A. Cover Page

1. Project Title: Investigating the potential of burrow fumigation and trapping for managing roof rats in nut orchards

2. Project Leader:
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3. Cooperators: NA

4. CDFA Funding Request Amount/Other Funding (Total = $119,033):
   PY1 (2024-2025) = $118,522
   PY2 (2025-2026) = $511

5. Agreement Manager:
Denise Ehlen
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B. Executive Summary

1. Problem: Roof rats (*Rattus rattus*) cause extensive damage in a number of tree crops including almonds and pistachios. Roof rat populations seem to be expanding and growing throughout many agricultural regions in CA, with associated losses reported in fall 2024 in almonds of between $109 and $311 million (Goodhue et al. 2025). The development of an IPM program could greatly reduce this damage, but we currently lack a good understanding of the efficacy of most management tools for roof rats in nut orchards. Almonds and pistachios are two of the most important commodities in California. Collectively, almonds and pistachios were worth >$5.4 billion to California in 2022 (California Agricultural Statistics Review 2022-2023). Effective management of roof rats in these orchard systems is needed to protect these valuable commodities.

2. Objectives, Approach, and Evaluation: There are multiple objectives for this project. They include: 1) conducting preliminary trials on trapping options (pocket gopher (*Thomomys* spp.) pincer-style traps, trapping tunnels at ground level, and trapping tunnels

in trees) for roof rat control in nut orchards, 2) conducting preliminary trials on fumigation options (gas cartridges, aluminum phosphide, pressurized exhaust machines, and a CO_2 injection device) for roof rat control in nut orchards, and 3) comparing efficacy of the best trapping and burrow fumigation approaches at an orchard scale to determine their potential utility as part of an integrated pest management (IPM) program for roof rat control in nut orchards. Traditional roof rat management, and management for rodents in many agricultural systems, often entails using a rodenticide application to knock down rodent populations. This approach may reduce rodent numbers over a short period, but invariably allows the rodent populations to rebound, often causing as many or more problems the subsequent year as the year prior. A plan that keeps rodent numbers low throughout the year may prove to be more efficacious and cost effective. Likewise, incorporating multiple tools and strategies into a management plan reduces the likelihood that rodents will adapt to any one management tool. That said, we know little about the effectiveness of alternative management plans for roof rat control in nut orchards. Ground-based trapping and burrow fumigation are two potential options to combine with rodenticide applications to develop an IPM program, but nothing is known about their effectiveness in deciduous orchards. Therefore, we will conduct initial trials to test the effectiveness of these approaches for removing roof rats from nut orchards. We will then select the most promising of these approaches for an orchard-level assessment of their efficacy. We will also keep track of material and labor costs associated with each tested approach to better gauge their potential cost when incorporating them into an IPM program that also includes a rodenticide application. Concluding thoughts will be provided as to the potential benefits of including these management tools into an IPM program for roof rat control. This project will be considered a success if we can better define the utility of various trapping and burrow fumigation options for managing roof rats in nut orchards.

3. Audience: Nut growers are expected to be the primary beneficiaries of this project. This could have a substantial impact on California agriculture given the high value of these crops in the state. Although this research is targeted toward nut growers, the results will likely be applicable to other deciduous orchard systems as well, thereby increasing the value of this project.

C. Justification

1. CDFA VPCRAC Mission and Responsibilities: At previous meetings, VPCRAC has identified projects that lead to more effective management of roof rats in orchards as a top priority. The PI on this project has completed numerous projects on roof rat management in orchards that have helped to better inform growers on how to manage roof rats. This proposed project will build off of some of this previous research. For example, we know that a 0.005% diphacinone bait application can be effective at reducing roof rat numbers in orchards (Baldwin et al. 2014a, 2022, 2025). That said, current and proposed regulatory changes could alter how rodenticides are used in orchards in the near future. It is important to know how alternatives to rodenticides can be used to manage roof rats in these agricultural systems should they become unavailable in the future. Furthermore, rodent management is most effective when incorporating multiple strategies into a management program (Baldwin et al. 2014b). Currently, burrow fumigants have not been tested as a management tool for roof rats, and the utility

of trapping as a management tool is untested in nut orchards in California. A greater understanding of their effectiveness is needed before recommendations can be made for their inclusion as part of an IPM program.

It is important to note that roof rats are invasive rodents that cause extensive agricultural damage throughout California and globally through direct crop loss, damage to irrigation infrastructure, by posing as a substantial human health and safety risk both through disease and parasite transmission and through food safety concerns, and they can have substantial negative impacts to native wildlife through predation, disease transmission, and by outcompeting them for limited resources. Therefore, results from this project may have substantial applicability across many crops and regions in California, and potentially to other parts of the U.S. and globally. As such, the development of effective management strategies for roof rats fits very squarely within the VPCRAC mission.

2. <u>Impact:</u> Rats (*Rattus* spp.) are a common and very damaging invasive pest found throughout much of the world, with one projection of damage caused by rats in the U.S. estimated at $19 billion annually (Pimentel et al. 2005). Although much of the damage they cause occurs in residential areas, they are also common agricultural pests. In particular, nut and tree fruit crops can incur substantial damage from rats when present. For example, roof rats (*Rattus rattus*) cause an estimated 5–10% loss in developing macadamia nut crops in Hawaii each year (Tobin et al. 1997). More recently, a joint memo by CDFA and UC Davis estimated rat losses in almond orchards in fall 2024 to be in the $109–$310 million range (Goodhue et al. 2025), <u>which is an extreme damage estimate for a rodent pest in a single crop</u>. This damage has led to increased requests for more information on how to manage roof rats in orchards. For example, over the last year, I have provided 11 presentations and field demonstrations, authored or co-authored 4 outreach articles, provided 4 interviews, and answered 11 direct correspondences on topics related to roof rat management in orchards. In many previous years, I would not address rat-related damage in ag fields a single time. This has probably been the most pressing rodent-related concern in my ~17 years with the University of California.

   Anticoagulant rodenticides are a common and effective tool for managing roof rats in orchards. However, growers cannot rely exclusively on anticoagulant rodenticides given the potential to develop resistance to these products, for which we have already noted genetic markers of resistance in the roof rat population from some orchards (N. Quinn and others, unpublished data). It should also be noted that there is increasing scrutiny toward the use of all rodenticides, reflecting a need to explore additional options to supplement bait applications for roof rat management. Although snap trapping has been tested in some crops (e.g., Baldwin et al. 2025), it has not been evaluated in nut orchards in California, nor do we have a good understanding of potential differences in efficacy when traps are placed on the ground versus in the tree canopy. Furthermore, the potential exists to trap rats directly in their burrow systems through the use of pocket gopher traps. The PI has experienced success with these traps, but it has never been quantified. Targeting roof rats directly within their burrow systems may prove to be an effective strategy, but to the best of my knowledge, it has never been tested in any orchard system globally. Burrow fumigants are also used to manage roof rats in orchards. In particular, aluminum phosphide is commonly used (R. Baldwin, *pers. obs.*), but no data exists on the utility of burrow fumigation for roof rat control in orchards. The inclusion of either trapping or burrow fumigation (or both) could greatly bolster roof rat management programs and is worthy of investigation.

3. Long-Term Solutions: Rats cause extensive damage to agricultural products each year (Pimentel et al. 2005), and based on feedback from numerous growers and PCAs, damage has become increasingly common and extreme in some settings (Goodhue et al. 2025). Rodenticides are an important part of an effective IPM program for roof rat control in nut orchards (Baldwin et al. 2014a). That said, more than one tool is needed to develop an effective IPM strategy for managing roof rats. Ground-based trapping and burrow fumigation are two options for inclusion into an IPM program for roof rat control in nut orchards given the extensive use of burrow systems by roof rats during the dormant season. Collectively, a combined bait application and trapping program could provide a longer-term solution to manage this increasingly common agricultural pest for nut growers.

4. Related Research: Several recent projects have been completed addressed roof rat management in citrus orchards. These projects provided substantial detail on movement patterns of roof rats in citrus, developed effective monitoring tools for roof rats, assessed the applicability of the use of trapping tunnels and Goodnature A24 traps for rat control, and determined the applicability of an elevated bait station using 0.005% diphacinone-treated oats for managing roof rats in citrus (Wales et al. 2021, Baldwin and Meinerz 2022, Baldwin et al. 2022, 2024). This ultimately allowed for the development of an IPM program for roof rat control in citrus (Baldwin et al. 2025). However, citrus is much different than nut crops, most notably due to the evergreen nature of citrus that provides abundant cover year-round, which allows roof rats to heavily utilize tree nests rather than ground burrows. In nut orchards, roof rats regularly use ground burrows given the lack of leaves on the trees during the dormant season. This opens the door for growers to target roof rats in the burrow systems through trapping and burrow fumigation practices, which could potentially allow for alternative control strategies to be mixed in with a bait application program which is already known to be effective against roof rats in nut orchards (Baldwin et al. 2014a). Such integrated approaches would likely allow for better long-term control of roof rats in nut orchards. More simply, information on the utility of these alternative control strategies would be very valuable should bait application not be allowed in a particular setting in the future.

5. Contribution to Knowledge Base: Roof rats (*Rattus rattus*) cause extensive damage to nut crops in California and globally. Roof rat populations are expanding and growing throughout many agricultural regions in California, yet the efficacy of potential management options for limiting this damage are largely unknown. The development of an IPM program could greatly reduce this damage, but we currently lack a good understanding of the efficacy of many management tools for roof rats in nut crops. We have previously identified the effectiveness of bait applications for roof rat control in almond orchards (Baldwin et al. 2014a). This proposed project would inform growers on the utility of trapping and burrow fumigation for managing roof rats in nut orchards, which would then allow growers to determine which alternative tools could be combined with bait application to effectively manage roof rats in nut crops. If successful, this IPM approach should provide nut growers with a management approach that will limit roof rat damage and food safety concerns in a cost-effective, practical manner.

6. Grower Use: Roof rats cause extensive damage in orchards and pose a food safety risk, as outlined previously. Previous research in nut orchards conducted by Baldwin et al. (2014a) led CDFA to alter their 0.005% diphacinone grain label to allow rodenticide application within orchards during the growing season. Before this change, little was known about the effectiveness of potential management strategies for roof rats in orchards. Even with this verified tool, alternative options are needed to develop an IPM program that would likely prove to be more efficacious and cost effective. Such a program has been developed in citrus, but nut orchards are substantially different given that they are a deciduous crop. For example, the limited use of tree nests by roof rats during the dormant season given minimal shelter provided by leafless canopies suggests that burrow fumigants could be a good management tool due to the roof rats' reliance on burrows for shelter. Likewise, the effectiveness of trapping could vary substantially between citrus and nut orchards including the potential increased effectiveness of ground-based traps in deciduous orchards during the dormant season. This needs to be investigated to assess the utility of this management tool in nut orchards. Collectively, this information on trapping and burrow fumigation could be used to develop an IPM program that could keep roof rats at low numbers within nut orchards long-term, thereby substantially reducing any damage or food safety concerns for growers.

Literature cited:

Baldwin, R. A., and R. Meinerz. 2022. Developing an effective strategy for indexing roof rat abundance in citrus orchards. Crop Protection 151:105837.

Baldwin, R. A., R. Meinerz, and A. B. Shiels. 2022. Efficacy of Goodnature A24 self-resetting traps and diphacinone bait for controlling black rats (*Rattus rattus*) in citrus orchards. Management of Biological Invasions 13:577–592.

Baldwin, R. A., R. Meinerz, and A. B. Shiels. 2025. Testing an integrated approach for managing roof rats in citrus orchards. Pest Management Science.

Baldwin, R. A., R. Meinerz, and J. A. Smith. 2024. Identifying black rat (*Rattus rattus*) movement patterns aids the development of management programs in citrus orchards. Wildlife Research 51:WR23149.

Baldwin, R. A., N. Quinn, D. H. Davis, and R. M. Engeman. 2014a. Effectiveness of rodenticides for managing invasive roof rats and native deer mice in orchards. Environmental Science and Pollution Research 21:5795–5802.

Baldwin, R. A., T. P. Salmon, R. H. Schmidt, and R. M. Timm. 2014b. Perceived damage and areas of needed research for wildlife pests of California agriculture. Integrative Zoology 9:265–279.

Goodhue, R. E., K. Mace-Hill, and S. Raburn. 2025. CDFA Memo: rat damage in almond orchards. Report to the California Department of Food and Agriculture.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52:273–288.

Tobin, M. E., A. E. Koehler, and R. T. Sugihara. 1997. Effects of simulated rat damage on yields of macadamia nuts. Crop Protection 16:203–208.

Wales, K. N., R. Meinerz, and R. A. Baldwin. 2021. Assessing the attractiveness of three baits for roof rats in California citrus orchards. Agronomy 11:2417.

D. Objectives: There are multiple objectives for this project. They include: 1) conducting preliminary trials on trapping options (pocket gopher pincer-style traps, trapping tunnels at ground level, and trapping tunnels in trees) for roof rat control in nut orchards, 2) conducting preliminary trials on fumigation options (gas cartridges, aluminum phosphide, pressurized exhaust machines, and a CO_2 injection device) for roof rat control in nut orchards, and 3) comparing efficacy of the best trapping and burrow fumigation approaches at an orchard-scale to determine their potential utility as part of an IPM program for roof rat control in nut orchards.

E. Work Plans and Methods (project dates: September 1, 2025 to December 31, 2026)

1. <u>Work Plan:</u>
   a. Trapping comparison (PY1): We will compare Gophinator traps placed in roof rat burrows to trapping tunnels placed both on the ground and elevated in the tree canopy to determine which is most effective and practical. This will be conducted in fall/winter 2025

   b. Burrow fumigation comparison (PY1): We will compare burrow fumigation using gas cartridges, aluminum phosphide, pressurized exhaust machines, and a CO_2 injection device to determine which is most effective and practical. This will be conducted in Winter 2026

   c. Field level assessment of burrow fumigation and trapping (PY1): Taking what we learn from our trap and burrow fumigation comparisons, we will test the broader-scale utility of the best trapping and burrow fumigation option for roof rat control in nut orchards. Trials will run from winter through spring 2026.

   d. Incorporation of these tools with bait into an IPM program (PY1-PY2): We will consider the utility of these approaches for inclusion with a 0.005% diphacinone bait application to represent an IPM program for roof rat control in nut orchards (summer/fall 2026).

   e. Data analysis and final report (PY1-PY2): We anticipate a completion of analyses and the final report by December 31, 2026.

2. <u>Methods:</u> Initial efforts will focus on testing three different trapping strategies for removing roof rats in nut orchards: 1) pincer-style pocket gopher traps placed in rat burrow entrances, 2) trapping tunnels containing two snap traps placed at ground level, and 3) trapping tunnels elevated within tree canopies. Our goal is to place 30 of each of these trap types in an orchard. Trap locations will be determined by placing traps in areas with active burrow entrances, with traps operated for up to 5 days plus 2 days of prebaiting to allow the rats to acclimate to the traps. Traps will be randomly placed throughout the orchard in case there are spatial differences in rat activity within the orchard. We will replicate this trial up to 5 times across different orchards to allow for a comparison of the number of roof rat captures for each trapping strategy.

During winter 2026, we will test 4 different fumigation strategies for roof rat control in nut orchards: 1) gas cartridges, 2) aluminum phosphide, 3) a pressurized exhaust machine, and 4) a CO_2 injection device. Our goal is to apply each of these fumigants to up to 30 burrow systems in an orchard. Fumigation locations will be determined by identifying active burrow entrances. Gas cartridges and aluminum phosphide will be applied following label specifications. For pressurized exhaust machines and CO_2 injection devices, we will use 3-minute injection times. Fumigation options will be randomly placed throughout the orchard in case there are spatial and soil moisture differences in rat activity within the orchard. We will replicate this trial up to 5 times across different orchards to allow for a comparison of the effectiveness of each burrow fumigation option for removing roof rats in nut orchards. We will determine if a fumigation was effective if no rat has dug out of the burrow entrance. To estimate the percentage of treated burrow systems that are inactive regardless of treatment, we will plug up to 30 untreated roof rat burrow entrances per study site and will adjust efficacy comparisons based on the proportion of roof rat burrow systems that were unoccupied.

Once we have determined effective trapping and burrow fumigation options, we will then identify 4 field sites approximately 16 ha in size to conduct more extensive trials. Each field site will consist of two treatment blocks and a control. We will use the preferred trapping strategy in one of the blocks, while the other block will receive the preferred burrow fumigation treatment program. The control plot will not receive any treatment. We will assess the efficacy of this treatment approach using the tracking tunnel design developed by Baldwin and Meinerz (2022). We will track relative costs of each treatment approach for comparison to bait applications in elevated bait stations. Concluding thoughts will be provided as to how trapping and burrow fumigation could be combined with bait application to develop a long-term efficacious and cost-effective management program for roof rats in nut orchards.

Literature Cited

Baldwin, R. A., and R. Meinerz. 2022. Developing an effective strategy for indexing roof rat abundance in citrus orchards. Crop Protection 151:105837.

3. Experimental Site: Exact observation location will be determined at the time of the study based on current roof rat activity. That said, we anticipate sites occurring in the Kings and Fresno County areas.

F. Project Management, Evaluation, and Outreach

1. Management: R. Baldwin will serve as the PI for the project and will oversee all aspects of the project.
2. Evaluation: The overarching goal for this project revolves around the need to identify alternative management strategies that can be combined with a 0.005% diphacinone bait application to maximize the long-term effectiveness of roof rat management programs in nut orchards. This project will be deemed successful if we are able to define the utility and effectiveness of several trapping and burrow fumigation options for roof rats, as well as to quantify the overall efficacy and cost-effectiveness of these tools when implemented across a whole orchard setting. This information will then be combined with data already

available on the management of roof rats via bait application to come up with an integrated approach for managing roof rats in nut orchards.

G. Budget Narrative

a. Personnel Expenses

Salaries - $42,679: *Salary costs use fiscal year 2025/2026 (July 1, 2025, through June 30, 2026) rates.*

Ryan Meinerz (Staff Research Associate II): Ryan will largely lead coordination of data collection. This will include travel to field sites to conduct all aspects of this study. Effort is estimated at 1,392 hours for year 1 at a wage of $30.66, respectively (PY1 = $42,679).

Fringe Benefits - $21,937: *Employee Benefits are based on Federally Approved Composite Benefit Rates. The University of California's current Composite Benefit Rates have been federally reviewed and approved through June 30, 2025.*

Ryan Meinerz (Staff Research Associate II): Fringe benefits calculated at 52.9% for 2025/26 (PY1 = $22,577).

b. Operating Expenses

Supplies - $4,398

Tracking tunnels ($9/station × 100 stations = $900)

Tracking cards ($1.00/card × 800 cards = $800)

Tracking tunnel attractant ($75/container × 2 containers = $150)

Trap lure ($22.00/pouch × 4 pouches = $88)

Gas cartridges ($2.20/cartridge × 175 cartridges = $385)

Aluminum phosphide ($45/cannister × 4 cannisters = $180)

Fuel for pressurized exhaust machine ($4.50/gallon × 10 gallons = $45)

Wooden boards for tracking tunnels and bait stations (25 boards by $14/board = $350)

Zip ties and bungees for attaching traps and tracking tunnels when needed ($200)

Heavy duty cart for hauling various fumigation machines ($200/cart × 2 carts = $400)

Phosphine detector ($700)

Miscellaneous field items (e.g., flags, flagging tape, data notebooks, etc. = $200)

Equipment:
N/A

Travel - $31,176:
Trip 1: From October 5 to October 29, 2025, SRA II will travel from Davis to anticipated field site in the Kettleman City area (TBD). This travel will correspond with identification of field sites, site set up, and initial trapping portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 3,060 miles round trip). Mileage is for a rental vehicle ($0.38/mile). The trip is anticipated to be 25 days/24 nights in duration with hotel ($135/night for 24 nights) and meals ($40/day x 25 days per trip) associated with this trip (PY1 = $5,403).

Trip 2: From October 8 to October 10, 2025, PI will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with identification of field sites, site set up, and initial trapping portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 660 miles round trip). Mileage is for a personal vehicle ($0.70/mile). The trip is anticipated to be 3 days/2 nights in duration with hotel ($135/night for 2 nights) and meals ($40/day x 3 days per trip) associated with this trip (PY1 = $852).

Trip 3: From October 13 to October 17, 2025, PI will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with trapping portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 860 miles round trip). Mileage is for a personal vehicle ($0.70/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($135/night for 4 nights) and meals ($40/day x 5 days per trip) associated with this trip (PY1 = $1,342).

Trip 4: From January 4 to January 29, 2026, SRA II will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with identification of field sites, site set up, and initial burrow fumigation portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 2,960 miles round trip). Mileage is for a rental vehicle ($0.38/mile). The trip is anticipated to be 26 days/25 nights in duration with hotel ($135/night for 25 nights) and meals ($40/day x 26 days per trip) associated with this trip (PY1 = $5,540).

Trip 5: From January 7 to January 9, 2026, PI will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with identification of field sites, site set up, and initial burrow fumigation portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 660 miles round trip). Mileage is for a personal vehicle ($0.70/mile). The trip is anticipated to be 3 days/2 nights in duration with hotel ($135/night for 2 nights) and meals ($40/day x 3 days per trip) associated with this trip (PY1 = $852).

Trip 6: From January 12 to January 19, 2026, PI will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with burrow fumigation portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,160 miles round trip). Mileage is for a personal vehicle ($0.70/mile). The trip is anticipated to be 8 days/7 nights in duration with hotel ($135/night for 7 nights) and meals ($40/day x 8 days per trip) associated with this trip (PY1 = $2,077).

Trip 7: From February 4 to February 28, 2026, SRA II will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with identification of field sites, site set up, and burrow fumigation and trapping portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 2,860 miles round trip). Mileage is for a rental vehicle ($0.38/mile). The trip is anticipated to be 25 days/24 nights in duration with hotel ($135/night for 24 nights) and meals ($40/day x 25 days per trip) associated with this trip (PY1 = $5,327).

Trip 8: From February 11 to February 14, 2026, PI will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with burrow fumigation and trapping portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 760 miles round trip). Mileage is for a personal vehicle ($0.70/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($135/night for 3 nights) and meals ($40/day x 4 days per trip) associated with this trip (PY1 = $1,097).

Trip 9: From February 19 to February 22, 2026, PI will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with burrow fumigation and trapping portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 760 miles round trip). Mileage is for a personal vehicle ($0.70/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($135/night for 3 nights) and meals ($40/day x 4 days per trip) associated with this trip (PY1 = $1,097).

Trip 10: From March 7 to March 27, 2026, SRA II will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with identification of field sites, site set up, and burrow fumigation and trapping portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 2,460 miles round trip). Mileage is for a rental vehicle ($0.38/mile). The trip is anticipated to be 21 days/20 nights in duration with hotel ($135/night for 20 nights) and meals ($40/day x 21 days per trip) associated with this trip (PY1 = $4,475).

Trip 11: From March 11 to March 14, 2026, PI will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with burrow fumigation and trapping portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at

760 miles round trip). Mileage is for a personal vehicle ($0.70/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($135/night for 3 nights) and meals ($40/day x 4 days per trip) associated with this trip (PY1 = $1,097).

Trip 12: From March 18 to March 21, 2026, PI will travel from Davis to anticipated field sites in the Kettleman City area (TBD). This travel will correspond with burrow fumigation and trapping portions of the trials. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 760 miles round trip). Mileage is for a personal vehicle ($0.70/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($135/night for 3 nights) and meals ($40/day x 4 days per trip) associated with this trip (PY1 = $1,097).

Trips 13-14: Travel from Davis to VPCRAC meeting sites (TBD) to provide update on project. Mileage will include travel to closest hotel locations, as well as to meeting location (anticipated at 350 miles round trip). Mileage is for a personal vehicle ($0.70/mile). Trips are anticipated to be 2 days/1 night in duration with associated hotel ($135/night) and meals ($40/day x 2 days per trip) associated with each trip. Total cost per trip estimated at $450. Two trips are anticipated during the project period. Travel reimbursement will be claimed by R. Baldwin (PY1 = $460; PY2 = $460).

Other Expenses: $6,300

Rental Truck - $6,300:
A rental truck will be needed to haul supplies around for project. The rental truck also comes with a lower mileage rate, which will save funds when compared to using a personal vehicle. The cost of the rental truck is $900/month. We will charge 7 months of the rental truck for field use in 2025-2026 (PY1 = $6,300).

Indirect (F&A) Costs - $11,903

Indirect costs are calculated in accordance with the University budgeted indirect cost rate in Exhibit B.

Indirect costs are calculated in accordance with the University budgeted indirect cost rate for Total Cost (TC) TC per the sponsor's indirect cost policy for Vertebrate Pest Control Agriculture Industry Fund 9999000087 (PY1 = $11,852; PY2 = $51).

c. Other Funding Sources –

N/A

I. Appendices – Resume: Roger Allen Baldwin

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EDUCATION

Ph.D. Wildlife Science/Range Science, Department of Animal and Range Sciences
New Mexico State University, Las Cruces, NM 88003. February 2008.

M.S. Biology, Emphasis on Vertebrate Zoology
The University of Memphis, Memphis, TN 38152. August 2003.

B.S. Wildlife Biology, Secondary Major in Natural Resource and Environmental Science
Kansas State University, Manhattan, KS 66506. May 2000.

CURRENT APPOINTMENT

Assistant (July 2013 to June 2015), Associate (July 2015 to June 2020), and Full Cooperative Extension Specialist (July 2020 – Present)—Human-Wildlife Conflict Resolution
University of California Cooperative Extension, Division of Agriculture and Natural Resources; and Department of Wildlife, Fish, and Conservation Biology, University of California, Davis.

RESEARCH FUNDING

Extramural grants: *Total funding $10,854,333*

Current and recent relevant titles:

Determining utility of carcass searches for reducing secondary exposure risk associated with ground squirrel rodenticide applications. Vertebrate Pest Control Research Advisory Committee (April 1, 2025 – February 28, 2026).

Investigating invasive roof rat resistance by screening for genetic mutations and metabolic changes. Vertebrate Pest Control Research Advisory Committee (July 2022 – June 2023; Co-PI).

Developing and testing an IPM approach for managing roof rats in citrus. Vertebrate Pest Control Research Advisory Committee (March 2022 – February 2024).

A test of management tools for invasive roof rats in citrus orchards. Vertebrate Pest Control Research Advisory Committee (February 2021 – December 2021; Co-PI).

An assessment of quantitative indexing tools and movement patterns in invasive roof rats in citrus orchards. Vertebrate Pest Control Research Advisory Committee (January 2020 – December 2020).

Intramural grants: *Total funding $258,571*

Industry/programmatic funding and in-kind support: *Total funding $236,879*

REPRESENTATIVE REFEREED PUBLICATIONS

Baldwin, R. A., R. Meinerz, and A. B. Shiels. 2025. Testing an integrated approach for managing roof rats in citrus orchards. Pest Management Science.

Stapp, P., A. McKenzie, D. M. Bucklin, **R. A. Baldwin**, and N. Quinn. 2025. Patterns of exposure of coyotes to anticoagulant rodenticides in California, USA. Journal of Wildlife Management 89:e22696.

Baldwin, R. A., R. Meinerz, and J. A. Smith. 2024. Identifying black rat (*Rattus rattus*) movement patterns aids the development of management programs in citrus orchards. Wildlife Research 51:WR23149.

Baldwin, R. A., T. A. Becchetti, J. S. Davy, R. E. Larsen, F. E. Mashiri, R. Meinerz, R. K. Ozeran, and D. Rao. 2022. Estimating reduction in standing crop biomass from California ground squirrels in central California rangelands. Rangeland Ecology & Management 83:50–58.

Baldwin, R. A., R. Meinerz, and A. B. Shiels. 2022. Efficacy of Goodnature A24 self-resetting traps and diphacinone bait for controlling black rats (*Rattus rattus*) in citrus orchards. Management of Biological Invasions 13:577–592.

Baldwin, R. A., T. A. Becchetti, R. Meinerz, and N. Quinn. 2021. Potential impact of diphacinone application strategies on secondary exposure risk in a common rodent pest: implications for management of California ground squirrels. Environmental Science and Pollution Research 28:45891–45902.

Baldwin, R. A., R. Meinerz, and G. W. Witmer. 2016. Cholecalciferol plus diphacinone baits for vole control: a novel approach to a historic problem. Journal of Pest Science 89:129–135.

Baldwin, R. A., N. Quinn, D. H. Davis, and R. M. Engeman. 2014. Effectiveness of rodenticides for managing invasive roof rats and native deer mice in orchards. Environmental Science and Pollution Research 21:5795–5802.

Baldwin, R. A., T. P. Salmon, R. H. Schmidt, and R. M. Timm. 2014. Perceived damage and areas of needed research for wildlife pests of California agriculture. Integrative Zoology 9:265–279.

Baldwin, R. A., T. P. Salmon, R. H. Schmidt, and R. M. Timm. 2013. Wildlife pests of California agriculture: regional variability and subsequent impacts on management. Crop Protection 46:29–37.

PRESENTATIONS

Extension Presentations

Over 360 presentations to various commodity groups, advisory committees, Master Gardener groups, universities, and private organizations.

Professional Presentations

Over 90 presentations at a variety of professional meetings and conferences, including The Wildlife Society National Conference, the Vertebrate Pest Conference, and the American Society of Mammalogists.

2025/2026 VPCRAC Project Proposal Budget Template

Complete the budget template below by filling in information. This template uses formulas to automatically calculate totals. **Do not** alter the formatting or formulas in cells. Rows may be added to accommodate additional personnel or funding sources, if necessary. Contact the CDFA staff at (916) 764-7759 or IPCinfo@cdfa.ca.gov for help filling out this template.

Project Title: Investigating the potential of burrow fumigation and trapping for managing roof rats in nut orchards
Project Leader(s): Roger Baldwin

		2025-2026	2026-2027	2027-2028	Total
A.	**PERSONNEL (name, role, % based on full time salary)**				
	Salary				
	Ryan Meinerz, SRA II: $30.66/hour at 1,392 hours	$42,679.00			$42,679.00
					$0.00
					$0.00
					$0.00
	Salary Total	$42,679.00	$0.00	$0.00	$42,679.00
	Benefits				
	SRA II: 52.9% for 2025-26	$22,577.00			$22,577.00
					$0.00
					$0.00
					$0.00
	Benefits Total	$22,577.00	$0.00	$0.00	$22,577.00
	Personnel Cost (A)	$65,256.00	$0.00	$0.00	$65,256.00
B.	**OPERATING EXPENSES**				
	Supplies	$4,398.00			$4,398.00
	Equipment				$0.00
	Travel	$30,716.00	$460.00		$31,176.00
	Professional/Consultant Services(Cannot exceed $65/hour)				$0.00
	Other	$6,300.00			$6,300.00
	Operating Cost (B)	$41,414.00	$460.00	$0.00	$41,874.00
	TOTAL Costs (A+B)	$106,670.00	$460.00	$0.00	$107,130.00
C.	Indirect Costs (Cannot Exceed 10% of Total Costs (A+B))	$11,852.00	$51.00		$11,903.00
	TOTAL CDFA FUNDING REQUESTED (A+B+C)	$118,522.00	$511.00	$0.00	$119,033.00
D.	**OTHER FUNDING SOURCES**				
					$0.00
					$0.00
					$0.00
					$0.00
					$0.00
	TOTAL OTHER FUNDING (C)	$0.00	$0.00	$0.00	**$0.00**
	TOTAL PROJECT BUDGET (A+B+C+D)	$118,522.00	$511.00	$0.00	$119,033.00