Report on CDFA Project 'Evaluating SPM adoption by Pest Control Advisors (PCAs)' in partnership with the California Association of Pest Control Advisors (CAPCA)

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Summary

Pest Control Advisors or "PCAs" are licensed professional who provide a crucial service in California agriculture, scouting for pest problems in fields and providing growers with recommended actions for their control. While pesticide applications are often recommended, PCAs base these recommendations on pest monitoring activities, field history, and regional and weather-based factors. Though reports of agricultural pesticide applications in California must be submitted to the Department of Pesticide Regulation, they do not include information on how the PCA reached their recommendation nor do they mention any non-pesticidal recommendations made by PCAs. In an effort to bridge this information gap, CDFA partnered with the California Association of Pest Control Advisors (CAPCA) to survey PCAs throughout the season and identify what factors influenced their management decisions and how that translated into pest management practices throughout the state. This information will assist in implementing the many objectives of the Sustainable Pest Management (SPM) Roadmap, which includes explicit aims to improve educational opportunities for PCAs.

The survey project provided a trove of information on PCA experience and decision-making, and this report provides only a brief overview into that data. Many PCAs provided extensive notes detailing their experiences and work processes. Most crucially, we show that across crops, business types, and experience levels, PCAs synthesize information from many sources before making recommendations. Furthermore, we find that in the majority of circumstances, PCAs recommend no action be taken to allow for further monitoring to occur. Recommendations for conventional chemical treatments, though common, occur only when justified by observed pest pressures, upcoming weather events, or known local factors. In many cases, agronomic practices such as hand-weeding, changing irrigation amounts, or adjusting the timing of planting or harvest were used prior to chemical applications.

Specific SPM practices described by PCAs varied by crop, likely based on how each specific production system functions. For example, alfalfa grown for livestock forage likely has a higher

tolerance for damage than high-value wine grapes, and PCAs make their recommendations accordingly. PCAs' business types and relationships with growers and distributors also had an effect on their management strategies, affecting which pesticides are used and what quality crops must attain to be marketable.

CDFA plans to conduct further analyses using the information collected with this pilot project, with the goal of assisting in the development of SPM-focused continuing education courses for PCAs.

Background

State agencies and the public have access to decades of pesticide use data through the Pesticide Use Reporting (PUR) database, which contains reports of pesticide applications by date, location, commodity treated, and pesticide product used. While valuable, PUR data is only generated when a pesticide application has occurred, and does not include information on the context behind the decision (weather, pest pressure, field history, etc) nor other non-pesticide management practices that were used. The state's goal of promoting and implementing Sustainable Pest Management (SPM) as established in Section 11520 of the Food and Agricultural Code will require a full understanding of how pest management is currently practiced throughout the state to help design effective programs and policies.

In the fall of 2023, CDFA awarded a grant to the California Association of Pest Control Advisors (CAPCA) to run a pilot project on data collection of pest management practcies and how decisions to apply pesticides are made; the project was titled "Evaluating sustainable pest management (SPM) adoption by Pest Control Advisers (PCAs) in selected cropping systems, documenting PCA decision making processes, and developing gap-addressing resources." The objective was to understand current practices, identify knowledge gaps, and spotlight opportunities in the uptake of IPM, SPM, and evolving innovations.

Participants for the study were identified by CAPCA, using online advertisements, outreach at conferences, and with the assistance of several interns who were trained and supported using funding from CDFA. Interns were based in four regions throughout the state, and specific efforts were made to recruit PCAs from across a geographic range and covering different crops. For ease of interpretability and comparison, we only selected PCAs who managed at least one of six crops: almond, alfalfa, lettuce, pistachio, tomato, or grape.

Methods

PCAs were provided monetary incentives ($2,000 per participant) to enroll a field and provide consistent, detailed updates on pest pressures, agronomic factors, grower conversations, and other information that informed their pest management decision-making in that field for the entire growing season. Fields varied in size, and PCAs likely managed several similar fields nearby. Reports included standardized information about the field's management and pest status, but also allowed for PCAs to fully explain their information gathering and decision-making processes leading up to a recommendation to the grower. Information was submitted using an app developed by CAPCA through this project, "CropSteward", that allowed for consistent and accurate data collection.

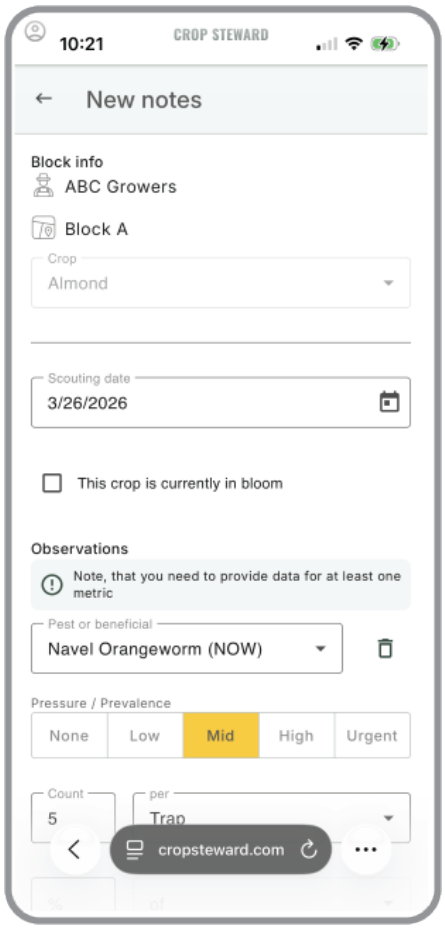


Figure 1: CropSteward Observation Interface on Mobile Phone

Once fully enrolled, PCAs received an online training to familiarize themselves with use of CropSteward and the objectives of the project. Throughout their respective growing season, PCAs recorded one observation whenever they made a recommendation to the grower about the observed field. These recommendations included making pesticide applications, changing farm management, and intensifying monitoring, but could (and often did) include no recommended action required for the field if pest pressures were not high. PCAs also selected what sustainable pest management practices were in place in the field, which included a range of mechanical, biological, and agronomic practices used to reduce pest pressures or improve the effectiveness of management actions. The data were anonymized by CAPCA then sent to OPCA for analysis.

CAPCA interns monitored PCA's reporting practices, including visiting several PCAs in the field, and at the conclusion of that field's growing season the PCA was awarded their financial incentive. A smaller survey project was also completed in 2024 using a different data collection system, but we have excluded that data here given limited participation and varied data structure.

Survey Data Collection

Below is an example of the type of data CDFA received. We also received data on the PCA experience, field size, and pest thresholds, but removed them here for ease of reading. PCAs had no text limits for their descriptions of SPM practices and "Insights", and the app included voice-to-text functionality, leading to extensive commentary by some PCAs. While many of these descriptions are duplicated by pest type for each observation date, our analysis later accounts for this by selecting only unique responses. The data below are from a Pistachio PCA in Fresno County:

Date	Pest	Action	SPM Practices	SPM Descriptions	Insights
5/29/2025	Fleabane, hairy	Mechanical control	Hand crew / hand labor / rogueing	Fleabane is too large to be happy with chemical results. I advised grower to hand crew the fleabane to pull the root out. He will be happier with the end result	Fleabane is a contrast problem. Wish new herbicides were available to rotate chemistries for control and not develop resistance
6/9/2025	Plant Bugs	NONE	Mowing and trimming	vegetation in the middles is getting large and can harbor plant bugs. I advised the grower to mow when he can	Overall the field looks good. We will continue to monitor for pests throughout the season until harvest. I am expecting weeds to continue to be a problem since there is little shade out in the young orchard.
6/9/2025	Botryosphaeria Blight	NONE	Mowing and trimming	vegetation in the middles is getting large and can harbor plant bugs. I advised the grower to mow when he can	Overall the field looks good. We will continue to monitor for pests throughout the season until harvest. I am expecting weeds to continue to be a problem since there is little shade out in the young orchard.
6/20/2025	Gill's Mealybug	NONE	Dust fencing / dust management	noticed now that the temps are rising and sustained dry conditions that the roads are getting very dusty. I spoke with grower about potentially watering roads or treating to settle dust	Field is still looking very healthy. Grower is on top of fertilizer practice and no need to treat for insects or disease. Expecting a herbicide application in the coming weeks to control Nutsedge and fleabane
6/20/2025	Yellow nutsedge	NONE	Dust fencing / dust management	noticed now that the temps are rising and sustained dry conditions that the roads are getting very dusty. I spoke with grower about potentially watering roads or treating to settle dust	Field is still looking very healthy. Grower is on top of fertilizer practice and no need to treat for insects or disease. Expecting a herbicide application in the coming weeks to control Nutsedge and fleabane

Participant Information

While all personally identifying information was anonymized by CAPCA before CDFA had access, the dataset includes information on what crop the PCA was observing, what county they were in, how many years of experience they have, and whether they worked as a retail, in-house, or independent PCA (defined below). Here we report details on the 118 PCAs who participated in the study.

While PCAs had to enroll one block for the study, many PCAs manage many different crop types and may have experience working with several crops included here. PCAs also self-reported their business affiliations for the study. Retail PCAs are those that work for a company that specializes in the sale of agricultural chemicals. Grower/In-House PCAs are those that are employed by a single farming operation, including growers who function as their own PCA. Independent PCAs are those that are operate their own businesses and are hired by growers to manage their fields. Rather than display PCAs by county, here we use the regional categories as designated in PUR. PCAs may cover fields in several counties; this graph reflects the region that the enrolled field was in.

Figure 2: Participant Information

PCAs were fairly evenly distributed by crop type enrolled. Retail PCAs made up half of the participants, with a fairly even split between In-House and Independent PCAs. Two thirds of PCAs had 6 or more years of experience, with only 11% having less than 3 years. Most PCAs in this study were based in either the San Joaquin or Sacramento Valleys, however agricultural production regions across the state are represented.

Importantly, we did not require PCAs to report whether the field they were managing was registered organic. While some identified fields as organic in their reports, we do not include that in any analyses.

Survey Results

In 2025, we had 2,084 unique observations from PCAs. Each observations correlates to a single pest species on a single date, so multiple observations on the same date could occur if multiple pests are recorded.

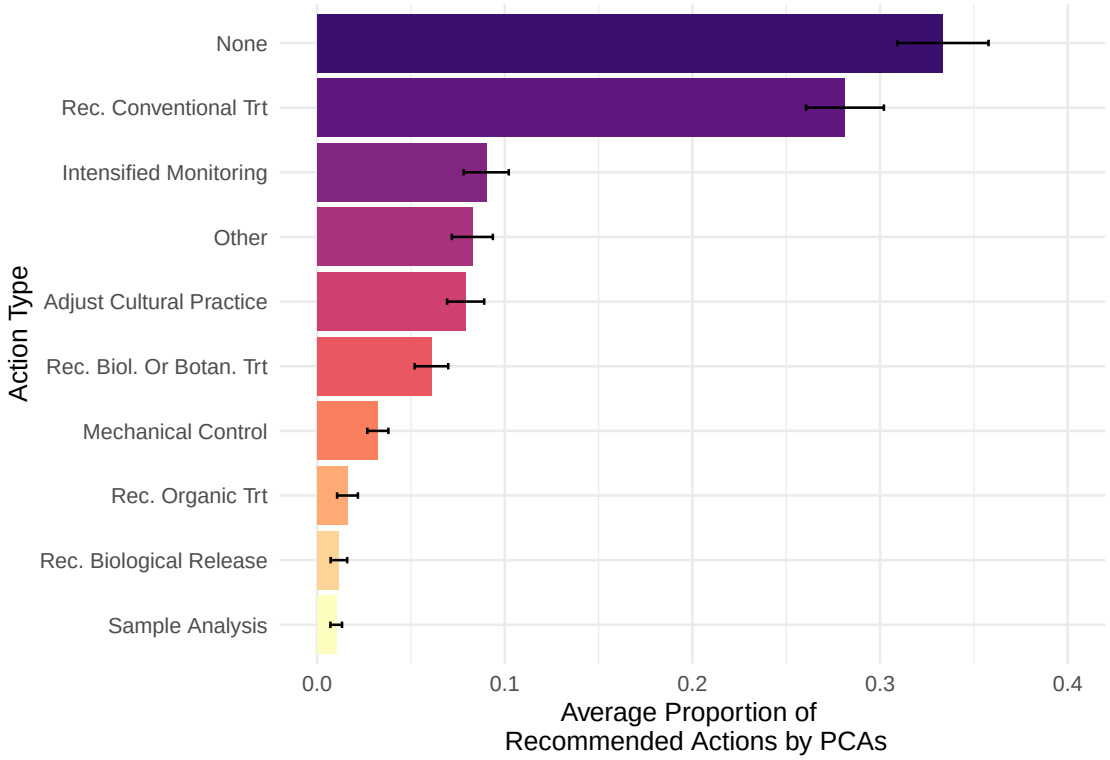
There is a plethora of data included in these observations, much of it text-based, and we plan to conduct several additional analyses in the coming months and years. Here we show summaries of responses by PCAs by action recommended, SPM practices described, and themes mentioned, as well as separate breakdowns by crop, business type, and years of experience. Region was notexpanded upon as crops are only primarily in 1-2 regions.

Actions Recommended

For each observation, PCAs had to record an action recommended for each pest species observed, including an option for "None". For example, on one day a PCA could have three pest observations and three different actions recommended for each (e.g. Conventional Treatment for plant bugs, No Action for Hairy Fleabane, and Biological Treatment for Botrytis).

The figure below shows what recommended actions were made on average by PCAs throughout the season. Error bars show the standard error among PCAs (118 total).

Figure 3: Management Actions Recommended by PCAs



Notably, the most frequently recommended action by PCAs was "None" at 34% of all recommendations, which was significantly greater than the second-most action, "Recommend Conventional Treatment" at 28%. This means that our sample of PCAs only recommended a conventional chemical application around 1 in 4 times after observing their fields. **In the words of a Kern County PCA walking pistacho, *"In IPM unless time stops, IPM doesn't stop. Often doing nothing is the correct answer if you don't create a problem."***

The next three common actions were "Intensified Monitoring", "Other, and"Adjust Cultural Practices". Continuous monitoring of pest populations was mentioned consistently by PCAS, who track pest populations prior to recommending treatments. **A San Luis Obispo PCA describes his monitoring outcomes in a vineyard in April: *"Not much to report. All trap counts for vine mealy bug were in the zeros. Light leafhopper damage showing up on edges of the block. No mildew or mites detected. Overall, vines look to be coming along well. Will continue to monitor every two weeks."*** . "Adjust Cultural Practice" includes planting and harvest timing, while "Other" was a self reported category by PCAs; the SPM Practices reported alongside "Other" describe practices ranging from hand weeding to chemical applications to installing blue bird boxes.

Other actions were less likely to be recommended by PCAs, and are potential areas for outreach if they are underutilized in certain cropping systems. As a reminder, these actions are combined across crops, regions, PCA types, and throughout the growing season, each of

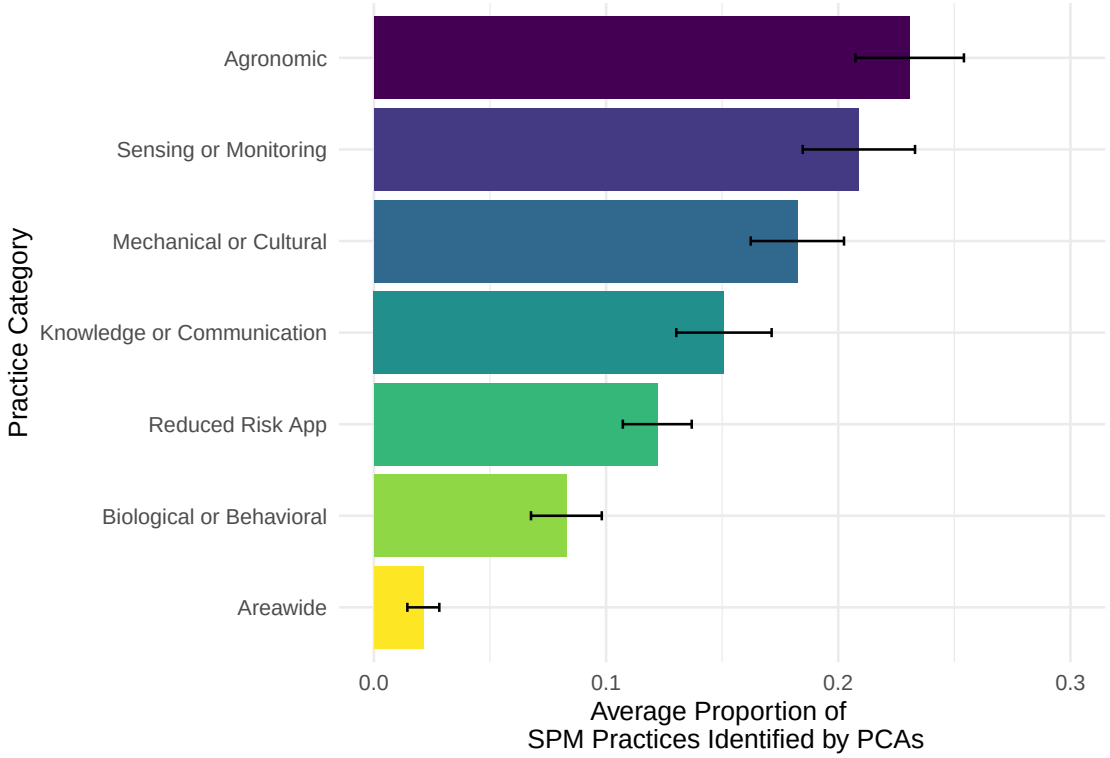
which can contribute to variation on recommendations.

Practices Reported

For each observation date, PCAs also chose from a list of 59 unique SPM Practices that were components of their management programs at that time. PCAs could list multiple practices for each observation. For example, a PCA could report in an observation that "Aerial imagery and remote sensing", "Conservation tillage", and "Irrigation management" were practices that were occurring in that field.

For ease of interpretation, we have placed reported practices into "categories" as shown below (full list in Appendix Table 2), and recorded how often each PCA listed a practice in that category. In the example above, that observation would include mention of "Sensing or Monitoring", "Agronomic" (Conservation tillage and Irrigation management). Since some PCAs reported many practices (sometimes 10-15 per observation) while others reported few (1-2 per observation), we show the average proportion of practices each PCA recorded below to each category. This shows what practices PCAs were most likely to *report* seeing in fields, but may not reflect how commonly growers are using them.

Figure 4: SPM Practices Reported by PCAs



Agronomic practices were the most commonly observed by PCAs, with irrigation management, laboratory samples (soil/tissue/water), cover crops, or adjusting planting/harvest timing as top practices. Sensing/monitoring were second, with PCAs frequently monitoring pest

population thresholds. Mechanical or Cultural practices were third most common, primarily mowing/trimming weeds, doing field sanitation, or managing dust (which can lead to mite or pathogen issues).

Other top practices included reviewing the field's history of pest pressures, using traps or lures, using precision application technology, and observing neighboring crops. Many fields are managing a wide variety of pest pressures with different strategies in place.

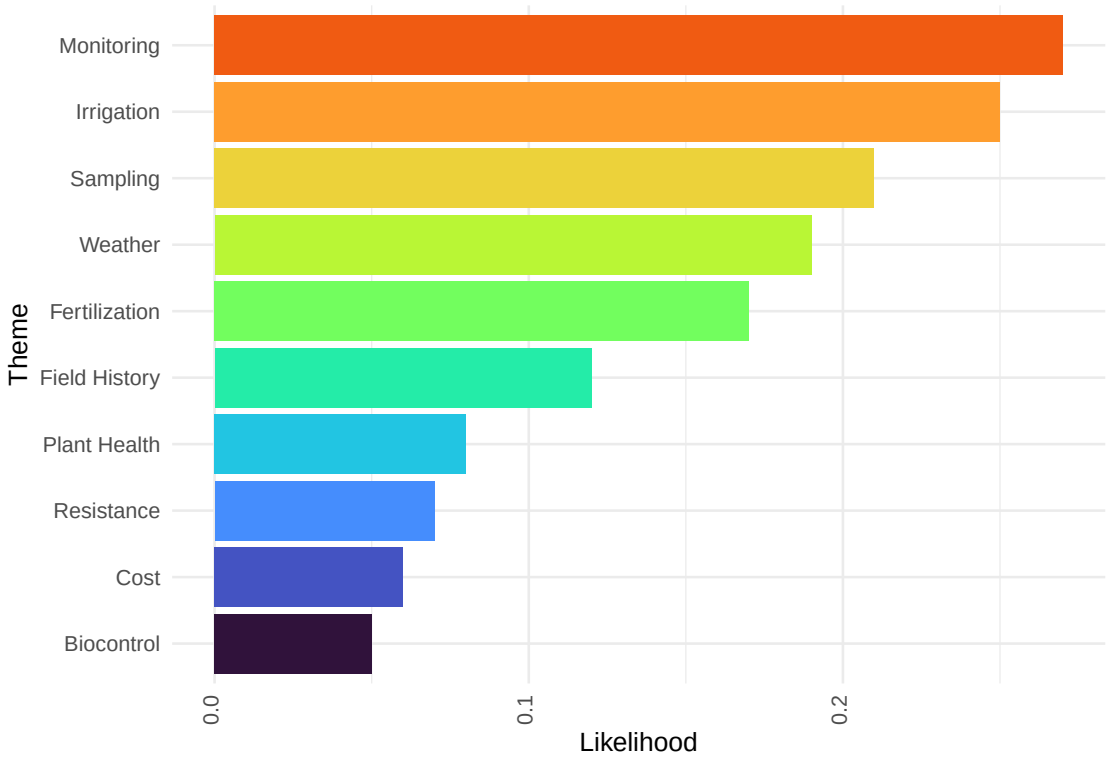
Themes Reported

Given the text-heavy responses in SPM Descriptions and Insights columns, we extracted and quantified the most common words and phrases used in PCA notes and assigned them to themes (Appendix Table 3). We broke down all text responses in those sections into single word (e.g. "weather", "spray", "irrigation") or two-word phrases (e.g. "mold damage", "biological control", "last year"), then assigned all relevant words or phrases into themes. For each observation by PCAs, we identified whether any words associated with themes were present.

Themes were examined for each observation made by PCAs, meaning some PCAs had more or fewer observations depending on the crop examined, length of their working season, and personal behaviors. These themes by no means capture all the priorities that PCAs are setting when examining fields, but gives us a general thematic overview of the language used in their note-taking, and what was frequently on the minds of PCAs as they described their decision-making process.

The value on the y-axis is the likelihood that a theme was mentioned during a PCA's observation. For example, "Irrigation" has a likelihood value of 0.25, which means an irrigation-related word fragment ("irrig", "water","sprink", or "drip") was used in 1/4 of the total observations made by PCAs.

Figure 5: Themes Described by PCAs



Throughout PCA reported insights and descriptions of SPM practices, words and phrases

associated with monitoring, irrigation, and sampling were most common, with weather and fertilization also frequently mentioned.

To be clear, this does not mean that PCAs were less likely to be using biocontrol or considering costs. Rather, it shows that language that PCAs use when describing what they're seeing in fields most often relates to pest monitoring, irrigation, etc. **In many cases, PCAs are describing several interacting factors as this Almond PCA in Stanislaus County describes, *"Scouting for early infection diseases to plan preventative treatments with fungicides in rotation of FRAC groups. With wet and warm temperatures, this could cause a host of various diseases to inoculate during the petal fall stages of almonds."*** This statement contains language that would indicate themes of monitoring, weather, and resistance.

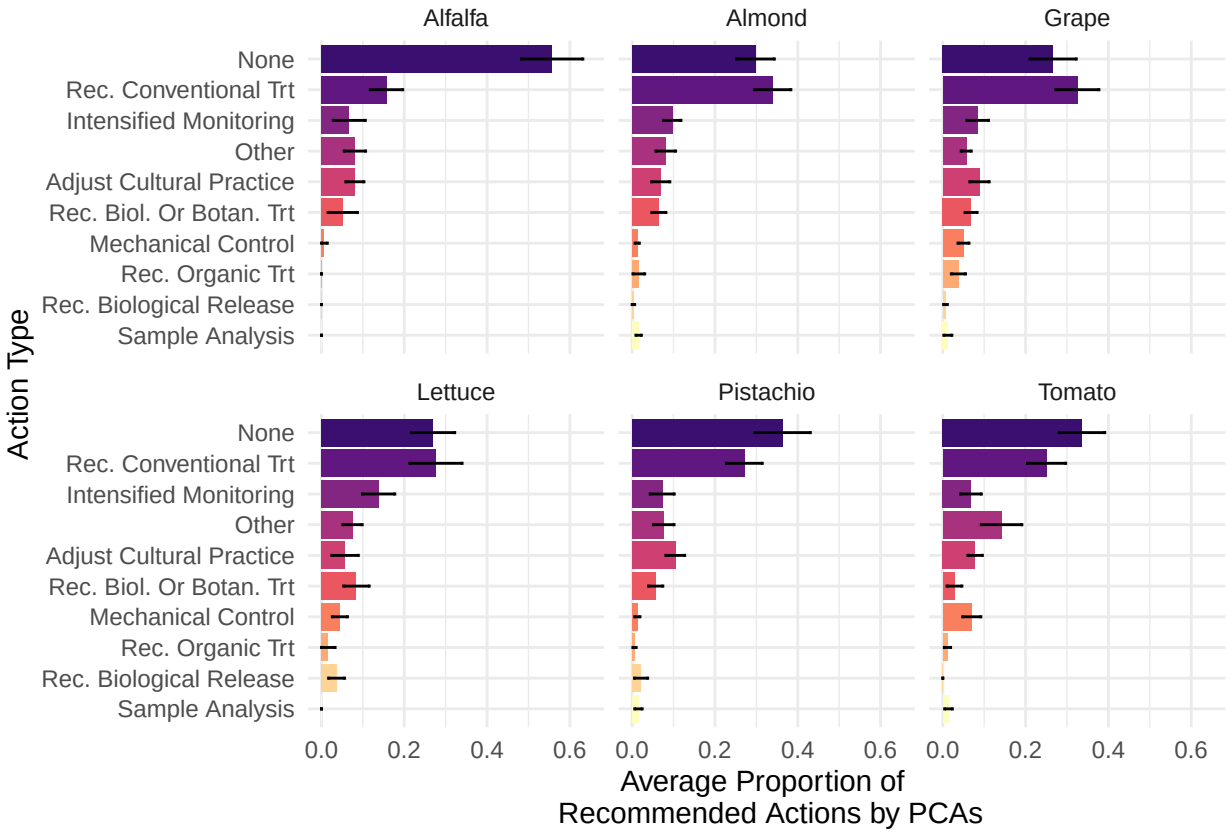
By Crop

PCA recommendations differ substantially among crops, with important regional and agronomic difference in practices. We selected the six crops for the study (alfalfa, almond, grape, lettuce, pistachio, and tomato) to reflect a range of cropping systems (field vs orchard) and regions (inland, coastal, southern). Here we break down actions, practices, and themes like above, but separate out the result by crop. As the data for each crop includes fewer PCAs, individual PCAs can affect averages more strongly so there is greater variation among categories relative to the full study group.

Actions Recommended

While the top actions for all crop groups were "None" or "Recommend Conventional Treatment", there was substantial variation among crops. PCAs for most crops regularly recommended intensified monitoring or adjusting a cultural practice. PCAs in Almond, Grape, and Lettuce most consistently recommended conventional treatments.

Figure 6: Management Actions Recommended by PCAs: By Crop



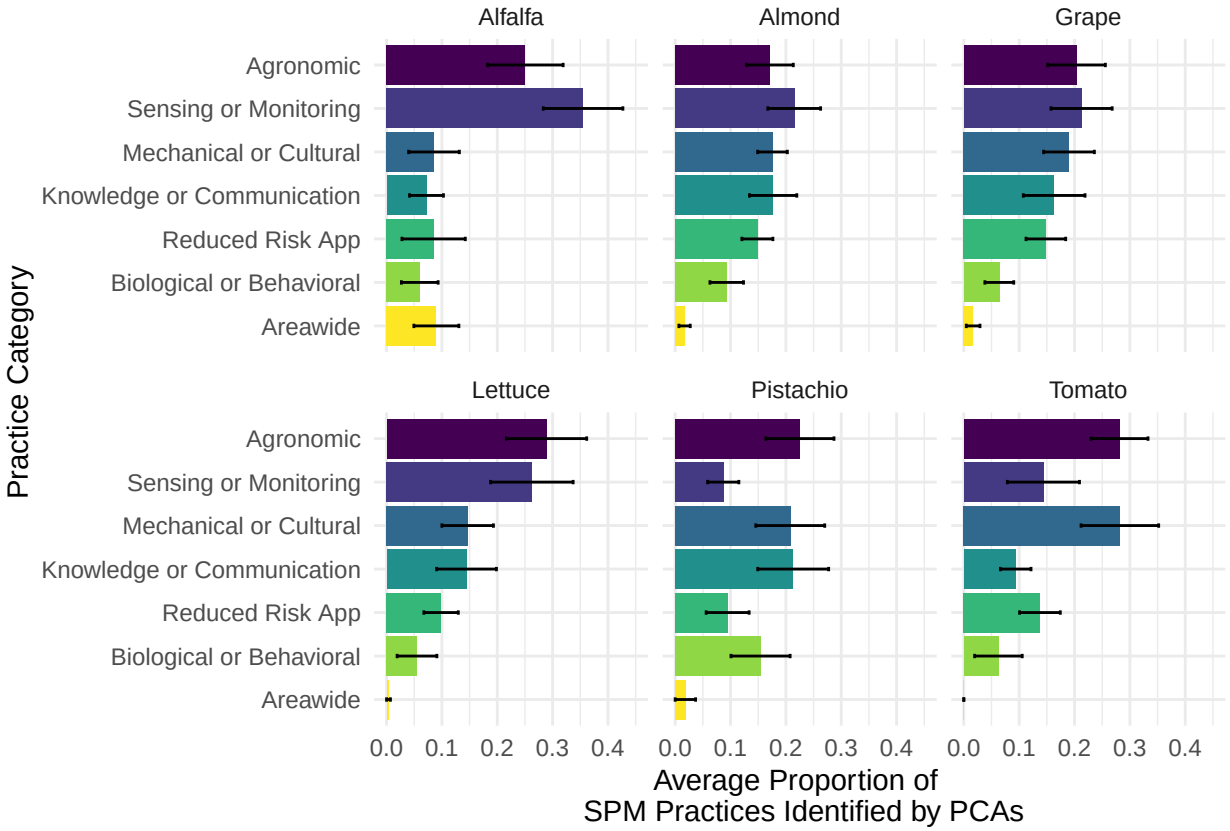
Notably, Alfalfa PCAs recommended no action over 50% of the time, possibly due to higher damage tolerance on the frequently cut forage crop, but never recommended organic

treatments, biological control, or sample analysis. **An Alfalfa PCA in Madera County describes tracking pest populations prior to their first cutting in March, *"Counts of weevil are picking up but still not too bad. Populations were higher last year. Should be able to make it to cutting next week if weather is good."***

Practices Reported

SPM practices noted by PCAs varied substantially by crop managed. Agronomic practices were consistently present across crop types, while Sensing/Monitoring practices and Mechanical/Cultural practices varied. Use of biological or behavioral practices and areawide coordinated practices were limited across most crops.

Figure 7: SPM Practices Reported by PCAs: By Crop



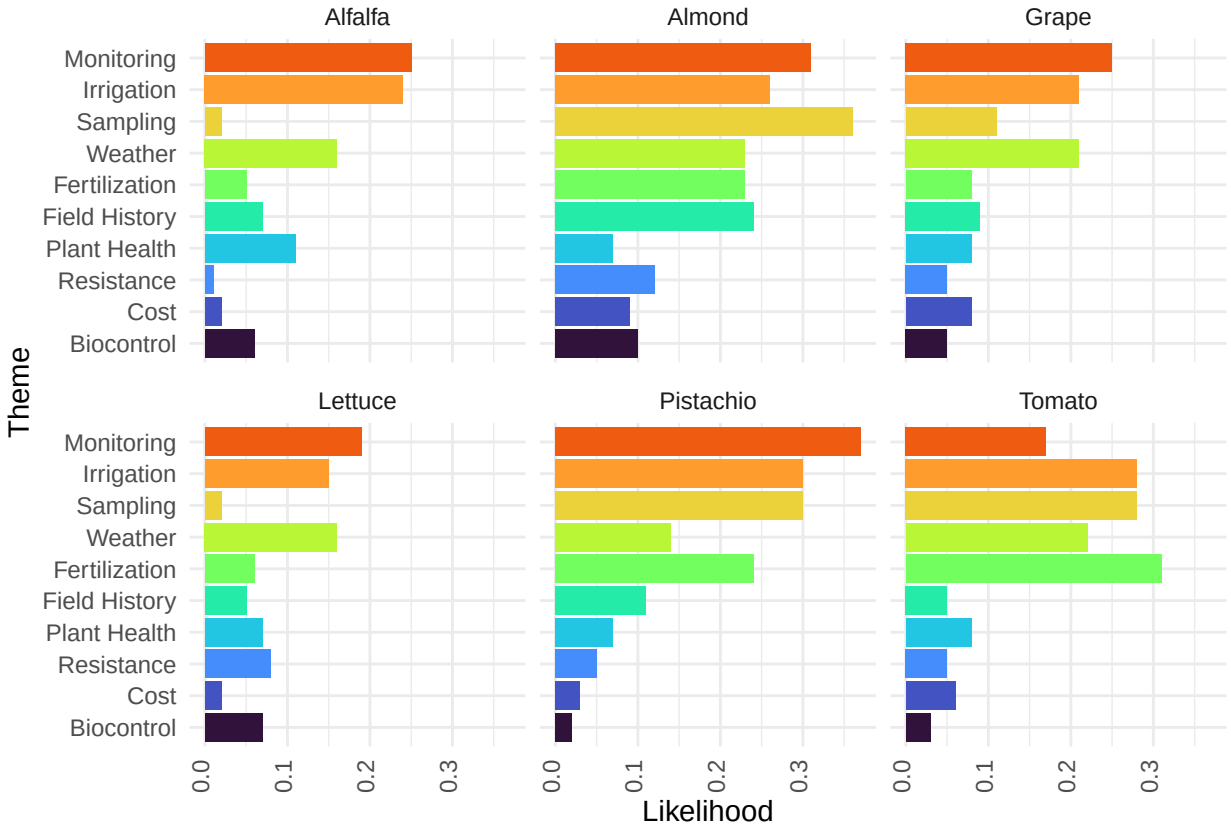
Tomato stands out for high uses of mechanical and cultural practices. Much of this appears to be related to weed management early in the season soon after transplants are in the ground. **A Yolo County PCA in tomato describes some of their practices, *"Because we are able to cultivate the majority of the field we only need to apply a band of herbicide about 20% of the total acreage that makes up the plant row. We do this to cut down on cost and chemical waste. This is a common practice in***

tomato production. It is much more expensive to utilize a hand crew for weeds than a chemical application. Any weed population decrease is a huge help for the grower because the less time a crew is in the field the less money he is paying."

Themes Reported

The most consistently common themes present in language PCAs used were monitoring, irrigation, and weather. PCAs in almond, pistachio, and tomato used words associated with sampling and fertilization more than other commodities. Words related to resistance, costs, and biocontrol were infrequent, but varied among commodities.

Figure 8: Themes Described by PCAs: By Crop



Almond PCAs also used words related to the fields history significantly more than other crops. **A PCA in Merced County describes their field's condition and the effects of age, *"This field has had historically low numbers (of Navel Orangeworm) due to its age, cultural practices, and pesticide product selections so no winter sanitation needed this season. The older the orchard gets, the higher the starting population usually is and more potential damage possible."*** Many other PCAs

describe similar situations, primarily with overwintering insect pests and fields with previous fungal disease pressure.

By Business Type

We also examine variation by the business type of PCAs. As a reminder, 50% of participants in the study were Retail PCAs, while the other categories had lower representation. This means an individual's reporting behaviors may more strongly affect the data shown for Independent and In-house PCAs. Six PCAs recorded "Other" for their business type and are not displayed here.

Actions Recommended

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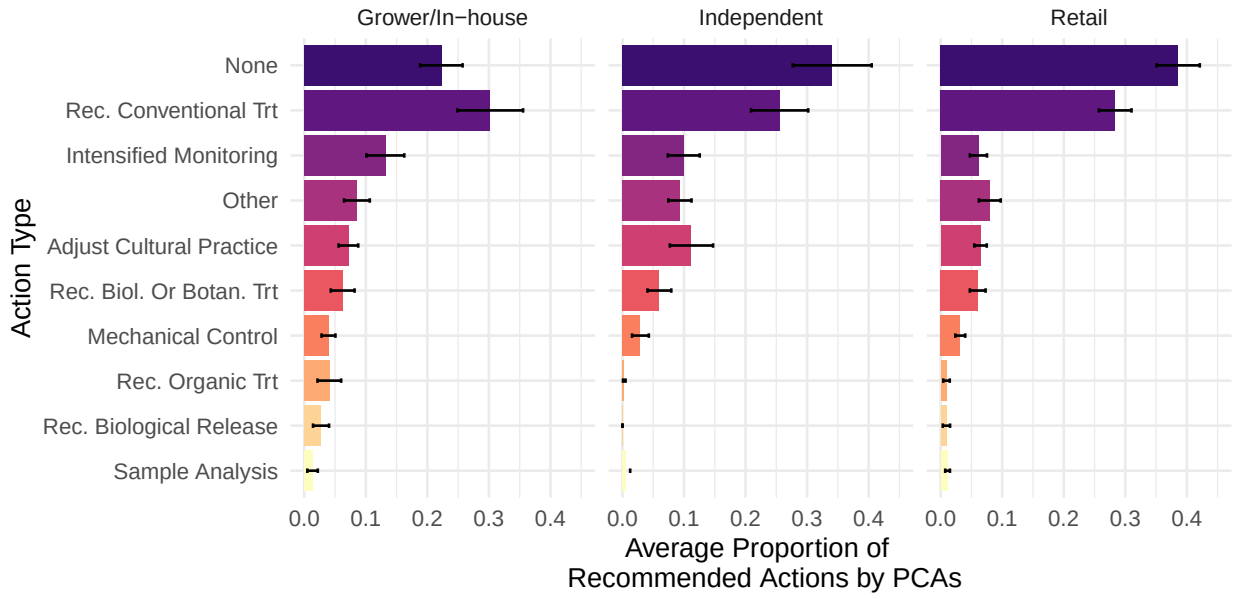
Figure 9: Management Actions Recommended by PCAs: By Business Type



Among PCA business types, Grower/In-house PCAs were the most likely to recommend conventional treatments, while Independent and Retail PCAs recommended no action the most. Intensified monitoring was fairly common among all PCAs. Independent PCAs were most likely to recommended adjusting a cultural practice. Grower/In-house PCAs were most likely to recommend organic treatments, however since we do not have data on which fields were registered organic this could be due to other factors. Release of biological control organisms and sample analyses were not frequently recommended.

Some PCAs described company-specific policies for their management recommendations. **An In-House PCA for Grapes describes their practice, *"It only takes 1 VMB to infect a vine with leaf roll virus and from past experience and previous scouting, this area is considered a high pressure zone. Company-wide we have adopted a***

zero tolerance threshold for mealybug, so the drip application of Belay @ 12 oz/acre is warranted as a preventative approach." Low tolerances for pests that can rapidly infect areas with virus may be important to a grower's long-term economic viability.

Business drivers can vary substantially based on the goals of the grower, or even other ownership entities. **One PCA in Pistachio describes how the interests of owners are affecting management, *"This property is an investment holding asset. Owners are very concerned with its appearance for stakeholders and manage exclusively based on the maximum EIL possible. This has caused issues with crop health in subsequent season e.g.: defoliation in the walnuts, alternaria defoliation in pistachios, damaged irrigation on seldom visited areas, etc."***

Practices Reported

As a reminder, these are practices that PCAs observed were part of the enrolled field's management program, but may not be reflective of choices made by the PCA themselves. Grower/In-house PCAs recorded agronomic practices most frequently, with an even distribution of other practices (excluding areawide management). Independent PCAs identified agronomic and mechanical/cultural practices the most, while Retail PCAs identified Sensing and Monitoring practices most often.

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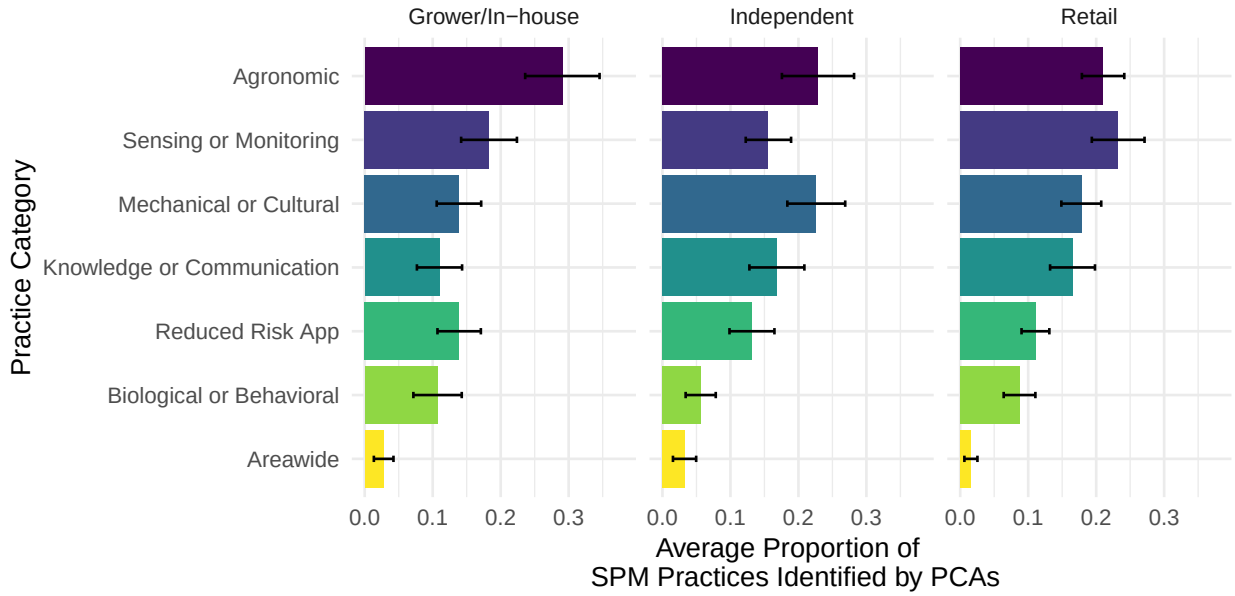
Figure 10: SPM Practices Reported by PCAs: By Business Type



Both Independent and Retail PCAs identified knowledge gathering or communication practices, which could reflect their need to communicate with clients, while In-House PCAs have a closer connection to growers. **A Retail PCA working in Kern County Almonds described a conversation with the grower: "Met with grower to discuss and display what the**

disease looked like. Informed him of options to prevent early season development of the disease and of the importance of continued chemical treatment to control this disease. Grower was financially struggling early in the season so we were not able to get chemical fungicides on early enough to prevent the damage we saw today. We will continue to monitor for further damage and treat proactively."

Themes Reported

Themes in PCA language were fairly consistent across PCA business types. Independent PCAs used words associated with sampling less frequently that other PCAs. Grower/In-House PCAs mentioned weather-related factors more and cost-related factors less than other PCAs.

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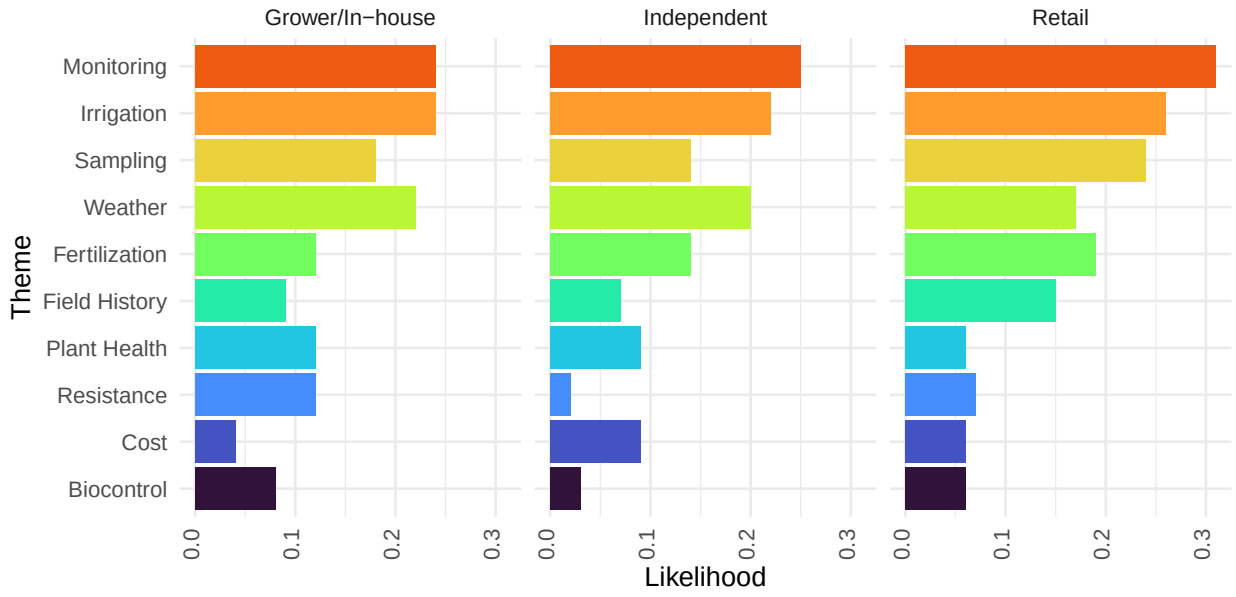
Figure 11: Themes Described by PCAs: By Business Type



Notably, In-House PCAs used terms associated with plant health more frequently that others. **This could be due to greater involvement in company obligations regarding contract sales, as a Lettuce PCA in Santa Barbara details, *"Harvest foreman has walked the field and is happy with how it looks. Very few plants are unmarketable due to mildew or pest damage. Field harvested on 8/11/2025. Fulfilled contract with zero rejections."*** In-House Grape PCAs also noted contract obligations with wineries for fruit quality and limited use of certain pesticides.

By Years of Experience

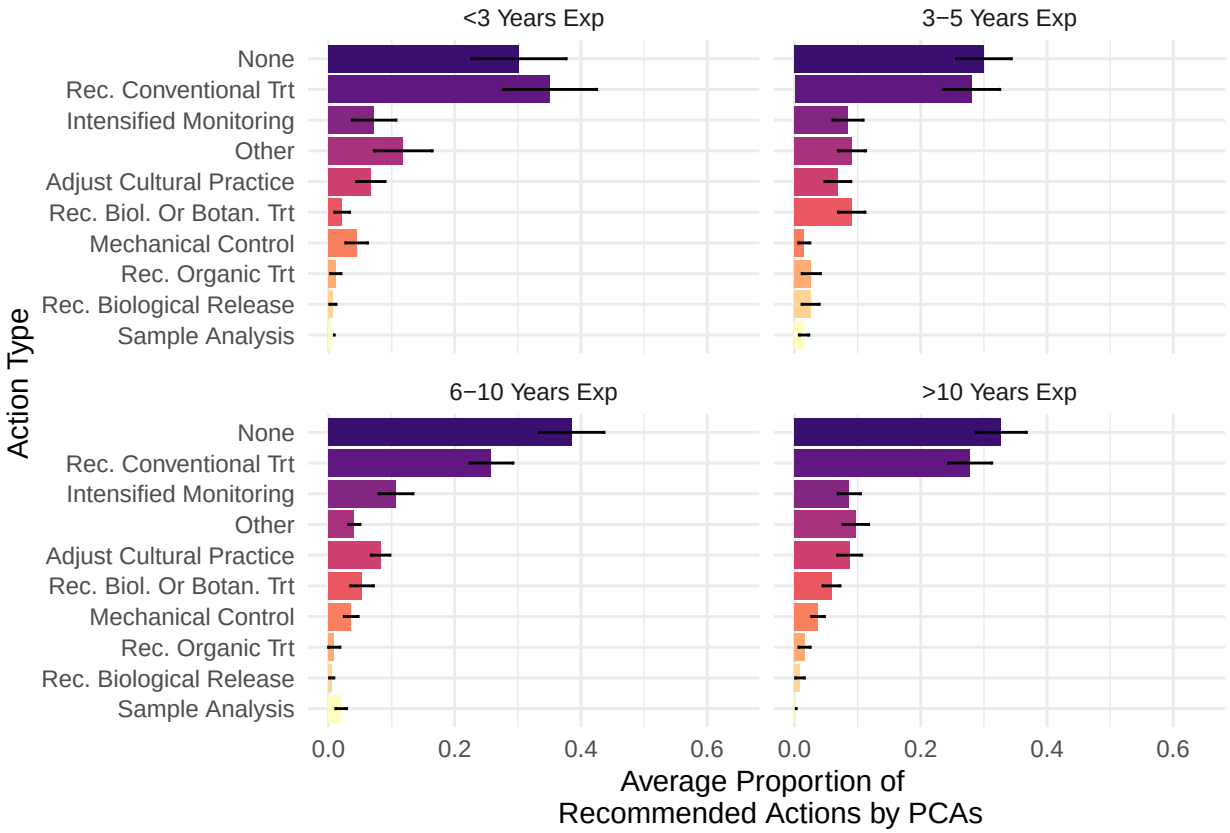
We also examined how years of experience as a PCA contributed to their experience. PCA experience ranged from less than a year to 46 years, with an average of 11.6 years practicing. While the spread of crops managed was fairly even between PCA experience levels, the < 3 years of experience group was the smallest and none were in Alfalfa, which could affect the results.

Actions Recommended

Years of experience as a PCA had only a minor effect on actions recommended by PCAs, with similar recommendations across groups.

As mentioned previously, none of the < 3 years of experience PCAs were in Alfalfa. This may explain the slightly higher rate of recommendations for Conventional applications, as Alfalfa growers disproportionately recommended taking no action.

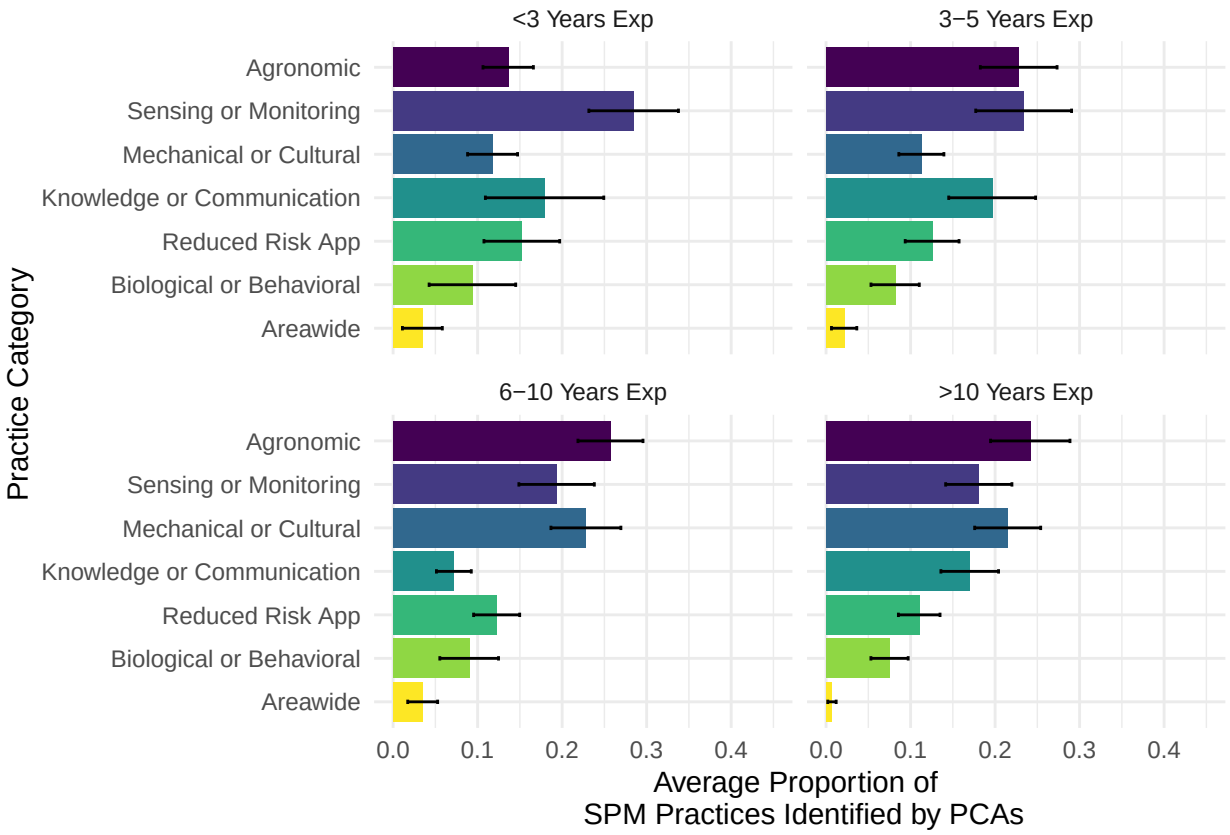
Figure 12: Management Actions Recommended by PCAs: By Experience



Practices Reported

Notably, PCAs with fewer years of experience were less likely to report agronomic, mechanical, or cultural practices in place in fields observed, but were most likely to report sensing or monitoring practices were being used.

Figure 13: SPM Practices Reported by PCAs: By Experience

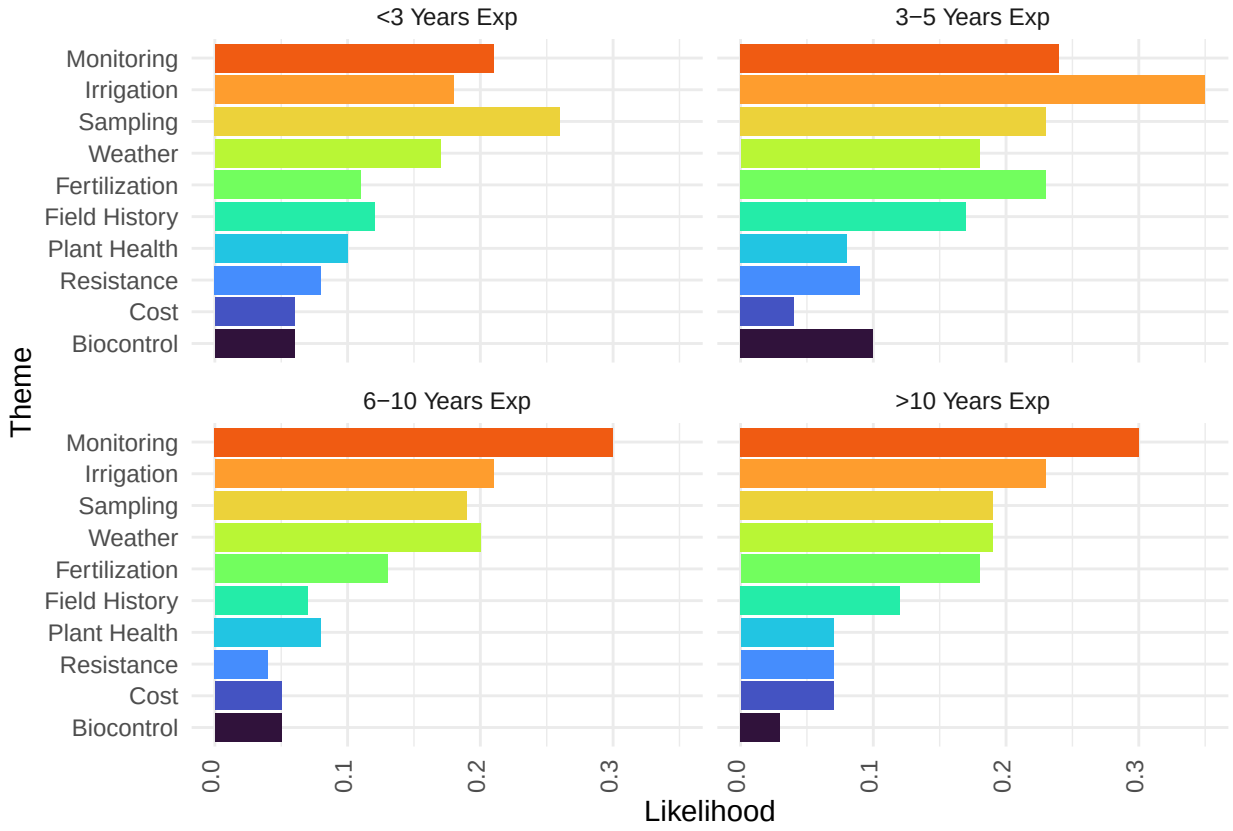


Anecdotally, many of the PCAs with the most experience provided extensive descriptions of their management practices, which reflect their long histories working with specific crops, pests, and regions. **One Pistachio PCA in Glenn County with 35 years of experience conveys their knowledge, *"The importance of an integrated approach to managing navel orangeworm (NOW) in pistachios. Rather than relying on a single metric, effective decision-making is based on trap counts, degree day accumulation, orchard history, and crop development, particularly around hull split, when nuts are most vulnerable. The variability in pressure between orchards reinforces that context matters: blocks with good winter sanitation and tighter hull split timing may tolerate higher trap counts, while high-value or high-risk blocks may require preemptive treatment at lower thresholds. This underscores the value of routine monitoring and local knowledge in maintaining crop quality and minimizing economic loss."***

Themes Reported

Language used by PCAs varied by experience, though not consistently as experience increased. PCAs with 3-5 years of experience were the most likely to use language associated with irrigation or field history. Those with over 10 years of experience were the least likely to mention biocontrol.

Figure 14: Themes Described by PCAs: By Experience



Even PCAs who reported few years of experience were communicating with growers to understand the history of the block they were managing. **A Tehama County Almond PCA in their first year working conveys their knowledge, *"This field does have a history of NOW flights hitting early. Due to the cooler weather this has slowed them down but we plan on seeing the trap counts rise with this warmer temperature coming. Using field history is a key component when managing for pests. Especially when comparing biofix dates from past years to current years which fluctuate due to independent factors. Either way it is still notable data."***

Appendix

Table 2: Categorization of SPM Practices

Category	SPM Practices
Mechanical.or.Cultural	Field sanitation , Hand crew / hand labor / rogueing , Mowing and trimming , Conservation tillage , Tillage , Post-harvest sanitation , Equipment sanitation , Dust fencing / dust management , Host eradication , Windbreak / hedgerow , Barriers ((nets/mulches/row cover)) , Flaming
Biological.or.Behavioral	Traps and lures (insects) , Vertebrate traps and control , Repellents , Mating disruption , Trap crop , Insectary crop , Raptor habitat , Beneficial insect release
Agronomic	Crop rotation , Irrigation management , Cover crop , Planting or harvest timing , Drainage , Soil health improvement , Laboratory sample ((soil/water/tissue)) , Pathology sample , Resistant varieties / rootstocks , Post-harvest packaging and handling , Crop selection for site
Reduced.Risk.App	Resistance management , Reduced use of high-risk pesticides , Calibration , Precision application , Bee check , Biological / botanical pesticide , Chemical Storage and Disposal , Robotic targeting , Residue management (MRLs) , Reduced risk formulation
Sensing.or.Monitoring	Climate change action , Weather / phenology / models , Pest thresholds , Aerial imagery and remote sensing , Observe neighboring crops , In field sensor
Areawide	Area-wide mandated spray , Area-wide cooperation
Knowledge.or.Communication	Field history , Field location , Farmer or practitioner knowledge , Farmworker training / outreach , Advised grower to an improved practice , PHI / REI communication , Pricing decision , Software , Data sharing

Table 3: Terms Used to Identify Themes

Theme	Text Selected
biocontrol	biocontrol , bio control , bio-control , predator , predat , parasit , natural enem , beneficials , beneficial insects , benfic , raptor , hawk , owl
weather	hot , cold , warm , cool , weather , temperature , rain , wet , dry , humid , drought
cost	cost , expens , cheap , price , pricing , afford , dollar
fert	ferti , nutri , nitr , potass , deficiency , compost , phosph , gypsum
irrig	irrig , water , sprink , drip
monitoring	monitor , watch , observ , look for , looking at

sampling	sampl , collect , identif , trap
history	history , previous year , last year , past exp , previous exp , last seas , previous sea
planthealth	quality , damaged , condition , symptom
resistance	resist , immun , frac , irac , hrac