Quantifying the frequency and effects of secondary exposure to rodenticides in barn owls

Progress report for SW18-063

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State: California
Principal Investigator:

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UC Davis

Project Information

Abstract:

Barn owls are a popular component of Integrated Pest Management (IPM) programs for
the control of rodent pests across the Western United States and contribute to sustainable agriculture through integration of natural biological control, enhancing the environmental quality of agricultural regions, and sustaining the economic viability of farm operations. However, because farmers utilize rodenticides to control rodent pests, owls can suffer from both lethal and sub-lethal secondary poisoning. Despite the important role that owls can play in providing long-term, sustainable, and
natural pest control services, we have little understanding of how often owls are exposed
to rodenticides and what effect this exposure has on their behavior and reproductive success.
To tackle this critical gap in knowledge, our study will address five key objectives:
1) Determine if rodenticide exposure affects growth rates in owl nestlings;
2) Understand how land use type, rodenticide applications, and prey choice affect the frequency of rodenticide exposure;
3) Inform predictive models on the efficacy of barn owls for controlling rodent pests on farms;
4) Create stakeholder-verified recommendations for the use of rodenticides in combination with barn owls for effective IPM; and,
5) Disseminate findings to producers through publications, a field-demonstration, visits to rural schools, and presentations to pest-control and agricultural groups.
We will use innovative blood- and fecal- testing methodologies to detect recent rodenticide exposure in adult and nestling owls, and will use GPS-tags on adult owls to
understand where they may be capturing poisoned rodents. Our project team is uniquely

positioned to execute the research and education proposed in this application. The producers on our project team have all utilized barn owls as part of IPM programs for rodent control on their land and the academics on our project team have contributed to
both research and outreach on vertebrate pest control utilizing raptors.

Project Objectives:

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Cooperators

- Greg Giguiere - Producer

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- Emma Torbert - Producer

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Research

Hypothesis:

Our proposal named 5 specific goals within the 3-year timeframe of our proposed project:

- Determine if rodenticide exposure affects growth rates and survival in owl nestlings;
- Understand how land use type, rodenticide applications, and prey choice affect the frequency at which barn owls are exposed to rodenticides;
- Use data on prey choice, prey delivery rates, and hunting patterns to inform predictive models on the efficacy of barn owls for controlling rodent pests on farms;
- Create stakeholder-verified recommendations for the use of rodenticides in combination with barn owls for effective IPM of rodent pests; and,
- Disseminate findings to producers through publications, a field-demonstration, visits to rural schools, and presentations to pest-control and agricultural groups.

Materials and methods:

Study design and procedures are designed to collect appropriate type and amount of data for analyses surrounding barn owl survival, reproductive success, chick growth rate, nest attendance, diet, foraging ecology, and rodenticide exposure in an agricultural setting in Yolo and Solano Counties.

NEST MONITORING:

We will routinely monitor pre-existing barn owl nest boxes located in agricultural fields for occupancy and nesting status to document nest box use from January (to locate roosting pairs) through September. We will visualize nest box status with minimum disturbance to owls using a live-streaming camera (SONY Action Cam) attached to an extension pole at the entrance hole to view inside nest box and determine the activity (i.e., roosting adults, incubating adults, nestlings present; Kross et al. 2016; Wendt and Johnson 2017). We will check barn owl nest boxes to monitor nest progress no more frequently than 1 week intervals. During the incubation period, we will not check barn owl nest boxes more frequently than every three weeks. We will not disturb barn owl adults and first hatched nestlings during the incubation process due to risk of nest abandonment from the adults (Taylor 1994), nor will we disturb females during the egg development period.

CAPTURE AND BANDING:

Having the population of owls banded enables future identification and also enables us to learn about other aspects of barn owl natural history such as age, longevity, mate choice, fitness, and dispersal. The following procedure will be used to capture adults roosting in boxes during the day. If adults are found roosting, but have not begun incubating (i.e., have not laid any eggs), we will use a plug at the entrance hole (i.e., wooden plug or towel) to prevent adults from flushing, which is a standard technique for capturing birds from nest boxes (Colvin and Hegdal 1986). We will carefully remove adults and cover their head with a hood to minimize stress during processing (Colvin and Hegdal 1986). Once owls are in hand, we will band them

using a standard U.S. federal metal locking leg band and record morphological measurements, including: mass, hallux length, wing chord, tail length, culmen length, and facial disc width, and inspect retrices and remiges for visible signs of molt. At time of capture and banding, we will 5 collect breast feathers for future population genetic or heavy metal contaminant studies (Smith et al. 2003). Prior to returning to box, we will give each bird a visual health check to screen for any obvious signs of disease, poor health, or stress. We will place adults back in their respective nest boxes after processing and use a plug to block the entrance hole for at least three minutes to reduce stress and the chance of flushing (Colvin and Hegdal 1986).

PREY DELIVERY AND PROVISIONING RATES:

We will utilize video monitoring of nest boxes to document prey delivery, which will enable us to identify prey species brought back to the nest and determine an adult's provisioning rate. Due to the cost of video monitoring, we will utilize a lower cost alternative, radio frequency identification devices (RFID), to document provisioning rate on boxes that will not be video monitored. Prey species will then be determined by pellets collected inside the box during nest checks for nestling growth rate, or upon fledging.

Video Monitoring:

We will monitor a sub-sample of up to 20 nest boxes each season. We will place recording cameras either inside or outside the nest, depending on size and style of nest box at ten different nest boxes. We will check nest boxes every 5 days for camera status, camera battery life and SD memory card replacement. Standard 12V car batteries will be placed below the nest box and camouflaged to reduce disturbance and for ease of weekly checking and replacement. We will remove cameras from the nest once chicks have fledged and parents are no longer provisioning young at the nest.

Radio Frequency Identification Devices:

We will use unpowered passive integrated transponder (PIT) tags that are affixed to a plastic split band in order to monitor nest attendance and provisioning rates. The housed tag will be attached to the unbanded tarsus on pairs of adults found roosting together in nest boxes before egg laying or incubation has been initiated. Tags may be placed on nestlings at the same time they are banded (once tarsus has reached full width) to observe the average age they begin leaving the nest and if they return. The tag and housing material together measure 8 mm in length, 2.5 mm in width, and weigh less than 0.15 g. This weight is less than the metal bands (2.3 grams) used to mark individual birds. As such these tags comprise less than 0.5% of the total body weight of an average 475 g adult male and 570 g adult female. This is significantly less than the standard recommended 3% tagging weight relative to body weight (Kenward 2001; Boal 2014). Total handling time for each individual to affix tags will not exceed 5 minutes. If a bird is caught with a PIT tag still attached, however, we will test whether the tag is still working and remove it if it has malfunctioned. All birds caught with tags at the end of the study will have their PIT tags removed. We will fix a thin wire antenna to the front of the boxes around the nest box opening which will not impede the birds' access to the box. A thin wire will be run below the nest box to an RFID logging unit and battery pack which will be camouflaged to minimize disturbance. The batteries in the logging unit will be replaced and information will be downloaded at weekly nest checks.

TELEMETRY:

Through telemetry, we will determine where owls are hunting in relation to rodenticide bait stations and how habitat affects prey species delivered to nest. GPS transmitters will be utilized to track the spatial hunting patterns of adult owls as they provision their chicks, and the data collected by this method will be compared with our data on rodenticide exposure rates to determine if barn owls are more likely to be exposed to secondary poisoning when hunting in specific habitat types. Therefore, the telemetry component of this study is critical to meet Objective 1a and Objective 1b. Once all eggs have hatched, we will make two trips out to a subset of nest boxes to attach (and detach) GPS transmitters on a nesting pair of adults. At each visit, we will either trap the adults in the nest box if roosting with the nestlings or set up a trap door to capture the provisioning adults using the methods provided by Colvin and Hegdal (1986). We will continuously watch the nest box during the GPS transmitter attaching/detaching process. Prior to returning the adults to the box after processing, we will give each bird a visual health check to screen for any obvious signs of disease, poor health, or stress. We will place adults back in their respective nest boxes after processing using a plug to block the entrance hole for at least three minutes to reduce stress and the chance of flushing (Colvin and Hegdal 1986). Our processing time for attaching and detaching GPS transmitters of each adult will not exceed 20 minutes. We will not handle nestlings during this time in order to minimize disturbance and time spent at nest. In order to have statistical power for our movement analyses, we will be monitoring the movement of up to 10 owls at a time and GPS transmitters will be affixed while nestlings are being provisioned, or until battery is drained.

At time of capture, GPS backpack transmitters will be attached to adult barn owls following procedures and training provided by raptor biologists at the Golden Gate Raptor Observatory. We are utilizing equipment recommended by Dr. Dylan Kesler, owl biologist with Vertebrate Systems, and Ecotone Telemetry professionals. We will affix barn owls, depending on body mass, with at 6g or 10g GPS-UHF battery powered transmitter (Alle-100 or Alle-300 models, Ecotone Telemetry, Poland) as recommended by Ecotone Telemetry professionals. We chose transmitters that weigh less than 3% of each individual bird’s body weight (USGS Bird Banding Laboratory; Kenward 2001; Boal 2014). If an owl with RFID tag is to be affixed with a GPS unit, the weight of all bands/tags and GPS unit will be taken into account and must be less than 3% of the body mass. GPS-UHF transmitters require a base station placed in the field that can detect and download data from the transmitter at a distance of ~ 1km away. Data downloads for these transmitters will occur on a weekly basis in conjunction with scheduled nest checks to minimize disturbance. Transmitters have four loops for attaching teflon ribbon which is used to attach to birds. Two loops are in the front and two loops are in the back. Prior to catching birds in the field, each teflon ribbon will be sewn and glued (using super glue) to the front two loops of the transmitter. At time of capture, the transmitter will be placed on the birds back and the two teflon ribbons will go over the head, cross at the breast just at the top of the keel (this ensures the crop is not obstructed), and under each wing to connect to the two loops at the bottom of the transmitter. The teflon ribbons will be adjusted for fit on each side by working it into the feathers to ensure feathers are on top of the teflon ribbon. After each adjustment, teflon will be clamped using small clamps at the point of attachment on the bottom loops of the transmitter to ensure fit is maintained before final placement is set. Once the teflon is adjusted, the teflon at the bottom of the transmitter will be carefully sewn (using a curved sewing needle which ensures the needle will not touch the bird) and glued (using a small amount of super glue) with a piece of cardboard placed behind the

teflon to ensure no glue touches the feathers. Teflon ribbon ends will be trimmed and glued to ensure no ribbon can fray. Transmitter fit will be rechecked before release by ensuring normal movement of the owl is not restricted, and that there is one finger width between the transmitter and the bird (this signifies the transmitter is not too tight or too loose and is a standard practice for transmitter attachment).

Just before nestlings have fledged, we will make every attempt to recapture individuals for transmitter removal. In field studies tracking wild animal movement using transmitters attached to animals, a small portion of individuals may not be able to be recaptured. In these cases, the teflon ribbon used to attach transmitters are designed to eventually degrade, allowing the transmitter to naturally and eventually fall off the bird. Our GPS transmitters will have a VHF antenna so that adults can be located if the GPS transmitter battery is drained, this will facilitate finding the owl so the transmitter can be safely removed.

NESTLING GROWTH RATE:

Due to extreme heat of the Central Valley in spring and summer, all handling and measurements will be completed in early morning to prevent hyperthermia. We will visit a subset of nests with nestlings weekly to determine chick growth rates and rodenticide exposure levels once all nestlings have hatched. Hatching occurs 30 to 32 days after incubation begins (Taylor 1994). Before entering a box, we will block the nest box entrance using a plug to prevent adults from flushing. We will remove adults from the nest box, apply a hood, and move them to a quiet cool location where we will monitor them for signs of stress. We will place nestlings together in an insulated soft cooler during their time outside of the nest box. We will remove a single nestling at a time from the cooler and record morphological measurements, including: mass, hallux length, and culmen length. Once feathers begin erupting from the skin, we will place nestlings individually in a box or soft cooler to prevent sibling aggression. At this time, we will process nestlings while hooded and record measurements for tail length and will briefly remove the hood to measure facial disc width. Each nestling will be marked with non-toxic fabric dye for future identification on downy feathers on the head, back or upper legs (Crouch, Benson, and Brennan 2018; Vergara, Fargallo, and Martínez-Padilla 2010). We will place nestlings, followed by adults, back in their respective nest boxes with an plug to block the entrance hole for at least three minutes to reduce the chances of flushing after processing (Colvin and Hegdal 1986). We will band nestlings once they have reached approximately 30 days old, when tarsi have fully developed (Taylor 1994). Processing time for measurements of each nestling will not exceed 5 minutes. Prior to returning to the nest box, we will give each bird a visual health check to screen for any obvious signs of disease, poor health, or stress. We will monitor barn owls continuously until all the nestlings and adults are placed back in their respective boxes, and the plug blocking the entrance hole is removed. The entrance hole will never be blocked without constant monitoring of the nest box. If there are any signs of significant stress in adults or nestlings at any time during procedures, we will stop procedures and immediately return all individuals to nest boxes.

RODENTICIDE SCREENING; PELLET, BLOOD, AND FECAL COLLECTION:

We will collect pellets, blood samples, and fecal samples from individuals in the subset of nest boxes where nestling growth rate is being monitored in order to determine rodenticide exposure. We will concurrently collect 3 sample types to test non-invasive methods for determining rodenticide exposure. Excess blood will be archived for future genetic study.

Pellet samples:

Prior to the first collection of pellets, we will remove and discard all pellets from the nest box to ensure pellets from before the nestling period are not incidentally analyzed. Once all individuals are removed from the nest box (nestlings moved into the insulated soft cooler and adults hooded moved to a quiet, cool location where they can be monitored for stress) we will collect any new pellets found in the nest box. We will place pellets in a plastic bag and mark the bag with the location, box number, number of nestlings, and date. We will store the pellets in a cooler in the field until they can be brought to the lab for freezing. Pellets will be dissected to measure the diet of nestling barn owls (e.g. Kross et al. 2016), and will be tested for rodenticide residues at a commercial laboratory.

Blood samples:

We will use blood samples for rodenticide screening, blood parasite screening, and archived for genetics studies. Only 0.2ml of blood are needed for both blood parasite screening and genetic archive purposes, however, a minimum of 2.0ml of blood is necessary for each sample used for rodenticide screening. Blood drawing will only be done by researchers that have been trained by UC Davis veterinary staff and amount taken will never exceed 1% of body weight of the owl.

All blood drawing will be done via medial metatarsal venipuncture using a 25 gauge needle and a 3cc syringe. Past experience working with owls and other raptors, as well as discussion with raptor veterinarians, indicates that this is the best location for drawing blood and minimizes the likelihood of hematoma. If we are unable to obtain blood from this site we will not attempt any other location. Prior to drawing blood, the metatarsus will be wetted with disinfectant and pressure will be applied to visualize the vein. One researcher will restrain the bird (the handler) while the second performs the blood draw. Following the blood draw, the handler will apply pressure to the draw site for a minimum of 1 minute to ensure bleeding has stopped (bleeding usually stops within 1 minute; if necessary pressure will continue to be applied until bleeding has stopped). Prior to release of the owl back into the nest box, we will inspect the draw site to ensure there is no bleeding or other injury.

Nestlings: Blood sampling of nestlings will occur no more frequently than 1 week intervals. We will weigh nestlings prior to blood draw to ensure the maximum of 1% of body weight allowed by IACUC guidelines is not exceeded. We will not begin to draw blood from an individual nestling until it has reached at least 50g, at this weight, the amount of blood drawn will be no more than 0.2ml. We will pool nestling blood samples by collecting 0.2ml or more from each individual (not to exceed 1% of individual body mass) in order to reach the 2ml sample size needed for a rodenticide screening sample and to gain an average weekly exposure rate for each nest. Once nestlings reach 200 grams, we will take a maximum 2ml blood sample from each individual each blood draw, which will allow us to determine if individuals within a nest are exposed to rodenticides at differing rates.

Adults: When we sample blood from nestlings, adults found in the nest or roosting in nearby boxes will also be sampled. Adult male owls are smaller than females and weigh 375g on average, therefore collection of 2ml of blood is less than the 1% of body weight (3.75ml) maximum blood draw allowed by IACUC guidelines. Prior to release back into their respective nest boxes, we will give owls a visual health check to screen for any obvious signs of disease, poor health, or stress. Owls will then be released back into their respective nest boxes and a plug will be placed in the entrance hole for at least three minutes to prevent flushing after processing.

Processing time for drawing blood from each nestling or adult will not exceed 10 minutes.

Fecal samples:

Fecal samples will be collected opportunistically to compare with other rodenticide testing methods we are proceeding to do in this study (i.e., blood and pellet samples). In both mammals and avian species, fecal samples have been shown to provide information on rodenticides an organism has previously ingested (Laas et al. 1985; Townsend et al. 1981). We will use Whirl-Pak sample bags to collect fecal samples held underneath the adult or nestling by an additional researcher until it has excreted feces. If during the measurement or banding process the adult or nestling does not excrete fecal matter, it will be placed back in its respective box. The fecal samples will be collected opportunistically, as in the field we will only have a short period of time to collect the samples, as compared to in a controlled laboratory setting where we would be able to collect from all individuals (Handrich et al. 1993).

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2) *Frequency of secondary exposure to rodenticides in wintering barn owls and diurnal raptors*

Natural pest control from raptors does not cease after breeding season is finished, and in winter months, pest control can be provided by barn owls that remain in the area to utilize nest boxes for roosting and by the influx of wintering diurnal raptors in the region. Because rodenticides may be applied year-round, it is important to document exposure levels outside of the breeding season to determine the level of impact on natural pest control agents during the non-breeding season.

CAPTURE, BANDING, AND RODENTICIDE SCREENING:

In non-breeding months (November through March), we will sample blood from barn owls found roosting in nest boxes and other diurnal raptors found foraging in agricultural fields in high abundances (red-tailed hawks and northern harriers; Martinico unpublished data). Nest boxes will be monitored for roosting owls with a live streaming camera (SONY Action Cam) attached to an extension pole up to 2 times per week. Diurnal raptors will be trapped with a remotely triggered bow-net baited with a carcass (American coot or mallard) collected locally (Northern California) with appropriate waterfowl hunting permits, or donated by a licensed waterfowl hunter (Skalos U.S. Geological Survey, unpublished data). Traps will be constantly monitored while set. Traps will be closed and carcasses removed during the processing of a raptor in order to prevent capturing additional birds.

All individuals handled will be banded with a federal leg band and blood will be drawn using the same blood drawing protocols for adult barn owls: '*All blood drawing will be done via medial metatarsal venipuncture using a 25 gauge needle and a 3cc syringe. Past experience working with owls and other raptors, as well as discussion with raptor veterinarians, indicates that this is the best location for drawing blood and minimizes the likelihood of hematoma. If we are unable to obtain blood from this site we will not attempt any other location. Prior to drawing blood,*

the metatarsus will be wetted with disinfectant and pressure will be applied to visualize the vein. One researcher will restrain the bird (the handler) while the second performs the blood draw. Following the blood draw, the handler will apply pressure to the draw site for a minimum of 1 minute to ensure bleeding has stopped (bleeding usually stops within 1 minute; if necessary pressure will continue to be applied until bleeding has stopped). Prior to release of the [bird], we will inspect the draw site to ensure there is no bleeding or other injury.' We will be able to identify individuals by band number, if an individual has been sampled within the last 7 days he/she will not be sampled and will be immediately returned to their nest box (owls) or released (diurnal raptors). If a female barn owl is suspected to be in egg production or is found incubating eggs during the wintering months, she will be immediately returned to the nest box without any blood collection.

DIET SAMPLING

We will determine prey species consumed by diurnal and nocturnal raptors in order to compare diet to rodenticide exposure levels in each group. To sample for dietary information in Barn Owls, we will collect pellets found below nest boxes at fields where owls are sampled for rodenticides. In order to ensure we are only collecting pellets from wintering owls, we will sweep or rake all pellets away from boxes prior to winter sampling. This method is non-invasive and has been shown to be a good indicator of diet for owls hunting in specific crop types (Kross et al. 2016).

To sample diet in diurnal raptors, after a blood sample is taken we will use a swabbing method to collect trace prey DNA from the exterior surface of beaks and talons use a nylon tipped swab moistened with ultra-pure water (Bourbour and Hull, in press). Brush tips will be cut off and stored individually in a buffer solution that will preserve any DNA collected. This method is minimally invasive, takes less than 1 minute, and has been proven to work even when prey blood and tissue is not visible. Collection of pellets is not feasible, as raptors do not typically regurgitate as much prey bones as owls and these would be difficult to find in the field. Additionally, sampling fecal is not feasible, as diurnal raptors typically do not defecate during the banding and blood sampling process.

Research results and discussion:

Nestling Growth Rates (Objectives 1 & 2)- proceeding as planned

Monitoring our nest boxes has led to interesting natural history insights as well. We found one barn owl box containing an American Kestrel nest- which isn't uncommon since both are cavity nesters. What *is* uncommon is that the kestrel nest also had 2 barn owl eggs in it (the larger eggs on the lower right side of the photo). The nest successfully raised a clutch of kestrel chicks (one chick can be seen here), but the barn owl eggs did not hatch.

Sometimes we find things we don't expect in our barn owl boxes- such as a raccoon lounging in one of the boxes.

Rodenticide Detection (Objectives 1 & 2)- additional fieldwork planned

We were not able to take as many blood samples from owls as planned in the first season of fieldwork due to an early breeding season combined with time constraints in processing the funding and gaining the necessary permits for the work. We would therefore like to alter our plans slightly to allow for a longer field season in the first year of this project, which will allow us to incorporate an important component into the project: understanding the rate that barn owls are exposed to rodenticides in

the non-breeding season.

We hope to use the remaining rodenticide testing budget to collect blood samples from overwintering barn owls in our study area. Barn owls remain in our study area year-round, and we have confirmed that they continue to use the artificial nest boxes provided by farmers as roost locations during the non-breeding season. These owls provide continued pest-control services for farmers, but we have no knowledge of the AR exposure rate in barn owls outside of the breeding season. This additional component in the first year of the project will be used by graduate student Breanna Martinico as a portion of her PhD dissertation work and adds a sub-objective to Objective 1 of our project. To date, we have sent in 30 winter owl blood samples for screening.

1. Collect baseline information on the frequency of AR exposure rates in barn owls roosting in artificial nest boxes in the non-breeding season

Collecting this data will also benefit farmers in our area by providing natural history information on barn owls in our study area in the non-breeding season. Because we have banded a large number of adult and juvenile barn owls in our Matchbook study site in particular, we will be able to better understand whether barn owls remain near their nesting territories during the non-breeding season. We will also gather more information on the proportion of nest boxes used by roosting owls, and on the diet of non-breeding barn owls.

Importantly, the farming landscapes of the Central Valley of California provide critical overwintering habitat for migratory raptors where they have a high risk of anticoagulant rodenticide (AR) exposure. The findings of this additional component to the study will lead to a more harmonious use of both raptors and rodenticides in agriculture. We expect that the results from this additional work will answer a number of questions that farmers we work with have asked us about the year-round role of owls in controlling rodent pests, and how best to manage for the owls. The information gathered as part of this extension of the project will also help us to hone our models for Objective 3 by providing data on the density of overwintering barn owls utilizing nest boxes, and on the winter diet of barn owls. While there have been a number of studies on nest box occupancy and barn owl diet in the breeding season, there has only been a single study on these variables conducted in winter- which is likely an important time for barn owls to contribute to pest control of rodents.

Breanna Martinico plans to apply for additional external funding to also test diurnal raptors (red-tailed hawks, Northern harriers) for AR exposure, to trap and test rodents for ARs, and to continue this work beyond this initial field season. Regardless of the status of that additional funding, the data collected this year on barn owl exposure to ARS using funding from our Western SARE project will provide vital baseline information on a heretofore un-investigated issue relevant to sustainable agriculture.

We have also developed a protocol for opportunistically collecting fecal samples, which we will test this winter.

Land Use (Objectives 2 & 3)- proceeding as planned

We have made progress on this component of our field work by working with our grower team to understand the scale and timing of AR deployment on their land, by applying for/obtaining the necessary permits for our GPS study, by determining and ordering the best GPS tags to use, and by receiving training in GPS tag attachment.

- We have started collecting rodenticide application data from our producer-partners. This data has not yet been mapped.
- Ryan Bourbour and Sara Kross shadowed a team of researchers from Matthew Johnson's lab at Humboldt State University this summer to observe the methods they have successfully used for GPS attachment.
- Prior to the awarding of the Western SARE grant, Sara Kross, Josh Hull, Ryan Bourbour and Emily Phillips attended an international workshop of barn owl researchers which included a training session on GPS harness attachment methods.
- We have consulted with Ecotone Telemetry and have ordered and received 10 GPS tags for our study. We expect to have the tags tested, prepped, and ready to deploy early in the 2019 breeding season.
- Once affixed and deployed, our GPS tags will be capable of recording up to 3000 location points per charge, which allows us to monitor movement on a fine enough scale to determine hunting behavior, home range, and most importantly the proximity of a hunting owl to rodenticide application sites.

Diet Analysis (Objectives 2 & 3)- proceeding as planned

We have made progress on this component of our field work by developing our methods for collecting barn owl pellets, by documenting cases of food caching, and by beginning our development of video-monitoring methods for the 2019 breeding season.

- We collected barn owl pellets from all barn owl boxes monitored this summer. Our winter work includes dissecting the pellets for diet analysis.
- We are collecting pellets from barn owl boxes over the non-breeding season as part of our additional work in order to describe the diet of overwintering owls in the same landscape. We specifically want to know if owls target more adult gophers and voles in the winter compared to during the breeding season.
- We have been testing 2 different self-contained camera traps for potential use for monitoring barn owl boxes next year for diet and prey-delivery rate information. The cameras will be tested over winter and we will order the necessary supplies in time for the 2019 breeding season.

Research conclusions:

We are only part-way through our project and therefore have no conclusions to share at this time.

Participation Summary

5 Farmers participating in research

Education

Educational approach:

February 2020. Educational event held at Peregrine Elementary School. Used hands-on materials to engage with 3rd and 4th grade students.

Educational & Outreach Activities

1 Published press articles, newsletters

2 Webinars / talks / presentations

PARTICIPATION SUMMARY:

Education/outreach description:

While education and outreach are more a focus of the second half of this project, we have already received significant interest in our project from farmers, IPM specialists, and the general public. Since beginning the project we have:

- Given lectures on our work:
  - Sara Kross gave a lecture on pest control services from owls and how to control pest birds in vineyards for a workshop hosted by the Napa County Agriculture Commissioner's Office.
  - Ryan Bourbour and Emily Phillips gave a talk on the role of barn owls and diurnal (day-hunting) raptors at a 'Ground Squirrel and Gopher Management Workshop' hosted by the Santa Clara County Division of Agriculture & UCCE Santa Clara County.
  - Breanna Martinico gave a similar talk at a second 'Ground Squirrel and Gopher Management Workshop' due to the overwhelming positive response from the first workshop participants.
  - Sara Kross gave a talk about barn owls at the 2018 UC Davis Alfalfa/Forages Field Day.
  - Sara Kross provided technical advice to the UC Extension farm on construction plans for a demonstration barn owl box.
  - Our project's connection with the California Raptor Center (CRC) and Turkovich Farms led to the CRC attending a visit from international buyers.
  - Breanna Martinico, Emily Phillips and Ryan Bourbour developed a poster and presented about our project at the annual California Raptor Center open house (see poster below).
- Worked with the media to get the news out about barn owls and our project:
  - Our project was highlighted by the Western IPM center in a newsletter and video post: http://westernipm.org/index.cfm/ipm-in-the-west/agriculture/helping-barn-owls-help-farmers/

Our project was featured in Western Farmer-Stockman magazine: https://www.westernfarmerstockman.com/crops/your-pest-control-killing-beneficials

- Our project was highlighted by The College of Agricultural and Environmental Sciences at UC Davis through a video on their YouTube channel-

https://www.youtube.com/watch?v=N0mjvyZhgnQ&feature=youtu.be&fbclid=IwAR2yDzrgyhdx-EdASA0IgoKjmBNrPkbJYLFupPyE66DK7BZ8aYOyFd8DPHY

- We provided background information and relevant papers for an article published online by Environmental Health News called “Protecting Crops with predators instead of poisons” which covered multiple types of natural pest control services including by owls: https://www.ehn.org/back-to-basics-tackling-farm-pests-with-predator-birds-2546940909.html
- Sara Kross wrote a longform article about the role of beneficial birds in agriculture:

https://www.yumpu.com/en/document/fullscreen/62280511/organic-farmer-dec-jan-2019

- Started social media accounts to share photos and insights from our work with a wide audience.
  - Project Facebook page: https://www.facebook.com/BarnOwlProject/?ref=br_rs
  - Project Instagram page: https://www.instagram.com/barnowlproject/
  - Project twitter feed (@barn_owlproject): https://twitter.com/barn_owlproject
  - Ryan Bourbour twitter: https://twitter.com/talonDNA

Video presentation to Wild Farm Aliance

Kross, Martinico, Bourbour, Phillips, Baldwin, Hull. Is it a trap? Raptors, rodenticides, and rain in California’s agroecosystems. North American Congress for Conservation Biology. July 2020.

Kross, Martinico, Bourbour, Phillips, Baldwin, Hull. Is it a trap? Raptors, rodenticides, and rain in California’s agroecosystems. North American Ornithological Conference. August 2020.