlap between anthropogenic and biological sounds (Dooling and Popper 2007; Halfwerk et al. 2011). Species with low-frequency vocalizations like owls and grouse tend to have the largest spectral overlap with traffic noise, for example, which means these species are more likely to have their mate attraction or territorial defense songs obscured by human-produced noises (i.e., experience a decline in signaling efficiency; Slabbekoorn and Ripmeester 2007; Bunkley et al. 2015).

Cannabis cultivation has the potential to add additional sources of anthropogenic noise into a landscape through, for example, diesel generators, irrigation pumps, climate control systems, landscaping equipment, and vehicles. There is concern that this additional anthropogenic noise may reach the level of take, as defined by the Federal Endangered Species Act (ESA; i.e., an action of or attempt to hunt, harm, harass, pursue, shoot, wound, capture, kill, trap, or collect a species), for sensitive species like the northern spotted owl (*Strix occidentalis occidentalis*) and marbled murrelet (*Brachyramphus marmoratus*; USFWS 2006). For northern spotted owl and marbled murrelet it was determined that disturbance may reach the level of take if 1) project-generated sound exceeds ambient nesting conditions by 20-25 dB, 2) project-generated sound, when added to existing ambient conditions, exceeds 90 dB, or 3) human activities occur within a visual line-of-sight distance of 40 m or less from a nest (USFWS 2006). We note that California's ESA has a narrower definition of take (i.e., any action of or attempt to hunt, pursue, catch, capture, or kill). This could make it more difficult to directly attribute take to anthropogenic noise under the California ESA when compared to the Federal ESA.

Information on the levels of noise produced by cannabis cultivation specifically and the subsequent influences on wildlife species, however, is scant. To predict how anthropogenic noise associated with cannabis cultivation may influence wildlife in California, we reviewed scientific literature that assessed the influences of human-produced noise on species' habitat selection, activity patterns, phenology, and physiology. We then provide recommendations on future research needs.

Habitat selection and Activity Patterns

Mobile animals are often guided by sound, with conspecific signals attracting group members or potential mates, heterospecific signals (i.e., signals from a different species) indicating suitable habitat, and overall soundscape signals providing cues for general orientation (Slabbekoorn and Bouton 2008). Consequently, site abandonment and changes in

habitat selection and activity patterns are among the most detected impacts of noise (Table 1; Francis and Barber 2013). Species ranging from deer to songbirds to frogs have been documented avoiding areas with anthropogenic noise, in turn influencing both fine-scale habitat selection and large-scale patterns of movement (Table 1; Sawyer et al. 2006; Mukhin et al. 2008; Francis et al. 2011; Ware et al. 2015; Caorsi et al. 2017). Further, avoidance or use by one species may lead to avoidance or use by others. This has been documented in nocturnally migrating bird species, where migrant birds listen for the heterospecific calls of resident birds to make decisions about which habitats to use as stopover sites (i.e., the heterospecific attraction hypothesis; Mönkkönen et al. 1990; Mukhin et al. 2008). It has

Table 1. Examples of changes in habitat selection and activity patterns resulting from anthropogenic noise.

Taxa	Species	Response	Source
Mammals	Mule deer (*Odocoileus hemionus*)	Radio-collared deer were more likely to occupy habitat away from noise-producing oil and gas developments than habitat in close proximity; changes in habitat selection happened within 1 year of development and there were no signs of acclimation.	Sawyer et al. 2006
	Sonoran pronghorn (*antilocapra Americana sonoriensis*)	Pronghorn at a military site where there was noise from overflights, ordinance deliveries, and human activity foraged less and stood and traveled more than pronghorn not exposed to military activity.	Krausman et al. 2004
	California ground squirrels (*Otospermophilus beecheyi*)	Close to wind turbines, where noise levels were higher than control sites (110.2 dB vs. 79.8 dB), squirrels exhibited increased rates of vigilance and were more likely to return to their burrows during alarm calling (i.e., increased caution).	Rabin et al. 2006
	Prairie dogs (*Cynomys ludovicianus*)	When exposed to road playback noise (77 dB at 10m), the number of prairie dogs aboveground decreased by 21%, the proportion of individuals foraging decreased by 18%, and vigilance increased by 48%. These results were consistent across a 3-month period suggesting there was no habituation.	Shannon et al. 2014
	Bat community	Bat species emitting low frequency (< 35 kHz) echolocation calls had a 70% reduction in activity levels at loud compressor sites (70 – 82 dB) vs. quieter well pads (53 – 70 dB). Bat species emitting high frequency calls did not show altered activity levels.	Bunkley et al. 2015
	Greater mouse-eared bat (*Myotis myotis*)	Successful foraging bouts decreased, and search time increased with proximity to acoustically simulated highway noise. At 7.5m from the noise source, it took the bats 5x longer to find their prey, which they locate by listening for faint rustling sounds.	Siemers and Schaub 2011
Birds	American robin (*Turdus migratorius*)	Foraging success was reduced when the auditory cues that robins rely on to locate buried worms were obscured by white noise (61 dB).	Montgomerie and Weatherhead 1997
	Nocturnally migrating birds	To test the effect of noise alone, a "phantom road" was created through an array of speakers broadcasting traffic noise. Among the bird community, 31% avoided using the phantom road as a stopover site during migration and the birds that did use the site showed a decrease in their overall body condition.	Ware et al. 2015
	Grey flycatcher (*Empidonax wrightii*)	Occupancy of flycatchers was lower at sites with 46-68 dB of noise than sites with 32-46 dB of noise.	Francis et al. 2011

Table 1. continued.

Taxa	Species	Response	Source
	White-throated sparrow (*Zonotrichia albicollis*), yellow-rumped warbler (*Dendroica coronata*), and red-eyed vireo (*Vireo olivaceus*)	Passerine density was 1.5x higher at energy sites that did not produce noise than at those that did (48 dB).	Bayne et al. 2008
	Greater sage-grouse (*Centrocercus urophasianus*)	Radio-marked female grouse were more likely to select habitat away from noise-producing oil and gas developments and were 1.3x more likely to occupy sagebrush habitats lacking wells within a 4-km^2 area.	Doherty et al. 2008
Herpeto-fauna	Bischoff's tree frog (*Boana bischoffi*) and fine-lined tree frog (*B. leptolineata*)	Both species moved away from playbacks of road noise (played at two intensities- 65 and 75 dB), suggesting the noise resulted in their spatial displacement.	Caorsi et al. 2017

also been documented in marbled newts (*Triturus marmoratus*) and smoot newts (*Lissotriton vulgaris*), which orient towards the calls of species that share similar breeding habitat (Diego-Rasilla and Luengo 2004; Pupin et al. 2007).

Sound is also important in determining how much time and energy a species expends on activities like resting, vigilance, and foraging (Quinn et al. 2006; Rabin et al. 2006; Shannon et al. 2014). Many animals use sound to detect approaching predators or to warn conspecific and heterospecific co-occurring species (e.g., through alarm calls) that a predator is approaching. Quiet environments facilitate detection of these auditory cues, so less time needs to be spent searching for predators. Conversely, noisy environments impede auditory cues resulting in species spending more time and energy on anti-predator behaviors like vigilance and caution (e.g., not traveling far from a burrow; Quinn et al. 2006; Shannon et al. 2014). A positive relationship between noise and predator avoidance has been documented in both mammal and bird species (Quinn et al. 2006; Francis and Barber 2013; Shannon et al. 2014). California ground squirrels (*Otospermophilus beecheyi*), for example, tend to exhibit increased rates of vigilance in noisy environments where their ability to hear conspecific alarm calls is hindered (Rabin et al. 2006). If noise causes ground squirrels to miss just a single conspecific alarm call, then they may underestimate potential threats and in turn, increase their exposure to predation (Sloan and Hare 2008). In chaffinches (*Fringilla coelebs*) and prairie dogs (*Cynomys ludovicianus*), alternatively, noise leads to more time expended on vigilance and less time on foraging (Quinn et al. 2006; Shannon et al. 2014). Delayed response times of ground squirrels and loss of foraging time in chaffinches and prairie dogs demonstrate how noise, through its influence on predator-prey dynamics, can have both immediate (i.e., survival) and long-term (i.e., decreased nutrition/energy) impacts on species' fitness (Frid and Dill 2002).

Lastly, anthropogenic noise may decrease foraging efficiency if the species relies on auditory cues to locate food. Bat species specialized in gleaning arthropods off vegetation or the ground, for example, find prey by passively listening for prey-produced sounds

(Schaub et al. 2008). Thus, in environments with more noise, gleaning bats have fewer successful foraging bouts and spend more time searching for prey (Table 1; Schaub et al. 2008; Siemers and Schaub 2011). Decline of 12 species of bats in California that are either endangered or species of special concern has been correlated to reduced foraging success in noisy environments (Schaub et al. 2008; Siemers and Schaub 2011). Bird species like American robins (*Turdus migratorius*), marsh hawks (*Circus cyaneius*), and barn owls (*Tyto alba*), as well as reptile species like geckos (*Hemidactylus tursicus*), also use auditory cues to detect and locate prey. Like gleaning bats, these species have reduced foraging success in noisy environments where cues are obscured (Knudsen and Konishi 1979; Rice 1982; Sakaluk and Belwood 1984; Montgomerie and Weatherhead 1997).

Phenology and Physiology

To mitigate the negative impacts that anthropogenic noise may have on acoustic communication, many species adjust the frequency structure (i.e., pitch), amplitude (i.e., loudness), or timing of their vocalizations (Table 2; Patricelli and Blickley 2006). Vocal adjustments have been documented in a range of species, including bats, birds, frogs, and insects (Table 2). Brazilian free-tailed bats (*Tadarida brasiliensis*), reed buntings (*Emberiza schoeniclus*), great tits (*Parus major*), cicadas (*Cryptotympana takasagona*), and grasshoppers (*Chorthippus biguttulus*), for example, use higher call frequencies in the presence of anthropogenic noise (Slabbekoorn and Peet 2003; Gillam and McCracken 2007; Gross et al. 2010; Lampe et al. 2012; Shieh et al. 2012). Conversely, various species of frogs often increase or decrease their call rates based on the level of background noise (Lengange 2008; Cunnington and Fahrig 2010; Vargas-Salinas and Amézquita 2013). The benefit of vocal plasticity is that it allows species to adjust to new, noisy conditions (Gross et al. 2010). The hindrance is that it may negatively impact species' fitness by reducing transmission distances (e.g., high frequency signals attenuate faster), increasing the risk of predation or parasitism by making animals more conspicuous, altering energy budgets causing vital information to be lost (e.g., for mate choice), or breaking down signaler-receiver coordination (Luther 2008; Read et al. 2013).

In addition to altering the phenology of a species, exposure to noise can also influence the physiology of a species. Ungulates, bears, whales, game birds, songbirds, and frogs have all been documented to have adverse physiological responses to anthropogenic noise (Table 2; Powell et al. 2006; Rolland et al. 2012; Troianowski et al. 2017). These responses include hearing loss, hypertension (i.e., raised blood pressure), and increased production of glucocorticoids or stress hormones (Wright et al. 2007; Dooling and Popper 2007; Shannon et al. 2016). Increased production of stress hormones can in turn, negatively impact the survival and reproduction of a species by causing decreased immune response, diabetes, or reproductive malfunctions (Kight and Swaddle 2011; Tennessen et al. 2014). Exposure to noise led to increased stress hormone levels in European tree frogs (*Hyla arborea*), for example, which led to an immunosuppressive effect (Troianowski et al. 2017). The severity of a species' physiological responses is likely dependent on season. Northern spotted owl (*Strix occidentalis caurina*) males, for example, had the strongest response to motorcycle noise in May, when feeding themselves, their mates, and their nestlings (Hayward et al. 2011). The physiological response of migratory birds, alternatively, may be most acute mid-migration when maintenance of body condition is particularly imperative (Ware et al. 2015).

Table 2. Examples of phenological and physiological changes associated with anthropogenic noise.

Taxa	Species	Response	Source
Mammals	General	If the inner ear sensory hair cells are damaged, then mammals will experience permanent hearing loss.	Dooling and Popper 2007
	Brazilian free-tailed bats (*Tadarida brasiliensis*)	Bats recorded in the presence of high-frequency sounds used higher call frequencies than bats recorded in silence, which suggests that bats adjusted their echolocation call structure to minimize acoustic interference.	Gillam and McCracken 2007
	Desert mule deer (*Odocoileus hemionus crooki*) and desert bighorn sheep (*Ovis canadensis mexicana*)	Heart rates of captive animals increased relative to dB levels (from simulated jet aircraft noise) but returned to pre-disturbance levels within 60-180 seconds.	Weisenberger et al. 1996
Birds	House finches (*Carpodacus mexicanus*)	Males increased the low frequency (1.62 kHz) of their songs in areas with higher ambient noise to reduce the masking effects of the noise.	Fernández-Juricic et al. 2005
	Ash-throated flycatcher (*Myiarchus cinerascens*)	Occupancy was not influenced by noise from gas well compressors but bird vocalizations were; and individuals in areas with more noise vocalized at frequencies ~200 kHz higher. Noise levels averaged 37.4 and 56.1 dB at control and treatment sites, respectively.	Francis et al. 2011
	Song sparrows (*Melospiza melodia*)	Males shifted more energy into the higher frequencies of their vocalizations when there was more noise (total ambient background noise ranged from 54.8 – 71.3 dB).	Wood and Yezerinac 2006
	House sparrows (*Passer domesticus*)	Nests in area with large generator noise (68 dB) produced fewer young of lower body mass, and fewer recruits; females also provided young with food less often in noisy area.	Schroeder et al. 2012
	Tree swallows (*Tachycineta bicolor*)	Nestlings exposed to white noise playbacks (65 dB) had begging calls with higher minimum frequencies and narrower frequency ranges. These effects persisted in the absence of noise, suggesting that noise may influence call development. Further, when exposed to playbacks, nestlings were less likely to beg when parents arrived with food.	Leonard and Horn 2008
	Black-capped chickadee (*Poecile atricapillus*)	Noise reduced the number of individuals that could be heard, thus limiting mate choice and rival assessment.	Hansen et al. 2015
	Northern spotted owl (*Strix occidentalis occidentalis*)	Males had highest glucocorticoid response to experimentally applied motorcycle noise in May, when they are generally responsible for feeding themselves, their mates, and their nestlings.	Hayward et al. 2011
	Quail (*Coturnix coturnix*)	When quail were exposed to 116 dB of noise for 4 hours, they experienced hearing loss of up to 50 dB immediately following exposure.	Niemiec et al. 1994
	Greater sage-grouse (*Centrocercus urophasianus*)	Fecal corticosterone metabolite levels were 16.7% higher, on average, at leks where 67.6 dB of road noise was broadcast vs. control leks with no noise. Further, peak male attendance and abundance at noise-treated leks decreased by over 29% when compared to paired controls.	Blickley et al. 2012a, b

Table 2. continued.

Taxa	Species	Response	Source
Herpeto-fauna	Bischoff's tree frog (*Boana bischoffi*)	Advertisement call rates decreased during playbacks of road noise (played at two intensities- 65 and 75 dB) and dominant call frequency decreased when exposed to noise.	Caorsi et al. 2017
	Green frog (*Rana clamitans*), leopard frog (*R. pipiens*), gray treefrog (*Hyla versicolor*)	Call rates were significantly lower at low-noise sites (mean = 43.8 dB) than high-noise sites (mean = 73.2 dB). Further, when traffic noise was broadcast at low-noise sites, green and leopard frog vocalizations changed to having higher frequencies.	Cunnington and Fahrig 2010
	European tree frog (*H. arborea*)	Exposure to traffic playback noise (76 dB) led to increased stress hormone levels and in turn, an immunosuppressive effect.	Troianowski et al. 2017
	Wood frogs (*Lithobates sylvaticus*)	Traffic playback noise (87 dB) increased levels of glucocorticoid hormones in females. It also negatively influenced female travel towards male breeding choruses, highlighting the sublethal impacts of acoustic habitat loss.	Tennessen et al. 2014
	Grey treefrog (*Hyla chrysoscelis*)	Traffic playback noise (70 dB) resulted in female frogs taking longer to localize male calls; females were also less successful in correctly orienting to male signals.	Bee and Swanson 2007
Inverte-brates	Grasshoppers (*Chorthippus biguttulus*)	Compared to males from quiet habitats, males in roadside habitats produced acoustic courtship songs with higher local frequency maximum (6-9 kHz).	Lampe et al. 2012
	Cicada (*Cryptotympana takasagona*)	Cicadas shifted the energy distribution of calling songs to higher frequencies when higher anthropogenic noise.	Shieh et al. 2012

The effects that anthropogenic noises can have on species' habitat selection, activity patterns, phenology, and physiology can culminate in decreased reproductive success. This decrease may be a consequence of limited mate choice, a reduction in pairing success, decreased provisioning rates to offspring, or a decline in offspring survival (Table 2; Francis and Barber 2013). If noise impedes the transmission of bird songs, for example, it may negatively impact mate attraction (Klump 1996; Hansen et al. 2005). If noise impedes parent-offspring communication, alternatively, it may result in young receiving food less often (e.g., if nestlings fail to beg when their parents arrive; Leonard and Horn 2012; Schroeder et al. 2012). Numerous species of birds, including eastern bluebirds (*Sialia sialis*), great tits (*Parus major*), and house sparrows (*Passer domesticus*), are known to produce fewer eggs in noisier areas (Halfwerk et al. 2011b; Kight et al. 2012; Schroeder et al. 2012). Lastly, anthropogenic noise may make it harder for females to detect and locate males, as has been documented in frogs (Bee and Swanson 2007; Tennessen et al. 2014).

FUTURE DIRECTIONS

California's Department of Food and Agriculture (CDFA) identified several potential impacts of the noises associated with cannabis cultivation in their Program Environmental Impact Report (PEIR; CDFA 2017). This noise may result from the use of irrigation pumps, diesel generators, landscaping equipment, equipment and water trucks, worker vehicles, and if a greenhouse has climate control, the heating, ventilation, and air conditioning systems.

As outlined in the PEIR, increased noise and human presence may cause substantial adverse effects on special-status terrestrial wildlife species, and use of mechanical equipment for the cultivation of cannabis may cause excessive ground borne vibration or ground borne noise levels, as well as substantial increases in ambient noise levels in the vicinity of a proposed program activity (CDFA 2017). Upon review, however, CDFA found all noise-related impacts to be "less than significant", stating that in general, the noises resulting from cannabis cultivation would be consistent with other land uses in the area (CDFA 2017). We propose, however, that the noises resulting from cannabis cultivation may differ from those associated with other land uses in the area and warrants further consideration and research.

Determining whether the noises resulting from cannabis cultivation are consistent with other land uses in the area requires an understanding of the noises' duration, loudness (i.e., decibels), and spatial location. Short-term noises from chainsaws, mowers, and vehicles may be consistent with other human-generated noises in an area; however, long-term noises from irrigation pumps, diesel generators, and climate control systems may be new. These long-term noises may adversely affect local fauna not only because they are novel, but also because they are perpetual, meaning they act as a constant impediment to the ability of the species to hear. Loudness of a noise may also play a role in determining impacts, particularly when loudness is considered in relation to ambient noise levels. A generator running at night, for example, likely has greater impacts on surrounding wildlife in a rural area, where ambient noise levels are around 20 dB, than in an urban area, where ambient noise levels are around 40 dB (Dooling and Popper 2007; CDFA 2017).

To date, most mixed-light licenses have been issued in Humboldt and Mendocino counties in northwestern California, a region of the state that is relatively undeveloped and until recently, was predominantly covered in natural vegetation (Butsic et al. 2018). This suggests that cannabis cultivation may be concentrated in rural, forested areas where the negative impacts of anthropogenic noise are likely amplified. Empirical data assessing the distribution and impacts of noises resulting from cannabis cultivation, however, are scant. Consequently, in relation to permitted cannabis cultivation in California, we encourage:

- Studies that evaluate the sound output (loudness, frequency, and duration) of cannabis growing operations in rural vs. suburban areas and how sound outputs (a) vary on a daily and annual basis, (b) compare to ambient noise conditions, and (c) compare to the sound outputs of other agricultural practices.
- Studies that assess the effectiveness of varying types of sound attenuation or insulation devices, with the goal of providing recommendations on the best devices/approaches for minimizing sound output to cannabis cultivators.
- Studies that evaluate the level of sound output (specific to cannabis cultivation) necessary to cause take, harassment, or behavioral changes in a variety of threatened and endangered species and how this varies between rural, forested habitats and suburban habitats.
- Studies assessing the call output levels (loudness, frequency, duration) and call response rates of songbirds and raptors in areas with cannabis cultivation vs. (a) areas with no human development and (b) areas with other forms of human development.
- Improving our understanding of the noises associated with cannabis cultivation and how they vary spatially, temporally, and in relation to ambient noise conditions is a critical first step in understanding how these noises may be impacting terrestrial wildlife in California and how they could be better mitigated in the future.

Author Contributions
Conceived and designed the study: LNR, ADB
Collected the data: LNR, ADB
Performed the analysis of the data: LNR, ADB
Authored the manuscript: LNR, ADB, EC
Provided critical revision of the manuscript: ADB, EC

LITERATURE CITED

Allen, M. L., Y. Wang, and C. C. Wilmers. 2016. Exploring the adaptive significance of five types of puma (*Puma concolor*) vocalizations. The Canadian Field-Naturalist 130:289–294.

Barber, J. R., K. R. Crooks, and K. M. Fristrup. 2010. The costs of chronic noise exposure for terrestrial organisms. Trends in Ecology and Evolution 25:180–189.

Bayne, E. M., L. Habib, and S. Boutin. 2008. Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest. Conservation Biology 22:1186–1193.

Bee, M. A., and E. M. Swanson. 2007. Auditory masking of anuran advertisement calls by road traffic noise. Animal Behaviour 74:1765–1776.

Blickley, J. L., D. Blackwood, and G. L. Patricelli. 2012a. Experimental evidence for the effects of chronic anthropogenic noise on abundance of greater sage-grouse at leks. Conservation Biology 26:461–471.

Blickley, J. L., K. R. Word, A. H. Krakauer, J. L. Phillips, S. N. Sells, C. C. Taff, J. C. Wingfield, and G. L. Patricelli. 2012b. Experimental chronic noise is related to elevated fecal corticosteroid metabolites in lekking male greater sage-grouse (*Centrocercus urophasianus*). PLoS ONE 7:e50462.

Bunkley, J. P., C. J. McClure, N. J. Kleist, C. D. Francis, and J. R. Barber. 2015. Anthropogenic noise alters bat activity levels and echolocation calls. Global Ecology and Conservation 3:62–71.

Butsic, V., J. K. Carah, M. Baumann, C. Stephens, and J. C. Brenner. 2018. The emergence of cannabis agriculture frontiers as environmental threats. Environmental Research Letters 13:124017.

Caorsi, V. Z., C. Both, S. Cechin, R. Antunes, and M. Borges-Martins. 2017. Effects of traffic noise on the calling behavior of two Neotropical hylid frogs. PLoS ONE 12:e0183342.

Cunnington, G. M., and L. Fahrig. 2010. Plasticity in the vocalizations of anurans in response to traffic noise. Acta Oecologica 36:463–470.

Diego-Rasilla, F. J., and R. M. Luengo. 2004. Heterospecific call recognition and phonotaxis in the orientation behavior of the marbled newt, *Triturus marmoratus*. Behavioral Ecology and Sociobiology 55:556–560.

Doherty, K. E., D. E. Naugle, B. L. Walker, and J. M. Graham. 2008. Greater sage-grouse winter habitat selection and energy development. Journal of Wildlife Management 72:187–195.

Dooling, R. J., and A. N. Popper. 2007. The effects of highway noise on birds. California Department of Transportation Division of Environmental Analysis 74, Sacramento, CA, USA.

Fernández-Juricic, E., R. Poston, K. De Collibus, T. Morgan, B. Bastain, C. Martin, K. Jones, and R. Tremínio. 2005. Microhabitat selection and singing behavior patterns of male house finches (*Carpodacus mexicanus*) in urban parks in a heavily urbanized landscape in the Western US. Urban Habitats 3:49–69.

Francis, C. D., and J. R. Barber. 2013. A framework for understanding noise impacts on wildlife: an urgent conservation priority. Frontiers in Ecology and the Environment 11:305–313.

Francis, C. D., C. P. Ortega, and A. Cruz. 2011. Vocal frequency change reflects different responses to anthropogenic noise in two suboscine tyrant flycatchers. Proceedings of the Royal Society of London B: Biological Sciences 278:2025–2031.

Frid, A., and L. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6:11.

Gillam, E. H., and G. F. McCracken. 2007. Variability in the echolocation of *Tadarida brasiliensis*: effects of geography and local acoustic environment. Animal Behaviour 74:277–286.

Gross, K., G. Pasinelli, and H. P. Kunc. 2010. Behavioral plasticity allows short-term adjustment to a novel environment. The American Naturalist 176:456–464.

Halfwerk, W., S. Bot, J. Buikx, M. van der Velde, J. Komdeur, C. ten Cate, and H. Slabbekoorn. 2011a. Low-frequency songs lose their potency in noisy urban conditions. Proceedings of the National Academy of Sciences 108:14549–14554.

Halfwerk, W., L. J. Holleman, and H. Slabbekoorn. 2011b. Negative impact of traffic noise on avian reproductive success. Journal of Applied Ecology 48:210–219.

Hansen, I. J. K., K. A. Otter, H. Van Oort, and C. I. Holschuh. 2005. Communication breakdown? Habitat influences on black-capped chickadee dawn choruses. Acta Ethologica 8:111–120.

Hayward, L. S., A. E. Bowles, J. C. Ha, and S. K. Wasser. 2011. Impacts of acute and long-term vehicle exposure on physiology and reproductive success of the northern spotted owl. Ecosphere 2:1–20.

Kight, C. R., M. S. Saha, and J. P. Swaddle. 2012. Anthropogenic noise is associated with reductions in the productivity of breeding Eastern Bluebirds (*Sialia sialis*). Ecological Applications 22:1989–1996.

Kight, C. R., and J. P. Swaddle. 2011. How and why environmental noise impacts animals: an integrative, mechanistic review. Ecology Letters 14:1052–1061.

Knudsen, E. I., and M. Konishi. 1979. Mechanisms of sound localization in the barn owl (*Tyto alba*). Journal of Comparative Physiology 133:13–21.

Krausman, P. R., L. K. Harris, C. L. Blasch, K. K. Koenen, and J. Francine. 2004. Effects of military operations on behavior and hearing of endangered Sonoran pronghorn. Wildlife Monographs 157:1–41.

Lampe, U., T. Schmoll, A. Franzke, and K. Reinhold. 2012. Staying tuned: grasshoppers from noisy roadside habitats produce courtship signals with elevated frequency components. Functional Ecology 26:1348–1354.

Leonard, M. L., and A. G. Horn. 2008. Does ambient noise affect growth and begging call structure in nestling birds? Behavioral Ecology 19:502–507.

Leonard, M. L., and A. G. Horn. 2012. Ambient noise increases missed detections in nestling birds. Biology Letters 8:530–532.

Luther, D. A. 2008. Signaller: receiver coordination and the timing of communication in Amazonian birds. Biology Letters 4:651–654.

Magrath, R. D., T. M. Haff, P. M. Fallow, and A. N. Radford. 2015. Eavesdropping on heterospecific alarm calls: from mechanisms to consequences. Biological Reviews 90:560–586.

Montgomerie, R., and P. J. Weatherhead. 1997. How robins find worms. Animal Behaviour 54:143–151.

Mukhin, A., N. Chernetsov, and D. Kishkinev. 2008. Acoustic information as a distant cue for habitat recognition by nocturnally migrating passerines during landfall. Behavioral Ecology 19:716–723.

Niemiec, A. J., Y. Raphael, and D. B. Moody. 1994. Return of auditory function following structural regeneration after acoustic trauma: behavioral measures from quail. Hearing Research 79:1–16.

Patricelli, G. L., and J. L. Blickley. 2006. Avian communication in urban noise: causes and consequences of vocal adjustment. The Auk 123:639–649.

Powell, D. M., K. Carlstead, L. R. Tarou, J. L. Brown, and S. L. Monfort. 2006. Effects of construction noise on behavior and cortisol levels in a pair of captive giant pandas (*Ailuropoda melanoleuca*). Zoo Biology: Published in affiliation with the American Zoo and Aquarium Association 25:391–408.

Pupin, F., R. Sacchi, A. Gentilli, P. Galeotti, and M. Fasola. 2007. Discrimination of toad calls by smooth newts: support for the heterospecific attraction hypothesis. Animal Behaviour 74:1683–1690.

Quinn J. L., M. J. Whittingham, S. J. Butler and W. Cresswell. 2006. Noise, predation risk compensation and vigilance in the chaffinch *Fringilla coelebs*. Journal of Avian Biology 37:601–608.

Rabin, L. A., R. G. Coss, and D. H. Owings. 2006. The effects of wind turbines on antipredator behavior in California ground squirrels (*Spermophilus beecheyi*). Biological Conservation 131:410–420.

Read, J., G. Jones, and A. N. Radford. 2013. Fitness costs as well as benefits are important when considering responses to anthropogenic noise. Behavioral Ecology 25:4–7.

Rice, W. R. 1982. Acoustical location of prey by the marsh hawk: adaptation to concealed prey. The Auk 403–413.

Rolland, R. M., S. E. Parks, K. E. Hunt, M. Castellote, P. J. Corkeron, D. P. Nowacek, S. KI. Wasser, and S. D. Kraus. 2012. Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society of London B: Biological Sciences 279:2363–2368.

Sakaluk, S. K., and J. J. Belwood. 1984. Gecko phonotaxis to cricket calling song: a case of satellite predation. Animal Behaviour 32:659–662.

Sawyer, H., R. M. Nielson, F. Lindzey, and L. L. McDonald. 2006. Winter habitat selection of mule deer before and during development of a natural gas field. The Journal of Wildlife Management 70:396–403.

Schaub, A., J. Ostwald, and B. M. Siemers. 2008. Foraging bats avoid noise. Journal of Experimental Biology 211:3174–3180.

Schroeder, J., S. Nakagawa, I. R. Cleasby, and T. Burke. 2012. Passerine birds breeding under chronic noise experience reduced fitness. PLoS ONE 7:e39200.

Shannon, G., L. M. Angeloni, G. Wittemyer, K. M. Fristrup, and K. R. Crooks. 2014. Road traffic noise modifies behaviour of a keystone species. Animal Behaviour 94:135–141.

Shannon, G., M. F. McKenna, L. M. Angeloni, K. R. Crooks, K. M. Fristrup, E. Brown, K. A. Warner, M. D. Nelson, C. White, J. Briggs, S. McFarland, and G. Wittemyer. 2016. A synthesis of two decades of research documenting the effects of noise on wildlife. Biological Reviews 91:982–1005.

Siemers, B. M. and A. Schaub. 2011. Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators. Proceedings of the Royal Society of London B: Biological Sciences 278:1646–1652.

Slabbekoorn, H., and N. Bouton. 2008. Soundscape orientation: a new field in need of sound investigation. Animal Behaviour 4:e5–e8.

Slabbekoorn, H., and M. Peet. 2003. Ecology: birds sing at a higher pitch in urban noise. Nature 424:267.

Slabbekoorn, H., and E. A. P. Ripmeester. 2007. Birdsong and anthropogenic noise: implications and applications for conservation. Molecular Ecology 17:72–83.

Sloan, J. L., and J. F. Hare. 2008. The more the scarier: adult Richardson's ground squirrels (*Spermophilus richardsonii*) assess response urgency via the number of alarm signallers. Ethology 114:436–443.

Templeton, C. N., and E. Greene. 2007. Nuthatches eavesdrop on variations in heterospecific chickadee mobbing alarm calls. Proceedings of the National Academy of Sciences 104:5479–5482.

Tennessen, J. B., S. E. Parks, and T. Langkilde. 2014. Traffic noise causes physiological stress and impairs breeding migration behaviour in frogs. Conservation Physiology 2:10.1093.

U.S. Fish and Wildlife Service (USFWS). 2006. Estimating the effects of auditory and visual disturbance to Northern Spotted Owls and Marbled Murrelets in northwestern California. Arcata Fish and Wildlife Office, Arcata, CA, USA.

Ware, H. E., C. J. McClure, J. D. Carlisle, and J. R. Barber. 2015. A phantom road experiment reveals traffic noise is an invisible source of habitat degradation. Proceedings of the National Academy of Sciences 112:12105–12109.

Wood, W. E., and S. M. Yezerinac. 2006. Song sparrow (*Melospiza melodia*) song varies with urban noise. The Auk 123:650–659.

Wright, A. J., N. A. Soto, A. L. Baldwin, M. Bateson, C. M. Beale, C. Clark, T. Deak, E. F. Edwards, A. Fernández, A. Godinho, and L. T. Hatch. 2007. Anthropogenic noise as a stressor in animals: a multidisciplinary perspective. International Journal of Comparative Psychology 20:250–273.

EXHIBIT G

PLoS one

Anticoagulant Rodenticides on our Public and Community Lands: Spatial Distribution of Exposure and Poisoning of a Rare Forest Carnivore

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Abstract

Anticoagulant rodenticide (AR) poisoning has emerged as a significant concern for conservation and management of non-target wildlife. The purpose for these toxicants is to suppress pest populations in agricultural or urban settings. The potential of direct and indirect exposures and illicit use of ARs on public and community forest lands have recently raised concern for fishers (*Martes pennanti*), a candidate for listing under the federal Endangered Species Act in the Pacific states. In an investigation of threats to fisher population persistence in the two isolated California populations, we investigate the magnitude of this previously undocumented threat to fishers, we tested 58 carcasses for the presence and quantification of ARs, conducted spatial analysis of exposed fishers in an effort to identify potential point sources of AR, and identified fishers that died directly due to AR poisoning. We found 46 of 58 (79%) fishers exposed to an AR with 96% of those individuals having been exposed to one or more second-generation AR compounds. No spatial clustering of AR exposure was detected and the spatial distribution of exposure suggests that AR contamination is widespread within the fisher's range in California, which encompasses mostly public forest and park lands Additionally, we diagnosed four fisher deaths, including a lactating female, that were directly attributed to AR toxicosis and documented the first neonatal or milk transfer of an AR to an altricial fisher kit. These ARs, which some are acutely toxic, pose both a direct mortality or fitness risk to fishers, and a significant indirect risk to these isolated populations. Future research should be directed towards investigating risks to prey populations fishers are dependent on, exposure in other rare forest carnivores, and potential AR point sources such as illegal marijuana cultivation in the range of fishers on California public lands.

Citation: Gabriel MW, Woods LW, Poppenga R, Sweitzer RA, Thompson C, et al. (2012) Anticoagulant Rodenticides on our Public and Community Lands: Spatial Distribution of Exposure and Poisoning of a Rare Forest Carnivore. PLoS ONE 7(7): e40163. doi:10.1371/journal.pone.0040163

Editor: Wayne M. Getz, University of California, Berkeley, United States of America

Received March 27, 2012; **Accepted** June 1, 2012; **Published** July 13, 2012

Funding: These authors have no support or funding to report.

Competing Interests: The authors have declared that no competing interests exist.

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Introduction

Anticoagulant rodenticide (AR) exposure and poisoning has emerged as a conservation concern for non-target wildlife [1,2,3]. These toxicants are used to eradicate or suppress rodent pest populations in agricultural or urban settings to minimize economic losses [1,4]. Generally, the mechanism of AR function is to bind and inhibit enzyme complexes responsible for the recycling of vitamin K_1, thus creating a series of deleterious clotting and coagulation impairments [4,5]. The ARs are grouped into two classes: first-generation compounds, which require several doses to cause intoxication, and second-generation ARs, which are more acutely toxic often requiring only a single dose to cause intoxication and persist in tissues and in the environment [1,4,6,7]. Rodents have started to develop resistance to both first-generation and second-generation ARs, prompting increasingly greater reliance on more acutely toxic compounds and increased distribution by AR users [1,7,8].

Primary exposure by ingestion of bait or secondary exposure through consumption of exposed prey has been documented in numerous species of endangered and common non-target wildlife [1,3,9,10,11,12,13]. Wildlife are thought to be at greatest risk of exposure to ARs in agricultural, urban or peri-urban settings, where large quantities of these compounds are often used [12,14,15]. However, little is known about the risks to wildlife in settings with little or no anthropogenic influences.

Fishers (*Martes pennanti*), a large mustelid and the largest member in the genus Martes, were once widely distributed throughout west coast of North America, but have experienced significant population declines, including extirpation from some regions and contractions of historic ranges [16,17,18]. Populations of fishers inhabiting California, Oregon and Washington have been

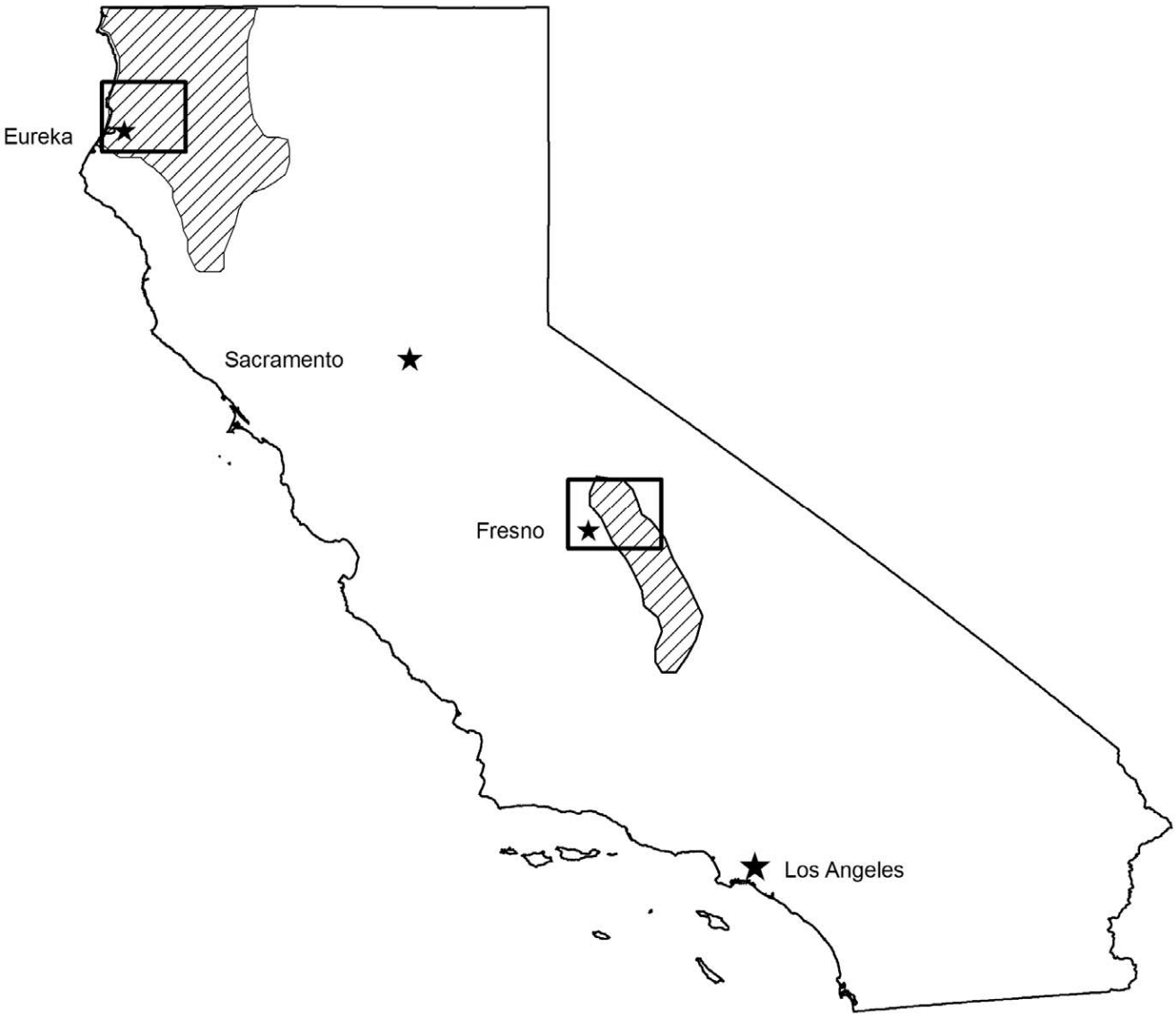

Figure 1. Fisher (Martes pennanti) current range in California and project areas. Current range (shaded areas) of the two isolated California populations of fishers (*Martes pennanti*). Areas of fisher projects that generated data for exposure and mortality to anticoagulant rodenticides are outlined within the two isolated populations.
doi:10.1371/journal.pone.0040163.g001

designated as a Distinct Population Segment (DPS) and declared a candidate species for listing under the federal Endangered Species Act [17,19]. The west coast DPS encompasses areas where fishers were extirpated from Washington and central and northern Oregon, a reintroduced population in the Cascade mountains of southern Oregon, and two extant and isolated populations, one spanning southern Oregon and northern California and another in the southern Sierra Nevada mountains of California [17,19]. The population status of fishers in the southern Oregon/northern California is unknown; however population estimates for the isolated fisher population in the southern Sierra Nevada range from 150–300 fishers, with 120–250 in the adult age class [17,20,21]. Because fishers in the DPS occur in and are dependent on mid to late-seral stage coniferous and hardwood forests and are not associated with agricultural or urban settings, toxicants have not been previously considered a likely threat to fisher populations [17,22,23].

We assessed the magnitude of AR exposure and poisoning among fisher carcasses submitted for necropsy from 2006 to 2011 as part of a collaborative effort studying threats to population persistence of fishers in California. Additionally, spatial analysis of telemetry data from sampled fishers was conducted in an effort to identify potential sources of AR in the environment. We hypothesized that due to fishers being a forest-dependent carnivore, exposure to ARs will be rare.

Methods

Ethics Statement

All procedures involving animals were reviewed and approved by the University of California, Davis, Animal Care and Use Committee (Protocol No. 16551).

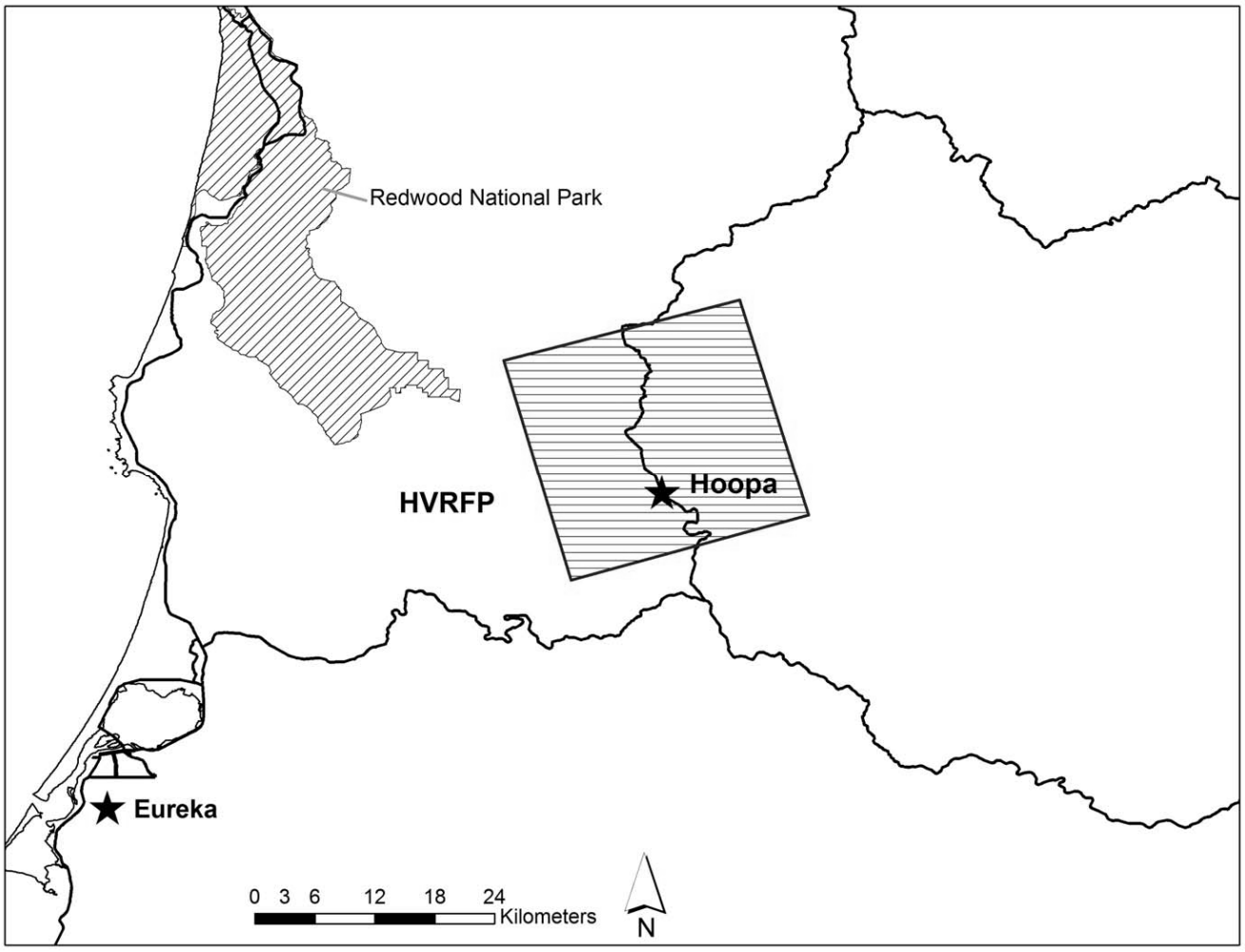

Figure 2. Enlarged map of fisher (Martes pennanti) project area for the northern California population at the Hoopa Valley Reservation Fisher project (HVRFP).
doi:10.1371/journal.pone.0040163.g002

Study Area

Fishers were captured in box traps modified with a plywood cubby box (model 207, Tomahawk Live Trap Company, Tomahawk, Wisconsin, USA), sampled, and fitted with a VHF radio-collar and monitored via telemetry. Fisher carcasses were submitted from the two isolated California populations by three fisher monitoring projects (Figure 1). Carcasses from the northern California population were submitted by the Hoopa Valley Reservation Fisher Project (HVRFP), conducted in northwestern California within tribal, private and public lands, and non-monitored fishers on public and private lands throughout the northern Sierra Nevada/southern Cascade Mountain borderlands of north central California (Figure 2). Carcasses from the southern Sierra Nevada California population were submitted by the Sierra Nevada Adaptive Management Project (SNAMP) and the USDA Forest Service Kings River Fisher Project (KRFP); both projects were conducted on the Sierra National Forest in the northern and central portions of this population's extent (Figure 3).

Sample Collection

Deceased fishers were collected by project personnel whenever a fisher was determined to be inactive for >24 hours, a mortality signal from the VHF collar was detected or when unmarked fisher carcasses were opportunistically observed at the project sites or adjacent areas. Fisher carcasses were stored in a −20 °C freezer until a complete necropsy to determine causes of mortality was performed by a board-certified pathologist specializing in wildlife at the California Animal Health and Food Safety Laboratory System (CAHFS) or the University of California Davis Veterinary Medical Teaching Hospital in Davis, CA, USA. Liver samples were collected during necropsy and submitted for screening and quantification of seven ARs at CAHFS by liquid chromatography-tandem mass spectrometry for screening presence of ARs and high-performance liquid chromatography to quantitate positive samples. The AR compounds tested for included first-generation ARs, warfarin (WAF), diphacinone (DIP), chlorophacinone (CHL), and coumachlor (COM); and second-generation ARs, brodifacoum (BRD), bromodiolone (BRM), and difethialone (DIF). The reporting limits were 0.01 ppm for BRD, 0.05 for WAF, BRM, and COM, and 0.25 ppm for DIP, CHL, and DIF. Detectable compound concentrations that were below quantitate limits were labeled as "trace" concentrations. All results were reported on a tissue wet weight basis and reviewed by a board-certified toxicologist [12,24].

Age classification was determined by tooth wear, sagittal crest or testicular/teat development, field and laboratory observation, and

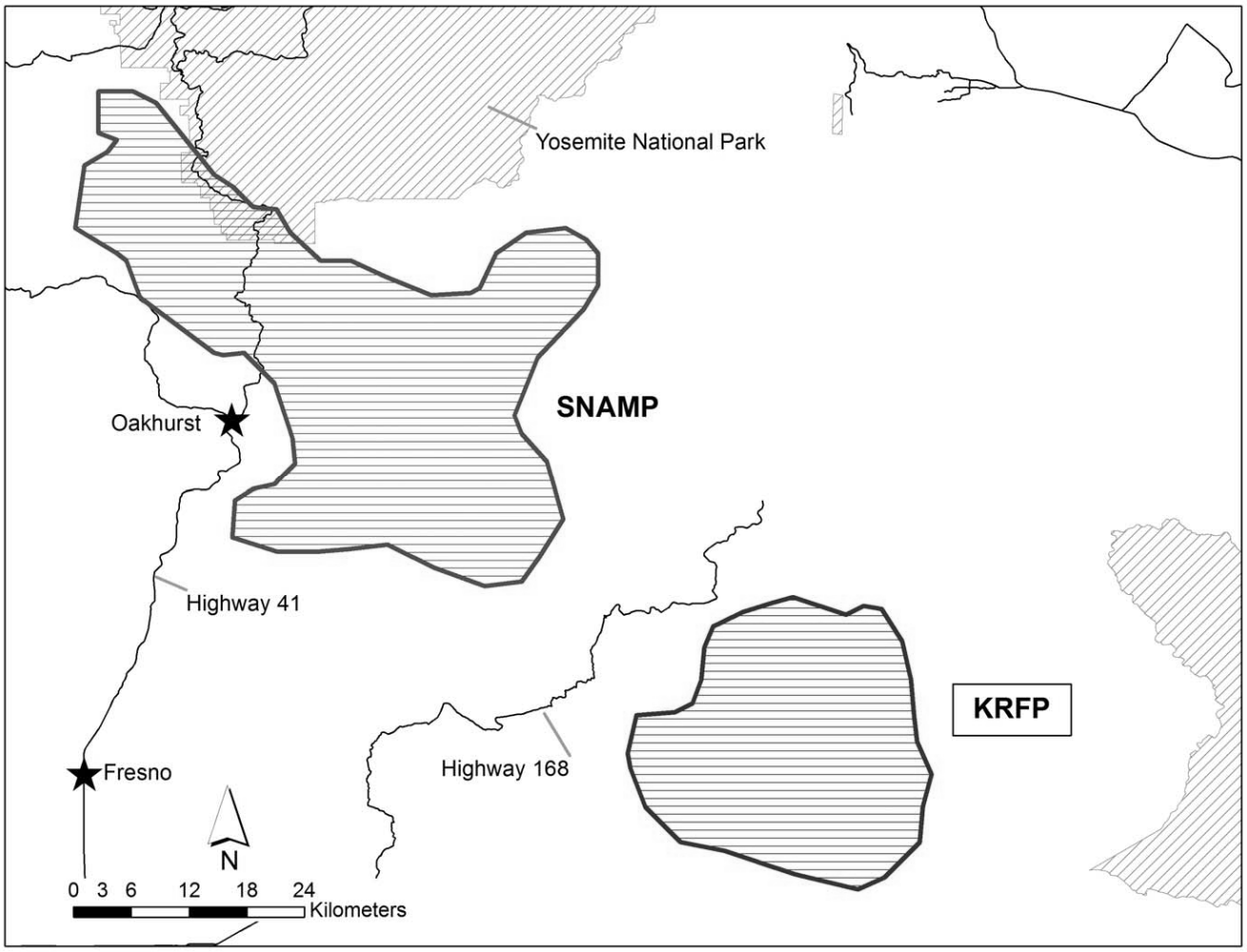

Figure 3. Enlarged map of fisher (Martes pennanti) project areas for the southern Sierra Nevada population: the Sierra Nevada Adaptive Management Project (SNAMP) and Kings River Fisher Project (KRFP).
doi:10.1371/journal.pone.0040163.g003

monitoring of individual animals [17,18,25]. Fishers were classified as kits when fully or semi-altricial and dependent on milk for nourishment (roughly $\leq$10 weeks), juveniles if weaned and $<$12 months of age, sub-adults when between 13–24 months of age, and adults $\geq$24 months of age [17,18,25].

Statistical Analysis

Prevalence of AR exposure among fishers was calculated for the total sample, each sex and each age class. We compared the AR exposure prevalence between sexes within and between the two California populations using two-tailed heterogeneity chi-square tests of association [26]. The effects of sex and population on the number of anticoagulant rodenticides found per individual were analyzed with a two-way ANOVA [27]. All tests were conducted using the program NCSS (Number Cruncher Statistical Software, Kaysville, UT, USA) with an alpha level $p = 0.05$.

Spatial Analysis

For monitored fishers, telemetry locations were used to generate 95% minimum convex polygon (MCP) home-range centroids to represent a centralized point within the core area of movement within each individual fisher home-range within each project area [28]. For each fisher, three centroids representing three sampling timeframes were calculated using ArcView 9.1 home range extensions (ESRI Inc., Redlands CA., USA) [29]. The first centroid incorporated all fisher locations from initial capture until death, irrespective of the monitoring time; the second centroid incorporated fisher locations collected six months prior to death; and the third centroid incorporated only the fisher locations collected three months prior to death. These two latter centroids containing locations collected over a shorter time period prior to death were calculated because some ARs have relatively short half-lives and any spatial clustering in these MCP centroids might suggest the locale of recent sources of AR exposure. Only fishers with $\geq$3 months of monitoring were used for spatial analysis, individuals that had less than or were opportunistically collected were excluded.

Centroids were analyzed by spatial scan statistics to determine whether exposure to ARs, exposure to different generation classes (1st and 2nd) of ARs, or exposure to individual compounds of ARs were distributed uniformly or spatially clustered in each of the two California populations [30]. SaTScan version 9.1.1 (M. Kulldorff, Harvard Medical School, Boston, MA, USA) was used to evaluate two separate models. First, a Bernoulli model utilizing count data was used to determine if spatial clustering occurred in exposed and non-exposed fishers, or in first or second-generation class AR

Table 1. Exposure and mortality due to anticoagulant rodenticides (AR) fishers (*Martes pennanti*) within the two isolated populations, northern California and southern Sierra Nevada.

Fisher population	Number of fishers tested (F:M)	Number of AR exposed fishers (F:M)	Number of AR mortalities	$\bar{x}$, SD and range in all, female (F) and male (M) exposed fishers	Chi-square	Probability Level	DF
Northern California	18 (11:7)	13 (72%) (8:5)	2	1.38 (SD = 0.84; range1–3) (F) 1.13 (SD = 0.35; range 1–3) (M) 1.8 (SD = 0.84; range 1–3)	0.004	0.952	1
Sierra Nevada	40 (18:22)	33 (83%) (16:17)	2	1.70 (SD = 0.88; range1–4) (F) 1.47 (SD = 0.87; range 1–4) (M) 2.00 (SD = 0.85; range 1–4)	0.925	0.336	1
All California	58 (31:27)	46 (79%) (26:20)	4	1.61 (SD = 0.83; range 1–4) (F) 1.33 (SD = 0.73; range 1–4) (M) 2.00 (SD = 0.82; range 1–4)	0.844	0.358	1
Heterogeneity chi-square					0.085	0.77	1

Mean number ($\bar{x}$x) of AR compounds detected per individual, range of numbers of AR per individual and standard deviation (SD) are given for all, female (F) and male (M) fishers for each population. Chi-square and heterogeneity Chi-square test analyzing exposure between the sexes both within and between the populations.

doi:10.1371/journal.pone.0040163.t001

exposure. The second model, a multinominal model using categorical data, was used to assign each fisher to a group based on the number of AR compounds detected and to examine possible clustering of individuals with high numbers of AR compounds [31]. SatScan uses these models to scan the geographic area encompassing the MCP centroids to detect spatial clusters encompassing not more than 50% of the centroids [32]. The elliptical scanning window option was chosen for both models because it utilizes both circular and elliptical shapes to allow for a better fit to linear geographic features (i.e. drainages or ridgelines) that occur within the fisher's habitat [32,33]. All statistical values from the models were generated by Monte Carlo simulations of 999 iterations and clusters evaluated for significance with alpha = 0.05.

Results

Population-level Exposure to AR

Forty-six of the 58 fisher carcasses tested (79%) were exposed to one or more compound of AR (Table 1). Frequency of exposure ($p > 0.05$) and the number of ARs per fisher ($p > 0.05$) were similar between populations and sexes (Table S1). The number of AR compounds detected per individual ranged from 1–4 (Table 1). Exposure to at least one AR among age classes ranged with one of 4 pre-weaned kits (25%), 4 of 4 (100%) juveniles, 12 of 17 (70%) sub-adults, and 29 of 33 (88%) adults. Both first and second generation ARs were detected, with BRD being most common and detected in 44 of the 46 (96%) exposed fishers, followed by BRM (16 of 46; 35%), DIP (8 of 46; 17%), CHL (four of 46; 9%), DIF (one of 46; 2%), and WAF (one of 46; 2%). Quantifiable levels of BRD ($\bar{x} = 0.22$ ppm; range trace −3.4 ppm) and BRM ($\bar{x} = 0.12$ ppm; range trace −0.54 ppm) were detected while only trace levels of other ARs were detected (Figure 4). No samples had detectable levels of COM and no indicator dye or AR bait was detected in either stomach or the GI contents of any fisher.

Northern California Fishers

Thirteen of 18 (72%) fishers from the northern California population were exposed to an AR compound (Table 1). Brodifacoum was detected in 12 (92%), BRM in two (15%), DIP in two (15%), CHL in one (8%), and WAF in one (8%) of the 13 exposed individuals.

Sierra Nevada Fishers

Thirty-three of 40 (83%) fishers from the southern Sierra Nevada were exposed to an AR compound (Table 1). Brodifacoum was detected in 32 (97%), BRM in 14 (42%), DIP in six (18%), CHL in three (9%), and DIF in one (3%) of the 33 exposed individuals.

Spatial Distribution of AR Exposure

Complete centroids were generated for 42 monitored fishers, 12 fishers from the northwestern California population (all 12 from HVRFP) and 30 from the southern Sierra Nevada population (19 from SNAMP, 11 from KRFP). Of these fishers, 3-month MCP centroids were generated for 39 fishers, and 6-month centroids for 27 (Table S2). Spatial analysis for 6-month centroids from the KRFP could not be conducted because all fishers in the data set were AR exposed. Sixteen fishers were excluded from the analysis due to lack of monitoring data. No spatial clustering of AR exposure was detected for any of the temporal periods, specific AR compounds, generation class of AR, or distribution of numbers of ARs per fisher in any of the study areas (Table S2; Figure 5, Figure 6).

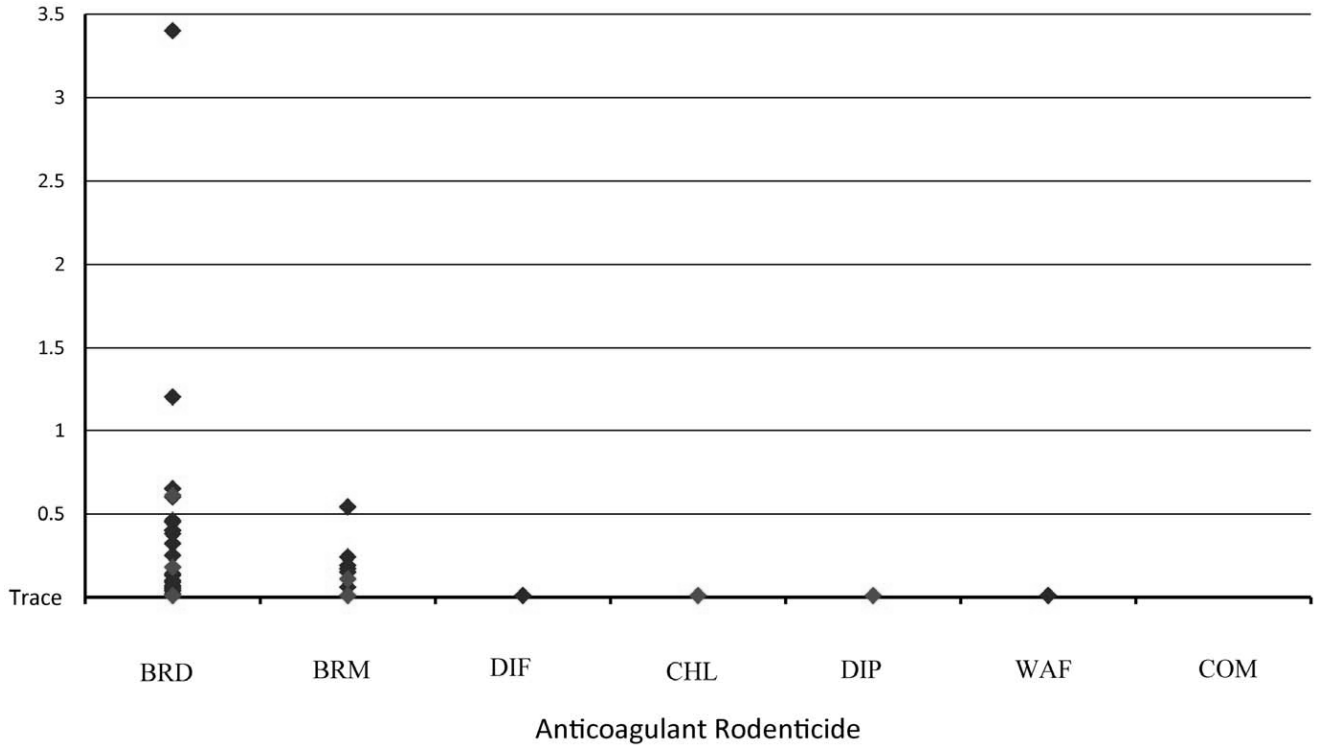

Figure 4. Quantification levels of anticoagulant rodenticides detected in California fishers. Anticoagulant rodenticides (AR) brodifacoum (BRD), bromodiolone (BRM), difethialone (DIF), chlorophacinone (CHL), diphacinone (DIP), warfarin (WAF) and coumachlor (COM) parts per million (PPM) levels detected in positive fishers (*Martes pennanti*) in California. Blue diamonds represent AR quantification levels (ppm). Red diamonds represent levels in fishers that died due to AR ingestion.
doi:10.1371/journal.pone.0040163.g004

AR-Mortalities

Cause-specific mortality factors for all 58 fishers sampled ranged widely and included predation, infectious and non-infectious disease processes and vehicular strikes (M.W. Gabriel unpublished data). The cause of death for four of these fishers was attributed to lethal toxicosis, indicated by AR exposure with simultaneous coagulopathy and bleeding into tissues or cavities and ruling out any concurrent processes that might cause hemorrhaging [34]. Two of the four fishers killed by ARs were from the southern Sierra Nevada population, and two were from northern California (Table 1) and the case details are described below.

Southern Sierra Nevada

An adult male fisher was recovered on 15 April 2009, in the southern Sierra Nevada at the SNAMP project area. The fisher showed no signs of predation or scavenging (Figure 7). Gross necropsy determined that the fisher was in good nutritional (3.45 kg) and fair postmortem condition. Frank blood was observed in both the thoracic and abdominal cavities (150 ml and 100 ml respectively), and in the pericardial sac (7 ml) (Figure 8). The stomach and lower gastrointestinal tract contained some blood but no prey or formed feces, and no mucosal changes were noted. There were no other findings on gross examination. Histopathologically, no significant changes were observed in any tissues. Brodifacoum and BRM were detected and quantified in the liver sample at 0.38 ppm and 0.11 ppm, respectively, and CHL at trace levels (Figure 4).

The second fisher mortality was a lactating adult female recovered on 2 May 2010 in the center of a paved rural highway in the SNAMP project area approximately 3.7 km from Yosemite National Park. Vehicular strike was initially suspected as the cause of mortality due to the location of the carcass but lacerations, abrasions and visual evidence of trauma were not seen on gross examination of the intact carcass. The post-mortem state of the carcass was good and the nutritional state was poor (2.54 kg). Shallow subcutaneous hemorrhage was noted over the hindquarters and spinal column with no associated fractures, punctures or abrasions. There was approximately 20 ml of frank blood within the thoracic cavity. There was no evidence of pneumothorax, vessel ruptures, or visceral tearing. No blood or visceral damage was seen in the abdominal cavity. Stomach contents contained various rodent parts with formed feces in the descending colon. Histopathologically, no significant changes were observed in any tissues. Brodifacoum and BRM were detected and quantified at 0.60 ppm and 0.17 ppm, while one first generation AR, DIP was detected at a trace level within the liver tissue (Figure 4). No evidence was present to suggest that this fisher died due to vehicular trauma, despite its location on the highway.

Northern California

A sub-adult male fisher was recovered on 4 May 2010 at the base of several riparian shrubs near a watercourse in northwestern California at the HVRFP. Severe ectoparasitism on the carcass was noted in the field with ticks in both replete and non-replete stages. Predation was not suspected due to absence of external wounds. The gross necropsy determined that this fisher (2.65 kg) was in poor nutritional condition with no subcutaneous or visceral fat. Frank blood was present in the right external ear canal, nasal and oral cavities, within the lumen of the trachea and within the periorbital tissue with no associated skull fractures or punctures.

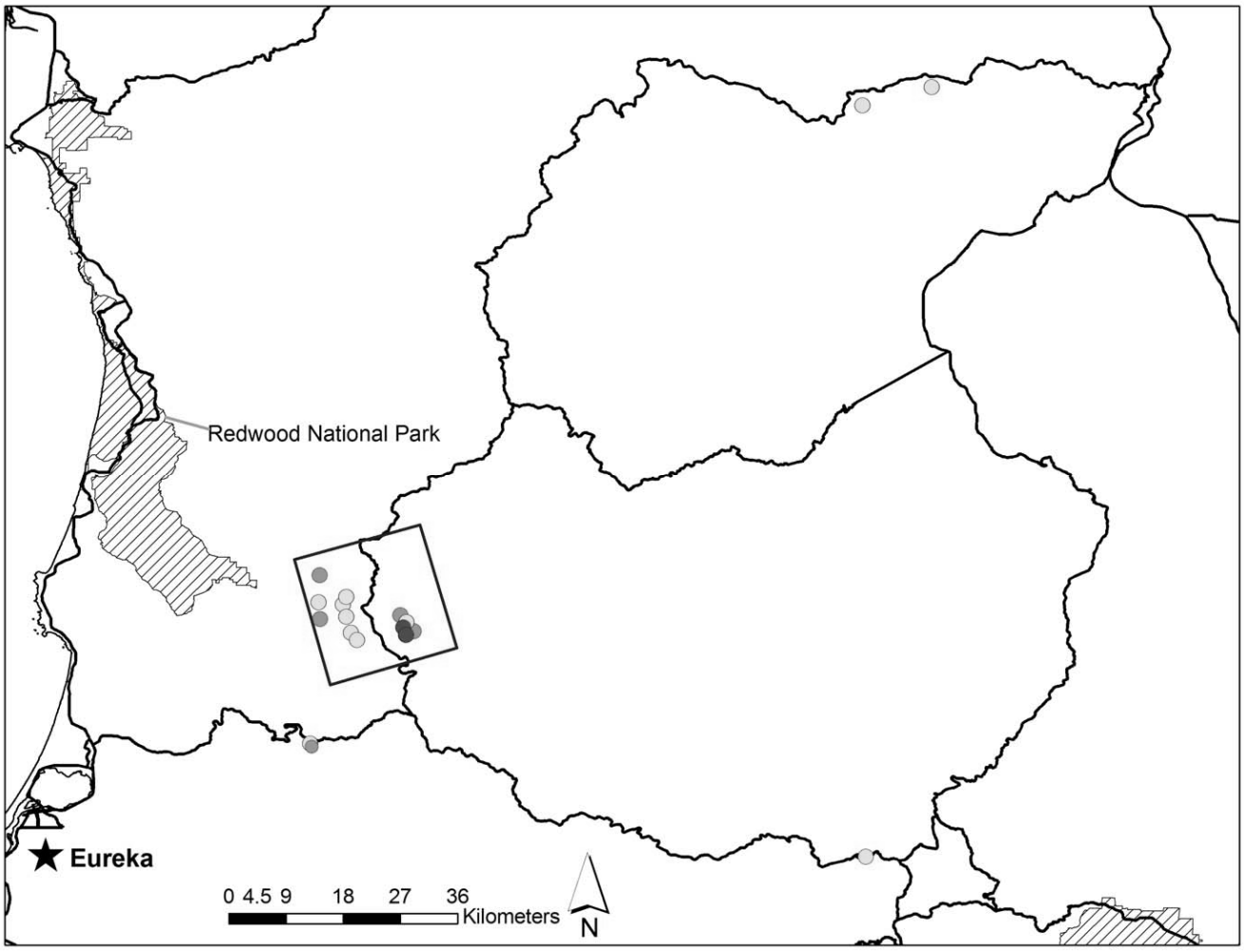

Figure 5. Exposure to and mortality from anticoagulant rodenticides (AR) in fishers (Martes pennanti) from the isolated northern California population. Green circles represent negative fishers, yellow circles represent exposed fishers, while red circles are fishers that died due to AR toxicosis.
doi:10.1371/journal.pone.0040163.g005

The stomach was devoid of prey. The colon only contained semi-formed feces. Ectoparisitism was severe with approximately 48 female and 10 male American dog ticks (*Dermacentor variabilis*) and 8 female and 2 male western black-legged ticks (*Ixodes pacificus*) removed from various regions of the fisher. The liver sample from this fisher had quantifiable levels of BRD at 0.04 ppm as well as a trace level of CHL (Figure 4).

The second northern California fisher AR death, was an adult male recovered on 26 May 2010 at the HVRFP. Field observations included no evidence of predation or scavenging. The nutritional state as well as the postmortem condition were poor. Gross necropsy determined that the fisher (2.89 kg) had no body fat present in any of the tissues. Frank blood was present in both thoracic and abdominal cavities. The stomach contained red and black fluid but no prey. Ectoparasitism was severe with 204 female and 27 male adult American dog ticks in both replete and non-replete stages on areas of the muzzle, chest, tops of fore-and hind-limbs as well as inguinal sections. Severe nematodiasis was seen in skeletal muscle throughout the body (trichinosis). Pulmonary nematodiasis (lungworm) was also noted in the marginal portions of the lungs. Histopathologically, no notable disease processes were seen but severe parasitism was noted. The liver sample for this fisher had quantifiable levels of BRD at 0.61 ppm and trace levels of BRM (Figure 4).

Neonatal Transfer of AR

Necropsies and AR testing was performed on four kits who were all still dependent on mother's milk when they died following maternal abandonment from their mothers death. One kit, a female fisher (0.32 kg) from KRFP tested positive for AR exposure. This kit was approximately six weeks of age and was recovered within a monitored maternal den tree shortly after maternal abandonment. Cause of death was determined to be acute starvation and dehydration. The liver tissue contained trace level of BRD but there was no associated hemorrhaging in any tissues, body cavities or lumina, suggesting that this finding was not clinically significant.

Discussion

Our findings demonstrate that anticoagulant rodenticides, which were not previously investigated in fishers or other remote forest carnivores, are a cause of mortality and may represent a conservation threat to these isolated California populations. This is

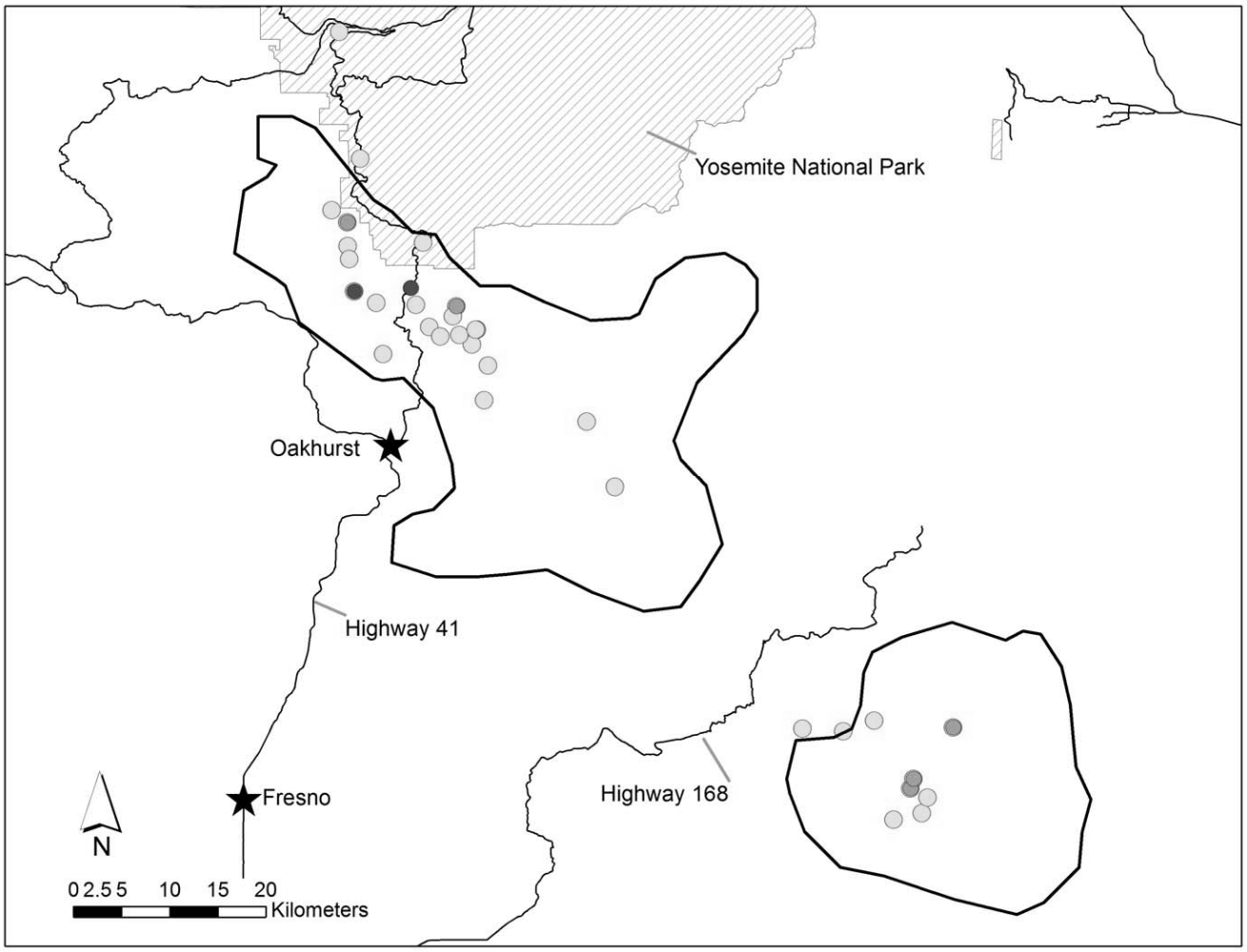

Figure 6. Exposure to and mortality from anticoagulant rodenticides (AR) in fishers (Martes pennanti) from the isolated southern Sierra Nevada population. Green circles represent negative fishers, yellow circles represent exposed fishers, while red circles are fishers that died due to AR toxicosis.
doi:10.1371/journal.pone.0040163.g006

the first documentation of exposure to ARs and of direct mortality from ARs in fishers anywhere in their geographic range. Earlier studies suggest ARs posed little or no additive mortality effects on non-target populations [7,35,36]. The shortfall of many of these studies was the utilization of common cosmopolitan species so they did not take in consideration that AR mortality may be additive in otherwise compromised populations. The spatially ubiquitous exposure observed within all post-weaning age classes and across the project areas in their contemporary range in California is of significant concern especially considering the recent work of Spencer et al. (2010), who demonstrated that even a small increase in human-caused mortality of 10–20% in the isolated Southern Sierra Nevada fisher population would be enough to prevent population expansion if other restrictive habitat elements were removed.

The high rate of exposure to second generation AR compounds (96% of exposed fishers) in these populations is surprising and cause for concern. This generation of ARs are not only more acutely toxic, but have long retention (>150 days half-life) through biphasic elimination in mammal tissues [1,37]. Second-generation ARs are more toxic because death can occur from a single primary ingestion by a rodent [1,5,37,38]. However, rodents can receive a lethal dose of second-generation ARs in one feeding bout and it can take up to 7 days before clinical signs manifest [1,39]. Therefore, prey that have consumed a "super-lethal" dose of AR can pose a substantial risk to predators for several days prior to death [39]. In one study, a group of Norway rats (*Rattus norvegicus*) was given a choice between BRD bait and untreated food and another group had access only to the BRD bait [1]. Both groups consumed 10 and 20 median lethal doses (LD_{50}) on the first day and 40 to 80 LD_{50} doses by day 6.5, respectively [1]. If sources for these toxicants are maintained for even short periods, exposed rodents, the main prey source for fishers in these populations [17] can pose significant threats to their predators.

Many manufactures use "flavorizers" since the AR compound may be bitter and unpalatable to rodent pests [1,39]. Emulsions used to increase palatability include sucrose, bacon, cheese, peanut butter, and apple flavors (Sure-Gro Inc., Brantford, Ontario, Canada and J.T. Eaton, Twinsburg, Ohio, USA), and thus could be palatable to generalist carnivores like fishers. Although we did not visually detect AR bait in the stomach or GI tracts of any fishers that died, primary poisoning cannot be completely ruled out.

Figure 7. Condition of the undisturbed mortality site in which a fisher (Martes pennanti) mortality due to anticoagulant rodenticide from the southern Sierra Nevada population was found.
doi:10.1371/journal.pone.0040163.g007

Sub-lethal AR Exposure

In addition to the risk from lethal toxicosis, sub-lethal AR exposure may compromise fishers through a reduction in the function of normal clotting [5,37,40,41]. The occurrence of AR -exposed wildlife dying from minor wounds that otherwise might have easily resolved themselves if ARs were not present suggests contributory lethal effects [1]. Several cases describe raptors receiving minor defensive lacerations or trauma from prey that lead to the raptor's death by exsanguination or hemorrhaging [1,42]. Fishers actively pursue a wide array of terrestrial and arboreal prey [17,18]. Hence, it is conceivable that a fisher could receive similar wounds or trauma from prey, or during the pursuit of prey. Consequently, if clotting mechanisms were compromised due to ARs, benign injuries could lead to serious complications [1,42,43,44]. The leading causes of mortality within the USFWS DPS is intraguild

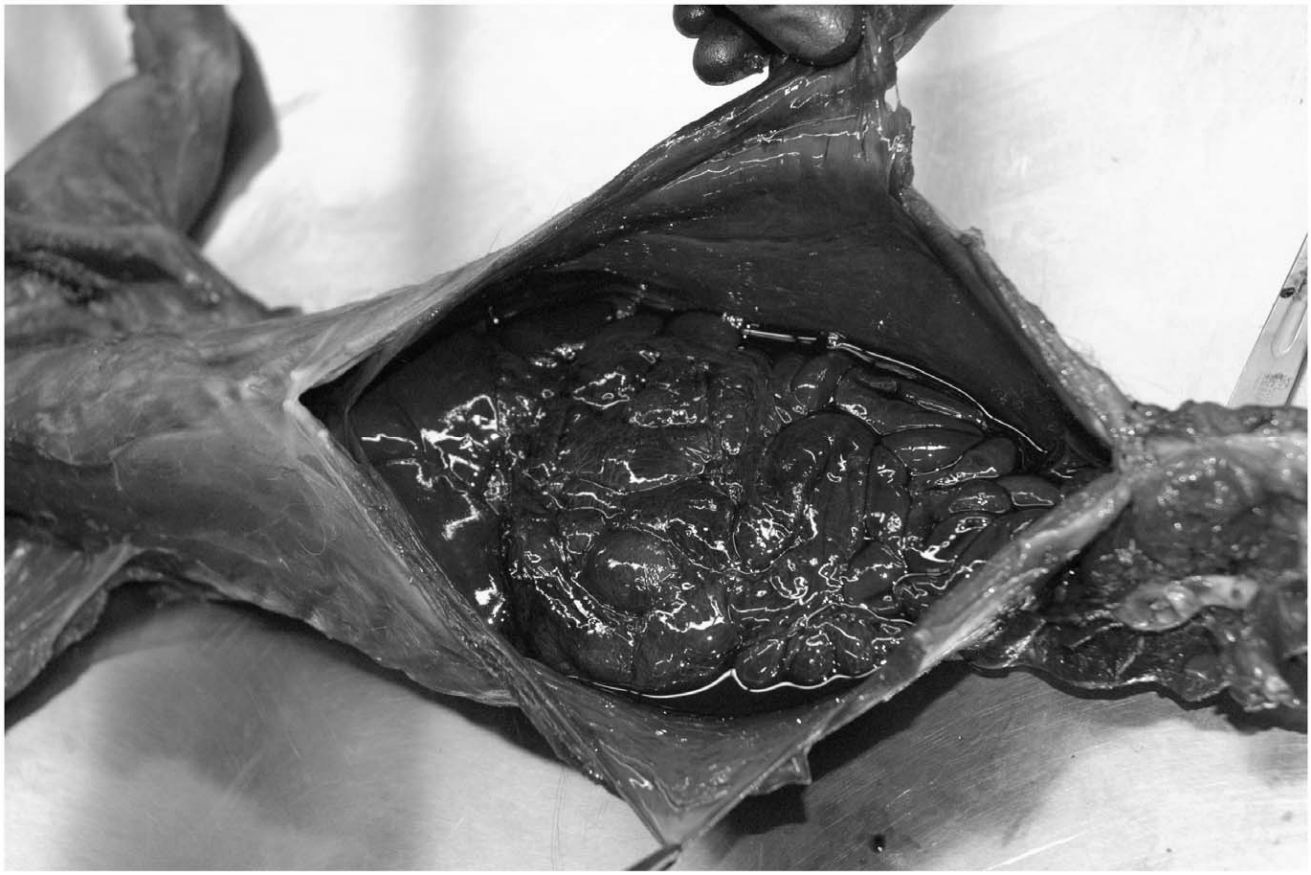

Figure 8. Thoracic cavity hemorrhaging containing 150 ml of frank blood due to coagulopathy after lethal exposure to anticoagulant rodenticides in a fisher (Martes pennanti) from the southern Sierra Nevada population.
doi:10.1371/journal.pone.0040163.g008

predation (G.M.Wengert, unpublished data). It is possible that some of these cases, AR exposure could have compromised clotting mechanisms at the predation attempt and this deserves further study.

High levels of tick infestations were noted in two of the AR mortalities when compared to other sympatric species within the same project area [45]. In addition, locations of of these replete ticks were in infrequent regions in other captures, most likely due to a lack of regular grooming. Whether ARs played a role by allowing more ticks to obtain a blood meal due to immobilization due to compromised clotting factors is unknown.

Furthermore, sublethal AR exposure may decrease an animal's resilience to environmental stressors. In a study on rabbits and rats subjected to stressors such as severe decreases in ambient temperature (i.e. frostbite), approximately 10% of test animals died; however when animals were exposed to low non-lethal doses of anticoagulants and subjected to the same stressors, mortality rates increased to 40–70% [46]. It is unknown if stressors or injuries from environmental, physiological or even pathogenic factors could predispose fishers to elevated mortality rates when coupled with AR exposure.

Neonatal Transfer of AR

The documentation of neonatal or lactational transfer of AR to a dependent fisher kit was unexpected, and the effects of AR exposure to a kit during fetal development or shortly after birth are unstudied. AR exposure in pregnant or whelping domestic canids varied, causing no clinical signs in some cases [47] but death due to coagulopathy immediately after delivery in other cases [48]. The female fisher who gave birth to this kit did not exhibit clinical signs at pre- or postpartum captures and monitoring of her maternal den site verified that one kit survived from that litter (Rebecca Green, United States Forest Service, personal communication). Nevertheless, clinical signs including hemorrhaging, inappetence and lethargy have been seen in domestic canid puppies of AR-exposed mothers [47,48]. Mild to severe manifestations such as low birth weight, stillbirth or eventually neonatal death has been documented in several cases [47,48,49]. In one human study where pregnant women received low doses of warfarin due to severe risk of thrombo-embolic events, 33% of them had stillbirths, 28% had abortions, and 11% of the neonates died shortly after birth [50]. The range for congenital anomalies and miscarriages in pregnant females for prescribed doses of warfarin varied from 15 to 56% and long-term neurological symptoms have been reported in children that were exposed in-utero [51]. The fetotoxic effects of AR in pregnant fishers and their fetuses are unknown. In addition, because fishers exhibit delayed implantation of the blastocyst, whether ARs may cause pregnant females to abort or reabsorb the fetus merits further research [52,53,54]. The transfer of first generation ARs from mother to offspring in milk is not well-understood and there are no data on lactational transfer of second-generation ARs [49].

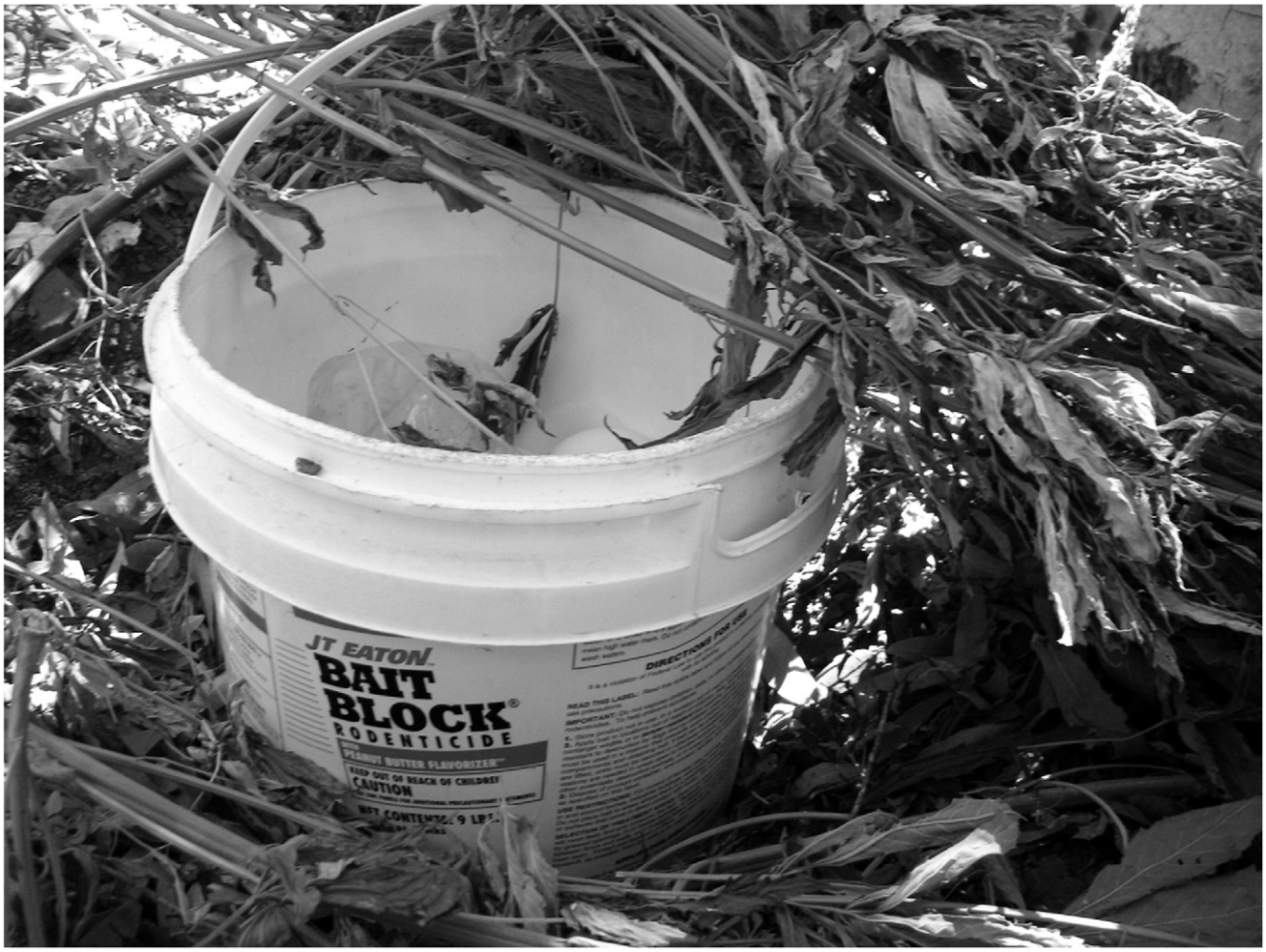

Figure 9. One of several nine-pound buckets of anticoagulant rodenticide removed from an illegal northern California marijuana operation within the northwestern California fisher (Martes pennanti) project boundary.
doi:10.1371/journal.pone.0040163.g009

Quantification Levels

The quantity (ppm) of AR we observed in fisher liver tissues varied and overlapped extensively in both sublethal and lethal cases with no clear indication of a numeric threshold that might indicate an amount leading to morbidity or mortality. This lack of predictive ability has been shown in numerous wildlife cases [1,12,55]. For example, Brodifacoum, the most prominent AR compound detected in fishers in this study ranged considerably in lethal cases among individual mustelid species, with 0.32–1.72 ppm in stoats (*Mustela ermine*) [55,56,57], 0.7 ppm in least weasels (*Mustela nivalis*) [56], 1.47–1.97 in ferrets (*Mustela furo*) [57] and 9.2 ppm in American mink (*Mustela vision*) [3,36]. In addition, there are stark differences for acute LD_{50} doses among genera, where minute amounts of brodifacoum bait caused death in domestic canids but domestic felids required doses 5 to 40 times higher [38]. The same variability seen in both mustelids and other carnivores suggests that predicting clinical thresholds for fishers would be pre-mature [1,58]. Furthermore, AR exposed fishers had an average of 1.6 AR types within their systems, and possible interaction effects from a combination of 2 or more AR compounds within a fisher and other species are entirely unknown [1,37].

Potential Sources of AR

Spatial analyses did not reveal any obvious point sources of AR exposure. Instead, these analyses suggested that exposure is widespread across the landscape. Previous studies expected that exposure to AR compounds would be clustered near areas of human activity or inhabitations and that exposure would not be common outside of these areas [1,12,14,24]. Incongruously, data from this study refuted this hypothesis thus making the finding even more significant. Furthermore, these exposures occurred within a species that is not closely affiliated with urban, peri-urban or agricultural settings in which second-generation ARs typically are [1,12,14,24]. Federal and state regulations for anticoagulant rodenticide usage are specific for both generations. Before the June 2011 Environmental Protection Agency (EPA) regulations [39], second generation class ARs could be purchased at local retailers, with recommendations for placement in weather- and tamper-resistant bait containers no more than 50 feet from any building [39]. However, since June 2011, second generation ARs have not been available to consumers at retail, but only at agricultural stores (farm, tractor or feed stores) with additional form and weight restrictions [39]. These newly passed regulations are aimed at further restriction of irresponsible and illegal use of ARs [39]. However, we would have expected that with either pre- or post-

Figure 10. Multiple packets of anticoagulant rodenticides found surrounding an illegal marijuana grow site within the southern Sierra Nevada fisher (Martes pennanti) project.
doi:10.1371/journal.pone.0040163.g010

June 2011 regulations, second generation AR exposed fishers would have overlapped with urban, peri-urban, or agricultural environments. This pattern is acknowledged in several studies, such as Riley et al. (2007) where bobcat (*Lynx rufus*) and mountain lion (*Felis concolor*) total quantification levels of AR exposure were associated with human-developed areas. Numerous studies have documented that secondary poisoning cases are closely associated with recent agricultural or urban pest eradication efforts [1,13,14,24].

The majority of habitat that fishers in California and fishers throughout the DPS currently and historically occupied is not within or near agricultural or urban settings [17]. Several fishers that were exposed had been monitored their entire lives and inhabited public or community lands where human structures are rare or non-existent (M. Higley, R. Sweitzer, C. Thompson unpublished data). Therefore, exposure from first or second-generation AR use at or within 50 feet of residential or agricultural structures and settings were considered unlikely due to fisher habitat requirements and general lack of association with humans. This suggests that wide-spread non-regulated use of second generation second generation ARs is occurring within the range of fishers in California, especially on public lands.

A likely source of AR exposure to fishers is the emerging spread of illegal marijuana cultivation within California public and private lands [59,60]. In 2008 in California alone, over 3.6 million outdoor marijuana plants were removed from federal and state public lands, including state and national parks, with thousands of pounds of both pesticides and insecticides found at grow sites [59,60,61]. In 2011, a three week eradication operation of marijuana cultivation removed over 630,000 plants and 23,316 kg of trash including 68 kg of pesticides within the Mendocino National Forest in the northern California fisher populations range [17,62]. Anticoagulant rodenticides and pesticides are typically dispersed around young marijuana plants to deter herbivory, [60,62,63] but significant amounts of AR compounds are also placed along plastic irrigation lines used to draw water from in order to deter rodent chewing [60,62,63] (M.W. Gabriel, personal observation). A recent example in which over 2,000 marijuana plants were removed less than 12 km from one of the project areas revealed that plants on the peripheral

Figure 11. Anticoagulant rodenticide bait pellets (bright green) with plant fertilizer freely dispersed around 2,000 plants from northern California marijuana grow site within the northwestern California fisher (Martes pennanti) project boundary.
doi:10.1371/journal.pone.0040163.g011

edges as well as nearby irrigation had large amounts of second generation AR placed (Figure 9, Figure 10, Figure 11). Finally, just within a single eradication effort, multiple kilometers (>40 km) of irrigation line within National Parks and Forests in California were removed [60,62]. Placement of ARs at the grow sites and along irrigation lines which jut out great distances from the grow site itself may explain why there are no defined clusters of AR exposure.

It is noteworthy that the AR fisher mortalities we documented occurred in different areas of their California range but within a relatively short seasonal period between mid-April to mid-May. We cannot specify the exact explanation or source contributing to all AR mortalities that occurred within this short temporal period. This period is when females are providing for offspring as well as males searching for mates; however, preliminary spatial data for fishers in California document that females have more confined home-ranges during this period, while males have slightly larger home-ranges (S. Matthews, R. Sweitzer, unpublished data).

Additionally, several books available to the general public identify the optimal time for planting marijuana outdoors is during mid to late spring, and seedlings are especially vulnerable to rodent pests [64,65,66]. Of additional concern is that April to May is the denning period for female fishers and a time when fisher kits are entirely dependent on their mothers [17,18]. The documentation of a lactating female mortality attributed to AR toxicosis during this period suggests that most likely kits would be abandoned and die from female mortalities during this time.

In conclusion, this study has demonstrated that fishers in the western DPS, which are of conservation concern and a candidate for protection under the Endangered Species Act, are not only being exposed to ARs, but ARs are a direct cause of mortality and indirect mortality (i.e. kit abandonment) in both of California's isolated populations. Consequently, these toxicants may not only pose a mortality risk to fishers but could also pose significant indirect risks by depleting rodent prey populations upon which fishers depend. The lack of spatial clustering of exposed individuals suggests that AR contamination is widespread within this species' range and illegal or irresponsible use of ARs continues despite recent regulatory changes regarding their use. Because we do not know the long-term ecological ramifications of these toxicants left on site long after marijuana grows are dismantled, heightened efforts should be focused on the removal of these toxicants at these and adjacent areas at the time of dismantling. Further regulation restricting the use of ARs to only pest management professionals

as well as continued public outreach through state wide Integrated Pest Management programs may be warranted. In addition, promotion of compounds that do not possess the propensity for secondary poisoning (i.e. zinc phosphide) should be considered in non-professional use settings. Furthermore, ARs in these habitats may pose equally grave risks to other rare and isolated California carnivores such as the Sierra Nevada red fox (*Vulpes vulpes necator*), American marten (*Martes americana*), wolverine (*Gulo gulo*), gray wolf (*Canis lupus*) or raptors such as northern spotted owls (*Strix occidentalis caurina*), California spotted owls (*S.o. occidentalis*) and great gray owls (*Strix nebulosa*). Future research should be directed to investigating potential risks to prey populations as well as other sympatric species that may allow a better understanding of the potential AR sources contributing to these exposure and mortality rates from anticoagulant rodenticides.

Supporting Information

Table S1 A two-way ANOVA analyzing the effects of California fisher (Martes pennanti) populations and sex on the number of anticoagulant rodenticides found per individual.
(DOCX)

Table S2 Results of spatial scan statistics to detect clusters of anticoagulant rodenticide (AR) exposed fishers within each California fisher project. Number of individual fisher minimum convex polygon (MCP) centroids used for each temporal period, specific AR types, generation class of AR and distribution of numbers of ARs per fisher (number of AR positive fishers per test in parentheses) are shown.
(DOCX)

Acknowledgments

We would like to acknowledge the contributions of two anonymous reviewers as well as the following people and organizations. University of California at Davis (UCD) Veterinary Medical Teaching Hospital and pathologists Megan Jones and Patricia Gaffney and the (UCD) graduate group of Comparative Pathology, Drs. Jonna Mazet and Richard Brown, the biologists at all the projects sites including Kerry Rennie, Rebecca Green, Tessa Smith, Jim Garner, and countless others. Logistical support was provided by Integral Ecology Research Center, California Animal Health and Food Safety Laboratory System, Hoopa Valley Tribal Forestry, U.C. Berkeley, United States Forest Service, National Park Service, United States Fish and Wildlife Service and the Bureau of Indian Affairs. Most of all we would like to thank the late Dr. Linda Munson for initially taking the fisher health project under her wing. Her mentorship and contributions to wildlife conservation will be remembered and appreciated.

Author Contributions

Conceived and designed the experiments: MWG LWW RHP RAS CT SMM JMH SMK KP RHB GMW DLC. Performed the experiments: MWG LWW RHP RAS CT SMM JMH SMK KP RHB GMW DLC. Analyzed the data: MWG LWW RHP RAS CT SMM JMH SMK KP RHB GMW BNS DLC. Contributed reagents/materials/analysis tools: MWG LWW RHP RAS CT SMM JMH SMK KP RHB GMW DLC. Wrote the paper: MWG LWW RHP GMW BNS DLC. Acquisition of funding: MWG RAS CT SMM JMH KP RHB GMW.

References

1. Erickson W, Urban D (2004) Potential risks of nine rodenticides to birds and nontarget mammals: A comparative approach. United States Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substance, Washington DC.
2. Hoare JM, Hare KM (2006) The impact of brodifacoum on non-target wildlife: gaps in knowledge. New Zeal J Ecol 30: 157–167.
3. Fournier-Chambrillon C, Berny PJ, Coiffier O, Barbedienne P, Dasse B, et al. (2004) Evidence of secondary poisoning of free-ranging riparian mustelids by anticoagulant rodenticides in France: implications for conservation of European mink (*Mustela lutreola*). J Wildlife Dis 40: 688–695.
4. Berny P (2007) Pesticides and the intoxication of wild animals. J Vet Pharmacol Ther 30: 93–100.
5. Valchev I, Binev R, Yordanova V, Nikolov Y, Pasha TN, et al. (2008) Anticoagulant rodenticide intoxication in animals–a review. Turk J Vet Anim Sci 32: 237–243.
6. Ogilvie S, Pierce R, Wright G, Booth L, Eason C (1997) Brodifacoum residue analysis in water, soil, invertebrates, and birds after rat eradication on Lady Alice Island. New Zeal J Ecol 21: 195–197.
7. Hadler MR, Buckle AP (1992) Forty five years of anticoagulant rodenticides-past, present and future trends. P Fifteenth Vertebra Pest C: 15: 149–155.
8. Lund M (1984) Resistance to the second-generation anticoagulant rodenticides. P Eleventh Vertebra Pest C 11: 89–94.
9. Brakes C, Smith RH (2005) Exposure of non target small mammals to rodenticides: short term effects, recovery and implications for secondary poisoning. J App Ecol 42: 118–128.
10. Hosea R (2000) Exposure of non-target wildlife to anticoagulant rodenticides in California. P Nineteenth Vertebra Pest C 19: 236–244.
11. Stone WB, Okoniewski JC, Stedelin JR (1999) Poisoning of wildlife with anticoagulant rodenticides in New York. J Wildlife Dis 35: 187–193.
12. Riley SPD, Bromley C, Poppenga RH, Uzal FA, Whited L, et al. (2007) Anticoagulant exposure and notoedric mange in bobcats and mountain lions in urban southern California. J Wildlife Manage 71: 1874–1884.
13. McMillin S, Hosea R, Finlayson B, Cypher B, Mekebri A, et al. (2008) Anticoagulant rodenticide exposure in an urban population of San Joaquin kit fox. P Vertebra Pest C 23: 163–165.
14. Proulx G (2011) Field evidence of non-target and secondary poisoning by strychnine and chlorophacinone used to control Richardson's ground squirrels in southwest Saskatchewan. P Ninth Prairie Conserv Endang Species C: 128–134.
15. Tosh DG, Shore RF, Jess S, Withers A, Bearhop S, et al. (2011) User behaviour, best practice and the risks of non-target exposure associated with anticoagulant rodenticide use. J Environ Manage 92: 1503–1508.
16. Matthews SM, Mark Higley J, Scott Yaeger J, Fuller TK (2011) Density of fishers and the efficacy of relative abundance indices and small-scale occupancy estimation to detect a population decline on the Hoopa Valley Indian Reservation, California. Wildl Soc Bull 35: 69–75.
17. Lofroth EC, C. M. Raley, J. M. Higley, R. L. Truex, J. S. Yaeger, et al. (2010) Conservation of fishers (*Martes pennanti*) in south-central British Columbia, Western Washington, Western Oregon, and California. Denver,: USDI Bureau of Land Management.
18. Powell RA (1982) The fisher: life history, ecology, and behavior: University of Minnesota Press Minneapolis, USA.
19. United States Fish and Wildlife Service (2004) 50-CFR Part 17 Endangered and threatened wildlife and plants; 12 month findings for a petition to list the west coast distinct population segment of the fisher (*Martes pennanti*); proposed rule. Federal Register 69: 18770–18792.
20. Spencer W, Rustigian-Romsos H, Strittholt J, Scheller R, Zielinski W, et al. (2010) Using occupancy and population models to assess habitat conservation opportunities for an isolated carnivore population. Biol Conserv 144: 788–803.
21. Spencer W, Rustigian H, Scheller R, Syphard A, Strittholt J, et al. (2008) Baseline evaluation of fisher habitat and population status, and effects of fires and fuels management on fishers in the southern Sierra Nevada. Final report prepared for USDA Forest Service, Pacific Southwest Region.
22. Zielinski WJ, Truex RL, Schlexer FV, Campbell LA, Carroll C (2005) Historical and contemporary distributions of carnivores in forests of the Sierra Nevada, California, USA. J Biogeogr 32: 1385–1407.
23. Zielinski WJ, Truex RL, Schmidt GA, Schlexer FV, Schmidt KN, et al. (2004) Home range characteristics of fishers in California. J Mammal: 85: 649–657.
24. Ruder MG, Poppenga RH, Bryan JA, Bain M, Pitman J, et al. (2011) Intoxication of nontarget wildlife with rodenticides in northwestern Kansas. J Wildl Dis 47: 212–216.
25. Coulter MW (1967) Ecology and management of fishers in Maine [Dissertation]: State University College of Forestry at Syracuse University.
26. Zar JH (1999) Biostatistical analysis. fourth edition. Upper Saddle River, NJ.: Prentice-Hall, Inc. 663 p.
27. Dowdy S, Wearden S (1991) Statistics for research. New York, NY: John Wiley & Sons. 629 p.
28. Powell RA (2000) Animal home ranges and territories and home range estimators. Research techniques in animal ecology: controversies and consequences. Columbia University Press, New York, New York, USA: 65–110.
29. Rodgers AR, Carr A, Smith L, Kie J (2007) HRT: Home Range Tools for ArcGIS. Version 1.1. Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research, Thunder Bay, Ontario, Canada.

30. Kulldorff M, Nagarwalla N (1995) Spatial disease clusters: detection and inference. Stat Med 14: 799–810.
31. Jung I, Kulldorff M, Richard OJ (2010) A spatial scan statistic for multinomial data. Stat Med 29: 1910–1918.
32. Kulldorff M (2001) Prospective time periodic geographical disease surveillance using a scan statistic. J R Stat Soc Ser A Stat Soc 164: 61–72.
33. Kulldorff M, Huang L, Pickle L, Duczmal L (2006) An elliptic spatial scan statistic. Stat Med 25: 3929–3943.
34. Maxie M, editor (2007) Jubb, Kennedy, and Palmer's pathology of domestic animals. 5th ed. Toronto: Saunders Ellsevier. 315–316 p.
35. North PM (1985) A computer modelling study of the population dynamics of the screech owl (*Otus asio*). Ecol Modell 30: 105–143.
36. Kaukeinen D (1982) A review of the secondary poisoning hazard potential to wildlife from the use of anticoagulant rodenticides. P Tenth Vertebra Pest C 10: 151–158.
37. Vandenbroucke V, Bousquet M, De Backer P, Croubels S (2008) Pharmacokinetics of eight anticoagulant rodenticides in mice after single oral administration. J Vet Pharmacol Ther 31: 437–445.
38. Dubock A, Kaukeinen D (1978) Brodifacoum (Talon™ rodenticide), a novel concept. P Eighth Vertebra Pest C 8: 127–137.
39. Bradbury S (2008) Risk Mitigation Decision for ten rodenticides. United States Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substance, Washington DC.
40. Petterino C, Paolo B (2001) Toxicology of various anticoagulant rodenticides in animals. Vet Hum Toxicol 43: 353–360.
41. Shore RF, Birks JDS, Freestone P (1999) Exposure of non-target vertebrates to second-generation rodenticides in Britain, with particular reference to the polecat *Mustela putorius*. New Zeal J Ecol 23: 199–206.
42. Papworth D (1958) A review of the dangers of warfarin poisoning to animals other than rodents. The J R Soc Promot Health 78: 52–60.
43. Eason C, Murphy E. (2000) Recognizing and reducing secondary and tertiary poisoning risks associated with brodifacoum; 2000. ACS Publ 771: 157–163.
44. Newton I, Shore R, Wyllie I, Birks J, Dale L (1999) Empirical evidence of side-effects of rodenticides on some predatory birds and mammals. In: D. P Cowan, Feare CJ, editors. Adv Vertebra Pest Manage: Filander Verlag, Fürth. 347–367.
45. Gabriel MW, Brown RN, Foley JE, Higley JM, Botzler RG (2009) Ecology of *Anaplasma phagocytophilum* infection in gray foxes (*Urocyon cinereoargenteus*) in northwestern California. J Wildlife Dis 45: 344–354.
46. Jaques L (1959) Dicoumarol drugs and the problem of haemorrhage. CMAJ 81: 848–854.
47. Munday J, Thompson L (2003) Brodifacoum toxicosis in two neonatal puppies. Vet Pathol Online 40: 216–219.
48. Mackintosh C, Laas F, Godfrey M, Turner K (1988) Vitamin Kt treatment of brodifacoum poisoning in dogs. P Thirteenth Vertebra Pest C 13: 86–90.
49. Greaves M (1993) Anticoagulants in pregnancy. Pharmacol & Therapeu 59: 311–327.
50. Sareli P, England MJ, Berk MR, Marcus RH, Epstein M, et al. (1989) Maternal and fetal sequelae of anticoagulation during pregnancy in patients with mechanical heart valve prostheses. Am J Cardiol 63: 1462–1465.
51. James AH, Abel DE, Brancazio LR (2006) Anticoagulants in pregnancy. Obstet Gynecol Surv 61: 59–69.
52. Krackow S (1995) Potential mechanisms for sex ratio adjustment in mammals and birds. Biol Rev 70: 225–241.
53. Rosenfeld CS, Roberts RM (2004) Maternal diet and other factors affecting offspring sex ratio: a review. Biol Reprod 71: 1063–1070.
54. Krüger O, Radford A, Anderson C, Liversidge R (2005) Successful sons or superior daughters: sex–ratio variation in springbok. P Roy Soc Lond B Bio 272: 375–381.
55. Brown K, Alterio N, Moller H (1998) Secondary poisoning of stoats (*Mustela erminea*) at low mouse (*Mus musculus*) abundance in a New Zealand Nothofagus forest. Wildl Res 25: 419–426.
56. Alterio N, Brown K, Moller H (1997) Secondary poisoning of mustelids in a New Zealand Nothofagus forest. J Zool 243: 863–869.
57. Alterio N (1996) Secondary poisoning of stoats (*Mustela erminea*), feral ferrets (*Mustela furo*), and feral house cats (*Felis catus*) by the anticoagulant poison, brodifacoum. New Zealand Journal of Zoology 23: 331–338.
58. Fisher P (2009) Residual concentrations and persistence of the anticoagulant rodenticides brodifacoum and diphacinone in fauna [Dissertation]: Lincon University. 153 p.
59. Eth W (2008) Up in smoke: Wholesale marijuana cultivation within the national parks and forests, and the accompanying extensive environmental damage. Pa State Environl Law Rev 16: 451–451.
60. Mallery M (2011) Marijuana national forest: encroachment on California public lands for cannabis cultivation. Berkeley Undergrad J 23: 1–50.
61. Drug Enforcement Agency (2008) Record breaking seizures of marijuana throughout California for 2008. In: McEnry C, editor. Drug Enforcement Agency Public Affaris. Sacramento: United States Department of Justice.
62. United States Department of Agriculture (2011) Operation full court press concludes three week operation targeting illegal marijuana plants on public lands. In: Unitied States Forest Service Pacific Southwest Region, editor: Press Release.
63. United States Department of Agriculture (2009) Marijuana on California's national forest: complete podcast. In: United States Forest Service Pacific Southwest Region, editor. Forest Focus.
64. Cervantes J (2000) Marijuana outdoors: guerilla growing. Vancouver, WA, USA: Van Patten Publishing. 144 p.
65. McCarthy T (2011) Growing marijuana: how to plant, cultivate, and harvest your own weed. New York, NY, USA: Skyhorse Pub Co Inc. 224 p.
66. Owner ST (2010) Marijuana outdoor growers guide. San Franscisco, CA, USA: Green Candy Press. 142 p.

EXHIBIT H

North Coast Regional Water Quality Control Board

INVESTIGATIVE ORDER NO. R1-2019-0023
(REVISED)

NORTH COAST REGIONAL SUPPLEMENT
TO ANNUAL MONITORING AND REPORTING REQUIREMENTS

FOR

CANNABIS CULTIVATION GENERAL ORDER WQ 2019-0001-DWQ

The California Regional Water Quality Control Board, North Coast Region (Regional Water Board) finds that:

1. This Investigative Order (Order) is issued pursuant to California Water Code (Water Code) section 13267 and includes monitoring requirements, effective January 1, 2021, for the purposes of reporting on March 1, 2022, and annually on that date thereafter. This Order (otherwise referred to as the Regional Supplement) outlines additional annual monitoring and reporting requirements for dischargers in the North Coast Region enrolled under the statewide Cannabis Cultivation General Order WQ 2019-0001-DWQ (Cannabis Cultivation General Order). This Order revises and replaces the previous version of the Regional Supplement, originally issued by the Regional Water Board Executive Officer on March 22, 2019, and subsequently updated on December 1, 2019. The revisions in this Order are intended to clarify and streamline the information required by the Regional Water Board and do not represent an expansion of the prior version of the Regional Supplement. This Order conforms to and implements policies and requirements of the *Porter-Cologne Water Quality Control Act* (Division 7, commencing with Water Code section 13000) including section 13267, and the *Water Quality Control Plan for the North Coast Region* (Basin Plan) adopted by the Regional Water Board, including beneficial uses, water quality objectives, and implementation plans. The Regional Water Board has the authority to investigate discharges of waste or suspected discharges of waste to waters of the United States and to waters of the state pursuant to Water Code section 13267.

2. The North Coast Region is inundated with cannabis cultivation in headwaters and main river systems, with active, developed sites in steep and rugged terrain. Cultivation and related activities throughout the North Coast Region have resulted in significant waste discharges and losses of instream flows associated with improper development of rural landscapes on privately-owned parcels, and the diversion of

springs and streams, to the cumulative detriment of the Regional Water Board's designated beneficial uses of water.

3. This Regional Supplement requires dischargers to provide additional quantitative site characterization information about their cultivation practices. The Regional Water Board's objective in requiring dischargers to submit additional quantitative site characterization information is to assist the Regional Water Board in its evaluation and prioritization of those sites for inspection that may pose a greater risk to water quality. This information will assist the Regional Water Board in better understanding the current status and trends of cultivation in the North Coast Region and how cropping, water storage, and irrigation practices may result in cumulative impacts and/or lead to greater or lesser threats to water quality, water supply, and designated beneficial uses within the North Coast Region. The information required by this Regional Supplement is necessary to assess the water quality impacts that result from water storage, water use, and discharges of waste associated with cannabis cultivation. In addition, Term 98 in Section 2 of the Cannabis Cultivation Policy, adopted by the State Water Resources Control Board (State Water Board) on February 5, 2019, and approved by the Office of Administrative Law on April 16, 2019, requires cannabis cultivators to maintain records of water use.

4. Surface water diversions represent only one of multiple sources of irrigation water for cannabis cultivation. Currently, cannabis cultivators in the North Coast Region are required to report surface water diversion information through the Division of Water Rights' Electronic Water Rights Information Management System (eWRIMS) Report Management System (RMS). Determining the water quality impact of cannabis cultivation requires an understanding of the amount and timing of water drawn from all sources, not just from surface water diversions. Understanding water use from all sources is germane to the protection of waters of the state in that it helps the Regional Water Board determine whether water is applied at agronomic rates, and whether storage facilities for a particular site are adequate for the size and nature of the operation. In addition, water used for irrigation often comingles with fertilizers, pesticides, herbicides, and/or other cultivation related waste (including sediment) that may impact surface or groundwater quality. The Regional Water Board's objective in requiring cultivators to submit additional information on water storage and use is to better understand how all potential sources and amounts of water used at cannabis cultivation sites may impact water quality. This includes obtaining water storage and use information beyond the scope of Division 2 of the Water Code that is already reported through the eWRIMS RMS to better understand the total amount of water necessary for cannabis cultivation activities, and how the storage and use of that water can individually and cumulatively impact beneficial uses in the North Coast Region.

5. The Cannabis Cultivation General Order requires dischargers to submit monitoring and reporting information via an Annual Report pursuant to Water Code section 13267. It also requires compliance with the monitoring and reporting program (Attachment B to the Cannabis Cultivation General Order) until a revised monitoring

and reporting program is required by a Regional Water Board Executive Officer. This Regional Supplement is required because the North Coast Regional Water Board Executive Officer has determined that additional site characterization and water use information is needed to ensure the protection of water quality in the North Coast Region. As this information is provided at the same time and via the same method as the Annual Report submission, the burden, including the cost, for dischargers in the North Coast Region to provide additional quantitative site characterization information is minimal and not expected to appreciably add to the cost of producing the Annual Report. The basic information required by the Regional Supplement has been required of cannabis cultivators in the North Coast Region since August 2015, when cannabis cultivation activities were first permitted through the North Coast Regional Cannabis Order (No. R1-2015-0023). When the original version of the Cannabis Cultivation General Order was adopted by the State Water Board in October 2017, it replaced the Regional Cannabis Order, but did not contain the same monitoring and reporting requirements as the Regional Cannabis Order. The Executive Officer thus issued the Regional Supplement to restore the requirements originally included in the Regional Cannabis Order.

6. Dischargers in the North Coast Region report information required by the Regional Supplement through the Cannabis Cultivation Regulatory Programs Portal at the same time and using the same method used to submit the Annual Report required by the Cannabis Cultivation General Order's monitoring and reporting program. Similarly, the burden for dischargers in the North Coast Region to provide additional water storage and use information is minimal. For water storage and use information not already reported through the eWRIMS RMS reporting process, this Regional Supplement does not require nor specify the manner or method of measurement for self-reporting this information. This provides dischargers with increased flexibility to choose the manner or method of measurement that is both cost effective and tailored to their needs. Based on the foregoing, the burden, including the costs, of these reports bears a reasonable relationship to the Regional Water Board's need for the reports and the benefits to be obtained from them.

7. Information collected via this Regional Supplement is in addition to the information collected in the Annual Report required under the Cannabis Cultivation General Order and the Division of Water Rights' annual reporting requirements and does not relieve dischargers of the responsibility to comply with these requirements. The evidence supporting the need for the Regional Supplement is outlined in the findings above and is supported by evidence in the Regional Water Board's record.

THEREFORE, IT IS HEREBY ORDERED, pursuant to Water Code section 13267, that beginning January 1, 2021, the following information must be collected for the purposes of inclusion in the North Coast Regional Supplement to the Annual Report for the statewide Cannabis Cultivation General Order WQ 2019-0001-DWQ, due March 1, 2022, and annually by that date thereafter:

Regional Supplement Annual Reporting Requirements

Section 1: Quantitative Site Characterization

Monitoring Criteria	**Format**
Sum of Outdoor cultivation area(s)	square feet (ft^2)
Total number of mature plants harvested & number of harvests: Outdoor	count (#)
Planting medium: Outdoor	soil bags, raised beds, directly in topsoil, other, multiple, NA
Sum of Mixed-Light cultivation area(s)	square feet (ft^2)
Total number of mature plants harvested & number of harvests: Mixed-light	count (#)
Planting medium: Mixed-light	soil bags, raised beds, directly in topsoil, other, multiple, NA
Sum of Indoor cultivation area(s)	square feet (ft^2)
Total number of mature plants harvested & number of harvests: Indoor	count (#)
Planting medium: Indoor	soil bags, raised beds, directly in topsoil, other, multiple, NA
Shortest distance from any cultivation area to a Class I Watercourse	0-49 ft, 50-99 ft, 100-149 ft, 150-199 ft, 200+ ft
Shortest distance from any cultivation area to a Class II Watercourse	0-49 ft, 50-99 ft, 100-149 ft, 150-199 ft, 200+ ft
Shortest distance from any cultivation area to a Class III Watercourse	0-49 ft, 50-99 ft, 100-149 ft, 150-199 ft, 200+ ft
Average slope of cultivation areas	percent (%)
Number of road crossings of surface waters	count (#)
Length of unpaved roads	none, <0.25 miles, 0.25-1 mile, 1-2 miles, 2-5 miles, >5 miles
Total annual nitrogen use	pounds (lbs)
Total annual phosphorous use	pounds (lbs)
Method(s) of water storage	tank(s), bladder(s), pond(s), other
Storage capacity by method of storage	gallons (ga)

Section 2: Water Storage and Use for Cannabis Cultivation

This section requires submittal of data on monthly water input to storage for cannabis cultivation and monthly water applied to cannabis plants (reported in gallons). Information provided in this section should address water storage and use that is not included in the annual report required for a Small Irrigation Use Registration (SIUR) or reported pursuant to any other valid appropriative water right. Multiple sources can be listed for storage and/or application to plants, respectively. Accepted responses for sources of water input to storage are: water delivery, water supply well(s), municipal, captured rainwater, none, and/or other. Accepted responses for sources of water applied to plants are: water delivery, water supply well(s), municipal, from storage, none, and/or other. The method of estimation for these data is also required to be submitted. Accepted responses are: water meter, pressure transducer, staff gauge, tank fill frequency, application rate, water bill, and/or other estimation method.

Provisions

A. Water Right Disclosure: Dischargers with a SIUR or other valid appropriative water right for water sources being used for cannabis cultivation activities shall provide their water right registration number in the Annual Report.

B. Signatory Requirement: The Annual Report shall be signed and certified by either the discharger or an authorized representative on behalf of the discharger. The individual certifying the report shall provide their full legal name and title.

C. Certification Statement: Any report submitted in response to this Order shall include the following perjury statement:

"I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and that, based on my collection of this information or my inquiry of those individuals immediately responsible for collecting the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

Notifications

A. Enforcement Discretion: The Regional Water Board and the State Water Board reserve their rights to take any enforcement action authorized by law for violations of the terms and conditions of this Order. Furthermore, compliance with this Order is wholly distinct from any possible enforcement that may follow from the discharges themselves, pursuant to violations of the Water Code or other orders issued by the Regional Water Board or State Water Board.

B. Enforcement Notification: Pursuant to Water Code section 13268, failure to submit the required technical reports as required by Water Code section 13267(b), or

falsifying any information provided therein, may result in the imposition of administrative civil liability up to $1,000 per violation per day.

C. California Environmental Quality Act Compliance: The issuance of this Order is categorically exempt from the provisions of the California Environmental Quality Act (CEQA) pursuant to Title 14 of the California Code of Regulations, section 15306 (information collection); section 15307 (actions by regulatory agencies for protection of natural resources); 15308 (actions by regulatory agencies for protection of the environment).

D. Appeal Notification: Any person aggrieved by this action of the Regional Water Board may petition the State Water Board to review the action in accordance with Water Code section 13320 and California Code of Regulations, title 23, sections 2050 and following. The State Water Board must receive the petition by 5:00pm, 30 days after the date of this Order, except that if the thirtieth day following the date of this Order falls on a Saturday, Sunday, or state holiday, the petition must be received by the State Water Board by 5:00pm the next business day. Copies of the law and regulations applicable to filing petitions may be found online at the State Water Board's Water Quality Petitions webpage (https://www.waterboards.ca.gov/public_notices/petitions/water_quality/) or will be provided upon request.

Digitally signed by
Matthias St John
Date: 2020.12.17 16:32:29
-08'00'

Ordered by: _____
Water Boards

Matthias St. John
Executive Officer