A. Cover Page

1. Project Title: Determining utility of drones for monitoring ground squirrel burrow systems.

2. Project Leader:

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3. Cooperators: NA

4. CDFA Funding Request Amount/Other Funding:

   PY1 (2022-2023) = $75,552
   PY2 (2023-2024) = $466

5. Agreement Manager:

Grace I. Liu, J.D.
Associate Director, Research Administration
Sponsored Programs
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University of California, Davis
Davis, CA 95618
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B. Executive Summary

1. Problem: California ground squirrels (*Otospermophilus* spp.) cause extensive damage to water-holding structures such as dams, levees, and irrigation canals through their extensive burrowing activities. As such, there is very little tolerance for their burrow systems in these structures, but finding their burrow systems and removing offending ground squirrels is very time consuming and costly for government agencies and private industry tasked with maintaining these structures. Identifying more efficient strategies for detecting ground squirrel burrow systems would provide substantial aid to these groups who are very resource strapped. I have been approached by several water districts over the last year seeking advice on how to more effectively monitor ground squirrel activity on these structures. Clearly, a better approach is needed.

2. Objectives, Approach, and Evaluation: The objective for this project is to determine the accuracy of drones and visual imagery software for identifying ground squirrel burrow systems on water-holding structures. We will first calibrate a red-blue-green (RBG) camera operated from a drone to detect ground squirrel burrows on water-holding structures. We will then use software developed by Alta Innovation Solutions to identify

ground squirrel locations. We will also georeference all ground squirrel burrow entrances by hand and use this location data to determine the accuracy of drone imagery for detecting ground squirrel activity in our studied areas. If effective, this approach could provide a much quicker method for water management/irrigation districts to monitor ground squirrel activity, ultimately allowing for more rapid implementation of control programs for ground squirrels in these areas. Additionally, this proof-of-concept project could open the door for implementation of this technology for monitoring ground squirrels and other burrowing rodents in agricultural fields as well.

3. Audience: The initial audience will be government agencies and private organizations involved in monitoring ground squirrel activity on water-holding structures. If successful, drone-based monitoring strategies could potentially be adopted in production agriculture to assist in the management of burrowing rodents.

C. Justification

1. CDFA VPCRAC Mission and Responsibilities: Over the last year, I have been contacted by three watershed/irrigation distracts (East Bay, Ventura County, and Fresno County) as well as Association of California Water Agencies, to provide guidance on developing better detection strategies and management tools for ground squirrels on water-holding structures. These groups are mandated to manage ground squirrels given the substantial risk associated with undermining and subsequent failure of these structures from ground squirrel burrowing activities. CDFA's rodenticide products are some of the tools commonly used by these groups. Likewise, these structures carry irrigation water essential for California's agricultural industry, and if proven effective, this monitoring approach could have direct utility for use in agricultural fields as well. As such, this project fits very squarely within the VPCRAC mission.

2. Impact: Burrowing rodents, such as California ground squirrels, pose a substantial risk to water-holding structures such as dams, levees, and irrigation canals given the potential for their failure from burrow systems excavated into these structures. As such, there is generally a very low (often zero) tolerance for burrow systems on these structures. That said, there are thousands of miles of water-holding structures in California; labor to monitor them is very time-consuming and costly given that current assessments involve on-the-ground monitoring by staff. This has often led to inefficient monitoring programs, which has been a great challenge to managers of these water-holding structures. For example, I have recently been contacted by individuals in the East Bay area (several counties), Ventura County, and Fresno County on this issue. The Association of California Water Agencies has also expressed much interest in this topic. All parties are interested in more efficient and cost effective methods for monitoring ground squirrel activity in these areas.

   One possible approach to accomplish this could be through the use of unmanned aerial vehicles, or drones. Potential uses for this monitoring tool have substantially increased in recent years given rapid advancements in this technology. One company at the leading edge of this technology is Alta Innovation Systems out of Israel. They have developed software to detect rodent burrow systems as small as voles, and currently deploy this technology in several countries to monitor burrowing mammals in agricultural fields. I am proposing to test this technology in California, and am initially focusing on water-holding structures given the extreme importance of effective ground squirrel management in these areas, combined with the higher likelihood of success in locating these burrow systems in more open habitats. If proven effective, the next logical step will be to test the effectiveness of drones and associated imaging software in agricultural fields.

3. Long-Term Solutions: Effective management of burrowing rodents relies on our ability to detect and monitor these pests to determine when management actions are needed. Traditional monitoring approaches, such as extensive on-site investigations by staff, are becoming more challenging given labor shortages and transportation costs. The use of drones has the potential to substantially reduce both labor and transportation costs, while allowing for more targeted ground squirrel management actions that should prove more effective at reducing their presence on these sensitive structures. Furthermore, if proven effective, a spatial analysis service will be available to analyze all imagery, allowing for rapid turn-around times for mapping of surveyed sites. Collectively, this approach could provide a substantial upgrade in how burrow activity is monitored for ground squirrels, ultimately allowing for more effective management of these damaging pests.

4. Related Research: Although the use of drones for monitoring terrestrial wildlife species has increased over the last decade due to technological advances, little research has been conducted into the effectiveness of this technology for monitoring burrowing rodents. Alta Innovation Solutions has shown that this technology works for small rodent species in alfalfa fields in Israel (Regev et al. 2019). In theory, it should be easier to detect larger burrow systems (such as ground squirrels) in more open habitats using this same technology. As such, the use of such an imaging process appears to have much potential for use by irrigation and flood control districts in California.

Regev, T., I. Kogel, D. Segev, B. Benzion, Y. Muller, and Y. Motro. 2019. Precise control of rodents in alfalfa fields using drones. In: Proceedings, 2019 Western Alfalfa Forage Symposium, Reno, NV. https://alfalfa.ucdavis.edu/+symposium/proceedings/2019/Articles/Precise%20Control%20of%20Rodents_Regev_Article.pdf

5. Contribution to Knowledge Base: Less labor intensive and more cost effective approaches for monitoring burrowing rodents are going to be needed in the near future. The use of unmanned drones and associated visual recognition software could provide the needed tools to accomplish this goal. This would not only allow for more effective monitoring of water-holding structures, but could also translate to agricultural fields as well. Although I will focus on California ground squirrels for this project, there is a high likelihood that this approach could extend to other burrowing rodents as well, further increasing the value of this study.

6. Grower Use: This project will serve as a proof-of-concept study for the utility of drones and aerial photography for monitoring ground squirrel activity in a given area. This is particularly important for water-holding structures given the zero-tolerance policy that agencies that manage these structures have for damage caused by burrowing rodents given the potential that this damage has for causing catastrophic failures. These water-holding structures are essential for California agriculture, and as has already been stated, if proven effective, this approach could then be considered for use in agricultural fields,

as well. Lastly, CDFA rodenticide products are often used to manage ground squirrels in these areas, which further justifies the use of VPCRAC funds to support this project.

D. Objectives: The primary objective for this proposed project is to determine the accuracy and utility of using aerial photographs taken via drones to accurately identify and map ground squirrel burrow system locations on water-holding structures such as dams, levees, and irrigation canals.

E. Work Plans and Methods (project dates: Feb 1, 2023 to Jan 31, 2024)

1. Work Plan: The initial portion of this study will involve calibrating the drones and aerial photography to develop guidelines for how to fly the drones and photograph areas of interest. This calibration process should take 1–2 weeks. We will then begin the testing portion of the study across at least two regions of the state (East Bay and Ventura County) to assess the accuracy of this monitoring approach. Ground-truthing of locations will occur immediately following drone flights to allow us to test this approach. This process will occur over the course of 1–2 months. Analysis and comparison of drone-collected and ground-truthed data will then occur over the course of several months to determine the accuracy of this approach. We anticipate a completion of analyses and the final report by January 31, 2024.

2. Methods: The first step will be to fly drones and take photographs of a few study sites to begin calibration of equipment. For this, Alta Innovation Solutions personnel will fly to California to conduct initial assessments of terrain and ground squirrel burrows to fine-tune their software. Additionally, University of California Division of Agriculture and Natural Resources Informatics and GIS Program (UC ANR IGIS) staff will visit the sites at the same time to coordinate drone equipment to be used for the study, as well as to clarify how they should be flown to provide the proper images.

   Once all the equipment and software are properly calibrated, we will initiate trials to test the ability of this imaging process to accurately detect ground squirrel burrow systems. For this process, we will map out 3–5 study plots along select irrigation canals or dams in both the East Bay and Ventura areas (1–3 acres in size). The presence of a relatively large number of ground squirrel burrow entrances will be one of the primary factors when selecting study sites. Drones will then be flown in a specified pattern over the study area, with photographs taken at defined intervals along this path. These photographs will be stitched together and sent to Alta Innovation Solutions for analysis. We should receive maps of ground squirrel burrow systems from Alta Innovation Solutions within 24 hours. After completion of our drone flights, we will walk the study areas in a grid manner. Whenever a ground squirrel burrow entrance is detected, the location will be recorded with a GPS unit with sub-meter accuracy. This data will be uploaded into ArcGIS to allow for a spatial comparison between maps provided by Alta Innovation Solutions and our georeferenced locations. Comparisons between drone and ground-truthed locations will be compared through ArcGIS software to determine how accurate the spatial analysis software is at determining ground squirrel burrow systems.

3. Experimental Site: Exact observation location will be determined at the time of the study based on current ground squirrel activity. That said, we anticipate 3–5 sites occurring in the East Bay area and 3–5 sites in Ventura County.

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. All drone flights and analysis of imaging will be provided by Alta Innovation Solutions and UC ANR IGIS.
2. Evaluation: Success for this project will depend on our ability to accurately identify ground squirrel burrow systems from drones and visual recognition software. If we are successful, this information will initially be provided to all interested water districts through presentations and a synopsis of our final report. We would then build upon this success by beginning to consider how to implement this technology for assessments of burrowing rodent activity in agricultural fields.

G. Budget Narrative

Personnel Expenses

Salaries - $19,230: *Salary costs use fiscal year 2022/2023 (July 1, 2021 through July 31, 2023) 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 696 hours for year 1 at a wage of $27.63. This is equivalent to 100% time for 4 months (PY1 = $19,230).

Fringe Benefits - $9,981: *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, 2023.*

Ryan Meinerz (Staff Research Associate II): Fringe benefits calculated at 51.9% 2022/23 (PY1 = $9,981).

Operating Expenses

Supplies - $300

Miscellaneous field items (e.g., flags, data notebooks, batteries for equipment, etc. = $300)

Equipment:
N/A

Travel - $20,945:

Trip 1: From Mar 14 to Mar 20, 2023, SRA II will travel from Davis to anticipated field site in the Pleasanton area (TBD). This travel will correspond with identification of field sites and calibration of the drone. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 280 miles round trip). Mileage is for a rental vehicle ($0.32/mile). The trip is anticipated to be 7 days/6 nights in duration with hotel ($145/night for 6 nights) and meals ($40/day x 7 days per trip) associated with this trip (PY1 = $1,395).

Trip 2: From Mar 14 to Mar 20, 2023, three personnel from Alta Innovations will travel from Israel to anticipated field site in the Pleasanton area (TBD). This travel will correspond with identification of field sites and calibration of the drone. Expenses will include flights (3 round-trip tickets at $1,357/ticket), vehicle rental ($100/day for 7 days), and fuel for travel in the area ($150 for trip). The trip is anticipated to be 7 days/6 nights in duration with hotel ($145/night for 6 nights x 2 rooms/night) and meals ($40/day x 7 days x 3 individuals) associated with this trip (PY1 = $7,501).

Trip 3: From Mar 14 to Mar 18, 2023, PI will travel from Davis to anticipated field site in the Pleasanton area (TBD). This travel will correspond with identification of field sites and calibration of the drone. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 480 miles round trip). Mileage is for a personal vehicle ($0.625/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($145/night for 4 nights) and meals ($40/day x 5 days per trip) associated with this trip (PY1 = $1,080).

Trip 4: From Mar 15 to Mar 16, 2023, UC ANR IGIS staff will travel from Davis to anticipated field site in the Pleasanton area (TBD). This travel will correspond with calibration of the drone. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 280 miles round trip). Mileage is for a personal vehicle ($0.625/mile). The trip is anticipated to be 2 days/1 night in duration with hotel ($145/night for 1 night) and meals ($40/day x 2 days per trip) associated with this trip (PY1 = $400).

Trip 5: From Mar 30 to Apr 8, 2023, SRA II will travel from Davis to anticipated field site in the Pleasanton area (TBD). This travel will correspond with data collection. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 880 miles round trip). Mileage is for a rental vehicle ($0.32/mile). The trip is anticipated to be 10 days/9 nights in duration with hotel ($145/night for 9 nights) and meals ($40/day x 10 days per trip) associated with this trip (PY1 = $1,987).

Trip 6: From Mar 30 to Apr 2, 2023, PI will travel from Davis to anticipated field site in the Pleasanton area (TBD). This travel will correspond with data collection. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 400 miles round trip). Mileage is for a personal vehicle ($0.625/mile). The trip is anticipated to be 4 days/3 nights in duration with hotel ($145/night for 3 nights) and meals ($40/day x 4 days per trip) associated with this trip (PY1 = $845).

Trip 7: From Apr 1 to Apr 5, 2023, UC ANR IGIS staff will travel from Davis to anticipated field site in the Pleasanton area (TBD). This travel will correspond with data collection via drone operation. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 460 miles round trip). Mileage is for a personal vehicle ($0.625/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($145/night for 4 nights) and meals ($40/day x 5 days per trip) associated with this trip (PY1 = $1,068).

Trip 8: From Apr 13 to Apr 23, 2023, SRA II will travel from Davis to anticipated field site in the Ventura area (TBD). This travel will correspond with site establishment and data collection. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,564 miles round trip). Mileage is for a rental vehicle ($0.32/mile). The trip is anticipated to be 11 days/10 nights in duration with hotel ($175/night for 10 nights) and meals ($40/day x 11 days per trip) associated with this trip (PY1 = $2,690).

Trip 9: From Apr 13 to Apr 17, 2023, PI will travel from Davis to anticipated field site in the Pleasanton area (TBD). This travel will correspond with data collection. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,084 miles round trip). Mileage is for a personal vehicle ($0.625/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($175/night for 4 nights) and meals ($40/day x 5 days per trip) associated with this trip (PY1 = $1,578).

Trip 10: From Apr 16 to Apr 20, 2023, UC ANR IGIS staff will travel from Davis to anticipated field site in the Ventura area (TBD). This travel will correspond with data collection via drone operation. Mileage will include travel to closest hotel locations, as well as to field sites in each area (anticipated at 1,124 miles round trip). Mileage is for a personal vehicle ($0.625/mile). The trip is anticipated to be 5 days/4 nights in duration with hotel ($175/night for 4 nights) and meals ($40/day x 5 days per trip) associated with this trip (PY1 = $1,553).

Trips 11-12: 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 ($0.625/mile). Trips are anticipated to be 2 days/1 night in duration with associated hotel ($115/night) and meals ($40/day x 2 days per trip) associated with each trip. Total cost per trip estimated at $414. Two trips are anticipated during the project period. Travel reimbursement will be claimed by either R. Baldwin or SRA II (PY1 = $424; PY2 = $424).

Professional/Consultant Services - $14,300:
UC ANR IGIS staff will provide 220 hours of service flying drones and data analysis at $65/hour (PY1 = $14,300).

Other Expenses - $4,352:
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 $755/month. We will charge 4 months of the rental truck for field use in 2022-2023 (PY1 = $3,020).

UC ANR IGIS staff will provide a drone for rent for this project for 12 days of service at $111/day (PY1 = $1,332).

Indirect (F&A) Costs - $6,910

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 (TDC) for the project (PY1 = $6,868; PY2 = $42).

Other Funding Sources –

N/A

California Department of Food and Agriculture
PHPPS - Integrated Pest Control Branch

2022 VPCRAC Project Proposal Budget Template

State of California
VPCRAC-B1
Revised 2/25/2021

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: Determining utility of drones for monitoring ground squirrel burrow systems.
Project Leader(s): Roger Baldwin

		2022-2023	2023-2024	2024-2025	Total
A.	**PERSONNEL (name, role, % based on full time salary)**				
	Salary				
	Ryan Meinerz, SRA II: 696 hours/yr at $27.63/hr for 2022-23	$19,230.00			$19,230.00
					$0.00
					$0.00
					$0.00
	Salary Total	$19,230.00	$0.00	$0.00	$19,230.00
	Benefits				
	SRA II: 51.9% for 2022-23	$9,981.00			$9,981.00
					$0.00
					$0.00
					$0.00
	Benefits Total	$9,981.00	$0.00	$0.00	$9,981.00
	Personnel Cost (A)	$29,211.00	$0.00	$0.00	$29,211.00
B.	**OPERATING EXPENSES**				
	Supplies	$300.00			$300.00
	Equipment				$0.00
	Travel	$20,521.00	$424.00		$20,945.00
	Professional/Consultant Services(Cannot exceed $65/hour)	$14,300.00			$14,300.00
	Other	$4,352.00			$4,352.00
	Operating Cost (B)	$39,473.00	$424.00	$0.00	$39,897.00
	TOTAL Costs (A+B)	$68,684.00	$424.00	$0.00	$69,108.00
C.	Indirect Costs (Cannot Exceed 10% of Total Costs (A+B))	$6,868.00	$42.00	$0.00	$6,910.00
	TOTAL CDFA FUNDING REQUESTED (A+B+C)	$75,552.00	$466.00	$0.00	$76,018.00
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)	$75,552.00	$466.00	$0.00	$76,018.00

UC DAVIS
OFFICE OF RESEARCH

September 16, 2022

David Kratville
Vertebrate Pest Control Research Advisory Committee
California Department of Food and Agriculture
1220 N Street
Sacramento, CA 95814

Proposal entitled:………….“Determining utility of drones for monitoring ground squirrel burrow systems”
Principal Investigator:……Dr. Roger Baldwin

Dear Administrator,

On behalf of The Regents of the University of California, Davis Campus, it is our pleasure to present for your consideration the above-referenced proposal in response to the Vertebrate Pest Control Research Program's 2022 call for proposals.

In the event that our supplemental proposal is selected for funding, we will expect to agree to general terms and conditions as allowed in previous contracts between UC Davis and the California Department of Food and Agriculture.

Please do not hesitate to contact me if you have any questions. We request that correspondence pertaining to this proposal be sent via email to proposals@ucdavis.edu.

We look forward to collaborating with you on this important project.

Sincerely,

Shanna Nation Jose
Contracts and Grants Analyst
snation@ucdavis.edu

Please refer to Proposal No. 23-1073 on all future correspondence.

Send Award Notice to:

Office of Research, Sponsored Programs
1850 Research Park Drive
University of California
Davis, California 95618-6153
awards@ucdavis.edu

Send Checks (Payable to The Regents of the University of California) to:

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