A. Cover Page

1. Project Title: Developing and testing an IPM approach for managing roof rats in citrus.

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3. Cooperators: NA

4. CDFA Funding Request Amount/Other Funding: PY 1 (2022-2024) = $147,279

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B. Executive Summary

1. Problem: Roof rats (*Rattus rattus*) cause extensive damage in a number of tree crops including citrus. Roof rat populations seem to be expanding and growing throughout many agricultural regions in CA, yet management options for limiting this damage have been largely unsuccessful. The development of an IPM program could greatly reduce this damage, but we currently lack a good understanding of the efficacy of management tools for roof rats in citrus. Citrus is an important commodity in California. Collectively, oranges, lemons, tangerines, and grapefruits were worth >$2.4 billion to California in 2018 (California Agricultural Statistics Review 2018-2019). Effective management of roof rats in citrus is needed to protect this valuable commodity.

2. Objectives, Approach, and Evaluation: We have multiple objectives for this project. They include: 1) developing an IPM program to manage roof rats in citrus, 2) comparing efficacy of the IPM and rodenticide-only management programs, 3) comparing costs of IPM and rodenticide-only management programs, and 4) collating all information to identify the most cost-effective and efficacious management strategy. Traditional roof rat management, and management for rodents in many agricultural systems, often entails using a single rodenticide application period once a year 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 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. To that end, our goal for this project is to develop and test the efficacy and cost effectiveness of an IPM program for managing roof rats in citrus orchards. We will incorporate information from current and recently completed projects to develop an IPM plan at the beginning of the project. This plan will include the use of indexing tools to monitor roof rat numbers at the start of the project, and at set intervals throughout the project to assess the effectiveness of our management program. We will use a combination of elevated bait stations using either or both of diphacinone and chlorophacinone products depending on trials underway. We will also incorporate trapping as part of this IPM program to help reduce and maintain low numbers of roof rats. We will use movement data previously collected from roof rats to determine proper spacing for these roof rat removal tools. This IPM program will be implemented for a full year to determine longer-term effectiveness of this approach. These trials will be conducted in multiple citrus orchards in the Central Valley.

   Concurrent with these IPM trials, we will also operate a more traditional approach for managing roof rats that will include a single rodenticide application period. For this approach, we will implement a bait application period (~4-6 weeks) in the same manner as that which we will use for the IPM program. However, this will be the only removal effort used for the entire year. We will then document changes in roof rat numbers throughout the year. We will keep track of labor and material costs for both the IPM and single rodenticide application strategies to allow for a comparison of both efficacy of each management approach (as measured by change in roof rat numbers over the entire year), as well as the total cost of each management strategy. Concluding thoughts will be provided as to the tradeoffs between altering strategies to lower costs vs. a potential reduction in effectiveness of the management program. This project will be considered a success if we can establish a management program for roof rats in citrus that will prove to be both efficacious and cost effective.

3. Audience: Citrus 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 citrus in the state. Although this research is targeted toward citrus production, the results may be applicable to other orchard systems as well, thereby increasing the value of this project.

C. Justification

1. CDFA VPCRAC Mission and Responsibilities: At several previous meetings, VPCRAC has identified projects that lead to more effective management of roof rats in citrus as a top priority. Both PIs on this project are currently involved in projects that are setting the foundation for addressing this issue. This proposed project will build off some of this early research. It is important to note that roof rats are invasive rodents that cause extensive agricultural damage throughout California and globally. As such, results from this project may have substantial applicability across many tree crops in California, and potentially to other parts of the U.S. and globally. Additionally, roof rat burrowing activity can potentially damage irrigation infrastructure, they pose substantial human health and safety risks 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. As such, the development of effective management strategies for roof rats fits very squarely within the VPCRAC mission.

2. Impact: 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). Furthermore, roof rats cause frequent damage to citrus crops (Worth 1950), with anecdotal information suggesting roof rat damage is on the rise in citrus orchards in California. Effective management options for these invasive rodents are needed to minimize losses in these orchard systems, yet little seems to work for roof rats in citrus orchards (Sun Pacific, pers. comm.).

   The UC IPM Pest Management Guidelines for citrus (https://www2.ipm.ucanr.edu/agriculture/citrus/Roof-Rats/) only lists three management tools for roof rats: 1.) cultural control, 2.) rodenticide baiting, and 3.) trapping. Cultural control primarily involves removing vegetative materials from orchards to help deter roof rats, but the practicality of this approach is substantially limited given that the trees themselves generally provide ample cover for rats. This leaves rodenticides and trapping as the two primary tools for managing roof rats in citrus. For rodenticides, we are aware of no studies officially testing their efficacy against roof rats in citrus. Furthermore, only within the last 2 years has rodenticide application been approved by the California Department of Pesticide Regulation for use in citrus orchards during the bearing season, thereby opening up a new potential strategy that could be highly effective against roof rats. Rodenticides are generally very effective options for managing roof rats (e.g., Baldwin et al. 2014a). Current research will determine if this is the case in citrus orchards, as well. If so, rodenticides will likely constitute a valuable part of an IPM program for roof rat control. That said, exclusive use of rodenticides can sometimes lead to problems such as bait avoidance and rodenticide resistance. Alternative tools are needed to combine with rodenticide applications to maximize the long-term efficiency and effectiveness of management programs (Baldwin et al. 2014b).

Currently, the only other likely tool to supplement rodenticide applications for roof rats in orchards is trapping. Snap traps and cage traps have historically been the two primary traps available for roof rats, but both require checking traps frequently to remove captured individuals and to reapply bait. The recent introduction of the A24 trap into the U.S. has the potential to greatly increase the utility of trapping as a management tool in that the traps allow for the capture of up to 24 rats without the need to check or reset. This could result in substantial savings in labor costs, making trapping a more viable tool for managing roof rats in orchards.

Both of these tools hold potential promise in helping to manage roof rats in citrus, but consideration must be made as to how these tools are distributed throughout an orchard to balance efficacy with cost effectiveness. Our recent research focusing on rat movement patterns has shown that spacing these devices approximately every 250 feet will be ideal. We have also completed analysis on an indexing strategy that will allow us to track changes in roof rat numbers over time. Collectively, this information will all be combined into an IPM program that will be tested for a full year to determine how effective this program can be at both removing roof rats from citrus orchards, as well as keeping these populations from rebounding within the orchards. We will also assess the material and labor costs of this IPM program to provide growers information on both the efficacy and cost effectiveness of this IPM program.

3. <u>Long-Term Solutions:</u> 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 in citrus in recent years. CDFA's rodenticide labels have not traditionally allowed for bait application within orchards during the bearing season, which has been substantially limiting in citrus where fruit is on the trees almost year-round. New changes to the CDFA diphacinone label now allow for bait application within elevated bait stations during the bearing season. A new chlorophacinone bait may soon be available for similar use if proven effective, as well. That said, more than one tool is needed to develop an effective IPM strategy for managing roof rats in citrus. Trapping is the most likely alternative. The A24 trap is one potential option, although snap trapping or live trapping could be a consideration as well. Collectively, a combined bait application and trapping program could provide a longer-term solution to manage this increasingly common agricultural pest for citrus growers.

4. <u>Related Research:</u> To effectively manage roof rats, we have to be able to monitor for changes in rat population size. Baldwin et al. (2014a) developed an index that used remote-triggered cameras in almonds to monitor roof rat populations. However, the effectiveness of indices can vary across cropping systems (Engeman and Witmer 2000). Therefore, following Whisson et al. (2005), we have developed two indices using tracking tunnels and remote-triggered cameras in citrus to accurately reflect rat populations in this cropping system. We have also tested potential attractants for roof rats, and have identified a commercial attractant (Liphatech Rat & Mouse Attractant) that is highly attractive to roof rats. We will use this in our proposed study.

   Chlorophacinone and diphacinone baits have effectively controlled roof rats in a number of locations and situations (Claffey et al. 1986, Donlan et al. 2003, Witmer et al. 2007). In particular, Baldwin et al. (2014a) determined that 0.005% diphacinone-treated oats were highly effective against roof rats in almond orchards. Interestingly, 0.005% chlorophacinone-treated oats were not found to be overly efficacious, yet studies have documented efficacy with chlorophacinone in other settings (e.g., Whisson et al. 2004). We currently have a project underway that is addressing the efficacy of both a diphacinone and chlorophacinone bait in elevated bait stations to determine their effectiveness at controlling rats in orchards. We anticipate one or both of these products proving successful at reducing roof rat numbers in citrus orchards, thus we plan to include one or both in our development of an IPM program for roof rats.

Another alternative for controlling roof rats in agricultural systems is trapping. Historically, snap trapping has been used in these settings, but snap trapping requires more consistent labor to set and check traps than baiting. More recently, we have seen an increase in the use of automatic resetting traps that allow for many captures without rebaiting or resetting (Goodnature A24 trap; e.g., Carter et al. 2016, Shiels et al. 2019). These traps are currently in use for removing rats from islands to protect native species, and are now sold in the U.S. for use in commensal and agricultural settings. We are currently addressing their effectiveness in citrus orchards. If effective, they would provide an interesting addition to bait application programs to bolster the concept of IPM in orchards. If not effective, standard snap trapping or targeted live trapping could be used to supplement bait application as part of an IPM approach.

Quinn and Baldwin (2014) previously provided an informative outreach document for orchards to help provide guidance on roof rat management. However, the spacing between bait stations in this document was based on expert opinion given a lack of movement data available for roof rats in California orchards. The PI for this proposal has finished a project that identified movement patterns in roof rats to better define the needed spacing for bait stations and traps in citrus orchards. This information will be used to guide bait station and trap distribution for IPM programs. Lastly, it bears noting that we are seeking cost-share funding from the Citrus Research Board to help defray the costs of this study.

5. Contribution to Knowledge Base: Roof rats (*Rattus rattus*) cause extensive damage in a number of tree crops including citrus. Roof rat populations seem to be expanding and growing throughout many agricultural regions in California, yet management options for limiting this damage have been largely unsuccessful. The development of an IPM program could greatly reduce this damage, but we currently lack a good understanding of the efficacy of management tools for roof rats in citrus. Citrus is an important commodity in California. Collectively, oranges, lemons, tangerines, and grapefruits were worth >$2.4 billion to California in 2018 (California Agricultural Statistics Review 2018-2019). Effective management of roof rats in citrus is needed to protect this valuable commodity. We are currently investigating the efficacy of elevated bait stations to determine their efficacy in citrus orchards. Likewise, the development of an automatic repeating trap has increased the practicality of trapping as a roof rat management tool in citrus orchards. Our ongoing investigation will identify the utility of this approach. Collectively, this information, as well as information on roof rat movement patterns and the development of roof rat monitoring tools, will allow us to develop and test the efficacy and cost effectiveness of an IPM approach to manage this damaging, invasive pest. If successful, this IPM approach should at long last provide citrus 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 pose a food safety risk and cause extensive damage in orchards systems, as outlined previously. Prior to our current and proposed studies, no research had been conducted to address this problem in citrus. 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 citrus orchards during the growing season. Before this change, little could often be done to remove roof rats from citrus orchards in an efficacious and cost effective manner. The availability of labor-saving A24 repeating traps now provides another potential strategy for managing roof rats. The foundation for a successful roof rat management program is currently being constructed, but additional research is needed to determine what tools to include into an IPM program for roof rats in citrus, how efficacious an IPM program can be compared to a more conventional rodenticide-only management strategy, and how cost effective these tools are at managing this invasive pest. The development of an efficacious, cost-effective management program for roof rats in citrus would result in reduced damage to trees and fruit, ultimately increasing crop production for growers. This IPM program will be developed to keep roof rats at low numbers within orchards long-term, thereby substantially reducing any food safety concerns associated with this pest. Although this research will most directly benefit growers, these tools will also have applicability to nurseries and packing facilities that experience damage and conflict scenarios associated with roof rats.

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D. Objectives: There are multiple objectives for this project. They include: 1) developing an IPM program to manage roof rats in citrus, 2) comparing efficacy of the IPM and rodenticide-only management programs, 3) comparing costs of IPM and rodenticide-only management programs, and 4) collating all information to identify the most cost-effective and efficacious management strategy.

E. Work Plans and Methods (project dates: Mar 1, 2022 to Feb 29, 2024)

1. <u>Work Plan:</u> This proposed project is part of a longer-term tiered project. The initial portion of this study developed indexing protocols to track roof rat population size, and assessed movement patterns of roof rats. This information is currently being used to test the efficacy of three different strategies for reducing roof rat numbers in citrus orchards: 1.) CDFA's Rodent Bait Diphacinone Treated Grain (0.005%), 2.) a 0.005% chlorophacinone soft bait, and 3.) A24 repeating traps. We anticipate fieldwork concluding in October 2024. This efficacy data will then be used to develop an IPM approach managing roof rats in citrus using all previous portions of this longer-term project to help develop this model. We will then compare the efficacy and cost-effectiveness of the IPM model against a rodenticide-only management strategy to determine which approach will be most practical for citrus growers to employ. Our final

task will be the completion of our final report for this project. We anticipate a completion of analyses and the final report by March 31, 2024.

2. Methods: Our initial step will be to incorporate information from current and recently completed projects to develop an IPM plan. This plan will include a combination of indexing tools to monitor changes in roof rat numbers over time, as well as the use of rodenticides and traps to help reduce roof rat numbers within orchards. We will use movement data already collected to inform the proper distribution of traps and bait stations throughout the orchards.

   Once we have developed an IPM approach to test, we will then identify 4 field sites to conduct trials. Each field site will consist of two treatment blocks. We will use the IPM strategy in one of the blocks, while the other block will receive a rodenticide-only treatment program. As previously stated, the IPM approach is yet to be determined, but will likely use bait stations at the start of the study to knock down roof rat populations. For this approach, bait stations will be distributed throughout the study area. The bait stations will be operated for 4-6 weeks. We will determine efficacy of this removal program through pre-and post-treatment indexing strategies (i.e., remote-triggered cameras and tracking tunnels). If roof rats remain in the treatment area, we will deploy traps to further reduce their numbers. The traps we use will depend on the success of our A24 study. If we find that the A24s successfully reduce roof rat numbers, we will use them. If they are unsuccessful, we will use rat-size snap traps in trees. We will continue to monitor roof rat activity quarterly using indexing tools. Trapping will likely be the only additional tool to keep roof rat numbers under control for the remainder of the year, although if roof rat numbers do increase substantially, we may apply additional bait to again knock down the numbers.

   For rodenticide-only blocks, we will deploy a bait application program that is the same as that used in the IPM block. Once the initial baiting program is complete, we will assess efficacy via our indexing program. At that point, no more rat removal efforts will be undertaken. However, we will continue to monitor roof rat activity quarterly to see how roof rat populations rebound in the treated area. We will keep track of labor and material costs for both the IPM and single rodenticide application strategies to allow for a comparison of both efficacy of each management approach (as measured by change in roof rat numbers over the entire year), as well as the total cost of each management strategy. Concluding thoughts will be provided as to the tradeoffs between altering strategies to lower costs vs. a potential reduction in effectiveness of the management program. Special consideration will be given to the potential long-term efficacy and cost effectiveness of each management strategy.

3. Experimental Site: Treatment sites will be determined at the time of the study based on current numbers of roof rats at orchard locations. That said, we anticipate sites occurring in Kern and Tulare Counties.

F. Project Management, Evaluation, and Outreach

1. Management: R. Baldwin will serve as the primary PI for the project and will oversee all aspects of the project. A. Shiels will serve as Co-PI and will be involved extensively in study design and data collection, and will assist in analysis and report/publication writing.

2. Evaluation: Success for this project will depend on our ability to identify the best strategy for managing roof rats in citrus based on the tools and methods listed in this proposal. This will involve balancing costs associated with a management program to the longer-term efficacy of each program. Once completed, we will develop a number of outreach materials to convey our findings to citrus growers. Initial efforts will involve providing results of our findings through various seminar and interview opportunities. The PI is a Cooperative Extension Specialist and regularly provides 20-30 presentations and several interviews on rodent management each year. We will also provide popular press and trade magazine articles to further the reach of our findings. Our study results will be particularly important to include into the UC IPM Pest Management Guidelines for citrus. This will be an easy addition, as the PI is the author for the vertebrate section.

   Of particular importance is a previous UC ANR publication on managing roof rats and deer mice in nut and fruit orchards that was coauthored by the PI (http://baldwin.ucdavis.edu/files/1814/7223/7069/Quinn_and_Baldwin_2014.pdf). This has been a useful resource, but it focused exclusively on rodenticide application and lacked information on roof rat movement patterns that are needed to optimize spacing of roof rat management tools. Furthermore, roof rat cover is quite a bit different in citrus crops than in other tree crops given the presence of thick cover year-round. As such, we will either update this previous publication, or more likely, we will create a separate UC ANR publication that will detail how to develop an IPM program for managing roof rats in citrus orchards. From a management perspective, this will be the seminal publication to come out of this project.

G. Budget Narrative

Personnel Expenses

Salaries - $52,820: *Salary costs use fiscal year 2021/2022 (July 1, 2021 through July 31, 2022) 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. Extensive lab time will be required for analyzing data as well. Effort is estimated at 522 hours for year 1, 1,044 hours for year 2, and 348 hours for year 3 at a wage of $26.28, $27.88 and $28.72 for 2021-22, 2022-23, and 2023-24, respectively. This is equivalent to 100% time for 3, 6, and 2 months per project year (PY1 = $13,718, PY2 = $29,107, PY3 = $9,995).

Fringe Benefits - $28,160: *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, 2022.*

Ryan Meinerz (Staff Research Associate II): Fringe benefits calculated at 51.9% for 2021/22, 53.4% 2022/23, and 55.0% for 2023/24 (PY1 = $7,120, PY2 = $15,543, PY3 = $5,497).

Operating Expenses

Supplies - $12,085

Tracking tunnels ($9/station × 250 stations = $2,250)

Tracking cards ($0.70/card × 2,300 cards = $1,610)

Ink for tracking tunnels ($20/container × 1 containers = $20)

Lithium AA batteries for remote-triggered cameras ($30/pack × 5 packs = $150)

Remote-triggered cameras (5 × $330/camera = $1,650)

SD cards for cameras (5 × $11/card = $55)

Bait for bait stations (200 lbs × $2.00/lbs = $400)

A24 traps (25 × $200/trap = $5,000)

Wooden boards for tracking tunnels and bait stations (50 boards by $13/board = $650)

Zip ties and bungees for attaching bait, traps, bait stations and cameras when needed ($200)

Miscellaneous field items (e.g., flags, flagging tape, Ziploc bags, data notebooks, etc. = $100)

Equipment:
N/A

Travel - $33,070:
Trip 1: From Apr 12 to Apr 25, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with site establishment and initiation of study. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,510 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 14 days/13 nights in duration with hotel ($105/night for 13 nights) and meals ($35/day x 14 days per trip) associated with this trip (PY1 = $2,293).

Trip 2: From Apr 18 to Apr 21, 2022, PI will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with initiation of study. 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 ($0.56/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($105/night for 3 nights) and meals ($35/day x 4 days per trip) associated with this trip (PY1 = $937).

Trip 3: From May 2 to May 15, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with site establishment. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,510 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 14 days/13 nights in duration with hotel ($105/night for 13 nights) and meals ($35/day x 14 days per trip) associated with this trip (PY1 = $2,293).

Trip 4: From May 8 to May 11, 2022, PI will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with indexing and bait application. 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 ($0.56/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($105/night for 3 nights) and meals ($35/day x 4 days per trip) associated with this trip (PY1 = $937).

Trip 5: From May 22 to May 23, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with bait station checks. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 730 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 2 days/1 night in duration with hotel ($105/night for 1 night) and meals ($35/day x 2 days per trip) associated with this trip (PY1 = $387).

Trip 6: From May 30 to May 31, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with bait station checks. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 730 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 2 days/1 night in duration with hotel ($105/night for 1 night) and meals ($35/day x 2 days per trip) associated with this trip (PY1 = $387).

Trip 7: From Jun 2 to Jun 10, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with removal of bait stations and post-treatment indices. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,185 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 9 days/8 nights in duration with hotel ($105/night for 8 nights) and meals ($35/day x 9 days per trip) associated with this trip (PY1 = $1,499).

Trip 8: From Jun 17 to Jun 18, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with bait station checks. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 730 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 2 days/1 night in duration with hotel ($105/night for 1 night) and meals ($35/day x 2 days per trip) associated with this trip (PY1 = $387).

Trip 9: From Jun 22 to Jun 30, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with removal of bait stations and post-treatment indices. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,185 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 9 days/8 nights in duration with hotel ($105/night for 8 nights) and meals ($35/day x 9 days per trip) associated with this trip (PY1 = $1,499).

Trip 10: From Jul 7 to Jul 20, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with site establishment, indexing, and bait application. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,510 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 14 days/13 nights in duration with hotel ($105/night for 13 nights) and meals ($35/day x 14 days per trip) associated with this trip (PY2 = $2,293).

Trip 11: From Jul 13 to Jul 16, 2022, PI will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with indexing and bait application. 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 ($0.56/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($105/night for 3 nights) and meals ($35/day x 4 days per trip) associated with this trip (PY2 = $937).

Trip 12: From Jul 22 to Aug 9, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with initiation of study site, as well as quarterly indexing. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,835 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 19 days/18 nights in duration with hotel ($105/night for 18 nights) and meals ($35/day x 19 days per trip) associated with this trip (PY2 = $3,087).

Trip 13: From Aug 2 to Aug 5, 2022, PI will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with indexing and bait application. 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 ($0.56/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($105/night for 3 nights) and meals ($35/day x 4 days per trip) associated with this trip (PY2 = $937).

Trip 14: From Aug 16 to Aug 17, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with bait station checks. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 730 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 2 days/1 night in duration with hotel ($105/night for 1 night) and meals ($35/day x 2 days per trip) associated with this trip (PY2 = $387).

Trip 15: From Aug 24 to Aug 25, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with bait station checks. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 730 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 2 days/1 night in duration with hotel ($105/night for 1 night) and meals ($35/day x 2 days per trip) associated with this trip (PY2 = $387).

Trip 16: From Aug 27 to Sep 4, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with removal of bait stations and post-treatment indices. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,185 miles round trip). Mileage is for a rental vehicle ($0.29/mile).

The trip is anticipated to be 9 days/8 nights in duration with hotel ($105/night for 8 nights) and meals ($35/day x 9 days per trip) associated with this trip (PY2 = $1,499).

Trip 17: From Sep 12 to Sep 13, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with bait station checks. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 730 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 2 days/1 night in duration with hotel ($105/night for 1 night) and meals ($35/day x 2 days per trip) associated with this trip (PY2 = $387).

Trip 18: From Sep 17 to Sep 25, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with removal of bait stations and post-treatment indices. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,185 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 9 days/8 nights in duration with hotel ($105/night for 8 nights) and meals ($35/day x 9 days per trip) associated with this trip (PY2 = $1,499).

Trip 19: From Oct 16 to Oct 20, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with quarterly indexing. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 925 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($105/night for 4 nights) and meals ($35/day x 5 days per trip) associated with this trip (PY2 = $863).

Trip 20: From Oct 24 to Oct 28, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with maintenance trapping. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 925 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($105/night for 4 nights) and meals ($35/day x 5 days per trip) associated with this trip (PY2 = $863).

Trip 21: From Nov 5 to Nov 9, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with quarterly indexing. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 925 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($105/night for 4 nights) and meals ($35/day x 5 days per trip) associated with this trip (PY2 = $863).

Trip 22: From Dec 6 to Dec 10, 2022, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with maintenance trapping. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 925 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($105/night for 4 nights) and meals ($35/day x 5 days per trip) associated with this trip (PY2 = $863).

Trip 23: From Jan 16 to Jan 20, 2023, PI will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with quarterly indexing. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 925 miles round trip). Mileage is for a rental vehicle ($0.56/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($105/night for 4 nights) and meals ($35/day x 5 days per trip) associated with this trip (PY2 = $1,113).

Trip 24: From Feb 5 to Feb 9, 2023, PI will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with quarterly indexing. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 925 miles round trip). Mileage is for a rental vehicle ($0.56/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($105/night for 4 nights) and meals ($35/day x 5 days per trip) associated with this trip (PY2 = $1,113).

Trip 25: From Mar 15 to Mar 19, 2023, PI will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with maintenance trapping. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 925 miles round trip). Mileage is for a rental vehicle ($0.56/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($105/night for 4 nights) and meals ($35/day x 5 days per trip) associated with this trip (PY2 = $1,113).

Trip 26: From Apr 16 to Apr 20, 2023, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with quarterly indexing. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 925 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($105/night for 4 nights) and meals ($35/day x 5 days per trip) associated with this trip (PY2 = $863).

Trip 27: From May 5 to May 9, 2023, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with quarterly indexing. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 925 miles round trip). Mileage is for a rental vehicle ($0.29/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($105/night for 4 nights) and meals ($35/day x 5 days per trip) associated with this trip (PY2 = $863).

Trip 28: From Jul 16 to Jul 19, 2023, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with quarterly indexing. 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 rental vehicle ($0.29/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($105/night for 3 nights) and meals ($35/day x 4 days per trip) associated with this trip (PY3 = $704).

Trip 29: From Aug 5 to Aug 8, 2023, SRA II will travel from Davis to anticipated field site in the Bakersfield area (TBD). This travel will correspond with quarterly indexing. 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 rental vehicle ($0.29/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($105/night for 3 nights) and meals ($35/day x 4 days per trip) associated with this trip (PY3 = $704).

Trips 30-32: Travel from Davis to VPCRAC meeting sites (TBD) to provide updates 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 ($0.56/mile). Trips are anticipated to be 2 days/1 night in duration with associated hotel ($105/night) and meals ($35/day x 2 days per trip) associated with each trip. Total cost per trip estimated at $371. Three trips are anticipated during the project period. Travel reimbursement will be claimed by either R. Baldwin or R. Meinerz (PY2 = $742, PY3 = $371).

Professional/Consultant Services:
N/A

Other Expenses - $7,755:
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 $705/month. We will charge 11 months of the rental truck for field use in 2022-2024 (PY1 = $2,115; PY2 = $4,230; PY3 = $1,410).

Indirect (F&A) Costs - $13,389

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

Per the agreement between the University of California and the California Department of Food and Agriculture, indirect costs have been calculated at 10% Total Direct Cost (MTDC) for the project (PY1 - $4,566; PY2 - $6,955; PY3 = $1,868).

Other Funding Sources - $5,000

Automatic Trap Company:
They will provide $5,000 in in-kind support for the project. This will include all A24 traps and all attachments and attractants required to properly operate these traps.

2021 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) 262-1102 or David.Kratville@cdfa.ca.gov for help filling out this template.

Project Title: Developing and testing an IPM approach for managing roof rats in citrus
Project Leader(s): Roger Baldwin

	2021-2022	2022-2023	2023-2024	Total
A. PERSONNEL (name, role, % based on full time salary)				
Salary				
Ryan Meinerz, SRA II: 522, 1,044, and 348 hours/yr at	$13,718.00	$29,107.00	$9,995.00	$52,820.00
$26.28, $27.88, and $28.72/hr for 2021-22, 2022-23, and				$0.00
2023-24, respectively.				$0.00
				$0.00
Salary Total	$13,718.00	$29,107.00	$9,995.00	$52,820.00
Benefits				
SRA II: 51.9%, 53.4%, and 55.0% for 2021-22, 2022-23, and	$7,120.00	$15,543.00	$5,497.00	$28,160.00
2023-24, respectively (includes 3% escalations at beginning				$0.00
of each FY).				$0.00
				$0.00
Benefits Total	$7,120.00	$15,543.00	$5,497.00	$28,160.00
Personnel Cost (A)	$20,838.00	$44,650.00	$15,492.00	$80,980.00
B. OPERATING EXPENSES				
Supplies	$12,085.00			$12,085.00
Equipment				$0.00
Travel	$10,619.00	$20,672.00	$1,779.00	$33,070.00
Professional/Consultant Services(Cannot exceed $65/hour)				$0.00
Other	$2,115.00	$4,230.00	$1,410.00	$7,755.00
Operating Cost (B)	$24,819.00	$24,902.00	$3,189.00	$52,910.00
TOTAL Costs (A+B)	$45,657.00	$69,552.00	$18,681.00	$133,890.00
C. Indirect Costs (Cannot Exceed 10% of Total Costs (A+B))	$4,566.00	$6,955.00	$1,868.00	$13,389.00
TOTAL CDFA FUNDING REQUESTED (A+B+C)	$50,223.00	$76,507.00	$20,549.00	$147,279.00
D. OTHER FUNDING SOURCES				
Automatic Trap Company	$5,000.00			$5,000.00
				$0.00
				$0.00
				$0.00
				$0.00
TOTAL OTHER FUNDING (C)	$5,000.00	$0.00	$0.00	**$5,000.00**
TOTAL PROJECT BUDGET (A+B+C+D)	$55,223.00	$76,507.00	$20,549.00	$152,279.00

Exhibit A6 – Current & Pending Support

CURRENT & PENDING SUPPORT

University will provide current & pending support information for Key Personnel identified in Exhibit A2 at time of proposal and upon request from State agency. The "Proposed Project" is this application that is submitted to the State. Add pages as needed.

PI: Roger A. Baldwin

Status (currently active or pending approval)	Award # (if available)	Source (name of the sponsor)	Project Title	Start Date	End Date
Proposed Project	TBD	California Department of Food and Agriculture	Developing and testing an IPM approach for managing roof rats in citrus.	03/01/2022	02/29/2024
Current	NA	Specialty Crop Research Initiative	Scientific challenges and cost-effective management of risks associated with implementation of produce safety regulations	09/01/2020	09/31/2024
Current	NA	California Department of Food and Agriculture	Development of a management program for voles in alfalfa.	09/01/2021	12/31/2022

Aaron B. Shiels

Status	Award #	Source	Project Title	Start Date	End Date
Proposed Project	TBD	California Department of Food and Agriculture	Developing and testing an IPM approach for managing roof rats in citrus.	03/01/2022	02/29/2024
Current	21-7485-1543-RA	California Department of Food and Agriculture	A test of management tools for invasive roof rats	02/01/2021	12/31/2021
Current	NA	Oregon Seed Council	Weatherability and palatability of four formulations of zinc phosphide for controlling vole damage to seed-grass farms in the Willamette Valley	02/01/2021	12/31/2021
Current	NA	U.S. Army Garrison	Effectiveness of an aerial application of diphacinone at low bait rate to suppress invasive rodents	11/01/2020	12/31/2021
Current	NA	U.S. Fish & Wildlife Service	An early assessment of aquatic environmental risk to toxic bait application for the eradication of invasive rats on Aleutian Islands, Alaska	09/30/2020	09/30/2025

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 $10,012,176*

Selected titles:

Development of a management program for voles in alfalfa. Vertebrate Pest Control Research Advisory Committee (September 2021 – December 2022).

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

Scientific challenges and cost-effective management of risks associated with implementation of produce safety regulations. USDA/NIFA/Specialty Crops Research Initiative (September 2020 – August 2024).

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).

Reregistration of CDFA baits for control of roof rats and deer mice in agricultural fields. Vertebrate Pest Control Research Advisory Committee (April 2010 – March 2012).

Intramural grants: *Total funding $257,071*

Industry/programmatic funding and in-kind support: *Total funding $227,034*

REPRESENTATIVE REFEREED PUBLICATIONS

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 doi.org/10.1007/s11356-021-13977-5.

Baldwin, R. A., T. A. Becchetti, N. Quinn, and R. Meinerz. 2021. Utility of visual counts for determining efficacy of management tools for California ground squirrels. Human-Wildlife Interactions doi.org/10.26077/1d43-fbea.

Lloyd, M. G., and **R. A. Baldwin**. 2021. Burrowing rodents: developing a management plan for organic agriculture in California. University of California Division of Agriculture and Natural Resources, Publication 8688.

Baldwin, R. A., H. Halbritter, R. Meinerz, L. K. Snell, and S. B. Orloff. 2019. Efficacy and nontarget impact of zinc phosphide-coated cabbage as a ground squirrel management tool. Pest Management Science 75:1847–1854.

Baldwin, R. A., D. I. Stetson, M. G. Lopez, and R. M. Engeman. 2019. An assessment of vegetation management practices and burrow fumigation with aluminum phosphide as tools for managing voles within perennial crop fields in California, USA. Environmental Science and Pollution Research 26:18434–18439.

Baldwin, R. A., B. G. Abbo, and D. A. Goldade. 2018. Comparison of mixing methods and associated residual levels of zinc phosphide on cabbage bait for rodent management. Crop Protection 105:59–61.

Sellers, L. A., R. F. Long, M. T. Jay-Russell, X. Li, E. R. Atwill, R. M. Engeman, and **R. A. Baldwin**. 2018. Impact of field-edge habitat on mammalian wildlife abundance, distribution, and vectored foodborne pathogens in adjacent crops. Crop Protection 108:1–11.

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. 2016. Vertebrate Pests. In: UC IPM Pest Management Guidelines—Citrus. University of California Division of Agriculture and Natural Resources, Publication 3441.

Baldwin, R. A., R. Meinerz, and S. B. Orloff. 2014. The impact of attractants on pocket gopher trapping. Current Zoology 60:472–478.

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.

Quinn, N., and **R. A. Baldwin.** 2014. Managing roof rats and deer mice in nut and fruit orchards. Division of Agriculture and Natural Resources, Publication 8513.

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

Professional Presentations

Over 70 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.

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08/15/2020

Attn:
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E-mail: rabaldwin@ucdavis.edu

Aaron B. Shiels, Ph.D.
National Wildlife Research Center
USDA-APHIS-WS
4101 LaPorte Ave.
Fort Collins, CO 80521
Phone: 970-266-6324
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Hello Roger & Aaron,

We understand that you are looking to conduct a study on the efficacy of Goodnature traps and black/roof rats (*Rattus rattus*) in agricultural and specifically orchard settings. Goodnature and Automatic Trap have supported clinical trials similar to this in the past. Most recently, we worked with Aaron on the USDA released study regarding the efficacy of the Goodnature A24 and its ability to humanely dispatch house mice (*Mus musculus*).

While studies like this have intrinsic and authoritative value for our traps, we originally come from the field of conservation and understand how trials such as this can help protect crop yields, quell the spread of diseases rats carry, and ultimately lead to better, safer rodent control.

We would like to offer our help with your study. Goodnature and Automatic Trap would be interested in providing you with in-kind support for the project in the form of our Goodnature A24 traps and all related trapping supplies (i.e., bio-attractant lure, Digital Strike Counters, etc.).

Is this something that would interest you both? Please let us know how we can help push the study forward and assist with any other equipment needed.

All the best,

Ty Huggins
Director of Marketing
Automatic Trap & Goodnature.co
ty.huggins@automatictrap.com
1-877-992-8868 ext. 616