# Addressing California's Occupational Pesticide Poisoning Issues

*2019*

Prepared by Alex Hassler

# Reducing California's Agricultural Pesticide Poisoning Cases With Updated Enforcement Strategies

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35 YEARS PAN

PESTICIDE ACTION NETWORK • NORTH AMERICA

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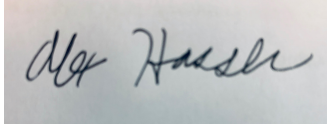
# DISCLAIMER

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

# HONOR PLEDGE

*On my honor as a student, I have neither given nor received aid on this assignment.*



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# EXECUTIVE SUMMARY

Agricultural workers are 39 times more likely to experience pesticide poisoning and 5 times more likely to die on the job when compared with all other industries (Calvert et al., 2008; Reeves & Schafer, 2003). This translates to approximately 350 cases of pesticide poisoning among farmworkers in California annually, with some researchers projecting that there are actually closer to 460 cases a year (Langley & Mort, 2012). Researchers believe that the vast industrial agriculture setting and various methods of pesticide exposure are to blame for the difficulties in enforcement and the resultant pesticide poisoning cases (National Research Council, 2000; Ye et al., 2013).

This report details the human health effects of pesticides, the regulations created to protect farmworkers from pesticide exposure, California's enforcement failures, and finally economic explanations for farm compliance failures. The final section provides relevant information for the Department of Pesticide Regulation and the Pesticide Action Network on how to address noncompliance and the resultant pesticide poisoning cases.

Following the background section, I provide the best practices for addressing compliance issues as discussed in the literature and real-world experiences. I propose the following alternatives to address these issues:

1. Raise the Maximum Potential Penalty for Pesticide Regulation Violations
2. Restrict the Use of Non-Penalizing Compliance Actions for Pesticide Regulation Violations
3. Maintain the Status Quo

Each of the above alternatives was evaluated based on six criteria: (1) Effectiveness in Reducing Agricultural Pesticide Poisoning Cases, (2) Cost-Benefit Analysis, (3) Equity in Impact on Small and Large Farms, (4) Equity in Impact on Farmworkers and Farm Owners, (5) Administrative Feasibility, (6) Political Feasibility. I provide quantitative estimates for the cost-benefit analysis and effectiveness sections, while the other four criteria had qualitative measures. Based on my thorough analysis and evaluation of the alternatives, I recommend that the Pesticide Action Network **advocate for an increase of the maximum penalty for pesticide regulation violations to increase compliance and reduce agricultural pesticide poisoning cases (Alternative 1).**

# PROBLEM STATEMENT

Agricultural pesticide use has significant externalities that are largely borne by the farmworkers who interact with them the most. Based on an analysis of pesticide poisoning incidents throughout the United States, farmworkers are 39 time more likely to experience pesticide poisoning while on the job and 5.4 times more likely to die on the job when compared with employees in all other industries (Calvert et al., 2008; Reeves & Schafer, 2003). An instance of pesticide poisoning is when an individual is exposed to the toxic substance, whether it be on purpose or accidentally. The pesticide is harmful when swallowed, inhaled, or exposed to skin. Skin contact is the most recognizable form of pesticide poisoning as it can occur during mixture, loading, application, exposure to treated goods, and pesticide drift from the intended target. In addition to the adverse health effects from exposure to pesticides, poisoned farmworkers may have to miss work, pay for expensive medical care, and potentially expose friends and family to the dangerous chemicals (Forget et al., 1993; Ramirez-Santana et al., 2014; Smith, S., 2004).

California has a clear issue with occupational pesticide poisoning, as there have been approximately 350 cases in the state annually since the early 2000s (Figure 1) ("California Pesticide Illness Query Database," 2018). Unfortunately, many researchers believe that this is the lower bound of the true pesticide poisoning cases. One article's data analysis estimates that there are 53.6 cases of pesticide poisoning per 100,000 farm workers (Langley & Mort, 2012). When translated to California's farm worker employee pool, there are actually around 455 annual cases of pesticide poisoning in the state. These estimates show a serious inadequacy in the protection of California's farm workers, as they are frequently exposed to the dangerous substances.

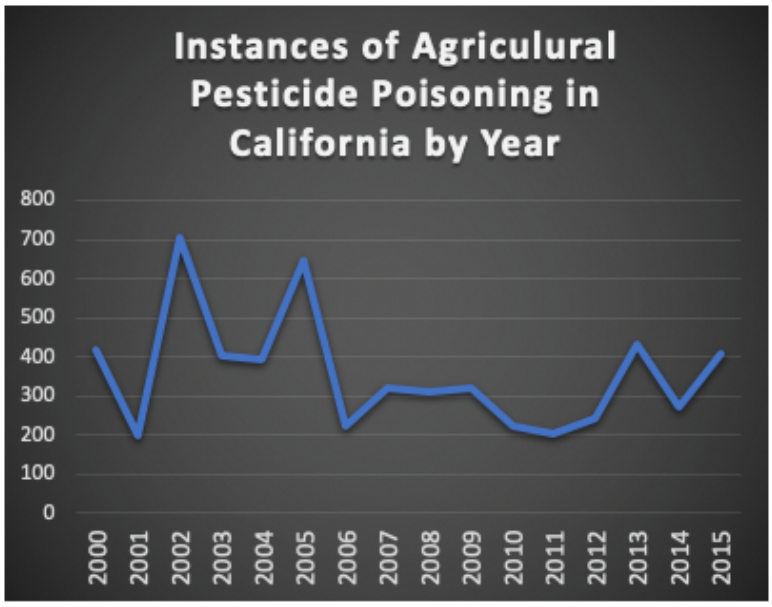


*Figure 1. Observed cases of agricultural pesticide poisoning in California from 2000-2015. ("California Pesticide Illness Query Database," 2018)*

Research has shown that a difficulty in enforcing pesticide regulations is the root cause of the problem. The enforcement agents find it difficult to monitor compliance due to the vast scale of the industrial agriculture operations where instances of noncompliance could occur throughout hundreds of acres of land (National Research Council, 2000). Additionally, farm workers can be exposed to the pesticides in a variety of ways, making it increasingly difficult for enforcement agents to monitor and protect farmworkers (Ye et al., 2013). An analysis of the causes of agricultural pesticide exposure has helped to confirm this, as 63% of cases occurred because of off-target drift, 17% of cases occurred due to contact with recently treated goods,

and 17% occurred due to use in conflict with the label (Calvert et al., 2008). In combination, the substantial geographic area and the numerous methods of exposure cause significant difficulty for pesticide enforcement agents. This makes it difficult to ensure that farms are fully compliant with the regulations that are meant to protect the farmworkers from pesticide exposure.

# BACKGROUND

## Agricultural Pesticide Use and Trends in California

Pesticides are a class of "substances or mixture of substances intended to prevent, destroy, repel, or mitigate insects, rodents, nematodes, fungi, weeds, [or] micro-organisms (Federal Insecticide, Fungicide, and Rodenticide Act of 1910)." The industry further categorizes pesticides as herbicides, nematodicides, fungicides, fumigants, and antimicrobials that describe the intended target of the substance. In their nature, pesticides are poisonous substances that are meant to destroy or repel pests that can be detrimental to humans, crops, and many other living organisms. The most common use, by far, is to protect agricultural crops from pest damage. This helps to ensure the value and quantity of the crop for the United States food supply.

The latest data on California's agricultural pesticide usage shows that approximately 208 million pounds were used in 2016 ("Summary of Pesticide Use Report Data," 2018). Total usage has increased by approximately 35 million pounds since 2010, showing a drastic increase in the use of pesticides throughout the state ("Summary of Pesticide Use Report Data," 2018). For the production agriculture sector, there has been a similarly significant annual increase of 31 million pounds between 2010 and 2016 ("Summary of Pesticide Use Report Data," 2018). Figure 2 provides a visual representation of the overall and sector-specific trends for pesticide use in this time span.

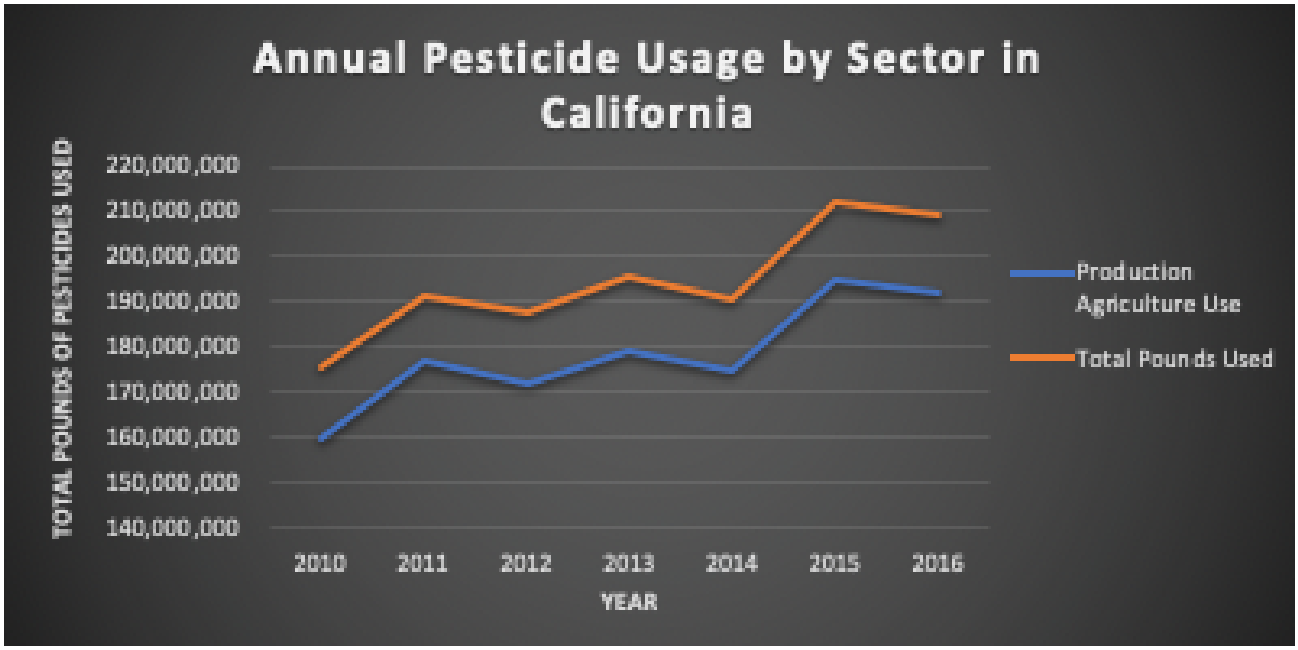


*Figure 2. Annual pesticide use trends in California overall and within the production agriculture sector ("Summary of Pesticide Use Report Data," 2018).*

This data shows that there has been a significant increase in pesticide usage throughout the state, with the vast majority of it occurring in the production agriculture sector. With the increase of pesticide usage in production agriculture, there is potential for a related increase in pesticide poisoning cases in the future.

## Health Effects of Pesticide Poisoning

Although pesticides play an important role in US agriculture, they have many detrimental side effects on human and environmental health. This report specifically focuses on the negative health outcomes caused by occupational exposure to pesticides. These negative health effects can be broken down into two categories: the acute symptoms experienced immediately after pesticide exposure and the long-term, chronic conditions that arise from frequent exposure.

In the short term, the conditions farmworkers experience can vary by the level of exposure and the toxicity of the pesticide. In mild cases, the individual may experience headache, diarrhea, fatigue, loss of weight, soreness, moodiness, and irritation of the eye and throat. The severe cases have all of the same mild conditions, but also can lead to vomiting, muscle twitches, inability to breathe, fever, and unconsciousness (Pesticide Safety Education Program, n.d.).

The chronic conditions from frequent pesticide exposure are much worse and are the cause of many significant healthcare costs. Impacted individuals have been found to develop Alzheimer's disease, asthma, cancer, ADHD, autism, diabetes, and Parkinson's disease at higher rates than the average individual. Exposed farmworkers can also experience reduced reproductive health capacities and have offspring with pesticide-induced birth defects (Owens et al., 2010).

## Federal Pesticide Regulations

To combat the dangerous health externalities of agricultural pesticide use, the federal government created two major regulations to restrict distribution and protect those who frequently interact with the harmful chemicals.

### *Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)*

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was enacted to expand federal control over pesticides, but over the years the regulation has changed drastically with advancements in technology and changes in the agricultural structure. In 1947, the most significant shift occurred when administration of FIFRA was transferred to the EPA from the Department of Agriculture. At this point, the clear purpose of the regulation was to focus on the safe application and distribution of pesticides to reduce the negative health and environmental externalities.

Under FIFRA, the EPA has a variety of pesticide focus areas that are meant to ensure safe usage and distribution of all pesticides. Their overarching responsibilities include control over pesticide labeling, enforcement of proper pesticide use, training of pesticide applicators, certification of pesticide applicators, and licensing of pesticide distributors and buyers.

The main party responsible for the enforcement of FIFRA is the EPA. However, the Act allowed for the delegation of control over enforcement to states that have sufficiently strong pesticide management bodies. Once states are entrusted with the primary enforcement capabilities, they are responsible for regulating pesticide practices, holding training sessions, licensing farms for pesticide use, and certifying pesticide applicators. However, the EPA is still loosely involved as they provide oversight to the state bodies to ensure effective implementation and the upholding of a constant level of protection across the country.

***Workers Protection Standard for Agricultural Pesticides***

The Workers Protection Standard for Agricultural Pesticides (WPS) regulation was issued by the EPA in 1974 to reduce pesticide exposure to workers within farms, forests, nurseries, and greenhouses. Through education, protection, and mitigation, the WPS was created to ensure that employers provide a safe agricultural workspace. To achieve the safe agricultural workplace, the WPS requires that applicators wear appropriate protective equipment, they follow safe procedures during and after the application of pesticides, the pesticide applicators are properly trained, farmworkers are warned about areas that were recently treated, and information regarding the products, individual safety, and medical treatment is accessible to all workers.

Since the WPS was enacted, it has been expanded twice to ensure that workers are sufficiently protected with the advancements in technology and agriculture. The first update came in 1992 and focused on stricter pesticide labeling, protection of an expanded pool of workers, required notices for pesticide application, restriction of entry into treated fields, increased emergency assistance, increased decontamination supplies, and improved safety training for applicators. The second round of updates occurred in 2015 and implementation required by 2017. This round once again focused on increased stringency of regulations to further protect agricultural workers. The goal of this expansion of the WPS was to reduce the number of poisoning incidents to maintain a healthier workforce with fewer absences from work or school along and a lower medical bill burden. To achieve this goal, the expansion required increased frequency and stringency of applicator trainings, increased requirements for personal protective equipment, increased decontamination supplies, stricter warning procedures for treated areas, and more frequent informational posters around the agricultural workplace to warn individuals of pesticide poisoning symptoms and remind them of safe pesticide application.

Managers and owners of agricultural establishments are the responsible party for ensuring the agricultural workplace is in compliance with the WPS. This means that the employers are required to ensure that their workplace contains all the necessary resources, their employees are properly trained, and their workers are frequently informed of the dangers of pesticide poisoning and how to prevent pesticide exposure.

## California's Enhanced Pesticide Safety Program

In 1997 California's Department of Pesticide Regulation's proposed Pesticide Safety Program was approved by the EPA (DPR, "Chapter 8"). This allowed for the state to have additional regulations to further protect agricultural workers beyond the regulatory responsibilities of the federal WPS. The California Pesticide Safety Program regulations focus on hazard communication, applicator training, personal protective equipment, restricted entry intervals, outreach, and medical supervision (DPR, "Chapter 8"). Through the increased stringency of these regulations, in comparison to the federal WPS, the state of California is working to ensure that the best methods of pesticide management and application are being utilized.

Examples of the stricter regulatory requirements are (DPR, "Chapter 8") :

- Written hazard communication program for employees that details pesticide use history and safety data sheets.
- Applicators must notify the farmer of application before and after the substance is applied.

- Annual training of all farmworkers who work with pesticides.
- Use of closed mixing systems for highly hazardous pesticides.
- Extended restricted entry intervals for a set of pesticides that contain 12 highly hazardous active pesticide ingredients.
- Employment of a bilingual specialist to coordinate outreach to workers and their families that have limited English language skills.
- Provision of emergency medical supervision by employers for individuals handle a specific class of insecticides.

## The Role of California's Department of Pesticide Regulation

The entity responsible for pesticide use monitoring, licensing, development, and public administration of all processes associated with pesticide use is the Department of Pesticide Regulation (DPR). The DPR is a division of the California Environmental Protection Agency that is focused on protecting human health and the environment through the regulation of pesticide sales and application (DPR, "Chapter 1"). More information on the responsibilities and efforts of the DPR can be found in Appendix A.

Within the DPR, the entity responsible for the administration of the WPS, FIFRA, and California's expanded pesticide regulations is the Pesticide Enforcement branch of the Pesticide Programs Division (DPR, "Chapter 1"). However, the majority of the true enforcement responsibility falls on the County Agricultural Commissioners (CACs) (DPR, "Chapter 1"). There are 55 CACs that cover California's 58 counties. The CACs have approximately 400 staff members, consisting of inspectors, administrators, and biologists, to assist in this difficult process (DPR, "Chapter 1").

The CACs and their staff are the primary local enforcement agents for the federal and state pesticide regulations (DPR, "County Plays Key Role"). They are tasked with the educating farmers, providing site-specific pesticide application permits, regulating pesticide use, investigating instances of pesticide illness or injury, and handling compliance actions (DPR, "County Plays Key Role"). The compliance actions in the CACs repertoire are (DPR, "Enforcement and Compliance Options Chart"):
- Administrative penalties up to a maximum fine of $5,000
- Disciplinary actions that include the refusal, revocation, or suspension of registration and permits
- Court actions that can lead to fines up to $50,000 and one-year imprisonment
- Compliance actions that do not include any monetary penalty, including violation notices, warning letters, and compliance interviews.
- Public protection actions that result in the immediate suspension, seizure, and prohibition of pesticide-related actions or materials for the protection of public health and safety.

## Data on California's Agricultural Noncompliance with State and Federal Pesticide Regulations

Although there are regulations to protect these workers, they are often violated. Noncompliance with these regulations leaves farmworkers susceptible to pesticide exposure on the job. This leads to unnecessary pesticide poisoning cases.

The latest data (2012-2015) on instances of noncompliance shows that there were 4,788 instances of noncompliance and 311,941 items in compliance on average each year. The annual compliance rate for this time period was approximately 98.5% ("California Pesticide Use Enforcement Statistical," 2017). Although this is a high rate of compliance, there are still a significant number of regulations that are violated in California's agricultural sector. Many of which pose serious health hazards to those who are frequently working with the hazardous pesticides.

The regulations that were most commonly violated in this time span are:

1. Follows labelling and/or permit conditions (1,744)
2. Regulations- personal protective equipment (1,468)
3. Respiratory protection (1,275)
4. Handler training (1,247)
5. Emergency medical care: posting (1,193)
6. Pest control business/equipment registered (994)
7. Handler decontamination facilities (967)
8. Service container labeling (799)
9. Labelling available at use site (679)
10. Hazard communication / field workers (479)

Seven of the top ten regulations from this list can pose serious risks to human health. The most obvious concerns are the two that regulate the protective equipment that farmworkers must wear while working with or near pesticides. Failure to comply with these regulations is a negligent behavior by the farm, as they are not properly protecting their workers from the hazards of the occupation. Handler training is another critical regulation to comply with in terms of human health impacts. This regulation helps to ensure that the workers managing the pesticides know what they are doing and how to minimize the risks associated with the chemicals. The remaining regulations that could lead pesticide exposure for farmworkers are "follows labelling and/or permit conditions," "emergency medical care: posting," "handler decontamination facilities," and "hazard communication / field workers." These four cover pre-application rules to ensure the pesticide is safely applied, post-application warning systems to protect workers from recently treated areas, and post-exposure systems that will result in rapid decontamination and treatment of the poisoning symptoms.

## Analysis of California's Enforcement Responses to Noncompliance

Although the CACs and their employees have a variety of actions to punish farms that fail to comply with pesticide regulations, the majority of the time the offending farms are not punished (Figure 3). Data from June 2016 to June 2017 shows that 70% of instances of noncompliance only received a violation notice or warning letter. In these instances, the farms are only informed of their failure to comply with the relevant pesticide regulations rather than punished for the violation. In comparison, only 24% of regulation violations received in financial penalties. The remaining 6% of violations either received farm license actions or a cease and desist order on all dangerous operations ("California Statewide Pesticide Regulatory Activities Summary," 2018).

This single-year analysis is not an anomaly in the grand scheme of DPR's enforcement efforts, shown by another analysis of enforcement and compliance actions in late 2017 and 2018. Within this time span, the DPR only penalized 1,334 instances of noncompliance of an estimated total of 9,500 regulatory violations. This rate equates to an enforcement rate of only 14%, whereas 86% of cases were given some form of a violation notice, a compliance interview, a licensing action, or a cease and desist order ("County Agricultural Commissioners: Administrative Penalties," 2018). The data utilized in this research did not have a further breakdown of the compliance actions given if the violation was not financially penalized. These two data analyses show that California's enforcement efforts for agricultural noncompliance have frequently underwhelmed, as they are only penalizing violators a small fraction of the time.

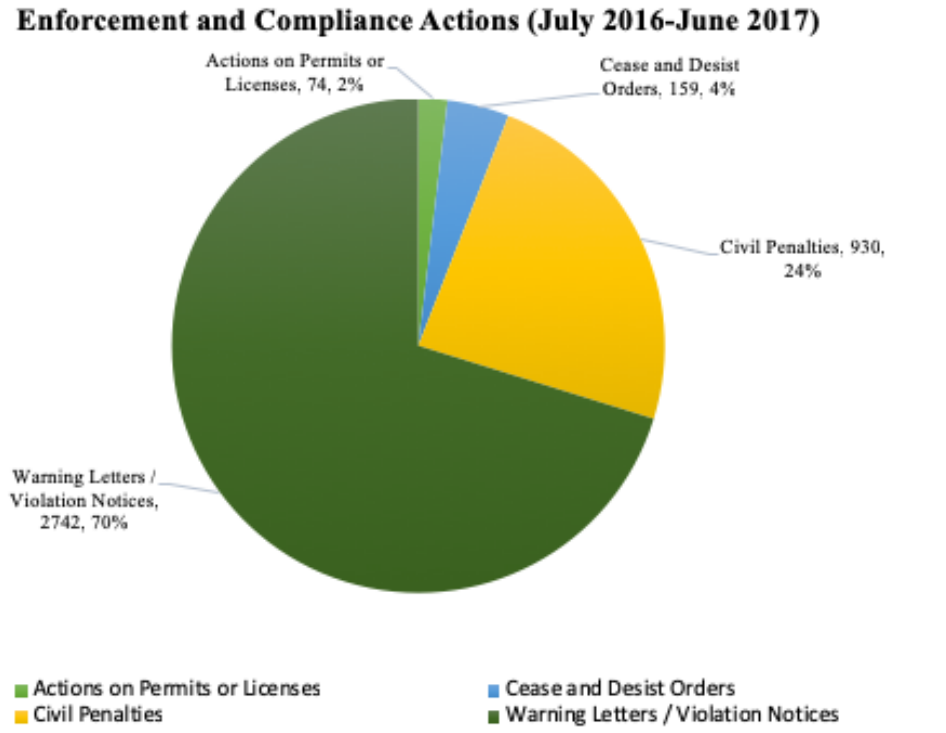


*Figure 3. DPR's Enforcement Actions from June 2016 to June 2017 ("California Statewide Pesticide Regulatory Activities Summary: Between July 2016 and June 2017," 2018)*

Even when the CACs monetarily penalize the farms for instances of noncompliance, the fines levied are too small to truly punish the violators. Figure 4 illustrates this, as 60% (809 cases) of the fines levied between January 2017 and November 2018 were $250 or less. Another 35% of the fines in this time span were between $250 and $1000. The remaining 4.3% were fines between $1000 and $25,000. It is important to note that the fines levied over $5,000 came as a result of criminal court proceedings. This breakdown helps to show that even when the farms are fined for violations, they are not financially incentivizing the farms to change their ways as they can be viewed as simple costs of business.

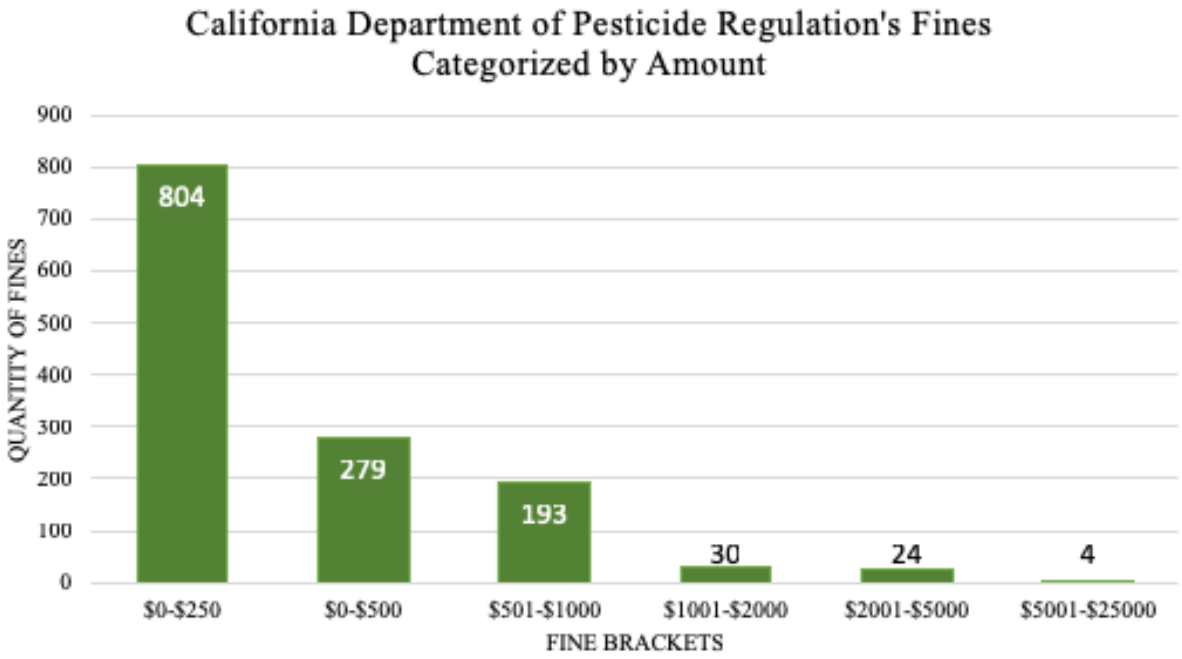


*Figure 4. Breakdown of Fines Levied by DPR Between January 2017 and November 2018. ("County Agricultural Commissioners: Administrative Penalties," 2018)*

## Economic Explanations for Farms' Compliance Failures

The regulatory compliance literature helps to explain California's issues with pesticide regulation compliance. This section utilizes academic research to show why noncompliance with environmental regulations occurs and potential avenues to address it.

The basis of environmental compliance literature arose from Gary Becker's famous paper analyzing the economics of crime in 1968. Becker created a model that helps to explain why individuals break the law and what criminals take into account when making the decision. This paper's main insight was that potential criminals respond to the probability of being caught and the severity of the punishment if caught (Becker, 1968). Becker's work formed the foundation of the environmental compliance field, but many other authors have built on this to better characterize the reasons for compliance with environmental regulations.

Scholars have reached many conclusions that will assist in addressing California's issues with agricultural noncompliance. Authors Mark Cohen (1998) and Anthony Heyes (2000) set the field, as they found that polluters are working to minimize the sum of expected compliance costs and the expected penalties of noncompliance. Additionally, Heyes found that the firms will only follow regulations if the costs of compliance are less than the expected penalties for noncompliance. Put another way, firms will only comply when the costs of noncompliance are greater than the benefits of noncompliance (Earnhart & Glicksman, 2015). Author Geoffrey Miller summarizes these conclusions well, as he describes how inefficiently low expected fines leads firms to violate the regulations more often and spend less than they should on compliance (2018).

Knowing the economic considerations of firms when deciding whether to comply or not helps to provide potential solutions to address this issue and increase overall compliance. Two methods to increase compliance arise in manipulating inspection rates or the penalties for noncompliance (Heyes, 2000; Earnhart & Glickman, 2015; Gunningham et al., 2004). The inspection rates aspect has already been addressed in California, as they frequently detect instances of noncompliance, but the enforcement methods for noncompliance leaves more to be desired. Therefore, the two possibilities for addressing California's agricultural noncompliance are to increase the severity of the fines or increase the frequency of punishment for violations (Adrison, 2008). The implementation of either of these options should lead to higher compliance by farms due to the high value of expected penalties (Miller, 2018).

# METHODOLOGY

The purpose of this report is to provide and evaluate policy alternatives that can address the Department of Pesticide Regulation's struggles with noncompliance and farmworker pesticide poisoning. The report was built to inform the Pesticide Action Network of North America on the topic and provide them with strategies for advocacy that will address the problem. The next section explains the six evaluative criteria that will be used to analyze the policy options. The following section will describe and evaluate the three alternatives using the provided criteria. After the evaluation of the third alternative, a quick analysis of the three alternatives will be presented in the form of an outcomes matrix. Following the outcomes matrix, I will provide a final recommendation to the Pesticide Action Network that outlines the most suitable alternative and why it was chosen. Additionally, this section will address the other two alternatives and why they were not ideal to address the compliance and pesticide poisoning issues. Finally, the report will close with implementation considerations that help to ensure prompt action on the recommendation. This section will provide suggestions on which actions to take and details why they are important in the implementation of the recommendation.

# EVALUATIVE CRITERIA

The alternatives proposed below will be evaluated on the criteria listed below. Using these criteria will allow for a systematic comparison of the three alternatives. The effectiveness criterion will ensure that the alternative results in a significant reduction in the number of instances of pesticide poisoning. Although effectiveness is the most important outcome of the alternative, it is also necessary to consider the four other criterion. The recommended outcome would be most likely implemented if the costs were sufficiently low and the benefits were high. It is also desirable if the political and administrative feasibility of the alternative is high to ensure that it would likely pass through the legislature and result in implementation. Finally, we want to consider the equity concerns associated with the implementation of each policy. Below I define six distinct criteria that will help to determine the best policy that fits these characteristics:

| |
|---|
| 1. Effectiveness in Reducing Cases of Pesticide Poisoning |
| 2. Cost-Benefit Analysis |
| 3. Equity in Impact on Small and Large Farms |
| 4. Equity in Impact on Farmworkers and Farm Owners |
| 5. Administrative Feasibility |
| 6. Political Feasibility |

## Effectiveness in Reducing Cases of Pesticide Poisoning

Effectiveness is the degree to which an alternative is successful in reducing the number of agricultural pesticide poisoning incidents in California annually. The measure is presented as the proportion of pesticide poisoning cases avoided. Effectiveness estimates are evaluated based on historical results and a review of the environmental regulation literature.

## Benefit-Cost Analysis

This criterion will project the costs and benefits of each alternative based on a review of the relevant pesticide regulations and literature. The private farms will bear the majority of the costs of each alternative, as the policy options are intended to increase compliance with the federal and state regulations. The benefits of each alternative accrue to the farmworkers using the pesticides frequently and are quantified by the value of avoiding missed work days, avoiding hospitalization, and avoiding serious chronic health conditions. The final result will be a net present value (NPV) of each alternative in a 10-year time frame with a 7% discount rate. Assumptions, operational details, and a sensitivity analysis of the cost-benefit analysis are provided in Appendix B.

## Equity

Equity focuses on which group bears the burdens of a situation compared to those who receive benefits. This criterion will focus on two different situations where there is potential for an inequitable standing.

a) *Large Farms v. Small Farms:* This will focus on the policy choice's impact on farms of different economic standing. This considers economic, administrative, and operative impacts to determine the outcome. The output for this criterion will either be a *low, medium, or high* impact on smaller farms. The focus on smaller farms in the final value is due to the inherent nature of regulations impacting smaller businesses more than larger businesses.

b) *Farmworker v. Farm Owner:* This will focus on how the externalities of pesticide application is balanced between the farm owners ordering their use and the farmworkers applying the harmful chemicals. This criterion will consider the economic and health costs for each party to analyze the policy's impact on shifting the externalities of pesticide use from the farmworkers to the farm owners. The output for this criterion will either be a *low, medium, or high* externality burden for the farmworkers after implementation.

## Administrative Feasibility

This criterion analyzes the feasibility of the CACs implementation of a policy alternative. This will focus on the likelihood of these individuals in levying higher fines or always financially penalizing for instances of noncompliance. The output for this criterion will either be a *low, medium, or high* likelihood of implementation by the CACs.

## Political Feasibility

The criterion analyzes the likelihood that each alternative will pass through the California Legislature in the current political atmosphere. This will focus on the state government's political divides and how the policy proposal will fare in garnering the necessary support to pass into law. The output for this criterion will either be a *low, medium, or high* likelihood of the proposal being enacted into law.

# POLICY ALTERNATIVES

## Policy Alternative 1: Raising the Maximum Potential Fine for Instances of Noncompliance

Farms that fail to comply with the relevant state and federal pesticide regulations can currently receive a maximum fine of $5,000 if they are not taken to criminal court. This maximum value was last increased in 2002 and does not represent a sufficiently high fine to deter farms from further noncompliance. An increased maximum fine to severely punish farms for instances of noncompliance is necessary to deter future compliance failure and to protect farmworkers from the health impacts of violations.

**This alternative suggests that the California Legislature increase the maximum civil penalty for instances of noncompliance with pesticide regulations to $25,000.** Increasing this maximum value would allow for sufficient penalization of regulatory violations, unlike the current rate. This would also target violations that pose serious impacts to human and environmental health, as fines of this size are reserved for violations with these outcomes ("A Guide to Pesticide Regulation in California," 2011). Therefore, the penalties for these violations will have the most severe penalties and deter future instances of noncompliance with these risks.

In addition to the main penalty increase, the Legislature Bill should include a clause that updates the value of the maximum fine every five years. This would ensure that there is not another 17-year gap between maximum penalty adjustments for the enforcement of pesticide regulations. This would follow the federal Environmental Protection Agency's rule that evenly adjusts federal maximum statutory civil penalties (2019). To carry out this adjustment, calculate the percentage increase of the Consumer Price Index (CPI) from year one to year five. Then multiply this value by the current value of the maximum penalty. The output is then rounded to the nearest dollar and added to the original value of the penalty. The sum of these values is the finalized maximum penalty for the next five years.

For example, in 2002 the CPI was 177.100 and the CPI in 2007 was 202.416. The percentage change in this five-year span was 14.3%. This value is then multiplied by $5,000 and the output is $715. The finalized maximum penalty value from 2007-2012 would have been $5,715. This example is not to show how the fine should have increased from 2002 to 2007, but rather a way to provide an example of the EPA's adjustment strategy. The maximum penalty value has been too low since 2002, making it necessary to adjust it to $25,000 in 2019.

## Evaluation of Alternative 1

To evaluate Alternative One, the maximum penalty adjustment was assessed based on the previously established criteria.

***Effectiveness***: *50% reduction in pesticide poisoning cases* – The projected 50% reduction in annual pesticide poisoning cases based on the implementation of this policy is based on the historical California pesticide poisoning data. The last maximum penalty value increase occurred in 2002. Comparing the data on annual pesticide poisoning cases before (1992-2002) and after this year (2003-2015), there was an approximate 55% reduction in pesticide poisonings after the maximum penalty increase ("CalPIQ Summary Report, 2019). The projected outcome is a slightly conservative estimate as there are fewer poisoning cases to reduce than there were based on data from 1997-2002. This reduction is believed to come from further compliance with the regulations that pose serious risks to human and environmental health if they are not complied with. The threat of higher penalties for these instances of noncompliance should lead to higher spending to ensure compliance with these regulations in the future. An outcome of the higher spending is the improvement in protection for farmworkers.

The economic compliance literature also supports these conclusions. Research has shown that higher potential fines influences farmers and workers to comply with more regulations (Miller, 2014). This goes along with Miller's similar conclusion where rational, profit-maximizing firms would increase compliance if the fine levied is equal to the social cost of the violation (2014). Additionally, other authors suggest that environmental regulations with "teeth" have been found to be a significant deterrent of future noncompliance (Gray & Shimshack, 2011). The final benefit having larger potential fines is that they have been found to not only increase environmental performance and compliance for the penalized firm, but also the surrounding firms (Gray & Shimshack, 2011).

***Cost-Benefit Analysis:*** *Net present value (NPV) between -$6.8 million and -$10.3 million* - This alternative has the least negative NPV. The difference in these estimates is the level of benefits accrued by the policy option. The benefit level depends on whether the reduction in cases is from the observed data on pesticide poisoning cases or the literary estimates on the true number of pesticide poisonings. The potential range of benefits for the next 10-years is between $12.8 and 15.8 million. The clear benefactors from this alternative are the farmworkers that will no longer be experiencing pesticide poisoning due to improved protection through compliance.

The estimated costs focus on the costs the farms must pay to achieve compliance with the listed alternatives that experienced the most frequent noncompliance and posed the most serious human health risks if they are violated. The range of costs for this estimate depends on the number of instances of noncompliance reduced with the implementation of this plan. The potential range of costs for the next 10-years is between $18.5 million and $27.8 million.

A sensitivity analysis of these estimates shows that the NPV will likely not become positive unless the costs are minimal while the benefits exceed even the highest projected values.

A further breakdown of the costs, benefits, assumptions, and the full sensitivity analysis is included in Appendix B and accompanying Benefit-Cost Analysis spreadsheet.

***Large Farm v. Small Farm Equity:*** *High impact on smaller farms* – This policy option would have a high impact on smaller farms due to their inability to internalize these larger penalties. When there are violations with severe human health risks, the smaller businesses will have to pay a greater proportion of their funds to pay off the fines when compared to the larger businesses. This leads to a larger impact on smaller farms, as a fine of $25,000 can be devastating to their business whereas it can be marked as a cost of business for the farms with larger funding pools.

***Farm Owner v. Farmworker Equity:*** *Low-medium externality burden for the farmworkers* – The externalities of pesticide use will shift significantly from the farmworkers to the farm owners. The farm owners will have to pay greater costs to ensure regulatory compliance that will guarantee better protection for the farmworkers, while the farmworkers will experience fewer episodes of pesticide poisoning. This alternative will not completely shift the externality burden, as it is only projected to reduce the number of pesticide poisoning cases by half. Therefore, the farmworkers will still shoulder some of the burden of pesticide externalities with their reduced number of pesticide poisoning cases.

***Administrative Feasibility****: High* – This alternative has a high level of administrative feasibility due to the low workload of implementation for the CACs. The enforcement agents will not have to change any of their inspection or enforcement strategies, instead they will just be able to give higher fines than they could in the past. This induces no extra workload for these individuals.

***Political Feasibility:*** *High* – Although a bill proposing this exact idea failed to pass in 2017, this policy alternative still has high political feasibility. The 2017 version lost by only 6 votes while the Democrats had 16 members that refused to vote due to a lack of knowledge on the topic. In 2019, the Democrats have grown their majority in the California Assembly and only need 41 of the 61 Democrats to vote for this proposal. With a sufficient education program for the previously non-voting Democrats, this alternative will likely pass if proposed again.

In the past, the parties that supported the Bill were the Democrats, DPR, PANNA, Environmental Working Group, Breast Cancer Prevention Partners, and California Rural Legal Assistance (Quirk, 2017). The opposition consisted of Republicans, the California Farm Bureau Federation, Western Growers Association, and the Western Plant Health Association (Quirk, 2017).

## Policy Alternative 2: Restricting the Use of Non-Penalizing Responses for Instances of Noncompliance

Currently, anywhere from 70-86% of regulatory violations only receive warning letters or violation notices. This current practice is teaching farmers that some instances of noncompliance are acceptable and will not be punished. Therefore, it is important that the Department of Pesticide Regulation shift away from non-penalizing, advising tactics and towards a stronger enforcement and prosecution strategy.

**This alternative suggests that the Department of Pesticide Regulation change the enforcement strategy of the CACs and require these individuals to levy a financial penalty for every instance of noncompliance**. These fines can be accompanied by the traditional warning letters and violation notices, but these non-penalizing actions can no longer be given on their own for regulatory violations. As noted previously, the other forms of non-penalizing responses are cease and desist orders and actions on licenses or permits. These types of responses must also be accompanied by a fine to ensure that the violators recognize their wrongdoing and are sufficiently punished to deter future violations.

In addition to the required use of financial penalties, there will be a minimum fine level of $100 to ensure that the CACs are not giving minute fines to work around this change. Fines between $100 and $500 are already the most common forms of financial punishments, so the CACs may levy more of these types of penalties for instances of noncompliance. This will help to sufficiently penalize the less risky regulatory violations that were previously only receiving violation notices and warning letters.

## Evaluation of Alternative 2

To evaluate Alternative Two, the restriction of non-penalizing compliance actions was assessed based on the previously established criteria.

***Effectiveness***: 25% *reduction in pesticide poisoning cases* - The projected 25% reduction in pesticide poisoning cases has no historical or literary background, as other environmental regulatory environments vary significantly in their number and size of fines. However, this alternative will likely be significantly less effective than Alternative One as it will largely focus on increasing compliance with regulations that previously were not penalized for noncompliance. These types of regulations are those that do not pose serious risks to human or environmental health, but rather affect the knowledge of farmworkers and the operations of the farm. A further breakdown of the regulations utilized to draw this conclusion is in the attached BCA spreadsheet.

The regulatory economic literature also supports this type of alternative to increase compliance. Two researchers found that an increase in the use of fines lead to a "surprisingly large decrease in violation rates (Shimshack & Ward, 2005)." Therefore, utilizing fines more frequently has academic support for its ability to increase compliance. Another paper found that an increase in enforcement and prosecution strategies can help to reduce instances of noncompliance that were previously treated leniently (Gunningham, 2011). These conclusions have led researchers to question why fines are not a more commonplace enforcement technique, as they have time and time again proved that they will lead to an increase in regulatory compliance (Shimshack & Ward, 2005).

***Cost-Benefit Analysis:*** *Net present value (NPV) between -$11.1 million and -$12.9 million* - This alternative has the most negative NPV of the action-alternatives evaluated. The difference in these estimates is the level of benefits accrued by the policy option. The benefit level depends on whether the reduction in cases is from the observed data on pesticide poisoning cases or the literary estimates on the true number of pesticide poisonings. The potential range of benefits for the next 10-years is between $6.4 and $8.2 million. The clear benefactors from this alternative are the farmworkers that will no longer be experiencing pesticide poisoning due to improved protection through compliance.

The estimated costs focus on the costs the farms must pay to achieve compliance with the listed alternatives that experienced the most frequent noncompliance and likely did not receive fines in the past. The range of costs for this estimate depends on the number of instances of noncompliance reduced with the implementation of this plan. The potential range of costs for the next 10 years is between $15.4 million and $23.1 million.

A sensitivity analysis of these estimates has been conducted and the NPV will likely never become positive unless the reduction in pesticide poisoning cases is much larger than expected. Even if the reduction is much larger than expected, the first alternative would still lead to a larger financial benefit.

A further breakdown of the costs, benefits, assumptions, and the full sensitivity analysis is included in Appendix B and accompanying Benefit-Cost Analysis spreadsheet.

***Large Farm v. Small Farm Equity:*** *Medium impact on smaller farms* – This policy option would have a medium impact on smaller farms due to the inherent nature of inequitable impact of regulations on smaller businesses. With the increased frequency of fines, the smaller businesses would likely be paying larger proportions than their bigger business counterparts. However, the impact would be slightly less as the fines will likely be less than $500 for instances of noncompliance.

***Farm Owner v. Farmworker Equity:*** *Medium externality burden for the farmworkers* – This policy option still leaves a large amount of the externality burden on the farmworkers, as this option is projected to only reduce the number of pesticide poisoning cases by 25%. This means that there will still be hundreds of cases of occupational pesticide poisoning annually in California. A portion of the burden will be shifted to the farm owners, as they are still paying a significant amount to increase compliance with the regulations, however it will not result in a noteworthy reduction of pesticide poisoning episodes.

***Administrative Feasibility:*** *Medium* – The administrative feasibility of this alternative is marked as medium due to the significant change in strategy required with this alternative. Instead of the current strategy of giving violation notices for approximately 80% of instances of noncompliance, the CACs will have to start levying fines for all of these regulatory violations. This will add a notable burden of work to the CACs, as they will have to impose fines in addition to a simple violation notice that details the regulation that the farm failed to comply with.

***Political Feasibility:*** *Low-Medium* – This alternative has low to medium political feasibility as this is a complete strategy change for the CACs. These enforcement agents will have to levy 80% more fines than they have in the past to farm owners and managers that they know and work with frequently. The farm owners have clear power in California's political landscape, so they will fight this policy option to avoid having to pay more frequent fines. This will add some complexity to the possibility of this strategy change, as the California Farm Bureau Federation and the Republicans will strongly oppose this alternative.

## Policy Option 3: Maintain the Status Quo

**This alternative suggests that the DPR does not take any action in regards to this issue.** Inaction may be the logical step, as the historical compliance rates were around 98.5% overall (DPR, 2017). Between 2012-2015 the annual average 311,941 items in compliance, while only 4,788 items did not comply annually (DPR, 2017). This shows that the farmers have been highly compliant with the present regulations, meaning that further enforcement action may be ineffective. Utilizing further resources on enforcement may be an inefficient way to address the true problem of pesticide poisoning.

Additionally, California's DPR is recognized as a leader in the pesticide regulation field nationally and internationally (DPR, "Pesticide Info"). The DPR strengthened the pesticide regulations within their state in hopes that it will further protect the relevant stakeholders from injuries and illnesses related to pesticides. They also have their divisions conducting research on the best practices in regards to pesticide regulation to ensure that the best practices for pesticide application and regulation are employed. With this knowledge, it is possible that the DPR has already considered relevant actions to further improve compliance in the field, but have not recognized any suitable methods. In California's agricultural context, the significant use of violation notices rather than monetary penalties may be the most effective strategy to ensure compliance.

Finally, status quo may be the preferred route of action as the root of the problem is the pesticides themselves rather than the methods of application of the harmful substances. There have been many instances where pesticides have drifted and caused harm, even when the label's direction were followed. This supports the idea that pesticides are the true problem and increasing the amount of regulation to ensure that sufficient protection measures are employed during and after their use may not be the most effective strategy to reduce the number of pesticide poisoning cases occurring in California. The instability and reactivity of the pesticides combined with their high levels of toxicity make them the likely target for limitations of their use rather than an increase in enforcement for the harmful substances.

## Evaluation of Alternative 3

To evaluate Alternative Three, the status quo was assessed based on the previously established criteria.

***Effectiveness:*** *0% reduction in pesticide poisoning cases* – This alternative will not have a clear impact in reducing the number of occupational pesticide poisoning cases in California. There current annual average of approximately 350 will continue with the possibility that there are even more cases that are not reported. Estimates have shown that there could be up to 450 cases of farmworker pesticide poisoning annually, imposing even larger costs on the farmworkers and society at large.

***Cost-Benefit Analysis:*** *NPV of $0* – If the status quo continues, there will not be any change to the baseline costs of the agricultural regulation world. The farms will still pay lesser costs than they should, while the farmworkers will continue to bear the burden of the externalities of pesticide use.

***Large Farm v. Small Farm Equity:*** *Low impact on smaller farms* – There will not be any change in the equity of large and small farms in the event that California maintains the status quo. However, there will still be an inequitable situation for small farms due to the inherent impact of regulations on smaller firms. These firms will continue to struggle to maintain the costs of compliance while their larger counterparts can easily internalize penalties as costs of business.

***Farm Owner v. Farmworker Equity:*** *High externality burden for the farmworkers* – The farmworkers will continue to bear the burden of the externalities of pesticide use due to their high potential for pesticide poisoning while on the job. Meanwhile, the farmers will continue to pay less than optimal compliance costs, as the penalties for noncompliance are insufficient.

***Administrative Feasibility:*** *High* – This alternative has high administrative feasibility, as the enforcement and inspection agents will not have to change their ways at all. This puts no extra workload on the DPR and CACs, making it highly feasible to continue present trends.

***Political Feasibility:*** *High* – This alternative has high political feasibility due to the lack of changes to the current system. The political sphere will not have to get involved, as there are no changes to the current regulatory and enforcement systems.

# OUTCOMES MATRIX

This matrix provides a summary of each alternatives scoring on the chosen evaluative criteria.

| Evaluation Criteria | Impact Description | Policy Alternatives | | |
|---|---|---|---|---|
| | | ***Alternative 1: Raising the Maximum Potential Fine for Instances of Noncompliance*** | ***Alternative 2: Restricting the Use of Non-Penalizing Responses for Instances of Noncompliance*** | ***Alternative 3: Maintain the Status Quo*** |
| **Effectiveness at Reducing Pesticide Poisoning Cases Among Agricultural Workers** | Estimated Proportion of Pesticide Poisoning Cases Avoided | 50% | 25% | 0% |
| **Equity** | Farmworker's Burden of Externalities | Low-Medium | Medium | High |
| | Impact on Agricultural Operations of Smaller Farms | High | Medium | Low |
| **Cost-Benefit Analysis** | Net Present Value for 10-Year Time Frame | -$8.55 million | -$12.0 million | $0 |
| **Political Feasibility** | Likelihood of Successful Adoption | High | Low-Medium | High |
| **Administrative Feasibility** | Ease of Implementation | High | Medium | High |

Given the project outcomes of the alternatives and their respective scores for the other evaluative criteria, I recommend that the Pesticide Action Network of North America pursue Alternative X to address the issues of occupational pesticide exposure in California's agricultural system.

# POLICY RECOMMENDATION

**The Pesticide Action Network of North America could best address California's occupational pesticide poisoning and regulatory noncompliance issues by advocating for an increase of the maximum penalty for instances of noncompliance (Alternative 1)**. To reach this conclusion, I evaluated each alternative's effectiveness in reducing pesticide poisoning cases, cost-benefit analysis, equity concerns, administrative feasibility, and political feasibility. The two government-action alternatives represent the best, economically-proven strategies to address these issues. However, after considering the true impacts of each strategy, Alternative 1 has the greatest potential to achieve the stated goals of increasing compliance and reducing the number of pesticide poisoning cases among farmworkers.

Alternative 2, Restricting the Use of Non-Penalizing Compliance Actions, was not recommended due to its lack of effectiveness in reducing the number of pesticide poisoning cases among agricultural workers. This strategy offers a slight benefit over the other alternative in the fact that the costs are lower than Alternative 1. However, the benefits are also much lower due to the lack of a reduction of the number of pesticide poisoning cases, so the NPV is far more negative. This alternative also helps to maintain a more equitable regulatory situation between the large and small farms, not offered by the first alternative. Unfortunately, this comes at the detriment of the farmworkers as they continue to bear a majority of the burden of pesticide externalities.

Alternative 3, Maintaining the Status Quo, was not recommended due to its failure to reduce pesticide poisoning and agricultural noncompliance. This alternative would not take any action to address these issues, so the problems with California's agricultural system would continue. However, this alternative would have some minor benefits in the fact that no spending would have to occur, the administrative actions would remain the same, and the political sphere would not have to get involved. Although these three criteria make it the easiest option to choose, it still does not disguise the clear failure to address the issues with pesticide poisoning and noncompliance.

Based on my systematic evaluation of all proposed alternatives, I recommend that the Pesticide Action Network of North America advocate for an increase in the maximum penalty for violations of state and federal pesticide regulations in California. Although this alternative has the highest costs, the effectiveness in increasing compliance and reducing the number of pesticide poisoning cases more than makes up for it. Additionally, this alternative has high political and administrative feasibility making it likely that this alternative will be implemented if chosen. Of the proposed options, Alternative 1 has the best chance to change the agricultural landscape of California by protecting the farmworkers and shifting the burden of the externalities of pesticides to the farm owners that are forcing their use.

# IMPLEMENTATION CONSIDERATIONS

Implementing this policy requires a four-pronged strategy to ensure that it will be passed into bill and properly utilized by the DPR and CACs.

## Advocacy Campaign

To ensure that this proposal is passed into law, PANNA should avoid the failures of the previous proposal by Bill Quirk in 2017. Quirk noted that a lack of knowledge on the effects of the proposal was the main reason that 16 of the Democrats refused to vote on the bill. PANNA should focus on the education of these individuals and new state politicians that were not in office for the previous voting session to ensure that they are educated and ready to support the proposal.

The Democratic California State Assembly members to target in this education campaign are: Cecilia Aguiar-Curry, Joaquin Arambula, Sydney Kamlager-Dove, Jesse Gabriel, James Ramos, Luz Maria Rivas, Christy Smith, Robert Rivas, Evan Low, Rebecca Bauer-Kahan, Buffy Wicks, Sabrina Cervantes, Ken Cooley, Susan Eggman, Eduardo Garcia, Mike Gipson, Adam Gray, Tim Grayson, Jacqui Irwin, Jose Medina, Sharon Quirk-Silva, Freddie Rodriguez, Blanca Rubio, and Rudy Salas. These are the Democratic individuals that either refused to vote on the previous rendition of the bill or were newly elected into office in 2018. Therefore, they are the state legislators with unknown votes on the topic and educating them will have the greatest impact on gaining their support.

The campaign should include information on previous pesticide poisoning incidents, the need to update this outdated limit on monetary penalties, how fines are effective in achieving compliance, and how this proposal would help to protect the farmworkers who are bearing the majority of the externalities of pesticide use. This report should help to fill in the majority of the information necessary to educate these members.

## Meeting with CACs

If this proposal passes into law, the DPR's Enforcement Branch should hold a meeting with the CACs to ensure that they take advantage of this newfound enforcement power to properly punish farms for noncompliance that poses serious risks to human health. This meeting will gather the relevant enforcement agents to inform the why this policy change was necessary, the economic merits of the proposal, and the desired outcomes from the policy implementation.

The DPR should focus on how this policy will help to increase compliance which will subsequently reduce the number of pesticide poisoning incidents among agricultural workers. They then should discuss the merits from the economic literature that will help to prove the effectiveness of this measure. The relevant information for this section can be found in the evaluation of the effectiveness of Alternative 1. Finally, they should close the meeting discussing how the main point of this regulation is to protect farmworkers from future exposure to pesticides. The DPR is not hoping to have higher penalties for farms that fail to comply, they would rather have them spend this money on further compliance actions that can protect the workers using the pesticides frequently. The desired outcome of this section is to show that they are not working against the farms, but rather with them to help protect the valuable farmworkers who are currently under-protected.

## Letter Distributed to Farm Owners

In the event that this proposal passes into law, it is also important for the DPR to address the regulated farms. This letter will help to inform farm owners why the change was necessary, the desired outcomes from the policy change, and how these farms will be affected.

In the letter, the DPR must discuss how the goal of the policy change is to increase compliance and subsequently reduce the number of pesticide poisoning cases among agricultural workers. Discuss how these regulations are the current best methods for protecting the farmworkers and safely managing pesticides in an agricultural setting. This will help to explain how these regulations are crucial to follow all the time as they ensure the farmworkers are sufficiently protected from the hazards of pesticide use.

The DPR should conclude the body of the letter discussing how the farmers can avoid these significant penalties by guaranteeing compliance with all of the relevant pesticide regulations. Compliance will lead to lower costs for farms than they would if they failed to comply and posed serious risks to their workers' health. This will help to sell them that they can maintain low costs while guaranteeing better protection for their farmworkers.

## Monitoring of the Use of Higher Penalties and the Resultant Effectiveness

Finally, it is important that the DPR continue their monitoring efforts and specifically focus on the effectiveness of this policy change. They should focus to see how the value of fines changes after implementation and if the higher fines are being used in all cases where there is a serious risk to human or environmental health. This monitoring will help to see if the policy change is actually being utilized and how the policy has affected the compliance rate and quantity of pesticide poisoning cases.

If the penalty increase is not being effectively utilized, then that suggests an area for improvement for the DPR. They can adjust their advisement to the CACs and alter their strategy to try and increase use of the higher penalties.

If maximum value fines are being used effectively, then the DPR should commend the CACs for their efforts and detail the effects of the policy change. They should specifically detail how the policy change has affected compliance and pesticide poisoning rates.

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# APPENDIX A

The seven main responsibilities of the DPR are (DPR, “Chapter 1”):
- Pesticide evaluation and registration
- Licensing of individuals consulting, selling, and applying pesticides in California
- Health impact evaluation through surveillance of illnesses and risk assessments
- Monitoring of air, water, and soil conditions relevant to pesticide use
- Enforcement of relevant pesticide regulations
- Testing fresh produce for excessive pesticide residue
- Developing safer, lower-toxicity pest management practices and encouraging their use with incentives and grants to those who apply them

The DPR is organized into three different divisions to ensure effective enforcement, development, and support regarding the relevant pesticide regulations for the state. The overarching divisions of the DPR are the Pesticide Programs Division, the Administrative Services Division, and the Office of Technology Services (DPR, “How Does California”). The Administrative Services Division and the Office of Technology Services operate on their own accord, while the Pesticide Programs Division is split up into seven separate branches. The underlying branches of the Pesticide Programs Division are Pesticide Registration, Human Health Assessment, Worker Health and Safety, Pesticide Enforcement, Environmental Monitoring, Product Compliance, Pest Management and Licensing (DPR, “How Does California”). To operate these divisions, there are approximately 400 employees with responsibilities ranging from public administration to scientific research (DPR, “Chapter 1”). In fiscal year 2017, the DPR had a budget of $100.8 million to carry out their listed responsibilities (DPR, “Chapter 1”).

# APPENDIX B - COST-BENEFIT ANALYSIS

**Problem Definition**

The California agricultural pesticide regulations and the actions taken to enforce them are ineffective at protecting the workers interacting with the dangerous pesticides. Researchers have found that workers in agricultural settings are 38x more likely to experience pesticide poisoning and 5.4x more likely to die on the job when compared with workers in all other industries. These workers disproportionately suffer from pesticide exposure due to insufficient regulatory enforcement and the resultant issues with noncompliance. Therefore, it is important for the government to take action to redistributive action to protect farm workers that are frequently exposed to dangerous pesticides.

**Opportunities to Solve the Problem**

The first policy change the Department of Pesticide Regulation could make is to increase in the maximum possible fine for an instance of noncompliance to $25,000. The current maximum fine is only $5,000 and has not been raised since 2002. An increase in the maximum potential fine should lead to an increase in compliance with regulations that frequently receive higher fines. Higher fines are associated with instances of noncompliance that have higher risks toward environmental and human health. Posing more significant fines to regulations with higher human health risks has been found to lead to an increase in compliance spending and overall compliance rates. This would lead to better compliance with protective regulations that will result in a reduction of the number of pesticide poisoning cases.

The second alternative to address the problem would restrict the use of non-penalizing actions when addressing instances of noncompliance. Over 80% of regulatory violations in California's agriculture sector receive non-penalizing actions such as warning letters or violation notices. Currently, only 20% of regulatory violations receive punishments for their compliance failures. Many of the instances of noncompliance that are not truly punished are regulations that have a lesser risk of environmental and human health impacts. Therefore, the implementation of this strategy would largely reduce more minor instances of noncompliance with a small reduction in the number of pesticide poisoning cases annually.

The third alternative considered is to let present trends continue. This alternative will not be analyzed, as there are no clear additional costs or benefits that need to be valued in this instance. This alternative will have no effect on the current baseline, so there will be no monetary change if this alternative is implemented.

**Benefits and How They're Valued**

The major benefits considered in this analysis are money saved by avoiding missing work, money saved by avoiding hospitalization, and money saved by avoiding cases of cancer due to pesticide poisoning. These are the major benefits categories related to farmworker health and pesticide exposure that could be reliably measured to conduct a thorough analysis. Other potential benefits that were not considered in this evaluation were benefits from a reduction in potential health risks without sufficient costs and incidence rate data, greater environmental protection, increased aesthetic value from greater environmental protection, and a reduction in the number of crops lost by pesticide use.

***Money Saved Avoiding Lost Work Days***

This value was calculated using David Pimentel's estimated average number of days of work missed due to pesticide poisoning. Pimentel found that, on average, five days of work were missed per case. I then found the average hourly wage of a farm worker and multiplied that by 8 hours per day and 5 days of missed work to obtain the value.

***Money Saved Avoiding Hospitalization***

This value was calculated using David Pimentel's estimated costs of hospitalization per pesticide poisoning case. This value was then CPI adjusted to obtain the 2019 value of the cost of hospitalization for an average pesticide poisoning case.

***Money Saved Avoiding Cases of Cancer Due to Pesticide Poisoning Cases***

This value was obtained using Pimentel's estimated costs of a case of cancer from pesticide exposure. This value was also adjusted using CPI to obtain the cost of each case of cancer in 2019 dollars. Pimentel also estimated that cancer occurred in only 0.5% of cases, so this cost was estimated by the number of cases reduced by each alternative.

**Costs and How They're Valued**

The major costs considered in this analysis focus on the increased costs of regulatory compliance for private farms. The potential policy alternatives are meant to increase spending by the farms to avoid higher or more frequent penalties, so the farms will instead spend more money to guarantee regulatory compliance. There are some potential costs that were not valued in this analysis, including unforeseen government costs of implementation and reductions in competitiveness in California's agriculture market. The latter would mainly focus on costs to smaller farms that may be pushed out of business due to higher compliance costs.

To quantify the costs, I utilized data on the most frequently violated regulations. This list included the average number of violations annually, which allowed for an estimated proportion of instances of noncompliance by regulation. Once there was a number of violations avoided for each of the regulations, the costs of each instance of compliance were calculated. The regulations included in the analysis of each alternative varied based on their potential for significant risks to human or environmental health. The regulations that posed significant risks to human and environmental health were all quantified in the first alternative. The second alternative included some of these regulations and the additional, low-risk regulations from the Department of Pesticide Regulation data. Each alternative projected a 40-60% reduction in the number of instances of noncompliance. This helped to quantify the costs of compliance for each alternative.

The list of regulations is provided below. Each regulation is followed by a one, two, or both, marking the alternatives where its costs are considered.

1. Follows labelling and/or permit conditions (both)
2. Regulations- personal protective equipment (one)
3. Respiratory protection (one)
4. Handler training (both)
5. Emergency medical care, posting (two)
6. Pest control business/equipment registered (two)
7. Handler decontamination facilities (both)
8. Service container labeling (two)
9. Labelling available at use site (two)
10. Hazard communication / field workers (one)

Each regulation was then analyzed to collect the relevant costs. These costs are discussed below in four overarching groups. The more specific costs of compliance are included in the assumptions section of the accompanying spreadsheet.

**Valued Costs and Benefits of Alternative One**

| **Costs** | | **Benefits** | |
|---|---|---|---|
| **Raising Max Fine** | NPV | **Raising Max Fine** | NPV |
| Cost of complying with "follows labelling and/or permit conditions" regulation | $9,252,409.10 | Benefit of avoiding hospital costs for each instance of pesticide poisoning avoided | $14,163,320.81 |
| Cost of complying with "personal protective equipment" regulation | $3,480,790.14 | Benefit of avoiding missed work for each instance of pesticide poisoning avoided | $944,160.60 |
| Cost of complying with "respiratory protection" regulation | $1,098,063.08 | Benefits of avoiding cancer for each instance of pesticide poisoning avoided | $729,010.03 |
| Cost of complying with "handler training" regulation | $6,962,348.55 | | |
| Cost of complying with "handler decontamination facilities" regulation | $2,159,468.94 | | |
| Cost of complying with "hazard communication / field workers" regulation | $195,854.34 | | |

### Valued Costs and Benefits of Alternative Two

| Costs | | Benefits | |
|---|---|---|---|
| Stop Use of ComActs | | Stop Use of ComActs | |
| | NPV | | NPV |
| Cost of complying with "follows labelling and/or permit conditions" regulation | $9,252,409.10 | Benefit of avoiding hospital costs for each instance of pesticide poisoning avoided | $7,078,544.85 |
| Cost of complying with "emergency medical care, posting" regulation | $39,953.58 | Benefit of avoiding missed work for each instance of pesticide poisoning avoided | $471,872.61 |
| Cost of complying with "handler training" regulation | $6,962,348.55 | Benefits of avoiding cancer for each instance of pesticide poisoning avoided | $364,344.65 |
| Cost of complying with "handler decontamination facilities" regulation | $2,159,468.94 | | |
| Cost of complying with "service container labelling" regulation | $178,214.02 | | |
| Cost of complying with "labelling available at use site" regulation | $475,938.32 | | |
| Cost of complying with "hazard communication / field workers" regulation | $195,854.34 | | |

### Annual Costs and Benefits of Alternative One

**Costs**

| Raising Maximum Fines | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 | 5 |
| High Costs | $3,462,135 | $3,235,640 | $3,023,963 | $2,826,133 | $2,641,246 | $2,468,454 |
| Best Costs | $2,885,112 | $2,696,367 | $2,519,969 | $2,355,111 | $2,201,038 | $2,057,045 |
| Low Costs | $2,308,090 | $2,157,093 | $2,015,975 | $1,884,089 | $1,760,831 | $1,645,636 |

**Costs**

| Raising Maximum Fines | 2025 | 2026 | 2027 | 2028 | 2029 | |
|---|---|---|---|---|---|---|
| Year | 6 | 7 | 8 | 9 | 10 | NPV |
| High Costs | $2,306,967 | $2,156,044 | $2,014,994 | $1,883,172 | $1,759,974 | $27,778,721 |
| Best Costs | $1,922,472 | $1,796,703 | $1,679,162 | $1,569,310 | $1,466,645 | $23,148,934 |
| Low Costs | $1,537,978 | $1,437,362 | $1,343,329 | $1,255,448 | $1,173,316 | $18,519,147 |

**Benefits**

| Raising Maximum Fines | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 | 5 |
| Estimated Value Benefits | $2,033,529 | $1,900,495 | $1,776,163 | $1,659,966 | $1,551,370 | $1,449,878 |
| Average Value Benefits | $1,815,236 | $1,696,482 | $1,585,497 | $1,481,773 | $1,384,835 | $1,294,238 |
| Observed Value Benefits | $1,596,942 | $1,492,469 | $1,394,831 | $1,303,581 | $1,218,300 | $1,138,598 |

**Benefits**

| Raising Maximum Fines | 2025 | 2026 | 2027 | 2028 | 2029 | |
|---|---|---|---|---|---|---|
| Year | 6 | 7 | 8 | 9 | 10 | NPV |
| Estimated Value Benefits | $1,355,026 | $1,266,380 | $1,183,533 | $1,106,105 | $1,033,743 | $16,316,188 |
| Average Value Benefits | $1,209,568 | $1,130,438 | $1,056,484 | $987,368 | $922,774 | $14,564,692 |
| Observed Value Benefits | $1,064,110 | $994,495 | $929,435 | $868,631 | $811,804 | $12,813,196 |

**Annual Costs and Benefits of Alternative Two**

**Costs**

| Stop Use of ComActs | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 | 5 |
| High Costs | $2,881,135.33 | $2,692,649.84 | $2,516,495.18 | $2,351,864.65 | $2,198,004.35 | $2,054,209.67 |
| Best Costs | $2,400,946.11 | $2,243,874.86 | $2,097,079.31 | $1,959,887.21 | $1,831,670.29 | $1,711,841.39 |
| Low Costs | $1,920,756.88 | $1,795,099.89 | $1,677,663.45 | $1,567,909.77 | $1,465,336.23 | $1,369,473.11 |

**Costs**

| Stop Use of ComActs | 2025 | 2026 | 2027 | 2028 | 2029 | |
|---|---|---|---|---|---|---|
| Year | 6 | 7 | 8 | 9 | 10 | NPV |
| High Costs | $1,919,822.12 | $1,794,226.28 | $1,676,846.99 | $1,567,146.72 | $1,464,623.10 | $23,117,024.22 |
| Best Costs | $1,599,851.77 | $1,495,188.57 | $1,397,372.49 | $1,305,955.60 | $1,220,519.25 | $19,264,186.85 |
| Low Costs | $1,279,881.41 | $1,196,150.85 | $1,117,897.99 | $1,044,764.48 | $976,415.40 | $15,411,349.48 |

**Benefits**

| Stop Use of ComActs | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|
| Year | 0 | 1 | 2 | 3 | 4 | 5 |
| Estimated Value Benefits | $1,016,317.29 | $949,829.24 | $887,690.88 | $829,617.64 | $775,343.59 | $724,620.18 |
| Average Value Benefits | $906,275.89 | $846,986.81 | $791,576.46 | $739,791.09 | $691,393.54 | $646,162.19 |
| Observed Value Benefits | $796,234.50 | $744,144.39 | $695,462.04 | $649,964.53 | $607,443.48 | $567,704.19 |

**Benefits**

| Stop Use of ComActs | 2025 | 2026 | 2027 | 2028 | 2029 | |
|---|---|---|---|---|---|---|
| Year | 6 | 7 | 8 | 9 | 10 | NPV |
| Estimated Value Benefits | $677,215.12 | $632,911.33 | $591,505.91 | $552,809.27 | $516,644.17 | $8,154,504.63 |
| Average Value Benefits | $603,889.89 | $564,383.08 | $527,460.82 | $492,954.04 | $460,704.71 | $7,271,578.51 |
| Observed Value Benefits | $530,564.66 | $495,854.83 | $463,415.73 | $433,098.81 | $404,765.24 | $6,388,652.40 |

**General Methodology Summary**

This analysis utilized a 10-year period to sum the costs and benefits. Each year, the costs and benefits were discounted by 7%. This discount rate was chosen as the costs and benefits are largely borne by the private farms and their hired farm workers. Other analyses often include 3 percent and 5 percent iterations, but the fact that the costs and benefits are consistent throughout the 10-year period means that the valuation will not change significantly. The only outcome that would change is the total sum of the costs and benefits, not the net present value.

**Sensitivity Analyses**

As observed above, there were three levels of costs and three levels of benefits calculated to analyze the impact of different values on the outcomes. The three cost levels were at a 40%, 50%, and 60% reduction in violations. The level of benefits varied by the estimated number of pesticide poisoning cases in California each year. The observed value is the 2003-2015 average annual tracked by the Department of Pesticide Regulation. The estimated value is based off of Sandra Mort and Rick Langley's research that found that there were approximately 58 cases per 100,000 farmworkers. This value was then extrapolated to the maximum farm worker population of 848,000 observed in California in 2017.

These values helped to set up a more thorough sensitivity analysis to address potential uncertainty in the estimates and establish confidence in the results. The following sections summarize the break-even analysis and an elasticity analysis. The data for these analyses can be found on the "Sensitivity Analysis" tab of the accompanying spreadsheet.

***Breakeven Analysis***

Since the net present value's for each alternative are positive when only evaluating the best costs and best benefits, it is important to conduct a break-even analysis to see which situations the net present value would be positive. For the first alternative, the net present value will not be positive in any likely situation. In the case that the number of cases avoided even exceeds the highest expected value, then the net present value would become positive.

The breakeven analysis of the second alternative found that it is highly unlikely that the net present value will ever become positive. This is because the benefits of this alternative are very small while the costs are close to that of the first alternative. This shows high confidence that this alternative will not be a logical policy for the government to implement.

***Elasticity Analysis***

This section discovers that the analysis is much more sensitive to shifts in the benefits than shifts in the costs. The elasticity of the benefits for the first alternative is 4.5 while the elasticity of the quantity is only around 1.5. This value is approximately 3 times larger, meaning variation in the benefits has a much larger impact on the net present value. Further research on this topic should work to determine an even more accurate estimate of the benefits provided by each alternative.

The second alternative has a similar trend to the first alternative. The elasticity of the benefits is around 3 while the elasticity of the quantity is below 1. This leads to a similar conclusion that focusing on the benefits for each alternative can help to lower uncertainty so that confidence in the net present value is higher in future iterations.

**Snapshot Comparison of Alternatives**

| Comparison of Costs and Benefits of Alternatives | | | | | | |
|---|---|---|---|---|---|---|
| *Policy Alternative* | *Costs* | *Benefits* | Benefit-Cost Ratio (high benefits) | Benefit-Cost Ratio (low benefits) | Net Present Value (high benefits) | Net Present Value (low benefits) |
| Alternative 1: Raising the Maximum Fine for Instances of Noncompliance | $18.5-27.8 million | $12.8-15.8 million | 0.68 | 0.55 | -$6,832,747 | -$10,335,738 |
| Alternative 2: Restricting the Use of Non-Penalizing Compliance Actions | $15.4-23.1 million | $6.4-8.2 million | 0.43 | 0.32 | -$11,109,682 | -$12,875,534 |
| Alternative 3: Maintain the Status Quo | No change | No change | 0 | 0 | $0.00 | $0.00 |

**Final Recommendation**

I recommend that the Pesticide Action Network advocate for Alternative 1, raising the maximum potential fine for regulatory violations. This is the best alternative as it has the least negative net present value of the two government-action alternatives, no matter what benefit level is obtained. This occurs because the benefits for a reduction of pesticide poisoning cases is much larger than that of the Alternative 2, while the costs are only slightly higher. Another method of comparison that shows Alternative 1 is more preferable to Alternative 2 is the benefit-cost ratio (BCR). The BCR is always higher for Alternative 1, no matter what level of benefits is achieved. This is an important measure, as it shows that the losses will always be less for Alternative 1 rather than Alternative 2. These conclusions are easily displayed in the comparison table found above, showing that Alternative 1 is always more preferable to Alternative 2 in terms of the cost-benefit analysis.

The inclusion of potentially unvalued benefits and costs could lead to a shift in the recommendation, but this is highly unlikely. The benefits that were left out of this analysis have a greater chance of making the NPVs less negative when compared to the chances that the unvalued costs would make the NPVs more negative. The unvalued benefits that could shift this outcome are benefits from a reduction in potential health risks without sufficient costs and incidence rate data, greater environmental protection, increased aesthetic value from greater environmental protection, and a reduction in the number of crops lost by pesticide use. On the other hand, the costs that were left out of this analysis are unforeseen government costs of implementation and reductions in competitiveness in California's agriculture market.

The spreadsheet displaying the finer details of the costs and benefits can be found at: https://www.dropbox.com/s/ofs8lwyhmxts92i/Final%20BCA%20Spreadsheet%20-%20Hassler.xlsx?dl=0