

UC Davis

UC Davis Previously Published Works

Title

Failure by design: lessons from the recently rescinded light brown apple moth (*Epiphyas postvittana*) eradication program in California.

Permalink

<https://escholarship.org/uc/item/8541t3gh>

Journal

Pest management science, 79(3)

ISSN

1526-498X

Authors

Carey, James R
Harder, Daniel
Zalom, Frank
[et al.](#)

Publication Date

2023-03-01

DOI

10.1002/ps.7246

Peer reviewed

Failure by design: lessons from the recently rescinded light brown apple moth (*Epiphyas postvittana*) eradication program in California

James R. Carey,^{a*} Daniel Harder,^b Frank Zalom^a and Nan Wishner^c

Abstract

This article was motivated by the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) announcement that on 17 December 2021 it rescinded Federal Orders of 2 May 2007 that regulated (what was believed to be) a new outbreak of the light brown apple moth (LBAM, *Epiphyas postvittana* (Walker)) in the mainland United States. Our article follows from, and builds on, a 2013 article published by Carey and Harder that outlined major concerns about the LBAM eradication program including the need, cost, safety, practicality, and feasibility of the program and the public opposition to it. The program began with an emergency order based on USDA claims of billions of dollars in potential crop losses and the need to circumvent safety review processes to urgently prevent the pest's establishment. The program ended with the realization by government decision-makers, 14 years after initiating the program, that LBAM posed no quarantine-level threat in the first place and with no evidence of any economic damage done by the insect. This article summarizes the mistakes made in devising and carrying out what has ultimately proven to be one of the most oversold, overhyped, misguided, ill-advised, unnecessary, and costly programs in the recent history of insect eradication programs in California. Termination of the LBAM program by USDA-APHIS presents an opportunity to review the program to identify lessons learned and provide recommendations to help avoid similar mistakes in future invasive species response programs.

© 2022 The Authors. *Pest Management Science* published by John Wiley & Sons Ltd on behalf of Society of Chemical Industry.

Keywords: eradication policy; LBAM reclassification; LBAM act; aerial spray; after-action report; policy fail

1 INTRODUCTION

In early 2007, a retired entomologist identified a light brown apple moth (LBAM; *Epiphyas postvittana* (Walker)) in his Berkeley, California backyard.¹ Although federal and California regulatory agencies had not been routinely surveying for this species other than at ports of entry and had no data on which to base conclusions about whether this was the first detection of a newly arrived *versus* established species within the state, the event set in motion hasty plans for an eradication program that planned to aerially spray monthly, for 5–7 years, both rural and urban areas of the state including the San Francisco and Monterey Bay regions which at the time were home to 8–10 million people. The active ingredient in the pesticide to be sprayed was initially a generic Tortricid-specific pheromone and, later, when it was available, an LBAM-specific pheromone.

The plan was communicated to the public through a series of press releases and news articles and several public meetings in which residents could approach California Department of Food and Agriculture (CDFA) representatives with questions.² Unsurprisingly, the program, which had been vetted by a Technical Working Group of 10 outside experts advising CDFA, provoked intense opposition from residents and local officials concerned about possible environmental and health impacts of the proposed program as well as the emergency declaration that exempted CDFA from conducting an environmental impact

review prior to initiating the program. The concerns about health impacts from exposure to aerial spraying were not hypothetical. After the initial spraying in Monterey and Santa Cruz counties, more than 600 complaints of adverse health effects were reported, including the near fatality of a previously healthy infant who suffered severe respiratory distress.³ The program also prompted criticism from members of the scientific community including Carey and Harder⁴ who questioned the LBAM program's need, feasibility, tactics, and costs.

Court rulings first shut down the aerial spray campaign and ultimately all management aimed at the moth except quarantines that lingered for another 7 years. Finally, as announced in the news release excerpted below, the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) rescinded the 2007 legislative act that had authorized nearly

* Correspondence to: JR Carey, Department of Entomology, One Shields Ave, University of California, Davis, CA 95616, USA, E-mail: jrcarey@ucdavis.edu

a Department of Entomology and Nematology, University of California, Davis, CA, USA

b University of California, Santa Cruz Arboretum, Santa Cruz, CA, USA

c California Environmental Health Initiative, Sacramento, CA, USA

\$100 million to support the LBAM eradication program. In contrast to the hyperbole that prevailed at the start of the program, with CDFA spokespersons referring to LBAM as the “light brown eats everything moth”⁵ and a state legislator predicting “Armageddon for agriculture”⁶ if the moth was not eradicated, the USDA-APHIS press release ending the program was understated:

‘Effective 17 December 2021, the Animal and Plant Health Inspection Service (APHIS) is removing the light brown apple moth (LBAM), *Epiphyas postvittana*, quarantine in California and Hawaii. APHIS is reclassifying LBAM as a non-quarantine pest, removing all areas under quarantine, and removing movement restrictions on LBAM host material. When APHIS first confirmed detections of LBAM in the United States in 2007, the best science available indicated that this moth would be a pest of economic significance. In response, APHIS and the California Department of Food and Agriculture (CDFA) developed an eradication program. Over time, however, it became clear that the moth’s impact was not as significant as expected. LBAM does not cause as much crop damage as APHIS initially anticipated. ...standard pest management practices implemented by producers for other routine pests have proven to also be effective ... APHIS has determined that LBAM is no longer a pest of regulatory significance.’⁷

The intent of this article is to prevent the tragic, costly decision-making errors that spawned the LBAM program to slip unnoticed into the dustbin of entomological history without drawing from the experience the lessons that can prevent such an error from being repeated by scientists advising government agencies in the future. In broad terms, we present our perspectives on how an LBAM found in a Berkeley backyard transitioned from being a newly-arrived, multi-billion-dollar threat requiring emergency legislation authorizing immediate action without health and safety review to being reclassified as a routine pest not requiring quarantine. Further, we ask why it took 14 years for APHIS to reach this conclusion and rescind the federal orders regulating LBAM. Directly related to, if not underlying, this reversal are questions about the selection and role of technical experts in advising and supporting public policy decisions of this type. How could a group of 10 seasoned entomologists and senior administrators make recommendations that were based on questionable scientific evidence, had virtually no chance of being accepted by the public, and based on the absence of evidence of efficacy, an equally unlikely chance of eradicating LBAM? How can scientists advising government agencies avoid a repeat of this failure, with its associated costs not just in taxpayer dollars but in public trust in government as well as in science?

2 LBAM ERADICATION: A RETROSPECTIVE

This section revisits CDFA- and USDA-sourced information used in 2007 and 2008 to both justify and operationalize the LBAM eradication program. Verbatim narrative is cited from the LBAM Emergency Act, CDFA’s press releases on the economic threat, the Technical Working Group’s eradication action plan recommendations, and the crisis exemption to use the synthetic pheromone-based pesticide Checkmate in ways not previously tested.

2.1 LBAM emergency act

The following is selective verbatim narrative from California State Senate Bill 556 (Wiggins)⁸:

‘This act shall be known as the Light Brown Apple Moth Act of 2007. The Legislature hereby finds and declares all of the following: The introduction of the light brown apple moth represents a clear, present, significant, and imminent danger to California’s natural environment and agricultural industry. Valued at \$31.7 billion in 2005, California’s agricultural economy continues to rank first in the nation constituting 13.3% of the total US agricultural economy value in 2005. It is estimated to have a minimum potential impact of \$133 million to only four of the potentially impacted crops (apples, pears, oranges, and grapes). This act is an urgency statute necessary for the immediate preservation of the public peace, health, or safety.’

2.2 Putative arguments that LBAM poses massive economic threat

The following narrative is from CDFA press releases stating the economic consequences of not eradicating LBAM⁹:

‘California must eradicate the Light Brown Apple Moth because it poses a complex threat – not only to our environment and habitats but also to our local farms, nurseries and farmers’ markets,’ said CDFA Secretary AG Kawamura. ‘Not only does this pest attack over 250 crops and 2000 host and ornamental plants, but a statewide infestation could cost California billions of dollars annually.’⁹

2.3 Rejection of report classifying LBAM as non-quarantine pest

Co-author Harder and Santa Cruz County nursery owner Jeff Rosendale, both negatively affected by the CDFA LBAM restrictions, travelled to New Zealand to understand best practices in managing this insect in a region where it is established and subject to control, import, and quarantine activities. After meeting with New Zealand entomologists, LBAM experts, and exporters, Harder and Rosendale summarized their expert knowledge and first-hand experience into a white paper and submitted it for public review and agency consideration. CDFA responded:

‘Harder/Rosendale report called unfounded and scientifically unjustified. [Their] account of the LBAM situation in New Zealand fails to recognize the natural resistance of New Zealand’s native plants and bio-control program developments that have just recently resulted in the reduction of this pest’s impact on the country’s agricultural sector. The report is “unjustified” and their “approach is inadequate given the significant environmental and crop production differences between New Zealand and California...”’⁹

2.4 LBAM technical working group: ‘World’s Foremost Experts’

The following narrative is from the 2008 CDFA press release 08–028 describing the names [removed here] and affiliations of the 10-member Technical Working Group (TWG) that developed the eradication plan and was advisory throughout the program^{10,11}:

‘Comprised of 10 scientists, the TWG was appointed by the US Department of Agriculture (USDA) to evaluate California’s LBAM infestation. The USDA/CDFA eradication

program was based on the TWG's recommendations. Its members, from Australia, New Zealand, California and the USDA, were considered the world's foremost experts in the biology of the pest. The scientists [came from USDA APHIS (=4), ARS (=1), University of California (=2), New Zealand/Australia (=3)].'

2.5 LBAM eradication action plan developed by TWG

The following narrative is selected from the Recommendations of the Technical Working Group for the Light Brown Apple Moth Infestation in California 8 June 2007¹¹ and the press release by CDFA¹⁰:

'The US Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS) and the California Department of Food and Agriculture (CDFA) should adopt a long-term goal of eradicating light brown apple moth (LBAM), *Epiphyas postvittana* (Walker), from the continental United States. The TWG envisions mating disruption as the primary strategy for LBAM suppression. Pesticides will likely be a part of any eradication program, and large-scale (e.g., aerial) application will likely be needed to reduce high LBAM populations. LBAM appears to be amenable to [sterile insect technique] SIT. A site for mass-production of LBAM must be selected, and mass-rearing technology and capacity ... developed quickly. Biological control is not often a major component of eradication efforts, but could be a major suppression strategy.'

Carey and Harder⁴ provided details of the proposed program:

'A total of approximately 450 000 acres were scheduled to be continuously treated in northern California, ... using the synthetic pheromone Checkmate® at the recommended rate of 3 oz./acre/release. The LBAM strategic plan that the CDFA developed in consultation with TWG members called for pheromone releases each month for nine months/year for five to seven years.'

2.6 Emergency safety review exemption

The following is selective verbatim narrative from the Federal Register pertaining to the request by USDA-APHIS for an emergency exemption to use CheckMate OLR-F, a micro-encapsulated, flowable product containing the monoane pheromone, over areas where LBAM had been detected.¹²

'USDA/APHIS has requested the Administrator to issue a quarantine exemption for the use of (E, E)-9,11-tetradecadien-1-yl acetate on host plants to control the LBAM. EPA is waiving the public comment period, as allowed in 40 CFR 166.24, due to the short period of time available with which to review this situation and render a timely decision.'

The California Environmental Protection Agency's (CalEPA) Office of Environmental Health Hazard Assessment (OEHHA) and Department of Pesticide Registration (DPR) noted in a carefully worded 'consensus statement'¹³ on the pheromone pesticide product that the proposed use would be 'one of the first instances of the aerial application of this material over a highly populated area' and that federal EPA review of the proposed use 'refers

primarily to the pheromone active ingredients generally used in emitter devices or aerial application over agricultural areas rather than aerial application over populated areas (such as in the present situation)'. CalEPA/OEHHA's role is considered advisory to CDFA. Although CalEPA is charged with protecting California's environment, the agency does not have authority to overrule decisions by another state agency.

3 NATIONAL RESEARCH COUNCIL REPORT ON PETITION TO RECLASSIFY LBAM

The following selected comments and recommendations are from National Research Council (NRC) committee members, chaired by entomologist and National Academy of Science member May Berenbaum, tasked with reviewing the USDA's response to petitions to reclassify LBAM as a non-actionable pest. Such a reclassification would have obviated the need for eradication. The NRC's overall review was critical of APHIS' then-draft Response.^{14,15}

3.1 Eradication justification unclear

In the verbatim comment below the NRC points out APHIS' failure to engage the question and explain in full why eradication was critical.

'APHIS has missed an important opportunity to explain and justify its course of action, that is, why it believes eradication is the best option for LBAM or what alternative strategies are available.' [see p3 in¹⁵]

3.2 Explanations of economic impact inadequate

The NRC report points out the flaws in USDA's estimates of economic values and losses and the assumptions upon which those calculations are based, using descriptors such as 'ambiguous', 'inconsistent', 'incomprehensible,' [see pp 4, 7 & 9 in¹⁵]:

'The committee has substantial concerns regarding the economic component of the Response. Its concerns are based primarily on the ambiguous foundation of the analysis for the predicted geographic distribution of LBAM and the inconsistent and sometimes incomprehensible analytic techniques used in the Response. The Response does not clearly document the basis of damage estimates. The Response provides no sources to substantiate damage estimates. It appears ... that the goal of the current Response was to show the greatest damage that might occur in extreme (and presumably unlikely) trade-restriction scenarios (for example, the \$9 billion in potential phytosanitary and trade-related losses).'

3.3 Uncertainty of invasion age

The NRC report noted that insufficient information was available to assess the age of the LBAM invasion or the extent of LBAM's geographic spread. We consider this to be a major shortcoming in the decision-making process to attempt to eradicate since the putative 'recency' of the LBAM invasion served as part of the basis for the TWG arguing that eradication was feasible.

'The biological data presented in the Response to support the invasive nature of LBAM, its history in California, and

its potential geographic distribution in the United States are problematic and in some cases not based on sound, rigorous science. Sufficient information is not available to allow a rigorous assessment of the true age of the LBAM invasion in California.' [see p5 in¹⁵]

'Similarly, the statement (Response, p. 5–6) that the recent trapping data from infested areas show a progressively increasing population is misleading in that the limitations of the census methods are not discussed. The increase in mean moths per trap per month may partly reflect the increasing number of traps and the increasing geographic area of their placement, inasmuch as both can increase the probability of inclusion of localized high-density populations. Data derived from repeated trapping at the same locations with constant trapping efforts are more informative.'

3.4 Overall NRC recommendations to APHIS

The bottom line of the NRC report on APHIS' initial response to the petition to reclassify LBAM was that it was inadequate at best and defective at worst. [see p12 in¹⁵]

'Independently of the Response to the petitions, APHIS would be well served by conducting a study, including scientific feasibility and cost–benefit analysis, of LBAM eradication and alternative control approaches. Thus, in response to its statement of task, the committee found that APHIS did not "fully consider and address the specific arguments" and did not "conduct a thorough and balanced analysis" supporting the conclusions in its Response. Full consideration would have included a more detailed economic analysis and a more complete response to the argument against. Overall, the committee found that the APHIS Response would greatly benefit from the use of more robust science to support its position. In responding to the petitions, APHIS would be well served by articulating the justification for its actions to the public clearly, and the Response should be revised accordingly.'

3.5 APHIS revised response to petition: final version

We are unaware of any NRC committee follow-up designed to hold USDA-APHIS accountable for the agency's Response to the reclassification petition. APHIS did not publish its revised Response until 5 years after NRC committee chair May Berenbaum¹⁵ forwarded the NRC report to APHIS (2009).¹⁶ Disappointingly, the agency's 550-word response concerning the economic justification for eradication was virtually identical to claims made in their original 2007–2008 CDFA News Releases. As the alleged economic threat posed by LBAM was the sole justification for attempting eradication, we were hoping for either greater clarity, new analysis and/or new data especially given the 5-year time lag before APHIS' response was published.

4 TAKING STOCK OF THE PROGRAM

4.1 Failure was predictable

The NRC report enumerated many of the flawed assumptions and rationales on which the LBAM eradication plan was based. The December 2021 announcement by then- APHIS-administrator

Osama El-Lissy⁷ that LBAM was being reclassified as a non-quarantine pest confirmed virtually all earlier claims by ourselves and others—that LBAM was of no serious economic importance, that management practices designed to control other pests would be effective against LBAM, and that LBAM's eradication was virtually impossible. This includes (i) the report by botanist Daniel Harder and nursery owner Jeffery Rosendale, rejected by CDFA and the USDA,¹¹ explaining why the economic impact of LBAM would not rise to a level justifying an attempt to eradicate¹⁷; (ii) a letter from UC Davis entomologists James Carey, Frank Zalom, and Bruce Hammock to Secretary of Agriculture Edward Schafer stating that LBAM eradication not only was impossible, but that it was not necessary because the pest was controllable using the same methods as currently used for other California Tortricids,¹⁸ and (iii) testimony to the California State Legislature by retired USDA entomologist Derrell Chambers asserting that eradication was neither necessary nor possible.¹⁹

The LBAM program's failure was not about the ineffectiveness of the eradication attempt itself (for perspective on preconditions for launching eradication programs see²⁰), but rather the launching of the program in the first place. The ultimate outcome was not a result of surprises about pest control efficacy (i.e., the ineffectiveness of LBAM mating disruption and SIT for eradication in this case), or of unanticipated legal roadblocks or unforeseeable responses of the public. Rather the program's outcome was completely predictable. Failure was essentially built into both its concept and operational design. Even non-entomologists would likely wonder how, in this 21st century, members of a technical panel or a government administrator would consider the following recommendations as anything other than non-starters¹¹:

- (1) Aerial spraying of chemicals over areas with a population of 8–10 million persons (including the San Francisco Bay Area), even once or twice, much less monthly for five to seven years;
- (2) Use of pheromone as the main eradication tool for a microlepidopteran pest, with multiple urban, wildland, and crop hosts, and spread over 2 million acres, with no evidence that there would be any chance of success even if the moth's distribution was localized;
- (3) Launching of a large-scale, multimillion dollar eradication program with predictable environmental and health-risk concerns without having strong, if not 100% unequivocal, evidence that the target pest is of major economic concern in California; and
- (4) Disregard for virtually all outside input, advice, and perspectives, not just from concerned lay public and government administrators, but from statured and widely respected entomological peers.

One of the most important consequences of the fraught decision to launch the LBAM eradication program in 2007 was its short- and medium-term irreversibility. No mileposts for re-evaluation or criteria for exiting the eradication were built into the program. Admitting the mistake and rescinding the order after a few months or years would have taken enormous political, professional, and personal courage because it would likely have stymied, if not ended, many executive-level careers. Considering what is at stake when making a hasty, poorly informed decision to launch an eradication program that will affect millions of people underscores the importance of making every effort to solicit and seriously consider unfiltered input from all sources, not just from a small, carefully selected group of siloed entomologists. A

decision to terminate the program after a few months or years would, at a minimum, have required the following: Returning the remaining funds from appropriations; laying off hundreds of newly hired trappers, drivers, pilots, technicians, and office staff; buying out leases for buildings, staging areas, aircraft, and vehicles; disposing of hundreds of barrels of pesticide and millions of twist ties; and terminating contracts for the research grants awarded to several entomologists serving on the TWG.

4.2 Remember the public resistance

Nearly a decade and a half after the launch of the LBAM program, it is easy to forget the intense public outcry in 2007–2008 in the Bay Area and surrounding regions—30 000 signatures on petitions, 1600 newspaper or OpEd articles, 32 city/county government resolutions opposing the program, seven pieces of legislation, and five lawsuits for starters. This does not count the hundreds of meetings of concerned citizens (including farmers, growers, and owners of commercial nurseries), the thousands of minutes of daily TV news coverage, and the millions of fliers that were distributed containing safety information. For additional perspectives on community involvement see.²¹

It is also easy to forget how perplexed we were when we learned that the program was based primarily on a 5-year monthly aerial release of a chemical (pheromone) over 8–10 million people. One of us (JRC), having served on the CDFA Mediterranean fruit fly scientific advisory panel in the late 1980s and early 1990s, witnessed aerial applications of malathion that occurred weekly during periods of intense medfly outbreaks; he thought that controversial program would end the practice of aerially releasing chemicals for pest control when the applications finally ended in the 1990s. The universal belief of everyone involved at the time—CDFA and USDA administrators and the five entomology panel members—was that aerial spraying would never occur again.

Yet, astonishingly, 30 years later the main strategy for LBAM eradication was not only based on the *aerial release of a chemical (pheromone)*, but on the likely need for *aerial applications of more traditional agricultural insecticides* as well.¹¹ We cannot fathom how the topic of aerial applications could possibly have been considered during the TWG's deliberations, much less actually recommended by any entomologist on the panel. Yet the 10-member committee composed of senior entomologists unanimously approved these aerial spray tactics.

The likelihood that program managers and the director realized early on that eradication and quarantine measures were unnecessary was clear in the details of the 2021 press release. El-Lissy⁷ noted that APHIS began to exempt many LBAM host plants from quarantine and that standard IPM practices against LBAM were effective.

In addition, a sequence of court rulings in 2008 caused the state to postpone further aerial spraying and then, just a few months after the first spraying began, to announce the end of the aerial spray component. Quarantines and use of pheromone 'twist ties' and other ground treatments continued while CDFA complied with a court order to prepare an environmental analysis of the program. That analysis was eventually thrown out by the courts in part because CDFA changed the program goal from eradication to control between the draft and final versions of the report, without soliciting public input on, or performing additional scientific analysis of, the nature of control *versus* eradication strategies or the health and environmental impacts of an indefinite control program. That change tacitly acknowledged that the agency realized eradication was impossible. The court ordered the agency to

void the environmental analysis, ending all treatment activities for LBAM in California. Only interior quarantines continued in some areas, yet no crop or other damage attributable to LBAM was being observed or reported.

Despite all of the evidence that LBAM was not causing damage, it took 14 years from 2007 to 2021 to completely rescind the LBAM Act and reclassify the insect.

4.3 The need to account—an after-action review

The poor decisions that led to the LBAM program and its perpetuation for 14 years underscore the need for a comprehensive review aimed at understanding how federal and state agencies came to launch what we consider to have been one of the most over-sold and misguided eradication programs in the recent history of California pest invasions, and then to continue the program for so long after it was obviously unnecessary. LBAM is unlikely to be the last pest to which there is a risk of over-reaction and reliance on flawed science. In the interest of improving decision-making regarding pest responses and of avoiding another such costly mistake, we and many in the public would like to have answers to a number of questions.

A comprehensive approach to answering the many questions about the program would be to convene an independent panel of experts to conduct the equivalent of an After Action Review. After Action Reports (AARs) originated in the military²² but are now used in contexts ranging from business²³ and medicine²⁴ to hurricane relief²⁵ and other emergency preparedness situations.²⁶ An AAR centers on four questions,²⁷ all of which are highly relevant for a thorough accounting of what went wrong in the LBAM program, and for identifying lessons learned to improve the decision-making processes in future programs. These four questions are: What was expected to happen? What actually occurred? What went well and why? What can be improved and how? We briefly consider the first two of these questions here.

The evidence summarized in this article, that LBAM did not pose a major threat and that there were fundamental scientific flaws in the agencies' justifications for the program, including that eradication using aerial spray of pheromone and pesticide would be both ineffective and untenable to the public, points to a number of specific questions that should be answered by those involved in the program; these questions fall under the broad categories of questions in an AAR.

4.4 What was expected to happen?

What was the basis for the belief that monthly aerial releases of pheromone over the Bay Area and surrounding regions would be accepted by its 8–10 million residents?

Retired USDA/ARS entomologist Derrell Chambers¹³ stated to the California Legislature: 'The technologies of pheromone application and SIT as reported to be applied here cannot work.' What evidence did the TWG have on which to base the collective decision that the technology would work that Dr. Chambers did not? Is there documentation for any members of the TWG pushing back regarding the unlikelihood of eradicating LBAM? This question implies others. How were TWG members selected? What latitude was the TWG given to question the basic assumptions underlying the program? How broad was the range of options that the TWG was asked to consider?

4.5 What actually occurred?

Farm Bureau member and apple grower Dale Hale stated 'The current [LBAM eradication] program accomplishes nothing except

more paperwork for farmers.²⁸ Was Mr. Hale correct? What grower impacts did the LBAM quarantines and treatments have? What was achieved by the initial aerial spray, subsequent ground treatments, and more than a dozen years of patchwork quarantines? What was accomplished with the \$100–200 million spent on the 14-year program?

With respect to the timing of the APHIS announcement ending LBAM's quarantine status⁷: What was learned in the last 10 years of the program that was not known in the first 3 to 5 years that delayed the decision to end the program until 14 years after inception? Were the dates of program termination (17 December 2021) and the resignation of the program director from the USDA 2 weeks later (31 December 2021) coincidental? An entirely new set of questions arises if the timing of the program termination was based less on evidence and more on the arbitrary timing of personnel change.

5 INVASIVE SPECIES RESPONSE PROGRAMS: WHAT CAN BE IMPROVED?

5.1 Recommendations

Based on flaws in the development and execution of the LBAM eradication program, we propose some general recommendations for decision-making regarding pest eradication and management programs, participation of scientists asked to advise public agencies about such programs, and community involvement.

First, any invasive species response that affects the general public, especially use of chemical treatments on public or private property, must be devised collaboratively in partnership with the affected communities and must consider a wide range of strategies. Top-down decisions by regulatory authorities should be avoided at all costs as should definitions of options that narrow the field *a priori* to only chemical controls. Public concern for health and environmental harm from chemical applications demands that other alternatives be prioritized. The concept of 'acceptable risk' from exposure is offensive to people who feel that their health is threatened. Collaborative decision-making treating the public as a partner is much more likely to lead to public acceptance of a pest response program, and to foster trust in government policies.

Second, any member of the scientific community invited to participate in a technical working group or similar body that advises government agencies regarding invasive species response strategies should subscribe to a code of ethics, as summarized in more detail in the next paragraph, that upholds the scientific method and professional standards of conduct, and is sensitive to public and environmental health impacts of the decisions that will result from the consultation process.

Third, a technical working group or advisory body should not be cherry-picked to favor a particular outcome the agency prefers. It must be given broad latitude in definition of its task so that problems with data and assumptions such as those identified by the NRC⁸ in the case of the LBAM program can be brought to light and appropriate changes advised in the fundamental course of the program (i.e., the task force purview should not be limited in such a way that the outcome is a foregone conclusion). Finally, it must take meaningful input from the affected public and be accountable to that public as well as the agency (e.g., providing timely, written responses to public concerns to foster genuine public trust in and acceptance of the decision-making process).

Fourth, all invasive species response programs should have built-in oversight and evaluation intervals with off-ramps and exit strategies for revising or terminating the program defined from the outset. Programs must not be allowed to drag on for more than a decade without being re-evaluated, revised, or terminated if there is not sufficient evidence for their need or efficacy.

5.2 LBAM and accountability

The desire for accountability is not new. In their article published a decade ago, Carey and Harder² concluded with the following general comment and specific appeal to the LBAM TWG:

'Six years [now 15 years] have passed since the emergency order was issued claiming that LBAM was a clear, present, significant, and imminent danger. Along with members of the lay public in northern California, many of whom we came to know and respect as citizens deeply concerned with health and environmental issues and who demand that policy decisions affecting their lives are transparent and based on sound scientific principles, we believe that the panel now has not only a responsibility but an opportunity to explain to the public and their entomology peers how these decisions were made and the science upon which they were based.'

Even though APHIS repealed its LBAM regulations in December 2021, CDFA maintained its interior LBAM quarantines until the time this article was drafted, over 15 years after the initiation of the program. Only on 14 September 2022 did the agency open a comment period to consider repealing the quarantine order, stating 'Over time it has become clear that despite the extensive host list this pest has, the impact is not as significant as APHIS predicted in 2007.' Repeal of CDFA's quarantines would finally conclude the LBAM saga, quietly, without acknowledgment of a poorly-conceived, failed, costly, and ultimately unnecessary invasive species response program. It is critical that we not allow this program to conclude quietly, without identifying lessons learned and considering policies that would prevent similar mistakes in the future.

ACKNOWLEDGEMENTS

We wrote this article largely at the urgings of a number of Northern California citizens, nursery owners and growers who, like all of us, questioned the wisdom of USDA and CDFA's decision to launch the LBAM program. We are grateful for encouragement, support, and input from each of the following: Tracey Bigelow, Debbie Friedman, Lynn Elliott-Harding, Jane Kelly, Tom Kelly, Tara Levy, Jeff Rosendale, Jennifer Kathrine Sedell, Lisa Tracy, and T'Hud Weber. Dedicated to the memories of entomology visionaries: Robert van den Bosch, Powers 'Bud' Messenger, and Carl Huffaker.

REFERENCES

- 1 Raine G, Foreign moth threatens crops, landscaping (5 April 2007), in *San Francisco Chronicle*. Hearst Communications, C-1 San Francisco (2007).
- 2 Reynolds J, Getting the apple moth jitters, in *Monterey County Herald* (21 August 2007). Monterey County Herald, B1: Monterey (2007).
- 3 McCord S, Hundreds of health complaints followed apple moth spraying, in *Santa Cruz Sentinel*. Santa Cruz Sentinel, Santa Cruz (2008).
- 4 Carey JR and Harder D, Clear, present, significant, and imminent danger. Questions for the California light brown apple moth (LBAM)

- working group (*Epiphyas postvittana*: Tortricidae). *Am Entomol* **59**: 240–247 (2013).
- 5 Fitzsimmons M, *Local Court Decides to Postpone Apple Moth Spray*. City on the Hill Press, Santa Cruz, California (2008).
 - 6 Robinson C, Moth balls, in *Ecologist: The Journal for the Post-Industrial Age*. Resurgence Trust, UK (2008).
 - 7 El-Lissy O. Federal Order Removal of the Domestic Quarantine for Light Brown Apple Moth DA-2021-2029. https://www.aphis.usda.gov/plant_health/downloads/da-2021-29-lbam-deregulation.pdf (2021).
 - 8 BAM Emergency Act. 2007. SB-556. The light brown apple moth. Legislative Counsel's Digest. 7 September 2007. Bill Text - SB-556 The light brown apple moth. [ca.gov](http://www.cdfr.ca.gov).
 - 9 CDFA. CDFA Report 08–028. Light brown apple moth science update technical working group comments on Harder/Rosendale report. https://www.cdfr.ca.gov/egov/Press_Releases/Press_Release.asp?PRnum=08-028 (2008).
 - 10 CDFA. Recommendations of the technical working group for the light brown apple moth program. 8 June 2007. <https://www.yumpu.com/en/document/view/36859616/recommendations-of-the-technical-working-group-aphis> (2007).
 - 11 TWG. Recommendations of the light brown apple moth working group (TWG) <https://www.yumpu.com/en/document/view/36859616/recommendations-of-the-technical-working-group-aphis> (2007).
 - 12 EPA. Federal Register. Vol. 72 (129) 6 July 2007. Environmental Protection Agency (EPA) exemption. <http://www.eastbaypesticidealert.org/USDA%20quarantine%20exemption%20request.PDF> (2007).
 - 13 California Department of Pesticide Regulation (DPR) & California Office of Environmental Health Hazard Assessment (OEHHA). *Consensus Statement on Human Health Aspects of the Aerial Application of Microencapsulated Pheromones to Combat the Light Brown Apple Moth*. (2007). California Department of Pesticide Regulation and California Office of Environmental Health Hazard Assessment, Sacramento.
 - 14 Berenbaum M, Letter to David Kaplan, Assistant Deputy Administrator Director, Emergency & Domestic Programs USDA/APHIS/PPQ (31 August 2009). *Review of the U.S. Department of Agriculture's Animal and Plant Health Inspection Service Response to Petitions to Reclassify the Light Brown Apple Moth as a Non-Actionable Pest: A Letter Report*. <http://www.nap.edu/catalog/12762.html>. 2009.
 - 15 NRC. National Research Council, *Review of the U.S. Department of Agriculture's Animal and Plant Health Inspection Service Response to Petitions to Reclassify the Light Brown Apple Moth as a Non-Actionable Pest: A Letter Report*. The National Academies Press, Washington, D. C. (2009).
 - 16 Federal Registry, Response to Petitions for the Reclassification of Light Brown Apple Moth as a Non-Quarantine Pest. Docket No. APHIS-2009-0101. Document Number: pages 7636–7639; 2014–02764. <https://www.federalregister.gov/documents/2014/02/10/2014-02764/response-to-petitions-for-the-reclassification-of-light-brown-apple-moth-as-a-non-quarantine-pest>. 2014.
 - 17 Harder D and Rosendale J. *Report: Integrated Pest Management Practices for the Light Brown Apple Moth in New Zealand: Implications for California*. University of California, Santa Cruz (2008). http://www.researchgate.net/publication/237302914_Integrated_Pest_Management_Practices_for_the_Light_Brown_Apple_Moth_in_New_Zealand_Implications_for_California
 - 18 Carey JR, Zalom F and Hammock B. Letter to U.S. Secretary of Agriculture Edward Schafer (28 May 2008) Report: University of California, Davis. http://www.pesticidewatch.org/sites/default/files/schafer_letter-may-28-2008.pdf. (2008).
 - 19 Chambers D, Testimony of Derrell L. Chambers on California Legislature Bill Number 87 – 'Relative to the Light Brown Apple Moth'. 6 June 2008. Sacramento. 2008.
 - 20 Myers JH, Simberloff D, Kuris A and Carey JR, Eradication revisited: dealing with exotic species. *Trends Ecol Evol* **15**:515–516 (2000).
 - 21 Zalom F, Grieshop J, Lelea MA and Sedell JK, Community perceptions of emergency responses to invasive species in California. Case studies of the light brown apple moth and the European grapevine moth, in *USDA-APHIS Cooperative Agreement #10–8100-1531-CA*. University of California, Davis. https://ucanr.edu/blogs/strawberries_caneberries/blogfiles/16221.pdf. USDA-APHIS, p. 54 (2013).
 - 22 Kewley R, Argenta C and Brawner K, Behaving like soldiers: a multi-agent system approach to course of action planning for simulated military units. *The International FLAIRS Conference Proceedings*, **35**.
 - 23 Darling M, Parry C and Moore J, Learning in the thick of it. *Harv Bus Rev* **83**:84–92, 192 (2005).
 - 24 Ferrer RR, Ramirez M, Sauser K, Iverson E and Upperman JS, Emergency drills and exercises in healthcare organizations: assessment of pediatric population involvement using after-action reports. *Am J Disaster Med* **4**:23–32 (2009).
 - 25 Anderson K, Hotchkiss E, Myers L, Stout S, Grue N, Gilroy N *et al.*, After the hurricane: validating a resilience assessment methodology. *Int J Disaster Risk Reduct* **51**:101781 (2020).
 - 26 Savoia E, Agboola F and Biddinger PD, Use of after action reports (AARs) to promote organizational and systems learning in emergency preparedness. *Int J Environ Res Public Health* **9**:2949–2963 (2012).
 - 27 Salem-Schatz S, Ordin D and Mittman B. Guide to the after action review. Version 1.1. https://www.cebma.org/wp-content/uploads/Guide-to-the-after_action_review.pdf (2010).
 - 28 Phillips YA, California farmers, nursery owners, and business people seek termination of moth eradication program. Press release (8 March 2010). <http://www.dontspraycalifornia.org/FarmerOppositionPressRelease.pdf>. 2010.