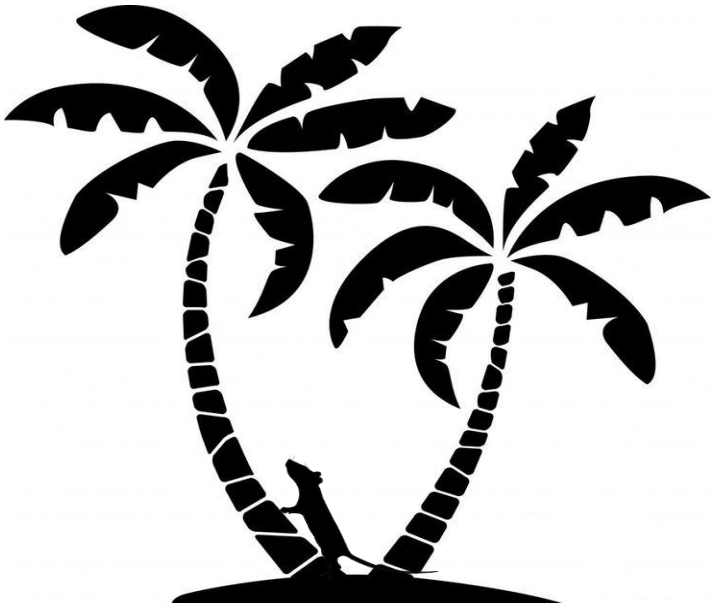
ABSTRACTS

29th VERTEBRATE PEST CONFERENCE
March 2-5, 2020
Santa Barbara, California



Conference Chair:
Stella McMillin

Program Chair:
Niamh Quinn

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ABSTRACTS FOR SESSIONS AND SYMPOSIA

Tuesday, March 3 - KEYNOTE ADDRESS AND PLENARY SESSION

9:20 **Reflections on 25 Years of Global Conservation on Islands as we Enter Into the UN Decade of Restoration**

Gregg Howald
Island Conservation, Santa Cruz, CA
gregg.howald@islandconservation.org

Representing 5% of the earth's surface, islands support a disproportionate amount of the earth's biodiversity – about 20%. However, since 1500, islands have been home to over 75% of known bird, mammal, amphibian and reptile extinctions. Today, islands support 41% of all IUCN critically endangered and endangered species. The majority of these extinctions have been caused introduced species, particularly introduced vertebrates such as rats and mice, cats, and ungulates. Because islands are whole functioning ecosystems, many of these introduced species can be eradicated, permanently removed from the ecosystem, facilitating the natural recovery or restoration, many with little input by people. With relatively minor investment into active restoration, recovery can be accelerated. Arguably one of the most damaging are the introduced rats and mice, which have been implicated in the ~50% of all bird and reptile extinctions, and having been introduced onto over 80% of the world's islands. Over the last 70+ years, conservationists around the world have been working to recover species and island ecosystems from the impacts of invasive alien species, particularly rodents, developing systematic approaches and techniques guided by principles of eradication that have been adopted worldwide. The eradication of rodents from islands is not only possible, but has been completed on over 600+ islands, from small offshore rocks to 400,000 ha South Georgia Island, with hundreds of species protected from the threat of extinction. Rodent eradication is becoming a mainstream tool used by managers worldwide, however, there are limits to the current technology and approaches in use, and currently, we can only reach a small number of islands and threatened species. As a community, if we want to protect and recover threatened species, we must increase the scale, scope and pace of eradication of invasive species from islands, and focus on innovation of new tools, techniques and strategies to be able to restore larger and more complex islands. One of the biggest barriers to success is ensuring that the public is on board and supportive enough to allow such tools to be used for pest management and conservation purposes. New technologies are being developed and are on the horizon to improve IAS eradications, and some of these include genetic tools and species-specific toxicants.

10:45 **A Retrospective Look at Mountain Lion Populations in California (1906-2018)**

Justin Dellinger, Steve Torres
California Department of Fish and Wildlife, Rancho Cordova, CA
justin.dellinger@wildlife.ca.gov

The history of mountain lion (*Puma concolor*) population management approaches in California has varied widely within the last 100 plus years, ranging from a bounty system (1906-1963) to a specially-protected status (1972-2018). In an attempt to understand ability of different management approaches to influence mountain lion population trends, we estimated historical population trends of mountain lions in California by combining purposeful (i.e., bounty and depredation) and incidental (i.e., vehicle strike) mortality statistics with scientific knowledge of annual growth and mortality rates of mountain lions derived from the literature. We used an annual backwards population projection method to estimate abundance and population trend of mountain lion populations in California, starting with population sizes drawn randomly from a uniform distribution ranging from 1,000-5,000 in 2018. These back-calculations demonstrate that the bounty was likely effective at reducing mountain lion populations as all simulations portrayed a statewide population decline during this period (1906-1963) of management. Further, special-protected status was also likely effective at allowing mountain lion populations to increase statewide following the bounty period. These analyses provide understanding of the ability of various management approaches to influence mountain lion population trends for the intended result. These analyses also provide context for understanding historic aspects of mountain lion populations in California which is likely unique from other areas given their current special-protection status.

11:10 **Vector Control in Oakland's Homeless Encampments**

Michael Mooney, David K. James, *Bruce Kirkpatrick*
Alameda County Vector Control Services District, Oakland, CA
michael.mooney@acgov.org

Homeless encampments are a persistent feature in the city of Oakland. Unsanitary conditions in these camps can contribute to large populations of *Rattus norvegicus* and associated vector-borne diseases. Alameda County Vector Control Services District has developed a surveillance program for safe and efficient data collection in these encampments. This program includes: outreach to residents, effective live trapping, ectoparasite collection, vector species suppression, and coordinating with other agencies. The District's operations around Oakland's pilot "tuff shed" homeless shelters will be presented as a case study for *Rattus norvegicus* and *Xenopsylla cheopis* risk assessment and control.

11:35 **Predator-Free New Zealand 2050 – Fantasy or Reality?**

James Ross[1], Grant Ryan[2], Elaine Murphy[3], Sophie Noebauer[4]
[1]Department of Pest-management and Conservation, Lincoln University, Canterbury, New Zealand
[2]The Cacophony Project, New Zealand
[3]Department of Conservation, Christchurch, New Zealand
[4]University of Natural Resources and Life Sciences Vienna, Vienna, Austria
james.ross@lincoln.ac.nz

Possums, stoats and rats introduced into previously mammal-free New Zealand (NZ) seriously impact our vulnerable native flora and fauna. As a result, considerable research effort has focused on developing control techniques for reducing and/or eradicating these pests, with excellent success in the eradication from many offshore islands (currently 105 mammal-free islands). This control work has created numerous predator-free sanctuaries thus enabling the translocation of many endangered native bird species. Unfortunately, we have run out of defendable, non-human occupied islands and the current focus is on the NZ mainland, with a new government goal called Predator Free NZ 2050 Ltd. In 2010, the Centre for Wildlife Management and Conservation (CWMC; based at Lincoln University) started a research programme investigating "environmentally-safer" alternatives to brodifacoum for rodent and possum control, with a focus on tools that could be used on the NZ mainland. In addition to this work, we also investigated the attractiveness of social and food-based lures for stoats and ship rats and species-specific delivery options for sustained ground-based rodent control. In 2015, a privately-funded research and development entity called Project Cacophony was established with the goal of developing technologies to identify predators automatically using machine learning algorithms and thermal cameras. We will present recent research investigating the efficacy of the thermal cameras as an "early detection" tool for reinvading possums in the Taranaki Mounga project.

Tuesday, March 3 - VERTEBRATE PESTICIDES & REPELLENTS

1:25 **Development of a Rodent Bait with Slug-Repellent Properties**

Tyler Bogardus[1], Stephanie Marie Joe[1], *Aaron Shiels*[2]
[1]University of Hawai'i Office of the Vice President for Research and Innovation, Honolulu, HI
[2]USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO
tyler.bogardus@gmail.com

Since 1995 the Army's Natural Resource Program on O'ahu has been controlling rodents in O'ahu's forests to protect native plants, invertebrates, and birds. Bait longevity and attractiveness are keys to successful rodent trapping. Success is impeded when slugs interfere with bait intended for rodents. Slugs can consume all or a portion of the bait, make it less attractive to rodents via their slime, and large slugs can trigger the traps. The goal was to determine whether food grade citric acid (5% concentration) added to bait would repel slugs while remaining attractive to rodents. We conducted several trials including: 1) a two-choice food experiment where captive slugs were offered both a test (5% citric acid added) and control bait, 2) a field trial comparing the catch success of rat (*Rattus* sp.) snap traps set with either the test or control bait 3) a field trial comparing bait longevity

in Good Nature A24 traps 4) a lab trial evaluating whether wild-caught house mice (*M. musculus*) avoided the test bait. In the lab, we found slugs significantly preferred the control bait in the two-choice feeding experiment. In the field, snap trap success was unaffected by bait type and bait longevity was increased with the treatment bait. Finally, mice showed no aversion to the test bait in the lab. This indicates that the addition of citric acid can improve the longevity and attractiveness of bait thereby aiding rodent control programs.

1:50 **Preliminary Field Efficacy of Anthraquinone Repellent to Reduce Drip Irrigation Line Damage by Cottontail Rabbits**

Christopher Anderson[1], Matthew Major[2], Alan Blake[3], Niamh Quinn[1]
[1]University of California Agriculture and Natural Resources, Irvine, CA
[2]Orange County Parks, Irvine, CA
[3]Irvine Ranch Conservancy, Irvine, CA
ctanderson@ucanr.edu

Unmanaged cottontail rabbit populations can cause significant damage to drip irrigation tubing. Common integrated pest management strategies to reduce damage include trapping, exclusion, and repellent use. Trapping and exclusion, while effective at managing cottontail rabbits, are impractical when applied to large scale habitat restoration projects. To evaluate repellent use under these conditions, we conducted a preliminary conditioned avoidance field trial using anthraquinone applied to drip irrigation tubing installed in a riparian habitat undergoing restoration in Silverado, CA. The post-ingestive repellent, anthraquinone, was selected due to its low toxicity and prior laboratory research indicating its effectiveness in inducing conditioned avoidance feeding behaviors in cottontail rabbits. Following a complete repair of the irrigation system, alternating sections of the irrigation tubing were treated. After the first treatment, there was an estimated 26.5% decrease in damaged tubing between the treated and control sections. An estimated 0.18% of the total tubing surveyed was damaged after the second treatment. Between the first and second treatments, we observed an estimated 99.5% decrease in total damaged tubing. Our results suggest that anthraquinone may be successful in reducing cottontail rabbit damage by inducing conditioned avoidance to drip irrigation line. As a preliminary study, these findings are promising and warrant future field trials to validate the use of anthraquinone as a repellant to reduce damage by cottontail rabbits.

2:15 **Evaluating the Efficacy of Carbachol at Reducing Corvid Predation on Artificial Nests**

Matthew P. Brinkman[1], David K. Garcelon[1], Mark A. Colwell[2]
[1]Institute for Wildlife Studies, Blue Lake, CA
[2]Humboldt State University, Arcata, CA
brinkman@iws.org

Nest predation can inhibit recovery of threatened and endangered birds, especially ground nesting species. Accordingly, a variety of techniques are used to reduce the impact of nest predation on these species. We examined the efficacy of conditioned taste aversion, a nonlethal technique designed to induce avoidance behavior in predators after being exposed to prey items that have been treated with a fast-acting chemical emetic. We used carbachol to condition corvids responsible for high levels of nest predation on 2 federally listed species—the western snowy plover (*Charadrius nivosus nivosus*) and California least tern (*Sternula antillarum browni*)—breeding in southern California. We conducted 2 separate experiments in 2013 and 2014, during which we deployed 772 artificial nests and 760 artificial nests in the first and second experiment, respectively. Each artificial nest contained 3 quail (*Coturnix* spp.) eggs. During the first stage of both experiments all nests only contained untreated quail eggs, and nest predation was high with >90% of nests failing within 2 days of deployment. In subsequent stages, we deployed carbachol-treated eggs in increasing proportion. We used nest survival models to evaluate daily survival rates (DSR) of artificial nests. During both experiments, DSR increased concomitant with a greater proportion of carbachol-treated eggs. Common ravens (*Corvus corax*) accounted for 98.1% (n = 471) of all artificial nest predations in Experiment 1, and 95.6% (n = 498) of all artificial nest predations in Experiment 2. Using carbachol as a taste-aversive agent was effective at reducing predation on artificial nests as illustrated by increased DSR (0.47 to 0.98 in the first experiment and 0.00 to 0.99 in the second experiment). These experiments were not designed to quantify how this technique influenced survival rates of plover and tern nests, but anecdotal evidence suggests ravens learned to differentiate between real and artificial nests.

2:40 **A Field Evaluation of Candidate Repellents to Reduce Black Bear Damage to Western Larch Trees**

Gary Witmer
USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO
gary.w.witmer@usda.gov

Bear damage to western larch trees on intensively managed public and private forest lands of the Intermountain West continues to be a problem for forest managers. Bark stripping and subsequent cambium feeding by bears commences upon den emergence in the spring, when foraging options are most restrictive. We tested the efficacy of three candidate repellents (Hot Sauce®, Tree Guard™ and grizzly bear feces) to reduce spring/summer bear damage to western larch trees on reforestation units in northern Idaho. Thirty-four of 300 (11.3%) treated trees were damaged by black bears. Of the newly-damaged trees, the highest damage rates were on the control plots, 15 of 75 (20%) trees. Damage levels to trees on other plots were: Hot Sauce® and grizzly feces-treated plots, six of 75 (8%) trees each and Tree Guard™-treated plots, seven of 75 (9.3%) trees. Almost half (47%) of the bear-damaged trees were completely girdled. Chi-square contingency table analysis showed that the damage rate of treated trees was less than of control trees. Further testing is necessary to reveal the true potential of chemical repellents for reducing black bear damage to conifers in the spring. Furthermore, the abundance of fresh damage already evident when treatments were applied in the spring suggests a need for early application of repellents (prior to fall) if efficacy can be maintained over winter. The cost effectiveness of this approach to reducing bear damage must also be assessed.

3:20 **Captive Canada Geese Acceptability and Toxicity Trials with Two Formulations of 0.005% Diphacinone Rodenticide Baits**

Gary Witmer
USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO
gary.w.witmer@usda.gov

The 0.005% diphacinone rodenticide pellets used in this study have been proposed for use in field applications to control introduced rodents on conservation lands in the state of Hawaii. Introduced rodents (especially *Rattus* spp.) cause a wide array of conservation problems in the Hawaiian Islands and on other islands. We assessed the acceptability and toxicity (should the pellets be consumed) of two rodenticide baits to Canada geese, a surrogate species for the endangered Hawaiian goose. Based on these trials with captive, wild Canada geese, it appears that neither the whole nor the chopped (to simulate broken or weathered baits) pellets pose a significant risk to the Hawaiian goose, a species considerably smaller than the Canada goose. The pellets (whole or chopped) were not accepted by the Canada geese during this study despite their having only a small amount of green grass sod as an alternative food. There were no mortalities of geese during the feeding trials and all geese remained healthy, based on body weights and packed blood cell volumes. The endangered status of the Hawaiian goose precluded using it as the target study species.

3:45 **Zinc Phosphide Analysis in Vole: Revisiting An Old Technique**

Philippe Berny[1], Léa Rouzoul[1], Olivier Cardoso[2], Geoffroy Couval[3], Michael Coeurdassier[4]
[1]Vetagro Sup, Marcy l'etoile, France
[2]Office National de la Chasse et de la Faune Sauvage, Paris, France
[3]FREDON, Franche-Compté, France
[4]University of Franche-Comté, Besançon, France
philippe.berny@vetagro-sup.fr

Zinc Phosphide has been recently approved in Europe as a vole control product. Currently, only one formulation (lentils/pellets) is marketed with 0.8% Zn_3P_2. It is applied with a delivery device for burrow baiting. In many instances, zinc phosphide poisoning has been confirmed in non-target species (primary poisoning). In order to be prepared to potential non-target poisoning incidents in wildlife, the SAGIR network, FREDON Franche-Comté and University of Franche-Comté conducted a field study on common voles to test the sampling method and storage impact under realistic field conditions on the detection of zinc phosphide. The toxicology laboratory of Vetagro Sup, member of SAGIR, worked on the improvement of the WHO technique in order to lower the LOQ and to validate the technique for the correct identification of field cases. The specificity was tested on 20 gastric content

samples (100%), and the LOQ was established at 0.01 g/l (100 fold decrease as compared with the 1995 WHO technique). Zinc content was measured by FAAS and non-poisoned animals were tested to check baseline values and to estimate recovery of spiked samples (88-98%). Quantification of Zn in the liver of poisoned vs control animals was also performed. A total of 30 voles were collected in treated and control fields and submitted for analysis. Technicians were not aware of the poisoning status of the animals. In the first series of analyses, 12 individuals were tested. 3 were positive for phosphine, 1 was uncertain. Zn analysis (gastric content) confirmed the phosphine test and one negative individual was also detected with a high Zn content. These results, together with the second series (still under investigation) as well as the validation of the analytical conditions will be discussed in view of anticipated field situations.

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4:10 **Contrapest, a Rodent Fertility Control Product, that Does Not Bioaccumulate**

Brandy Pyzyna[1], Stephen Shuster[2]
[1]SenesTech, Phoenix, AZ
[2]Department of Biological Sciences, Northern Arizona University, Flagstaff, AZ
brandy.pyzyna@senestech.com

Bioaccumulation is the process by which environmental toxins become concentrated at the top of the food chain. It occurs because most organisms store rather than metabolize these poisons. The more prey that predators consume the more toxic their bodies become, a process few predators can survive. Anticoagulant rodenticides are notorious for their tendency to bioaccumulate. Many states and countries now limit their use or have banned their sale outright. Integrating a non-lethal, non-bioaccumulating chemical compound into pest management programs is an essential long-term solution to rat infestation. ContraPest®, a product of SenesTech, Inc., is a liquid contraceptive bait that limits the fertility of both male and female Norway, Roof and Black rats. ContraPest contains two active ingredients, 4-vinylcyclohexene diepoxide (VCD) and triptolide. VCD is an ovotoxicant; when ingested or injected it causes depletion of primordial and primary ovarian follicles in mammals. Because VCD does not affect endocrine function it is not an endocrine disruptor. Triptolide affects fertility in both male and female mammals but primarily affects the number and motility of epididymal sperm, thus males are more sensitive to its effects than females. We present results showing that ContraPest: (1) is highly effective at inducing infertility of Norway and Roof rats (Rattus norvegicus and Rattus rattus) within 15 days, (2) causes temporary infertility in both sexes that lasts from 2-6 months, (3) is 99% metabolized within 24 hrs, making bioaccumulation negligible, and (4) is reversible in its effects, reducing the chance of evolved resistance in treated populations. We show that ContraPest provides an effective, long-lasting, and environmentally friendly solution to rat population control.

4:35 **Brodifacoum and Diphacinone Exposure in Fetal Tissue of Pregnant Mountain Lions in California**

Jaime Rudd[1], Stella C. McMillin[1], Deana L. Clifford[1], Robert H. Poppenga[2]
[1]California Department of Fish and Wildlife, Rancho Cordova, CA.
[2]California Animal Health and Food Safety Laboratory, Davis, CA.
Jaime.Rudd@wildlife.ca.gov

Brodifacoum (BRD) is a potent long-acting 4-hydroxycoumarin anticoagulant rodenticide while diphacinone (DIPH) is an indane-dione anticoagulant rodenticide with a short half-life and is generally considered less hazardous than the coumarin derivatives. DIPH and BRD are similar to warfarin and inhibit the enzyme vitamin K-epoxide reductase in the liver, leading to a depletion of normal vitamin K coagulation factors and bleeding. Both BRD and DIPH were detected in the fetal livers from a pregnant mountain lion carcass, however coagulopathy and hemorrhage were not observed at the time of necropsy. The pregnant female was also exposed to anticoagulant rodenticides but, similar to the fetuses, coagulopathy was not observed. In humans, fetal warfarin syndrome is dose dependent and is manifested by spontaneous abortion and embryopathy during the first trimester and central nervous system abnormalities, fatal hemorrhage, and stillbirth at any stage during pregnancy. Similar pathologies have been reported in animals exposed to BRD and fetal exposure to anticoagulant rodenticides have been described in the literature. Unlike other anticoagulant rodenticides, 4-hydroxycoumarins have low molecular weights, cross the placenta readily, and inhibit synthesis of vitamin K-dependent proteins in fetal liver as well as extrahepatic tissues. However, the teratogenic fetotoxic effects of BRD and DIPH concentrations and other vitamin K antagonists are still mostly unknown and their presence in the fetal tissues of free-ranging wildlife is concerning.

1:25 **Rose-Ringed Parakeets in California: Established Populations and Serious Agricultural Threats**

Aaron B. Shiels[1], Page E. Klug[1], Bryan M. Kluever[1], Shane R. Siers[2]
[1]USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO
[2]USDA APHIS Wildlife Services National Wildlife Research Center, Fort Collins, Barrigada, Guam

The rose-ringed parakeet (*Psittacula krameri*) has been introduced to >40 countries, gaining its status as the most widely introduced parrot in the world. Although regarded as a strikingly beautiful bird by many people, this species is a severe agricultural pest that establishes and reproduces rapidly or experiences a lag time prior to exponential population growth. These birds cause noise and fecal pollution, aggregate in large night roosts near human structures, and they may transmit disease. In the U.S., rose-ringed parakeets have been reported in several southern states but established populations are in Hawaii, Florida, and California. Escapees from the pet trade probably account for most introductions, and parakeets have been reported occurring in California as early as the 1970s. The estimated population in Bakersfield was 3000 birds in 2012, and additional smaller populations have been reported in San Diego, Anaheim, Santa Cruz, Malibu, and Pasadena. Nearly all of California (excluding the Sierra Nevada Mountains) is potentially at risk of rose-ringed parakeet colonization, and this species represents an important threat to California agriculture. Rose-ringed parakeets are known to consume and damage crops such as rice (*Oryza sativa*), sunflower (*Helianthus anuus*), safflower (*Carthamus tinctorius*), rapeseed (*Brassica napus*) and citrus in native India, almonds (*Prunus dulcis*) in rural Italy, and corn (*Zea mays*) and fleshy fruit (e.g., mangos, lychee, papaya) in Hawaii. In 1975, the California Department of Agriculture estimated that the potential crop losses due to a well-established rose-ringed parakeet population could reach $735,000 annually, a value that resulted from an estimate of their damaging 0.1% of crops grown in the area. This is a serious agricultural pest that thrives in human-altered landscapes. An update on the species distribution, establishment, and growth within California is needed, as well as efforts to prevent their spread and reduce their threat to California agriculture.

1:50 **Utilizing Wireless Endoscopes to Capture Visual Nesting Data: An Affordable Time-Efficient Solution**

Jason Thomas[1], Jacob Rickman[2], Joel Packham[3], Terrell Sorensen[4]
[1]University of Idaho Extension, Minidoka County, Rupert, ID
[2]University of Idaho Extension, Oneida County, Malad, ID
[3]University of Idaho Extension, Cassia County, Burley, ID
[4]University of Idaho Extension, Power County, American Falls, ID
jasont@uidaho.edu

Collecting data with wildlife can present several challenges to researchers, especially when the species is a bird nesting at heights requiring a ladder. These challenges can include using time to efficiently collect visit large quantities of nesting sites, the costs to purchase new technology and minimizing disturbances to wild animals. In order to meet these parameters our team came up with a solution to allow us to do head counts and note general nesting behavior of barn owls (*Tyto alba*) a biological control agent of voles. Our solution cost just $60 to provide equipment for a trained volunteer or researcher to collect this data on their own. Each team member uses a wireless endoscope, a small LED flashlight, a painter's pole and a cell phone to collect data in the field without a need for cell phone service. This solution allows more data collectors to participate for less money and time. Otherwise this would require more costly equipment or the setup and usage of ladders saving time and money. Usage of said technology can also be used as an affordable way to advocate for wildlife by mounting permanent cameras to boxes that do not require a wi-fi or cellular connection. This setup could also be used to monitor other wildlife in hard to reach places with minimal disturbance for a low price.

2:15 **Urban/Suburban Resident Goose Management: Insights from Colorado**

Kendra Cross[1], Dustin Reid[1], Vicki Vargas-Madrid[2], Emily Blizzard[1], Martin Lowney[1]
[1]USDA Wildlife Services, Lakewood, CO; [2]Denver Parks and Recreation, Denver, CO
Kendra.B.Cross@usda.gov

Populations of local-nesting or "resident" Canada geese (*Branta canadensis*) in urban and suburban settings are increasing human-wildlife conflicts. Re-introduction programs in the 1960s -1990s have successfully established

local breeding populations of Canada geese throughout Colorado. Today, it is unknown how many resident geese occur in the state. However, wildlife officials estimate summer statewide populations of 17,400 – 26,100 birds with approximately 1,534 breeding pairs residing in metropolitan Denver. Many of these sites were experiencing extensive damage from saturated goose activity. We examined local Canada goose population trends at 7 urban-suburban locations (along the I-25 corridor) in conjunction with implementing an integrated goose management program. Non-lethal and lethal techniques have included the use of lasers, pyrotechnics, remote-controlled boats, kayaks, egg oiling, and removal of geese during molt. Egg oiling programs and hazing did not result in an immediate reduction of goose numbers, but when combined with the removal of geese provided some relief at nesting sites and may limit local population growth. To better understand the effectiveness of our programs, we conducted site-visits to each location 2-3 times during the molting period to estimate local resident goose populations at each of the 7 study locations. On average local populations per site varied between 11 and 592 individuals. During the summer molt from June 15th-July 15th, 2019 we live-captured and removed 2,051 resident geese (mostly adult birds) and oiled 635 eggs. We anticipate that in subsequent years, counts from selected sites will indicate if an integrated management program can be an effective way to reduce local goose populations in some areas.

2:40 **Wild Turkey Use of Agricultural Fields in Southern Utah**

Nicki Frey
Berryman Institute, Utah State University, Cedar City, UT
nicki.frey@usu.edu

A hybrid of Merriam's (*Meleagris gallopavo merriami*) and Rio Grande (*M. g. intermedia*) subspecies of wild turkey ('Merrio') inhabits southern Utah. In the arid climate of southern Utah, riparian habitat is often the preferred nesting and brood-rearing habitat for wild turkeys, providing both nesting cover and food for adult hens and chicks. The dense thickets of Russian olive in these riparian areas are used for food and shelter in the winter. Since 2009, the Escalante River Watershed Partnership has been working to eradicate non-native vegetation such as Russian olive and tamarisk on public and private lands in an effort to return natural hydrology, and native wildlife and vegetation to the region. To date, the partnership has eradicated non-native vegetation from more than 64 river miles, restoring native vegetation such as willows and more cottonwoods to the area. Local landowners within the watershed have raised concerns that removing the Russian olive may create more agricultural depredation impacts because turkeys will forage more in the hay and alfalfa fields as a result. We used GPS and VHF telemetry to study wild turkey home range size, movements, and habitat use around Escalante, to determine their use of agricultural habitat throughout the year. Both hens and males predominantly used agricultural areas and habitat within the treatment footprint throughout the winter. A portion of hens used the treated riparian areas to nest and raise chicks. Our results suggest that while the treatments may be attractive to hens for brood-rearing, they could be concentrating turkeys into agricultural areas during the winter.

3:20 **Understanding and Preventing Bird Damage on Dairies**

Amber Adams Progar[1], Karen Steensma[2], Stephanie Shwiff[3], Susan Kerr[1], Tyler Caskin[1], Julie Elser[3]
[1]Department of Animal Sciences, Washington State University, Pullman, WA
[2]Department of Biology, Trinity Western University, Langley Township, British Columbia, Canada
[3]USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO
amber.adams-progar@wsu.edu

Wild birds cause significant damage to dairy farms through the consumption and spoilage of cattle feed. A survey of Washington State dairy farmers revealed approximately $14 million in bird damage losses for the Washington State dairy industry, annually. Furthermore, farms that reported the presence of more than 10,000 birds per day were more likely to report the presence of *Salmonella* or Johne's disease. Over the course of three years, we assessed the impact of bird populations on the nutritional composition of cattle feed, presence of bacteria in bird feces, and changes in cattle behavioral patterns. Five dairies were enrolled into the study and visited to collect bird fecal samples, cattle feed samples, and cattle behavioral observations. Several pens were monitored on each dairy. Bird fecal samples were analyzed for *E. coli*, *Campylobacter*, and *Salmonella*. Fresh and bird-depleted feed samples were analyzed for dry matter, total digestible nutrients (TDN), protein, crude fiber, ash, fat, and net energy. Cow behavioral patterns and the number of birds at the feed bunk were recorded using on-farm cameras. The

prevalence of bacterial populations in bird fecal samples did not differ among farms but *Campylobacter jejuni*, a strain known for causing abortions in cattle, was discovered in one location. The number of birds observed at the feed bunk and the percentage of nutritional loss in cattle feed differed among pens. Understanding where birds prefer to feed on dairies may improve the effectiveness of bird deterrent management techniques. A variety of bird deterrent methods are available for dairy farmers but, at best, the most commonly used methods are considered only "somewhat effective" by farmers. The use of more sustainable methods, such as attracting native birds of prey to dairies, may be beneficial to dairy cattle well-being as well as dairy farmer economic sustainability.

3:45 **Pest Control by Generalist Predators Depends on Prey Density and Predator Effectiveness**

Elizabeth Hiroyasu[1], Sara M. Kross[2], Roger A. Baldwin[3], Bruce E. Kendall[1]
[1]Bren School of Environmental Science & Management, University of California Santa Barbara, CA
[2]Columbia University, New York, NY
[3]Department of Wildlife, Fish, and Conservation Biology-University of California, Davis, CA
ehiroyasu@bren.ucsb.edu

Pest management represents a broad class of problems where pest mortality levels are largely dictated by people rather than environmental parameters. One approach is to add predators to the agricultural system, and in some cases (such as providing nest boxes) the predator abundance is primarily controlled by the producer rather than the abundance of the pest species. We modified a set of standard predator-prey models to incorporate this management approach by setting predator density to be constant through time rather than responding numerically to prey abundance. Depending on parameter values (predator density, prey growth rate, predator effectiveness, etc.), these models predict a stable equilibrium at high prey density (ineffective control), a stable equilibrium at low or zero prey density (effective control), or both. In the latter case, an example of alternative stable states, the predator cannot control a pest population that is already at high density, but can maintain control of a pest population that has been driven down via other means. To demonstrate the application of these models to a particular pest management problem, we parameterized the models using data on barn owls (*Tyto alba*) preying on pocket gophers (*Thomomys* spp.) and voles (*Microtus* spp.) in California agricultural fields. We found that the barn owl-rodent system may exhibit alternate stable states encompassing both effective and ineffective control. In the Type III functional response, there is no area of stable extinction of the rodent pests, but barn owls can hold them to very low population densities. These findings suggest that generalist predators can be an effective tool in Integrated Pest Management strategies, but it depends on both the prey density and the effectiveness of the predator being introduced. Careful accounting of the dynamics of the target prey species can ensure the effectiveness of biocontrols in controlled settings.

4:10 **Applying UAV Systems in Wildlife Management**

Matthew P. Brinkman[1], David K. Garcelon[1], Mark A. Colwell[2]
[1]Institute for Wildlife Studies, Blue Lake, CA
[2]Humboldt State University, Arcata, CA
brinkman@iws.org

Use of UAVs in wildlife applications has been increasing in recent years as system costs have come down and regulations regarding their use have become more well-defined. Medium and larger UAVs can accommodate sophisticated payloads, allowing for missions using LIDAR for accurate vegetation measurements, high resolution video and thermal imaging for surveying wildlife, remote spraying for control of exotic plants, and broadcasting audio calls for hazing wildlife at oil spills. At IWS we have been developing some additional capabilities for potential use in wildlife research. The first is using UAV platforms as a means to remotely deliver anesthetic darts into larger wildlife species. This capability would allow for anesthetizing free-ranging species such as deer, elk, bison, horses, etc. without the restriction of being close enough to use traditional rifle-based darting. Other drugs that could be deployed include those for immunocontraception and disease inoculation. Secondly, we are developing a drone-based remote net launcher system to allow for capture of both birds and mammals. Use of UAVs to aid in wildlife management activities that previously required more expensive aerial assets (planes or helicopters) or were not possible due to other restrictions, may allow managers to be more efficient and expand capabilities beyond what are currently available.

4:35 **Vampire Bats: Preparing for Range Expansion into the US**

Michael J. Bodenchuk[1]*, David L. Bergman*[2]
[1]USDA-APHIS-Wildlife Services, San Antonio, TX
[2]USDA APHIS Wildlife Services, Phoenix AZ
michael.j.bodenchuk@usda.gov

The common vampire bat (*Desmodus rotundus*) is apparently expanding its range northwards in Mexico and appear poised to enter the US. Climate models predict suitable habitat in the US in South Texas and parts of Southern Arizona. While range expansion isn't unexpected, vampire bats host a specific strain of rabies which impacts livestock and people. Anderson et al. (2014) estimated annual economic damages between $7M and $9M, largely associated with rabies deaths of livestock. To prepare for the emerging rabies issue, Wildlife Services programs in Texas and Arizona have begun training employees to recognize symptoms and respond to bat presence. Surveillance of livestock at sale barns and on ranches is designed to maximize the opportunity to detect bat bites in livestock. Outreach on the issue, via one-on one training and a DVD handout to landowners along both sides of the border has been initiated. This presentation will detail the extent of preparations for an emerging disease, quantify expenditures necessary for a responsive program and discuss emerging issues associated with the proximity of vampire bats to the US Border.

Wednesday, March 4 - PREDATORS AND THEIR MANAGEMENT

8:15 **Does Aversive Conditioning Change Lake Tahoe (CA) Black Bear Behavior?**

Mario Klip
California Department of Fish and Wildlife, Mill Valley, CA
mario.klip@wildlife.ca.gov

Human-wildlife conflict has been growing globally and conflicts involving black bears also increased in number and significance throughout the western United States. This trend was particularly evident throughout the Lake Tahoe Basin (CA). After meetings throughout the last decade with many local and regional stakeholders the California Department of Fish and Wildlife decided to implement aversive conditioning (AC) in addition to a continued education effort and depredation process allowing lethal removal of nuisance bears. AC was not intended to, nor had it previously been successful in persuading bears to leave urban areas. It had shown success, though, in modifying the behavior of certain bears by scorning bold behavior and rewarding their natural, shy behavior. I studied the effectiveness of using Karelian bear dogs and less-lethal ammunition to condition the behavior of bears. Three protocols were used: soft release, release with dogs, release with dogs and less-lethal ammo. I tested when bears would return to the capture location, reliance on the urban envelope, whether averted bears became more nocturnal, selected a hibernacula further away developed areas, were less winter active, decreased their foraging on anthropogenic resources and usage of known conflict areas. Contrary to expectation, some bears did not return to their capture or release locations. The majority of these individuals had experienced AC, with AC with Dogs appearing to have the greatest effect. Additionally, the return to patch time (BRP) for bears treated with Karelian bear dogs was greater than bears in the Control group for their return to both capture and release locations. Dogs also had the greatest effect on all behavioral proxies examined and bears treated with Dogs seemed to become more nocturnal, less winter active and spent less time in urban areas. These impacts of bear behavior may ultimately reduce the level of conflict with humans.

8:40 **A Case Study of the Eviction of a Female Bobcat and her four Kittens from a Suburban Backyard in Fremont, California**

Bridget C. Mooney, Macy Wannamaker
Alameda County Vector Control Service District, Alameda, CA
bridget.mooney@acgov.org

Since 2000, the Alameda County Vector Control Services District has received only 10 requests for service regarding bobcats (*Lynx rufus*). Seven of those cases have occurred in the past three years. Of those, only one case has involved the bobcats creating a den on a residential property. This is the case study of the queen bobcat and

her four bobcat kittens denning in the backyard of a suburban home in Fremont, California. The eviction of the bobcats from the deck of the vacant home was completed in May and June of 2019. During a four-week period, a wide range of eviction techniques were used, including noise, light, and water harassment, along with eviction fluid and human presence. This experience gave us the opportunity to observe and record the behaviors of bobcats living in a suburban environment and to test various eviction methods that had previously been untested in Alameda County. After four weeks of continuous humane harassment, the eviction was successful.

9:05 **Exploiting Olfactory Habituation with Unrewarding Prey Cues to Reduce Unwanted Predation**
Grant Norbury[1], Catherine Price[2], Peter Banks[2], Dave Latham[1], Cecilia Latham[1]
[1]Manaaki Whenua - Landcare Research, Alexandra, New Zealand
[2]School of Life and Environmental Sciences, University of Sydney, Sydney, Australia
norburyg@landcareresearch.co.nz

Two fundamental processes in predator-prey interactions have never been exploited in pest control. First, predators constantly make foraging decisions to maximize their energy intake, thereby ignoring unrewarding food cues; and second, predators and prey frequently use chemical mimicry to avoid being recognized. Given olfaction is the primary sense of most mammalian species, we tested whether we could deceive generalist mammalian predators into ignoring the odor cues of secondary prey by repeatedly providing prey odor with no food reward until predators gave up and searched elsewhere. We habituated predators in the wild to bird odor by exposing them to odor extracted from commercially available bird species before native birds (banded dotterel, wrybill, pied oystercatchers) arrived for nesting. We continued the odor treatment during nesting to camouflage the birds' real odor from that of the extracted odor. Chick production over a 25–35-day period in treated areas was 1.7 times greater compared to non-treated areas, after which treatment effects disappeared. These results suggest that filtering of rewarding and unrewarding food cues by generalist predators is powerful enough as a conservation management tool to protect secondary prey species temporarily without removing a single predator.

9:30 **Ten Years of Successful Management of the Invasive Raccoon Dog (*Nyctereutes procyonoides*) and the Evolution of a National Task Force for Invasive Alien Species: The Swedish Raccoon Dog Project**
P-A Åhlén
Swedish Association for Hunting and Wildlife Management, Ånäset, Sweden
P-A.Ahlen@jagareforbundet.se

The raccoon dog (*Nyctereutes procyonoides*) is a generalist predator introduced from eastern Asia to the European parts of former Soviet Union between 1929 and 1955. The raccoon dog invaded northern Sweden via Finland in the early 2000s. The Swedish raccoon dog project has been ongoing since 2008 and the Swedish Association for Hunting and Wildlife Management is leading the project funded by the Swedish Environmental Protection Agency (SEPA). As a prerequisite for a successful management the project has permission to work on all areas in the country, even if the land owner does not agree. During the run of the project we have improved the knowledge of our population through applied research integrated in the management, resulting in more efficient management. We have established a successful citizen science observation system to detect raccoon dogs. To catch detected animals, we are using Judas animals, game cameras, baits, traps and dogs. We primarily use professional hunters to capture or cull animals. Without our management it would be about 10 000 raccoon dogs in Sweden today, but instead our monitoring data shows a collapse of the population. According to EU-regulation 1143/2014 on IAS, EU-listed species has to be managed, preferably eradicated. Many of the tools developed for the raccoon dog can also be used on other species. To keep the competence of the professional staff SEPA has taken the decision to, instead of lowering the projects resources (since the raccoon dog now needs less work), broaden the mission to cover all mammal and bird IAS, plus water turtles, in the country. The national task force for eradication of invasive alien mammals and birds has proven both practically and economically successful in Sweden and could be used as a template for other countries.

10:10 **M-44 Use by Non-USDA-Wildlife Services Applicators between 2006-2019 in Montana**

Stephen M. Vantassel
Montana Department of Agriculture, Lewistown, MT
svantassel@mt.gov

M-44 use has been increasingly opposed by various groups contending that M-44s threaten human health and safety and endanger non-target animals. In Montana, M-44 sodium cyanide devices may be used by non-USDA-Wildlife Services individuals licensed by the Montana Department of Agriculture. This paper summarizes the use data submitted by these non-federal applicators between 2006-2019. The data includes use records, take (both target and non-target) as well as livestock loss reports. It is hoped that this information provides additional data and context to inform the debate over this controversial predator management tool.

10:35 **Paying for Prevention: Evaluating AZ Rancher Spending to Avoid or Reduce Conflicts with the Mexican Wolf**

Dari Duval[1], Ashley K. Bickel[1,2], George Frisvold[2]
[1]University of Arizona Cooperative Extension, Tucson, AZ
[2]Department of Agricultural and Resource Economics, University of Arizona, Tucson, AZ
duval@email.arizona.edu

The re-introduction of the Mexican gray wolf to the southwest U.S. has been controversial because of documented wolf-livestock conflict (and fear of potential conflicts). Wolf-livestock interactions have led to economic losses for ranchers directly from depredation and from physiological impacts on livestock such as weight loss. Ranchers report that, in addition to these economic losses, they face additional management costs due to the presence of wolves. Relying on a survey of Arizona ranchers, this study examines ranchers' attitudes toward wolf reintroduction, identifies and estimates the costs of management practices implemented by Arizona ranchers to avoid or reduce wolf-livestock conflicts, and explores ranchers' investments in preventative management practices. Building upon existing literature that finds that ranchers are strongly motivated by lifestyle and other non-monetary benefits, we posit that non-economic factors play a role in ranchers' decision to implement management practices to avoid or reduce wolf-livestock conflicts. We explore various aspects including ranchers' pre-conceived perceptions of wolves, risks of depredation, and overall acceptance of wolf presence. This study illuminates the complexity of rancher attitudes and management decisions related to predator coexistence and conservation.

11:00 **The Wolf and Coyote Education Program**

Skie Bender
Wolf Haven International, Huntington Beach, CA
skiebend@gmail.com

The Wolves and Coyotes Education Program takes a close look at the differences and similarities between wolf, coyote and dog biology, behavior, social structure, historical and current ranges, and ecosystem roles. How do our domesticated dogs compare and contrast with these wild canids? We will discuss both wild wolves and urban coyote challenges, and of course the latest update of wolves in California! The program features in-depth video clips of wolves at Wolf Haven International, as well as wild wolves and coyotes.

11:35 **Developing Alternatives to Protect Domestic Sheep from Predation in South Africa**

David L. Bergman[1], Nico Avenant[2], Michael Bodenchuk [3], Eddie Steenkamp [4]
[1]USDA APHIS Wildlife Services, Phoenix AZ.
[2] National Museum, Bloemfontein, Free State Province, South Africa.
[3] USDA APHIS Wildlife Services, San Antonia TX.
[4] Doornboomsfontein, Beaufort West, Western Cape, South Africa.
david.l.bergman@usda.gov

South Africa has approximately 8,000 commercial sheep farms and 5,800 communal sheep farmers throughout the country. Reported rates of small stock loss to predation range from 3-13% and 0.5-19% from communal farming areas. A range of predators exist on the African continent, but in southern Africa major livestock losses are

primarily due to black-backed jackal (*Canis mesomelas*) and to caracal (Felis caracal). South Africans have been managing jackals and caracals for over 300 years with no elimination of predation. During the aforementioned time frame, producers have used and/or developed a number of techniques including lethal, nonlethal, and integrated wildlife damage management to address predation losses. In the Karoo area of South Africa, one producer decided that a new way needed to be developed after losing over 60 lambs in a month and continuous removal of predators. The sheep producer developed an integrated wildlife damage manage system that includes using a prototype collar system for sheep and lambs. The collars are used to train dominant pairs of predators to avoid predation while maintaining their territories and keeping transient predators out of the area. The system has now gone into production in South Africa and is being distributed by its inventor.

1:25 **At the Interface between Livestock and Predators: Reducing Depredation through Livestock Husbandry**

Martin H. Smith[1], Niamh Quinn[2], Colette Ankenman[1], Hilvy Cheung[1]
[1]College of Agricultural and Environmental Sciences, UC Davis, Davis, CA
[2]University of California Agriculture and Natural Resources, Irvine, CA
mhsmith@ucdavis.edu

Effective curricula are considered foundational to Extension programming and are used widely in the 4-H Youth Development Program. To be effective, a curriculum must include a progression of educational experiences (i.e., activities; modules) that address a societal need or concern. One strategy to help connect 4-H programming to real-world issues or situations is through the intentional inclusion of youth service-learning opportunities as a component of curricula. Predator interactions with livestock and poultry represent a community-based issue that is national in scale. 4-H Animal Science is one of the largest and most popular project areas for youth members. Nationally, approximately 1.5 million youth participate in 4-H Animal Science each year, with the highest enrollment in livestock and poultry projects. However, when raising 4-H livestock and poultry there are inherent risks associated with predation, and improved animal husbandry practices are essential to help mitigate these risks. The purpose of this project was to develop a curriculum for 4-H youth who raise livestock and poultry. The overarching goal of the curriculum, entitled At the Interface between Livestock and Predators: Reducing Depredation through Livestock Husbandry, is to reduce risks of interactions between predators and 4-H project animals through improved husbandry practices. The curriculum also includes a youth service-learning component. The curriculum was tested with 4-H youth in Northern California. Results revealed statistically significant improvements in participants' content knowledge and skills. Furthermore, youth applied their new knowledge and skills to authentic contexts through the development of an informational video they shared with community members.

1:50 **The Secret Lives of Livestock Guardian Dogs: Current Knowledge and Future Research**

Dan Macon
UC Cooperative Extension - Placer-Nevada-Sutter-Yuba Counties, CA
dmacon@ucanr.edu

Rangeland livestock operations in California and elsewhere are increasingly turning to livestock guardian dogs (LGD) to protect their herds from predators. At the same time, laws and regulations that protect predators (especially gray wolves, mountain lions, and grizzly bears) limit lethal control options for ranchers, in turn increasing reliance on non-lethal tools like LGD. LGD success depends on a variety of factors, including social bonding, environmental and operational context, and individual behaviors. Observation and first-hand experience with LGD on foothill rangeland, Sacramento Valley cropland, and Sierra Nevada/Great Basin rangeland can provide practical evaluation of historic and current research regarding LGD efficacy, breed differences, and economic costs vs. benefits. However, little is known about the relationship between LGD and livestock behavior and forage utilization. Furthermore, some current research suggests that LGD disrupt predator behavior (allowing predators to remain present on the landscape), while other research suggests that LGD may displace predators (pushing them to adjacent lands). Finally, an updated understanding of the principles of bonding LGD pups to livestock (including cattle) will improve LGD success rates and reduce costs for producers. This presentation will focus on current research, experiential knowledge from practitioners, and new frontiers for LGD research.

2:15 **The Need, Challenges, and Responsibility to Track Human-Coyote Conflicts in California**

Alex Heeren[1]*, Victoria Monroe*[1]*, Niamh Quinn*[2]
[1]California Department of Fish and Wildlife, Rancho Cordova, CA
[2]University of California Agriculture and Natural Resources, Irvine, CA
alexander.heeren@wildlife.ca.gov

A common adage is "you can't manage what you can't measure." How applicable this saying may be to wildlife management is debatable; however, understanding the "where," "who," and "why's" of human-wildlife conflict can help managers evaluate and prioritize incident response and conflict mitigation efforts. It is critical to note that no tracking or reporting system is capable of effectively capturing all human-wildlife incidents. The format of the tracking system, how the system is advertised, and who manages the system are all important factors in the accessibility, utility, and success of the tracking system. Here, we examine three different systems for tracking reported human-coyote encounters in California: 1) the Wildlife Incident Report (WIR) System operated by the California Department of Fish and Wildlife, (2) Coyote Cacher operated by the University of California Agricultural and Natural Resource Extension, and (3) iNaturalist, a citizen science initiative operated by a non-governmental organization. We find that because each system offers different incentives (and poses different barriers) to the public, each receives a significantly different volume of coyote reports. Each system provides a different perspective of human-coyote conflicts in California. Understanding these differences and being cognizant of the inherent or potential limitations of a reporting system are crucial for integrated, scientifically-defensible, and robust wildlife management, policy development, and decision-making.

2:40 **Do Coyotes Eat Mesocarnivores in Southern California? A Molecular Genetic Analysis**

Jennifer M. Shedden[1]*, Niamh Quinn*[1,2]*, Danielle Martinez*[1,2]*, Paul Stapp*[1]
[1]Department of Biological Science, California State University, Fullerton, Fullerton, CA
[2]University of California Agriculture and Natural Resources, Irvine, CA
jshedden@csu.fullerton.edu

Urban coyotes (*Canis latrans*) are commonly exposed to rodenticides used to control, non-native commensal rodents, but these rodents are reportedly rare in their diets. An alternative source of rodenticide exposure is through consumption of mesocarnivores that have themselves eaten either toxic bait directly or poisoned rodents or invertebrates. Carcasses of 311 nuisance and road-killed coyotes from suburban and urban areas of southern California were collected from 2016-2018. Stomachs were dissected and those containing suspected mammalian prey (N=178) were homogenized and DNA was extracted. Genus-specific primers (123-366 bp) were designed for Virginia opossums (*Didelphis*), raccoons (*Procyon*), and striped skunks (*Mephitis*), regionally common species that are known to be consumed by coyotes. PCR was performed for each primer pair and PCR product presence and amplicon lengths were determined by gel electrophoresis. Coyote stomachs containing a PCR product of the appropriate length were considered to contain that prey item. Land use data were used to determine landscape factors that predict consumption of mesopredators. All mesocarnivores were detected at low frequencies, with opossums (3%) and raccoons (3%) most common, whereas skunks (1%) were less common. These numbers were roughly comparable to visual estimates of consumption of these species based on stomach contents analysis (7%, 0.5% and 0.5%, respectively, of 200 stomachs containing mammalian prey). Opossums were associated with all land use types, while raccoons were found in more urban areas and skunks were associated with large natural areas. The extent to which mesopredators themselves eat poisoned prey remains unknown, although they may be a potential source of exposure for coyotes. Additionally, landscape factors do not appear to predict opossum consumption, but may influence presence, and therefore consumption, of skunks and raccoons.

3:20 **Genetics and Movement: How Relatedness and Home Ranges of Feral Cats on Kaua'i Inform Management Strategies**

Alex Dutcher, Kyle Pias
Hallux Ecosystem Restoration LLC, Lihue, HI
adutcher@hallux-eco.com

The Hono O Na Pali Natural Area Reserve (HONP) encompasses both remote sea cliffs and high-elevation rainforests of Kauai's iconic northern coast. HONP is a nesting area for the federally endangered Hawaiian Petrel

(*Pterodroma sandwichensis*) and the federally threatened Newell's Shearwater (*Puffinus newelli*). These long-lived species face threats from a variety of sources including powerline strikes, light attraction, and invasive predators. Control of such predators in the HONP NAR is a key component to the protection and management of these species, specifically feral cats (*Felis domesticus*), rats (*Rattus rattus*, *R. norvegicus*, *R. exulans*) and barn owls (*Tyto alba*). Feral cats predate both adults and chicks, making them a primary target of predator control activities in HONP. One of the greatest challenges in trapping and removing feral cats is predicting movement routes and points of ingress on the ground. Understanding ingress of feral cats into HONP and movement throughout the colonies can aid managers to more effectively remove feral cats before they enter the seabird colony, where cats have the most direct impacts and trapping is most difficult. A related challenge in feral cat management is understanding where feral cats in HONP come from, and how to stop immigration. Genetic analysis of population relatedness can reveal how quickly cats from lowland urban areas move into the remote mountain habitats. Furthermore, by understanding relatedness, managers will be better able to understand the impacts the removal of urban feral cats can have on seabirds in HONP. Three feral cats were captured within HONP and tracked using Lotek Iridium LiteTrack GPS/Satellite collars. Using the movement data collected from those collars, in combination with genetic analysis of feral cats in lowland and upland areas, we are able to implement and modify trapping strategies that will allow more complete protection of Kauai's sensitive areas.

3:45 **Are TNR Practices Increasing Conflicts Between Urban Coyotes and Free-Roaming Cats in Southern California?**

Danielle Martinez[1,2]*, Niamh Quinn*[2]*, Jennifer M. Shedden*[1]*, Paul Stapp*[1]
[1]Department of Biological Science, California State University, Fullerton, Fullerton, CA
[2]University of California Agriculture and Natural Resources, Irvine, CA
daniellem1013@csu.fullerton.edu

Coyotes (*Canis latrans*) are among the most successful carnivores in urban and suburban environments, which has increasingly led to conflicts between coyotes, people, and pets in southern California. One possible contributor to high coyote population densities and human-coyote encounters is the abundance of free-roaming domestic cats (*Felis catus*) subsidized by backyard feeding and trap-neuter-release (TNR) programs. To determine if coyotes regularly eat free-roaming cats, we identified prey items in 311 stomachs of road-killed coyotes and coyotes purposely killed as nuisance animals. We used two approaches: visual identification of stomach contents and polymerase-chain reaction (PCR) analysis of tissue in stomachs. A total of 200 stomachs contained mammal remains and 177 of these had tissue from which DNA could be extracted. Combining the two methods, we found cat remains in 30% (59) of stomachs of coyotes that ate mammalian prey (19% of all coyotes studied), making cats the most common mammalian prey item consumed other than small mammals. Using GIS, we compared environmental characteristics associated with collection locations of coyotes that ate cats to the same characteristics around TNR cat colonies. Logistic regression revealed that cat-eating coyotes were associated with landscapes that were more highly developed, had little natural green and altered green space, and a higher building density than coyotes that did not eat cats. Locations of TNR cat colonies had similar landscape characteristics. The high frequency of cats in the diet of coyotes, combined with the concordance of environmental characteristics associated with TNR colonies and cat-eating coyotes, support the argument that high densities of cats and/or cat feeding may attract coyotes. Effective mitigation of human-coyote conflicts in southern California may require a ban on outdoor feeding of cats and wildlife, and the elimination of TNR colonies that coyotes see as an abundant source of prey.

4:10 **Measuring Density and Activity of Feral Cats on San Clemente Island using Camera Traps**

Greg Gustafson, Mitchell Parsons, Andrew Bridges, Dave Garcelon
Institute for Wildlife Studies, San Diego, CA
gustafson@iws.org

Feral cat (*Felis catus*) predation has negative impacts on native species, especially in island ecosystems. Understanding their activity patterns and estimating density are important to improve the efficacy of feral cat management efforts. Camera traps are used to quantify activity patterns and population sizes of a variety of species world-wide, but have seldom been used to address these questions with feral cats. We used camera traps on San Clemente Island (SCI), California to quantify activity patterns and population size of the feral cat population.

During our 2-year study we deployed 75 camera trap stations, each with 2 cameras located on opposite sides of game trails. Each trap array was separated by 1 feral cat home-range radius size of =1.32 km. We deployed a scent lure at each site which was replenished every 2 weeks. Cats photographed <1 hour apart were considered to be the same individual. We analyzed resultant photographs using time-lapse software. We used N-mixture models to analyze density data and also examined temporal activity patterns. We recorded an average of 1.4 cats per camera station, and documented 110 unique cats. From these data we estimated total island population size at 319-331 feral cats. Daily activity was less nocturnal than expected, with peaks in the early afternoon and at dusk. These data will help wildlife managers on SCI in their efforts to control feral cat impacts on native species by allowing us to better focus our efforts in both spatially and temporally.

Wednesday March 4-ISLAND INVADERS

8:15 **Large-Scale Aerial Baiting to Suppress Invasive Rats in Hawaii: Efficacy of Diphacinone and Associated Risks**

Aaron B. Shiels[1], Tyler Bogardus[2], Jobriath Rohrer[3], Kapua Kawelo[4], Paul Smith[4]
[1]USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO
[2]Pacific Cooperative Studies Unit, University of Hawaii, Hilo, HI
[3]Pacific International Center for High Technology Research, Honolulu, HI
[4]U.S. Army Garrison, Natural Resource Program, Honolulu, HI
aaron.b.shiels@usda.gov

Invasive rats (*Rattus* spp.) are among the most damaging animals to native species on many island ecosystems including those in Hawaii. Oahu Army Natural Resources currently manages invasive rat populations to protect natural resources by using grids of A24 automated traps, and previously snap-trap grids and rodenticide bait stations. Despite these control efforts generally suppressing rats, some lands with natural resources that are at risk to rat predation are not easily accessible for implementing these traditional rat control methods. In a 420 ha mesic forest on Oahu Island where ungulates are excluded and site access is limited due to military training and presence of live ordnance, we tested the efficacy of aerial application of anticoagulant rodenticide bait pellets (Diphacinone-50 Conservation), applied in two applications at a rate of 12.82 kg/ha per application. We measured the effectiveness of the rodenticide bait application by deploying tracking tunnels (inked and baited cards to identify rat presence) before, during, and after applications within treated and nearby untreated areas. Due to restricted access, we failed to estimate nest success of an endangered bird; yet previous research showed rat control increases this bird's population. We also measured diphacinone residues in stream water at the treatment site to determine this method's risk level to the aquatic ecosystem. The aerial application resulted in immediate and sustained reduction in the rat population, as evidenced by rat activity decreasing from ~50% to <20% for 10 months. Trail cameras and recovered rat carcasses also highlighted effectiveness. One of 34 stream samples analyzed had detectable diphacinone residues and this single sample was taken 1 week after application and it had very low levels of diphacinone (below levels quantifiable). Aerial application of diphacinone appears to be an efficient and effective rat suppression technique for natural resource protection in complex landscapes.

8:40 **Effectiveness of Automatic Traps for Landscape Level Rodent Control**

Tyler Bogardus
The University of Hawai'i Office of the Vice President for Research and Innovation, Honolulu, HI
tyler.bogardus@gmail.com

Beginning in 2009, the Army's Natural Resource Program on O'ahu implemented the first of three ecosystem-scale trapping grids of traditional snap traps in the Waianae Mountains using the model outlined in The New Zealand Department of Conservation's current best practices for kill trapping rats. Traps were generally checked every two weeks and bait longevity was an issue. Because of the amount of labor required for single set traps trials with GoodNature A24s were conducted from 2014-2016. Early findings showed that traps were malfunctioning at a rate of ~25% and there were major deficiencies with the bait and delivery system. In 2016 the bait system was improved when GoodNature developed the automatic lure pump (ALP) that continually releases fresh bait for ~4-6months. Other improvements were also made to the A24 trap as well to decrease the malfunction rate. In 2017

we replaced more than 1,300 snap traps at all ecosystem-scale grids with 1,000 A24s. Tracking tunnels were used as an independent monitoring system to determine effectiveness. At all sites rat activity measured in the tracking tunnels has been low (less than 15%) for over 18 months. This presentation will discuss results of this transition, highlight some successes and obstacles, and describe grid spacing and applicability to other sites.

9:05 **Behavior of Invasive Ship Rats, *Rattus rattus*, on Goat Island around Self-Resetting Traps**

Markus Gronwald, James Russell
School of Biological Sciences, University of Auckland, Auckland, New Zealand
mgro692@aucklanduni.ac.nz

Invasive ship rats (*Rattus rattus*) are the major threat to the native species and ecosystem of Goat Island (9.3 ha), New Zealand. In December 2015 a grid of 8 kill traps (DOC200s) was installed across the island to manage rat numbers. In June 2016 we extended the trapping grid with 10 self-resetting traps (GoodNature A24s), monitored with motion-activated cameras and trigger counters. All devices were checked approximately monthly until November 2017. Data on rat abundance from the kill trapping devices were consistently low. The number of animals killed by the self-resetting traps varied among months and peaked in summer. The videos reveal high rat activity on the island, which reduced over time, with the highest number of interactions happening in the first months after installing the self-resetting traps. The rats showed interest in the self-resetting traps and interacted with them when rat abundance was high, resulting in deaths, but along with the kill traps (i.e. two devices per hectare) the number of rats killed was insufficient to offset intrinsic population growth and reinvasion from the adjacent coast, and hence achieve eradication on the island. Size selectivity is potentially an issue for both traps as young rats were not observed being killed. Self-resetting devices at one per hectare did reduce rat numbers in an area where kill trap maintenance was time and cost intensive, but maintaining very low rat numbers or achieving eradication requires additional refinement of the system (e.g. a combination of different tools or a higher density of devices).

9:30 **Do the Remains Remain? The Fate of Rat and Bird Carcasses in a Hawaiian Rainforest that is Managed for Rodents and Ungulates**

Abigail Kreuser[1], Lisa H. Crampton[1], Aaron B. Shiels[2], Christopher A. Lepczyk[3], Tyler A. Winter[1]
[1]Kauai Forest Bird Recovery Project, Hanapepe, HI
[2]USDA APHIS Wildlife Services National Wildlife Research Center, Barrigada, Guam
[3]School of Forestry & Wildlife Sciences, Auburn University, Auburn, AL
abigailkreuser@gmail.com

The introduction of rodents to islands poses a threat to native fauna, which often have no adaptation to defend their offspring or themselves. To combat predation of nests and brooding females, we have deployed 425 Goodnature A24 rat traps at two field sites where high densities of native forest birds remain. Routine trap checks are conducted every 4 months to assess bait and trap function and count carcasses; typically, we find 0-3 rat or mouse carcasses. We assume that traps kill more animals than indicated by carcass counts, because 75% of traps have counters to record when fired, and those tallies exceed carcasses found. We hypothesize carcasses are scavenged or decompose in between trap checks, which may include non-target animals such as birds. To test the hypothesis that we fail to detect by-catch corpses, we placed 30 non-native bird carcasses on transects in the trapping grid within a fenced, ungulate-free site in early December 2018. To further investigate if seasons, species, and ungulates have an effect on our ability to detect carcasses at traps, in May 2019 we placed 60 carcasses, 30 non-native birds and 30 black rats, at the fenced site again, and 60 carcasses at an^3 unfenced site that is managed for rodents. Carcasses were surveyed at 10, 20, 45, 90, and 120 days after deployment. Four months after the 30 bird carcasses were deployed in December 2018, 19 could be easily detected. Of the carcasses deployed in May 2019, 82 of 120 remained detectable after 4 months. The unfenced site had greater removal rates as 33 of 60 carcasses remained detectable compared to 49 of 60 detectable carcasses at the fenced site. Majority of carcasses remained detectable, suggesting that we are likely to detect most corpses rat or bird after 4 months unless they are scavenged.

10:10 **Using AI to Improve Efficacy and Reduce By-Catch of A24 Traps in Hawaii**

Lisa H. Crampton[1,2], Mari K. Reeves[3], Erica M. Gallerani[1], Justin M. Hite[3], Lainie Berry[1], Steve E. Miller[3]
[1]Pacific Cooperative Studies Unit, University of Hawaii, Hilo, HI
[2]Hawaii Division of Forestry & Wildlife, Hanapepe, HI
[3]U.S. Fish and Wildlife Service, Pacific Islands Fish & Wildlife Office, Honolulu, HI
crampton@hawaii.edu

Camera traps provide an unobtrusive means to monitor wildlife presence and behavior. Yet evaluating large numbers of digital images can be time consuming for low frequency events. The application of artificial computer intelligence to digital image datasets can greatly increase efficiency with stunning success. We used Reconyx Hyperfire2 cameras to compare performance of four variations of GoodNature™ A24 trap sets, aimed at increasing rat (target) kills while minimizing bird (by-catch) kills at 84 traps on Kauai, Hawaii. This area is home to several endemic and endangered passerines. The variations were: automatic lure pump (ALP) + blocker, ALP – blocker, static lure + blocker, static lure – blocker. Computer vision models reduced the workload of reviewing camera trap data by 75%. Models run on training data correctly identified photos with rats or without rats with an accuracy of 97% and a loss of 11%—where no photos with rats and only 9 of 130 photos without rats were mis-identified. Camera placement at traps appears to be a critical feature in capturing images that are more amenable to deep neural network analyses. Here we describe our development of deep neural network models to review and sort camera trap data and results from our comparison of the four trap set variations. These data will be used to inform trap set throughout predator control grids on Kauai where birds are present. Camera traps will also be used to assess other trap set variations (e.g., trap height, microhabitat etc.,) to enhance trap efficacy and reduce by-catch, which is especially critical where endangered species are present.

10:35 **Trappability of Low Density Invasive Rats**

Markus Gronwald, James Russell
School of Biological Sciences, University of Auckland, Auckland, New Zealand
mgro692@aucklanduni.ac.nz

On Aotea/Great Barrier Island, New Zealand, two invasive rat species, Pacific rats (*Rattus exulans*) and ship rats (R. *rattus*) pose risks to the ecosystems and challenge the management in two sanctuaries. At Glenfern Sanctuary (83 ha) an eradication attempt has successfully removed ship rats and a predator proof fence prevents reinvasion. However, Pacific rats persist in the sanctuary in low abundance. At Windy Hill Sanctuary (770 ha) intensive rodent control maintains both species at low abundance despite ongoing reinvasion. A capture-mark-recapture study was conducted between February and April in 2016 and repeated between July and September 2017 to determine population densities, confirm species composition and analyse the effects of time, population density and interspecific competition on rat behaviour. Live traps were monitored with camera traps to analyse behaviour of rats around traps. Population density and detection probability of Pacific rats varied between times reflecting seasonality in food abundance and rat reproduction. The detection probability of Pacific rats also differed between sites, being higher at Glenfern Sanctuary than at Windy Hill Sanctuary, presumably due to interspecific competition with ship rats. Where Pacific rats were the sole species they were captured in the first night. However, in coexistence with ship rats Pacific rat detection was delayed by at least ten days. Population density influenced the number of trap encounters and interactions but did not significantly influence the capture rate. A strong correlation between population density and an index of abundance from camera traps showed the suitability of camera traps for monitoring rats in low population densities. Interspecific competition was identified as problematic for monitoring, controlling and eradicating Pacific rats. Using effective second generation anticoagulants, a higher device density and the extension of reinvasion control are all suggested to improve rat management.

11:00 **Proposed House Mouse Eradication from the South Farallon Islands, California USA**

Gerry McChesney
U.S. Fish and Wildlife Services, Freemont, CA
gerry_mcchesney@fws.gov

The South Farallon Islands, part of the Farallon Islands National Wildlife Refuge, are a group of small islands and islets (50 ha) located 44 km offshore of San Francisco, California, USA. The islands are significant for their diverse and unique wildlife and plant populations. They host the largest seabird nesting colony in the lower 48 United States, with nearly 350,000 breeding birds of 13 species. Thousands of seals and sea lions use the islands for breeding and resting. The Farallon camel cricket (*Farallonophilus cavernicolas*) and Farallon arboreal salamander (*Aneides lugubris farallonensis*) are endemic species, and a unique native plant community is dominated by the seabird island endemic Lasthenia maritima. House mice (*Mus musculus*) were introduced to the islands in the 19th century, most likely by early human inhabitants. The Farallon mouse population follows an annual cycle, peaking in fall at the end of the dry season then crashing during the wet winter season, reaching annual minimums in late winter and spring. When at near peak in fall, densities have been measured at up to 1,297 mice/ha. Studies and inferences from the literature have demonstrated impacts of house mice on the native Farallon ecosystem. Mice indirectly impact the Farallon population of Ashy Storm-Petrels (*Oceanodroma homochroa*), where nearly 50% of this rare seabird's population resides. Mice also impact native salamanders, invertebrates such as the endemic cricket, and native plants. To help restore the islands' ecosystem, the U.S. Fish and Wildlife Service has proposed to eradicate house mice from the South Farallon Islands using primarily aerial application of the rodenticide Brodificoum-25D Conservation. An extensive planning process resulted in this alternative, incorporating best practices from other mouse and rat eradications along with extensive mitigation measures to minimize non-target impacts. Project hurdles, including public opposition, also will be discussed.

11:35 **The Lord Howe Island Rodent Eradication: Lessons Learnt From an Inhabited Island Rodent Eradication**

Grant Harper
Biodiversity Restoration Specialists, Murchison, New Zealand
biodivrestoration@gmail.com

The 2019 rat and mouse eradication on 1450ha Lord Howe Island was the second and largest inhabited island to be attempted. With 350 residents, it presented numerous novel challenges, resulting in an operation best summed up in three words; Compromise, Complexity, and Cost. A ground-based operation was conducted across the built-up portion of the island, some 190ha, with aerial bait applied on forested higher ground (1300ha). Initial community resistance and the presence of mice meant that almost 19,000 external bait stations were established within the Settlement, in a 10m grid. The intensive grid was expected to result in innumerable bait stations within each rat home range. An additional 3,500 internal bait stations were put in all buildings and 9,500 hand-broadcast points overlapped the aerial and bait station boundaries. Over 60 field staff was employed locally, from Australia and overseas, to run the toxic baiting operation for 5.3 months. On-going resistance from a small community group resulted in two legal challenges early in the operational stage, including one in the Australian Supreme Court. Additional complications included initial active opposition to private land access, the need for careful team selection when entering private land to avoid conflict, resistance to livestock removal requiring novel bait station infrastructure, significant bait loss to invertebrates, along with a small proportion of rats apparently avoiding bait stations. A fundamental aim of future operations on inhabited islands should be that they are community-led, which is likely to take several years to mature to the operational stage. At the outset, eradication practitioners should only provide professional advice and let local leaders develop the groundswell to set an invasive species eradication in motion.

1:25 **An Evaluation of Aggressive White-Tailed Deer Behavior on a College Campus**

George R. Gallagher, Mary K. Boyd, Claire Taylor, Lex Vick
Department of Animal Science, Berry College, Mount Berry, GA
ggallagher@berry.edu

The Berry College campus has a population of white-tailed deer habituated to the presence of humans. One area of the campus contains residential houses, duplexes and apartments for faculty and staff. In this area there have been numerous reports, as well as photographic and video evidence, of white-tailed deer eliciting aggressive behavior particularly toward dogs being walked on leashes. In addition, deer following individuals or circling humans at a distance making them uncomfortable has been reported. The objective of this project was to document and establish the locations, frequency and types of behaviors being elicited by deer in response to humans walking with and without leashed dogs. During the summer of 2019, a total of 12 instances of aggressive behavior were encountered by residents of the area and the research team. Deer would typically follow individuals with their dogs, circle in front of the individuals and stop in the walking path, forcing them to turn another direction or be subjected to warning snorts, pawing and other behaviors. We had proposed to administer a negative reinforcement stimulus in the form of impact of a needleless paint-marking dart delivered by a tranquilizer dart gun. It was hypothesized that the negative reinforcement may reduce the likelihood of individual deer repeating the aggressive behavior. However, no deer elicited the aggressive behavior when researchers were carrying the tranquilizer dart gun. This project will continue during the summer of 2020.

1:50 **Success of Anuran Traps Improved by Manipulating Acoustic Characteristics of Lures**

Benjamin J. Muller[1], Steven A. Johnson[2], Lin Schwarzkopf[2]
[1]Department of Wildlife Ecology and Conservation, University of Florida, Gainsville, FL
[2]Centre for Biodiversity & Climate Change, James Cook University, Townsville, Australia
benjamin.muller@ufl.edu

Management of invasive vertebrates is a crucial component of conservation. Trapping reproductive adults is often effective for control, and modification of traps may greatly increase their attractiveness to such individuals. Cane toads (*Rhinella marina*) are invasive in tropical regions worldwide, and males use advertisement vocalizations to attract reproductive females. In amphibians, including toads, specific structural parameters of calls (e.g. dominant frequency and pulse rate) may be attractive to females. Some cane toad traps use an artificial advertisement vocalization to attract toads. We determined whether variation of the call's parameters (volume, dominant frequency and pulse rate) could increase the capture rate of gravid females. Overall, traps equipped with loud calls (80 dB at 1 m) caught significantly more toads, and proportionally more gravid females, than traps with quiet calls (60 dB at 1 m), and traps with low dominant frequency calls caught more gravid females than traps with median frequency calls. Traps with high pulse rate calls attracted more females than traps with low pulse rate calls. Approximately 91% of the females trapped using a low frequency and high pulse rate combination call were gravid, whereas in traps using a call with population median parameters only approximately 75% of captured females were gravid. Calls that indicated large-bodied males (low frequency) with high energy reserves (high pulse rate) are often attractive to female anurans and were effective lures for female toads in our study. The design of future trapping regimes should account for behavioral preferences of the target sex.

2:15 **Female Cane Toads Prefer Low Frequency, High Pulse-Rate Calls Globally**

Steve A. Johnson[1], Benjamin J. Muller[1], Lin Schwarzkopf[2]
[1]Department of Wildlife Ecology and Conservation, University of Florida, Gainsville, FL
[2]Centre for Biodiversity & Climate Change, James Cook University, Townsville, Australia
tadpole@ufl.edu

Evolutionary divergence of mating signals may occur rapidly in response to climatic factors, habitat structure, resource availability, or the pressures of sexual selection. Many anurans use advertisement calls to attract mates. Specific structural parameters of these vocalizations (e.g., dominant frequency and pulse rate) provide information about the body size, condition, and energetic capabilities of the caller, and females may select mates using this

information. Advertisement calls often differ among populations, therefore female preferences for the magnitudes of specific parameters may also differ. Cane toads (*Rhinella marina*) are invasive species at many sites globally. Males of the species emit a repeated drumming call to attract females for mating. In a single location (Townsville, Australia), cane toads were most attracted to artificially manipulated advertisement calls with a dominant frequency lower than the population median, and a pulse rate higher than the population median. To determine if these characteristics were universally attractive, we recorded calls from 5 cane toad populations across Australia and Florida. From those, we constructed unique, artificial vocalizations with relatively low frequencies and relatively high pulse rates for each population, based on the median parameters of the sampled calls. We then used traps equipped with the median and artificially manipulated advertisement calls as lures to compare the attractiveness of modified calls with the median call in each population. We found variation in both dominant frequency and pulse rate of calls among populations. In every population, females strongly preferred modified calls to the median calls. Our results show that a general pattern of mate choice was consistent across populations (females prefer low frequency and high pulse rate calls across sites), relative to the medians for those populations. This information may be useful for optimizing traps to remove this invasive anuran.

2:40 **Temperature and Humidity Variation Between Cage and Plastic-Walled Traps: Implications for Animal Welfare which used Cage and Box Traps**

Stephen M. Vantassel
Montana Department of Agriculture, Lewistown, MT
svantassel@mt.gov

The author received reports from wildlife control operators that animals caught in plastic-walled traps in summer conditions were showing signs of extreme heat stress. To investigate these anecdotal reports, three temperature and humidity sensors were obtained and used to monitor local environmental

3:20 **Feral Horse Use and Competition on Native Rangelands in Northeastern California**

Laura K. Snell[1], David F. Lile[2], Roger A. Baldwin
[1]University of California Cooperative Extension, Modoc County, Alturas, CA
[2]University of California Cooperative Extension, Lassen County, Susanville, CA
[3]Department of Wildlife, Fish, and Conservation Biology-University of California, Davis, CA
lksnell@ucanr.edu

In northeastern California there are two distinct rangeland areas heavily populated by feral horses, the Devil's Garden area managed primarily by US Forest Service and the East Lassen County area managed primarily by the Bureau of Land Management. Feral horse herds in both locations have significantly exceeded appropriate management levels in recent years. This increase has prompted concern about resource degradation particularly associated with spring areas. In otherwise arid sage steppe rangelands, springs provide critical watering sources as well as wildlife habitat for sage grouse, deer, elk, pronghorn, etc. Our objective is to quantify the relative frequency, duration, and timing of use by horses, permitted livestock, and wildlife at spring locations. In turn, we assess to what extent there is competition between species for watering sites. We also correlate how varying levels of horse and/or livestock use affects spring site vegetation and riparian health standards. Ten representative study locations were selected in both the Devil's Garden and East Lassen areas. Motion sensitive cameras were deployed at each location for 14-day sampling periods the spring, summer, and fall of 2015, 2016, and 2017. Number of photos recorded per site ranged from less than 100 to more than 6000. All photos were visually assessed to record species present, number of each species, and the time, date, and location of the observation. We present spring site results of vegetative cover, plant community, and bank alteration sampling geared towards wildlife habitat. Implications for management and on-going research are discussed.

3:45 **The Pocatello Supply Depot: An Update**

Patrick Darrow
USDA/WS Pocatello Supply Depot, Pocatello, ID
patrick.a.darrow@usda.gov

Since the Pocatello Supply Depot (PSD) was created in 1936, the PSD has gone through many transformation and organizational changes. The most recent of these changes occurred in 2014, when the PSD transitioned from a cooperative service agreement between USDA and the Greater Pocatello Chamber of Commerce, to a fully federal facility within USDA. Despite the many organizational changes, the purpose of the PSD has remained the same. The PSD manufactures and provides specialized wildlife damage management materials and services that are not readily available from commercial sources, for use by Wildlife Services, other Federal and non-Federal government entities, and the public. The products produced and distributed by the PSD have changed over time to meet the needs of those managing wildlife damage. The PSD produces and/or distributes gas cartridges, zinc phosphide and strychnine grain baits, zinc phosphide concentrate, DRC-1339, synthetic fatty acid lures, Neutroleum Alpha deodorizer, M-44 capsules and components, sylvatic plague vaccine baits and warning signs. Besides products that are distributed directly from the PSD, the PSD process orders for other APHIS products such as brodifacoum conservation rodenticide baits, diphacinone conservation rodenticide bait, acetaminophen tablets and acetaminophen mouse baits for brown treesnake control, GonaCon immunocontraceptive vaccines for deer and horses, and livestock protection collars. The PSD works closely with Wildlife Services (WS) operations, the WS National Wildlife Research Center (NWRC) and the Animal and Plant Health Inspection Service (APHIS), Environmental and Risk Analysis Service (ERAS) to maintain its products' pesticide registrations with the Environmental Protection Agency and state pesticide regulatory agencies.

4:10 **Imperfect Data: Offering the Best Available Objective Data for NEPA Compliance**

Emily L. Blizzard, Martin S. Lowney
USDA Wildlife Services, Lakewood, CO
emily.l.blizzard@usda.gov

The National Environmental Policy Act (NEPA) requires federal agencies to examine the direct, indirect, and cumulative impact of their proposed actions on the human environment. Typically, Chapter 3 of Environmental Assessments provides a comparative analysis of these actions and discusses information pertinent to making an informed selection among the identified alternatives. When analyzing bird species population estimates, WS-Colorado used the best data available and compared the data quality for each source. Bird populations were evaluated using trend data derived from Breeding Bird Survey, Christmas Bird Count, Partners in Flight Landbird Population Estimates Database (version 2.0), the Bird Conservancy of the Rockies (Rocky Mountain Avian Data Center), and scientific publications. In the analysis, we clearly explain the inherent problems associated with each dataset to the reader while allowing them to examine all available data. Other factors are also objectively explained including: natural factors that limit bird population, the decline of North American aviafauna, additive and compensatory mortality, logistical growth of bird populations, and individual bird species life tables. Through a more thorough and detailed analysis, all agencies, cooperators, stakeholders, and individuals can use the best available data to generate an informed decision on proposed management actions.

4:35 **Pilot Studies Keep Me Flying High**

Scott Hygnstrom
Wisconsin Center for Wildlife, University of Wisconsin-Stevens Point, Stevens Point, WI
shygnstr@uwsp.edu

Those who have been in the field of wildlife damage management as long as me probably have a file drawer full of half-baked ideas and ill-fated projects that never should have seen the light of day. This presentation will be a tongue-in-cheek look at the scientific method and the saving grace of pilot studies. A pilot study is a small-scale test of the procedures to be used in a larger scale study. The goal of pilot work is not supposed to be the testing of hypotheses, but sometimes we researchers just can't help ourselves. I have been involved in more pilot studies than I care to admit that ended up being expanded slightly and published because the variation in data was so low and results were so clear-cut. Years ago, I watched with envy as researchers repeatedly demonstrated the efficacy

of lasers in dispersing a variety of bird species. Of course, I had to try it on deer. The first four bolted from the field like their tails had been lit on fire, but after 300 attempts in a designed study, we had absolutely no response to red lasers. The editors couldn't wait to publish. Of course deer can't see red, but they can see blue-green. One week later, we were ready to publish again in the "Journal of Negative Results." In another pilot study, we learned that only one of six fence materials stands a chance of containing feral swine. Appropriately, they are named "hog panels." Later we learned that no matter what the level of motivation (stalkers, drivers, shooters, and even helicopter gunners), we couldn't blow feral swine out of hog panel enclosures. This time, it was an 8-week study and we were off to the printers again. Recently I have been involved in pilot studies of the impacts of Canada geese and muskrats on wild rice, the response of big brown bats to exclusion, and the response of elk to hazing by drones. For one reason or another (ok, time and money), we have not been able to implement full-blown studies, but the results of these pilot studies have expanded our knowledge considerably.

Thursday, March 4-ISLAND INVADERS

8:15 **Factors Leading to Successful Island Rodent Eradications Following Initial Failure**

Araceli Samaniego[1], Peter J. Kappes[2], Shane R. Siers[3]
[1]Pacific Invasives Initiative, Auckland, New Zealand
[2] Department of Wildlife Science, Oregon State University, Corvallis, OR
[3]USDA APHIS Wildlife Services National Wildlife Research Center, Fort Collins, Barrigada, Guam
ara.samaniego.mx@gmail.com

Island rodent eradications are a proven tool to restore island ecosystems, albeit the success rate of eradications on tropical islands is lower than the global rate. Efforts have been made to identify the factors associated with eradication failure in general, and particularly in tropical environments, which resulted in a large list of physical, ecological, biological, and operational factors. Likewise, in-depth reviews of recent failed eradication projects have suggested a suite of factors as explanations of eradication failure. Here we present a new, complementary study approach: a review of successful rodent eradications where initial efforts failed. There are over 15 such cases across countries such as Australia, Ecuador, Mexico, Seychelles and territories in the tropical Pacific (France, UK, USA). Understanding what in the environment and in the operation changed, leading to success, will help shed light on factors influencing failure among projects in the tropics. Recommendations for Wake Island, where planning is ongoing for a second rat eradication attempt, will be developed.

8:40 **If At First You Don't Eradicate: Remediating Rat Eradication Failure on Wake Atoll**

Peter J. Kappes[1], Kristen Rex[2], Chad Hanson[3], Shane R. Siers[1]
[1]USDA APHIS Wildlife Services National Wildlife Research Center, Barrigada, Guam
[2]Center for Environmental Management of Military Lands, Colorado State University
[3]Island Conservation, Santa Cruz, CA
peter.j.kappes@usda.gov

Island rodent eradication operations have been remarkably successful at eliminating damages caused by these harmful vertebrate pests. As efforts increase in scale and complexity, so does risk of eradication failure. We use the example of a partially-successful rodent eradication project to highlight how best practices and lessons learned are being integrated to reduce risk of failure during a second attempt. In 2012 the US Air Force (USAF) commissioned an attempted eradication of two rat species from Wake Atoll in the Western Pacific. Asian house rats were successfully eradicated, but it was soon confirmed that some Polynesian rats survived; population numbers have since soared. A panel of outside experts was asked to review the project and identify factors that may have contributed to failure. The USAF and Wildlife Services National Wildlife Research Center (NWRC) have used this report as a road map for further studies addressing issues including bait delivery strategies, bait application rates, and alternate bait formulations. A subsequent data gap analysis conducted by USAF, NWRC, and Island Conservation documented technical advances in the intervening years that address risk factors identified in the original review, and highlighted remaining needs including development of a community outreach component and refinement of baiting strategies for inhabited areas and abandoned structures. This exchange of knowledge and expertise among cooperating organizations is helping to refine feasibility assessments and address lingering

knowledge gaps. These efforts include a review of other failed rodent eradications that were redone successfully. Ongoing studies continue to resolve areas of uncertainty, and results are being integrated into operational planning for a subsequent eradication effort on Wake Atoll. This process highlights the importance of ongoing refinement of best practices, incorporation of lessons learned, and transfer of knowledge to the wider eradication community.

9:05 **Tropical Island Rat Eradication Failures – Hope For the Future**

Grant Harper
Biodiversity Restoration Specialists, Murchison, New Zealand
biodivrestoration@gmail.com

Recent failures of tropical island rat eradications provoked a re-appraisal of the approach required to increase the success rate. Several possible reasons for eradication failure were postulated and have since been the subject of recent research, changes to operational protocols, and more searching analyses. As a result updated information is now paring down the possible factors leading to failure and providing promising avenues for research and operational application. This paper outlines some of the aspects of tropical island rodent eradication planning that may need modifying to improve operational efficacy.

9:30 **The Effectiveness of Long-Term Adaptive Predator Control Programs for the Protection of Endangered Seabirds on Kaua'i**

Kyle Pias[1], Alex Dutcher[1], Andre Raine[2]
[1]Hallux Ecosystem Restoration LLC, Lihue, HI
[2]Kauai Endangered Seabird Recovery Project, Hilo, HI
kpias@hallux-eco.com

Hono O Na Pali (HONP) Natural Area Reserve is an important breeding site for the federally threatened Newell's Shearwater (*Puffinus newelli*), the federally endangered Hawaiian Petrel (*Pterodroma sandwichensis*), and the federally endangered Band-rumped Storm-Petrel (*Oceanodroma castro*). Breeding colonies of these seabirds elsewhere on the island of Kaua'i face threats from anthropogenic sources such as light pollution and power-line strikes. While the colonies in HONP are relatively unaffected by anthropogenic threats given the lack of human habitation and infrastructure on the northwest coast of the island, they do face predation from a variety of invasive predators. The terrestrial predators that have been documented depredating seabirds in HONP colonies are feral cats (*Felis catus*), black rats (*Rattus rattus*), and feral pigs (*Sus scrofa*). The colonies in HONP are within an ungulate proof fence as of 2014, and thus are protected from further pig predation. However, the site remains open to rodents and cats and thus ongoing trapping efforts are necessary to control those predators. Predator control activities were implemented in 2014 and have expanded every year since. Seabird reproductive success at all sites increased once predator control operations were in place and depredations by all terrestrial species decreased significantly. Seabird depredation rates were also found to be negatively related to predator control effort for both cats and rats. This work highlights the importance of controlling introduced predators at endangered seabird colonies and shows that with effective and adaptive predator control programs in place, seabird colonies are able to persist and recover.

10:10 **Modeling the Management of Non-Native Game Mammals to Reduce Future Conflicts With Native Plant Conservation in Hawai'i**

Steven C. Hess[1], Christina R. Leopold[2], Lucas B. Fortini[3], Seth W. Judge[2], Jacob Muise[3], Jonathon Sprague[4]
[1]U.S. Geological Survey, Pacific Island Ecosystems Research Center, Hawai'i National Park, HI, USA
[2]Hawai'i Cooperative Studies Unit, University of Hawaii at Hilo, HI, USA
[3]KIA Hawai'i, Big Island, HI
[4]Pulama Lana'i, Lana'i, HI
shess@usgs.gov

Introduced ungulates cause agricultural damage and degradation of native biodiversity throughout Hawaiian ecosystems. These ungulates include feral livestock which have been successfully managed and eradicated on many other oceanic islands, but also more recently introduced wild species which are more difficult to control. The

Hawai'i Interagency Biosecurity Plan has identified ungulate control as the single most expensive invasive species problem in the state largely because of costly barriers necessary to separate areas managed for sustained-yield hunting from those where ungulates are eradicated. Large numbers of wild and feral ungulate species have been removed from Maui, Lana'i, and Moloka'i during recent years, partly under marketing initiatives, but substantial population reductions have not yet occurred. Long-term solutions that are being considered to reduce annual management costs will include land use prioritization modeling with stakeholders to protect native threatened and endangered species from extinction, minimize ingress, and to facilitate both population control and sustained-yield hunting. Population modeling would also inform seasonal and daily bag limits to manage for desired levels of abundance; selective removals of females could be particularly effective for reducing adult sex ratio bias and population growth rates similar to "earn-a-buck" programs used in other states to manage overabundant deer.

10:35 **Flavor Preference of Oral Rabies Vaccine Baits by Small Indian Mongooses (*Herpestes auropunctatus*) in Southwestern Puerto Rico**

Are R Berentsen[1], Fabiola B. Torres-Toledo[1], Mel J. Rivera-Rodriguez[2], Amy J. Davis[1], Amy T. Gilbert[1]
[1]USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO
[2]USDA APHIS Wildlife Services, Auburn, AL
Are.R.Berentsen@usda.gov

The small Indian mongoose (*Herpestes auropunctatus*) is an invasive pest species and rabies reservoir in Puerto Rico and other islands in the Caribbean. In the United States and Europe rabies in wild carnivores is largely controlled through oral rabies vaccination (ORV), but no ORV program for mongooses exists. The oral rabies vaccine currently licensed for use in wild carnivores in the United States has not been reported as immunogenic for mongooses. A mongoose-specific bait has been developed but field-based bait flavor preference trials have not been performed in Puerto Rico. We evaluated removal of egg-flavored (treatment) vs unflavored (control), water-filled placebo ORV baits in a subtropical dry forest in Southwestern Puerto Rico from 2014-2015. During six trials at four plots we distributed 350 baits (175 treatment and 175 control) and monitored baits until at least 50% of baits had been removed or were rendered unavailable to mongooses due to inundation by fire ants (*Solenopsis invicta*) or for five days. The estimated overall probability of bait removal within five days was 85% (95% CI 75-91%) and 45% (95% CI 35-55%) for treatment and control baits, respectively. Removal rate estimates in the spring were 95% (95% CI 86-98%) and 63% (95% CI 49-76%) for treatment and control baits, respectively. Removal rate estimates in autumn were 68% (95% CI58-77%) and 30% (95% CI 22-39%) for treatment and controls, respectively. Model estimates suggest that treatment and season were more influential on bait removal rates than diel period or experimental day, although bait removal rates were higher at night than during the day, suggesting non-target bait removal by nocturnal rodents. Our results suggest that egg-flavored baits were preferred by mongooses over unflavored baits. During operational ORV bait application, non-target bait removal should be taken into consideration when calculating bait application rates.

11:00 **Evaluating the Airsoft Electric Gun for Control of Invasive Reptiles: Ballistic Tests and Impact on Brown Treesnakes**

Adam Knox[1], Bjorn Lardner[2], Amy Yackel Adams[3]
[1]Maui Invasive Species Committee, Wailuku, HI
[2]Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, CO
[3]US Geological Survey, Fort Collins Science Center, Fort Collins, CO
knoxa@hawaii.edu

Firearms are often used in lethal control of invasive vertebrates, but safety and regulatory aspects limit the circumstances under which they can be used. Here we evaluate if hobby-grade Airsoft Electric Guns (AEGs)-a lower-powered, less hazardous, and less regulated alternative-could potentially be used in the control of small animals, with specific emphasis on invasive brown treesnakes (*Boiga irregularis*). Tests of different AEGs with ammunition (plastic pellets) masses ranging from 0.20 to 0.39 g, fired at gelatin blocks from distances of 4, 8, and 12 m, confirmed that heavier ammunition penetrates deeper. The 0.39-g pellets even penetrated more deeply at12 m than did 0.20-g pellets at 4 m. Inspection of tissue damage in brown treesnake carcasses subjected to fire with the 0.39-gammunition from the same distances suggested that injuries sustained by a direct hit from 12 m away would often be lethal, and that brown treesnakes would be unlikely to survive multiple hits from automatic

fire (ca. 17 s-1). Limited trials with live snakes helped us understand what the behavioral response may be in a snake hit by one or more pellets, and to assess the risk that an injured snake might avoid subsequent capture. We discuss regulatory advantages, and what type of invasive reptiles and other taxa (in terms of size, morphology, and habitat) might be suited to control with AEGs.

11:25 **Automated Aerial Baiting for Invasive Brown Treesnake Control: System Overview and Program Status**

Shane. R. Siers[1], Robert J. Gosnell[2], Aaron F. Collins[2], Scott M. Goetz[1,3], Eric T. Hileman[3], Melia G. Nafus[3], Amy A. Yackel Adams[3], William C. Pitt[1], John D. Eisemann[1], Larry Clark[1], William C. Coon[4], and Michael C. Messaros[4]*
[1]USDA APHIS Wildlife Services, National Wildlife Research Center, Fort Collins, CO
[2]USDA APHIS Wildlife Services, Guam State Office, Barrigada, Guam
[3]USGS Fort Collins Science Center, Fort Collins, CO
[4]Applied Design Corporation, Boulder, CO.
shane.r.siers@usda.gov

The economically and ecologically catastrophic introduction of brown treesnakes to the Pacific Island of Guam has long served as a cautionary tale about the dangers of invasive species and the seeming impossibility of their management on a landscape scale. USDA Wildlife Services and federal and private partners have engineered a system for the automated manufacture and aerial delivery of toxic baits for landscape-scale suppression of brown treesnakes in large and remote forest plots. The helicopter-borne dispensing module can launch four bait cartridges per second, and a single payload of 3,600 cartridges can treat 30 ha of forest at 120 baits/ha in 15 to 30 minutes. In this presentation, we will recap the research, development, testing, and implementation of the system, including the biological response to bait applications during an experimental eradication within a 55-ha forest plot surrounded by a snake-proof barrier.

1:25 **Field Efficacy Following Re-Development of the Rat-Specific Toxin Norbormide**

Lee Shapiro[1,3], Charles Eason[2,3], Duncan MacMorran[3], David Rennison[4], Margaret Brimble[2], Michael Jackson[5]
[1]Boffa Miskell Ltd, Auckland, New Zealand
[2]Cawthron Institute, Nelson, New Zealand
[3]Centre for Wildlife Management and Conservation, Faculty of Agriculture and Life Sciences, Lincoln University, New Zealand
[4]IPC Ltd, Auckland, New Zealand
[5]Victoria University, Wellington, New Zealand
charles.eason@cawthron.org.nz

Norbormide is a uniquely selective rat toxicant that causes vasoconstriction and death from heart failure. Rats are 150-fold more sensitive to norbormide than most other mammals, and birds tested are >100-fold less sensitive. Despite this target specificity and its promise as a powerful rat control tool, taste aversion has previously limited its efficacy. After several false leads we have optimized routes of chemical synthesis to limit impurities and improve bait palatability, a historical impediment to its use. Recent successes have shown this commitment to be worthwhile. Cage trials on both Norway and Ship rats have shown good efficacy and most recently two small scale field trials run in late 2018/early 2019 targeting Norway rats achieved 100% and 96% reductions of wild Norway rat populations. During the second field trial, dead ship rats as well as Norway rats were found <5m from bait stations. Although these trials were primarily aimed at Norway rat control, the efficacy on both rat species is encouraging. Whilst the results are very promising there are big hurdles to be addressed to ensure all process steps in the research and development, registration, production and supply of norbormide baits are completed, these are being systematically address. Further field trials will be reported.

1:50 **Island Eradications of the Future: RNAi as a Selective Tool**

Katherine Horak
USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO
katherine.e.horak@usda.gov

Rodents cause devastating damage to both agriculture and ecosystems worldwide. Invasive rodents are commonly found on islands, historically free of these animals, and have enormous negative impacts on both native plant and animal species. Rodents are exceptionally well adapted to their environments and therefore, quite challenging to control. Current control strategies often include large-scale applications of toxicants, which have potential adverse effects on non-target wildlife. In island ecosystems, these adverse effects are a major hurdle to eradication efforts. The time and financial resources devoted to minimizing risks to non-targets and perform post-eradication exposure monitoring limits the number of islands that can be successfully eradicated. Therefore, the development of new species-specific rodenticides would be a valuable advancement in the effort to control these pest species, especially for island eradications. To that end, we are investigating the use of RNA interference, RNAi, as a novel way to control rodent species. RNAi is a new technology that has shown much promise as both a therapeutic for human diseases and in the efforts to control insects and plant diseases. In essence, RNAi is a gene-silencing technology in which small, specifically designed sequences of RNA are introduced into cells and induce the degradation of sequences of RNA encoding a target gene of interest whereby preventing the synthesis of the corresponding protein. By inhibiting protein synthesis, RNAi enables researchers to selectively alter cell function in both normal and disease states. By screening the rodent genome and comparing sequences of rodent genes to non-target species, we are able to choose genes that are present in the pest species and not in the non-target species. Therefore, if non-target species consume the RNAi they will not be effected. The use of RNAi for rodent control shows promise because of its species specificity and low non-target impact.

2:15 **Efficacy of Snap Traps and Automatic Traps for Rodent Removal in Montane Rainforests on on Kaua'i**

Tara Mojzuk, Kyle Pias, Alex Dutcher
Hallux Ecosystem Restoration LLC, Lihue, HI
mojzukta@msu.edu

The Hono O Na Pali Natural Area Reserve (HONP NAR) on Kaua'i is home to many endemic and endangered species, including the federally endangered Hawaiian petrel (*Pterodroma sandwichensis*) and federally threatened Newell's shearwater (*Puffinus newelli*). A major barrier to the recovery of these ground-nesting species is widespread predation by invasive rodents. Rodent species present Kaua'i include black rats (*Rattus rattus*), Norway rats (*Rattus norvegicus*), and Polynesian rats (*Rattus exulans*). All species of rats found on Kaua'i have potential to predate upon nesting seabird eggs and chicks, as well as disturb trapping efforts designed for feral cat removal. In order to control rodent populations, a combination of Victor snap traps and GoodnatureA-24 automatic traps are currently used in the HONP NAR. Multiple trap types are necessary due to species-specific responses to different trap and bait types. Daily presence of each rodent species is monitored using Reconyx PC900 game cameras. In order to understand each species response to various trap types, daily rodent presence probability is compared to rodent removal rates by trap type. Understanding differences in rodent species response to trap types can help managers understand trap efficacy for different species and impacts on rodent populations.

2:40 **Towards a Predator-Free New Zealand**

Grant Norbury
Manaaki Whenua - Landcare Research, Alexandra, New Zealand
norburyg@landcareresearch.co.nz

In 2016, the New Zealand government announced $28 million to eradicate invasive rats, possums and stoats from the mainland by 2050. Predator Free 2050 Ltd was established to distribute these funds to groups who could demonstrate local eradication and landscape scale suppression of predators, and lever additional funding to achieve their goals. Achieving eradication of predators at a national scale requires quantum leaps in pest management, including: (1) new tools and strategies for removing predators; (2) more accurate methods of detecting predators at very low abundance; (3) statistical methods for declaring probability of success; and (4) public co-operation and involvement in the program. To date, we have developed a free decision-support tool

(TrapSim) to simulate the effects of varying trapping and poisoning regimes. The tool is being further developed to include reinvasion and variation amongst individual predators' interactions with control devices. We are co-developing artificial intelligence that automatically identifies pest species in trail camera images, saving thousands of hours of image processing and massively increasing the cost-effectiveness of this detection tool. Declaring local eradication reliably is a critical part of moving from one eradication zone to the next. Lack of detections does not necessarily mean eradication, as this depends on the detection network and the probability that a predator can be detected if it is present. We have developed a decision tool to use this information to declare the probability of eradication. The software also allows design of optimum surveillance effort, thereby reducing the costs of proving local absence of predators. A key component of the success of this program is demonstrating the biodiversity, economic and social benefits. We conduct repeated surveys of urban and rural public to gauge the extent to which the program affects their lives in terms of fewer encounters with pests, more encounters with native biodiversity, perverse outcomes, and greater awareness and understanding about their local biodiversity.

Thursday, March 5 - RODENT MANAGEMENT AND DISEASE

8:15 **Prevalence of *Rickettsia felis* and *Rickettsia typhi* in Urban Wildlife in Orange County, California, 2016-2019**

Amanda Penicks, Laura Krueger, Robert Cummings, Carrie Fogarty, James Campbell, Kiet Nguyen, Daisy Rangel
Orange County Mosquito and Vector Control District, Garden Grove, CA
lkrueger@ocvector.org

Fleas infesting urban wildlife have been epidemiologically linked to the transmission of flea-borne rickettsial pathogens in urban and suburban areas of Orange County, California. To understand the prevalence of flea-borne rickettsioses (*Rickettsia felis* and *Rickettsia typhi*), surveys of wildlife were conducted to determine flea species composition of host animals, and prevalence of rickettsial pathogens in fleas and host animals. This study highlights the medically-important species of fleas found on backyard wildlife (domestic cats and dogs, coyotes, skunks, opossums, squirrels, raccoons, and commensal rodents) collected in residential neighborhoods of Orange County, in response to locally-acquired human cases of flea-borne rickettsioses. The prevalence of flea-bone rickettsioses in fleas has been used by the Orange County Mosquito and Vector Control District to guide decisions regarding risk management and potential intervention strategies to reduce and prevent the transmission of flea-borne pathogens.

8:40 **No Clear Path toward Prevention: Lessons Learned from Fifteen Years of Investigating Flea-borne Rickettsioses in Orange County, California**

Robert Cummings[1]*, Laura Krueger*[1]*, Amanda Pennicks*[1]*,* Danielle Martinez[1]
[1]Orange County Mosquito and Vector Control District, Garden Grove, CA
[2]University of California Agriculture and Natural Resources, Irvine, CA
rcummings@ocvector.org

Flea-borne rickettsiosis has re-emerged as an important vector-borne disease in southern California and parts of Texas during the last 20 years. The reasons for this resurgence are unknown, but one important factor may be related to changes in animal care and control practices of nuisance animals, especially opossums, feral cats, and urban Norway rats, by public and privately sponsored entities. Since 2006, the Orange County Mosquito and Vector Control District (OCMVCD) has been investigating human cases of flea-borne rickettsioses in Orange County, Calif. OCMVCD has also provided testing of specimens for other governmental agencies during outbreaks of this disease in Los Angeles County. Research by OCMVCD has found that host animals, such as opossums, feral cats, Norway rats, and to a lesser extent, raccoons and coyotes, can support large populations of fleas that can be found infected with *Rickettsia felis* and *R. typhi*, the pathogenic bacteria responsible for human cases of flea-borne rickettsiosis. OCMVCD, local health care agencies, and a 2015 Orange County Grand Jury investigation have recognized a link between the feeding of feral cats in colonies and human disease risk. Despite an awareness of this link, no local human health care, animal care, or city code enforcement agency has implemented policies and procedures to stop the feeding of feral cats in colonies in areas with disease risk. The lack of enforcement of "No

Feeding of Wildlife" regulations by governmental jurisdictions, and the fact there are no feed-through flea control formulations, prevents a clear pathway forward for disease prevention. In summation, flea-borne rickettsiosis is a prime example of a zoonotic disease that is difficult to manage because of conflicting perspectives between public health agencies and animal rights advocates who perceive the zoonotic disease risks associated with cat rescue programs, such as Trap-Neuter-Return, at significantly different thresholds of concern.

9:05 **Live-Trapping Norway Rats in Homeless Camps in Oakland, California, and the Implications for Public Health**

Adena Why, Sutapa Biswas, Natalia Federova, Augustine De Villa, David K. James
Alameda County Vector Control Service District, Alameda, CA
adena.why@acgov.org

The City of Oakland is the largest city within Alameda County is the 8th largest city in California and 45th largest in the United States. Due to various socioeconomic factors the number of homeless encampments within the City has been increasing over the past few years. A recently completed survey showed that there has been a 47.45% increase in the number of homeless living within the city limits. Approximately 4071 people are now living in various encampments around the city, primarily concentrated underneath freeway overpasses and on adjoining lands. Surveillance by our staff found that several of these encampments also had active Norway rat populations as indicated by active burrows within, and adjacent to, the camps as well as resident reports. Beginning in the fall of 2017, District biologists began live-trapping at a few of the larger encampments to try and ascertain the composition and load of ectoparasites on corresponding Norway rat populations. We were specifically looking at flea abundance and species composition, as they are vectors of diseases such as Murine typhus, *Rickettsia typhi*, flea-borne typhus, *Rickettsia felis*, and plague, *Yersenia pestis*. We trapped at four different camps in Oakland over a nine-month period and found that the flea, mite and lice abundance, along with species composition, varied between the camps. To date we have yet to determine the causes of these differences, but fleas tested at two of the four camps have come back as positive for *R. felis*. We are continuing to trap at the four initial camps, and are expanding our trapping program to include additional camps in an effort to determine what variables affect the ectoparasite composition on Norway rat populations.

9:30 **Homeless Encampments Location Critical in Vector-Borne Disease Potential**

Daniel Wilson
Alameda County Vector Control Service District, Alameda, CA
daniel.wilson@acgov.org

As of January 2019, Homeless Point in Time Count in Alameda County, California we had 8,022 homeless individuals countywide, with 6,312 un-sheltered, half of which reside in Oakland. We have dozens of diverse homeless encampments throughout the County, and most lack sanitation facilities, e.g. rodent-proof garbage storage, and weekly removal, sanitary toilets and running water to wash hands, bodies or laundry. This is a total breakdown of the sanitation interventions that make urban areas work and can easily lead to an outbreak of vector-borne disease, such as the typhus outbreaks experienced this year in southern California. There are some interesting characteristics of these encampments we have surveyed, which make them ripe for Norway rat problems, since Norway rats thrive on garbage left out in the open. Many of our urban encampments are in parts of Oakland that has old infrastructure where there may be undetected sewer breaks that allow rats into these areas. Before the introduction of unmanaged food sources (garbage) the rats go virtually unnoticed due to their low population, but with a regular supply of food, their populations skyrocket. A female Norway rat can have 7 or more liters per year, averaging 8 young per litter, which reach sexual maturity in 3 months (Parker 1990). Furthermore, one breeding pair of rats can result in the production of 15,000 rats in a year (New Scientist May 2017). This makes these unmanaged encampments situations of great concern for our overall public health, when you add in fleas and the potential for rodent-borne diseases; disaster may be just around the corner.

10:10 **Proposed Methods for Detecting Nutria (*Myocastor coypus*) in California Using Environmental DNA**

Michael R. Buchalski, Daphne A. Gille
Genetics Research Laboratory, California Department of Fish and Wildlife, Sacramento, CA
michael.buchalski@wildlife.ca.gov

Nutria (*Myocastor coypus*) is a semi-aquatic mammal and invasive pest species with destructive feeding and burrowing behavior that can result in substantial soil erosion, marsh habitat loss, and disruption to agriculture. The initial invasion of nutria into California occurred in the 1940s as individuals either escaped from fur farms, or were intentionally released into the wild, leading to the establishment of localized feral populations. The initiation of costly, multiagency eradication efforts eventually led to reports that nutria had been completely eradicated from California by 1978. However, in 2017 the first sightings of nutria in California in nearly 40 years raised concerns that the species may be reinvading the state. To avoid future damage to California wetlands and agriculture, it is a top management priority to determine the current distribution of the nutria reinvasion statewide so targeted eradication actions can proceed. One alternative to traditional surveys or trapping is to detect nutria DNA in the environment, also known as environmental DNA (eDNA). Trace amounts of target eDNA can be extracted from environmental samples (e.g., water or sediment) and identified using a highly sensitive quantitative polymerase chain reaction (qPCR) assay. The benefits of developing such an assay for nutria include reduced sampling effort and training for field crews, the ability to detect presence across a wide, potentially inaccessible area, and more rapid results. This presentation will outline the proposed development of an eDNA assay using a series of laboratory- and field-based validation steps, followed by a pilot field surveillance effort to delineate the extent of nutria reinvasion in California. The proposed eDNA assay for nutria will complement existing detection methods and provide managers with more comprehensive data for targeting eradication. Once developed, the eDNA assay can be used for long-term surveillance of nutria and serve as a warning system in the event of further reinvasion.

10:35 **Assessing Beaver Occupancy and Dam Building Potential: A Case Study in the Umpqua Watershed of Southwestern Oregon**

Vanessa Petro[1], John Stevenson[2], Jimmy Taylor[3]
[1]Department of Forest Ecosystems and Society**,** *Oregon State University, Corvallis, OR*
[2]Department of Fisheries and Wildlife**,** Oregon State University, Corvallis, OR
[3]USDA/APHIS/Wildlife Services, National Wildlife Research Center, Corvallis, OR
vanessa.petro@oregonstate.edu

Interest in beaver-related restoration (BRR) is growing in the western US, although efforts to relocate beaver or mimic beaver damming may be made without knowledge of extant beaver populations (*Castor canadensis*). Understanding the spatiotemporal distribution of beaver populations is an important and often overlooked factor when integrating beaver into stream restoration activities. Our study investigated the distribution of beaver colonies and their damming activities to better inform stream restoration projects in the West Fork Cow Creek sub-basin of the Umpqua watershed in southwestern Oregon. During fall 2017, we conducted beaver activity surveys at 144 randomly selected reaches predicted to be either suitable or unsuitable for damming, but suitable for beaver occupation. We categorized beaver use at each reach using assessments of their activities and time of last use. We recorded dam structure and impoundment characteristics at all identified dams. Evidence of beaver activity was documented at 57% of locations suitable for dam establishment and 48% of unsuitable dam sites, supporting other research that suggests not all beaver build dams. We documented 48 total dams that were concentrated throughout two tributaries located on private lands. Our beaver activity observations will be combined with other data collected in the Umpqua Basin, and used to construct a probability of use model that will identify dam and non-dam habitat associations. This work will provide novel insights into the landscape ecology of beaver, and inform critical decisions involving trade-offs of ecological benefits and human-beaver conflicts in fluvial systems of interest.

11:00 **Bait Station Placement as a Method to Reduce Wildlife Exposure to Rodenticides**

Christopher B. Burke[1], Niamh Quinn[2], Paul Stapp[1]
[1]Department of Biological Science, California State University, Fullerton, Fullerton, CA
[2]University of California Agriculture and Natural Resources, Irvine, CA
chrisbburke@csu.fullerton.edu

Anticoagulant rodenticides (ARs) are commonly used to control commensal pest species, especially in highly urbanized areas. However, primary exposure of these rodenticides to smaller native mammals and secondary exposure to larger carnivores has become a large problem in these urban landscapes. Surprisingly little is known about the exact pathway of rodenticides from bait station to carnivore, and about potential ways to reduce exposure risk. Our goal was to determine a simple method of reducing bait station use by wildlife without reducing use by target commensal species. To accomplish this we deployed Reconyx trail cameras to monitor rodenticide bait stations placed in 90 residential yards across Orange County, California. Two commercial bait stations, baited with non-toxic bait, were monitored continuously in each yard for ~30 consecutive days during the dry and wet seasons. One bait station was placed on the ground, whereas the other was elevated 1.5-2 m in a tree or along a fence line. This camera-trapping effort yielded more than 800,000 images, of 12 different mammal species. Most yards (84%) were visited by at least one wild mammal species (range = 0-6). Commensal species were also very common, with presence in 80% of yards. All wild species were photographed less often at elevated stations compared to ground stations, whereas roof rats (*Rattus rattus*), a commensal species and the primary target of rodenticide applications, showed no significant preference for either station. The only species that displayed a significantly higher presence at elevated stations was the fox squirrel (*Sciurus niger*), reflecting its arboreal nature. With these results we hope to provide a low-cost, low-effort solutions to non-target bait station use that could be implemented by pest management professionals in areas with a high potential risk of exposure to wildlife.

11:25 **Potential Secondary Toxicity Risk Associated with Differing Application Strategies of Diphacinone-Treated Grain for California Ground Squirrel Control**

Roger A. Baldwin[1], Ryan Meinerz[1], Niamh Quinn[2], Theresa A. Becchetti[3]
[1]Department of Wildlife, Fish, and Conservation Biology-University of California, Davis, CA
[2]University of California Agriculture and Natural Resources, Irvine, CA
[3]University of California Agriculture and Natural Resources, Modesto, CA
rabaldwin@ucdavis.edu

California ground squirrels (*Otospermophilus* spp.) cause extensive damage to agricultural lands, residential areas, and natural ecosystems. First-generation anticoagulants (e.g., diphacinone and chlorophacinone) are a common tool used to manage ground squirrels. Three application strategies are allowable for use when distributing these baits to ground squirrels: 1.) spot treatment, 2.) broadcast application, and 3.) bait stations, yet little is known about how residual anticoagulant levels in carcasses, time to death, and proportion of ground squirrels that die aboveground vary across these treatment types. Therefore, we established a study using radiotransmittered ground squirrels to determine residual diphacinone levels in ground squirrel carcasses post-treatment, time to death, and proportion of ground squirrels that die above ground across all three treatment types when using diphacinone treated oats. Data were collected in San Joaquin and Stanislaus Counties during summer/autumn 2018 and 2019. We will provide the results from this study in this presentation. These results will provide information needed to better describe potential impacts of diphacinone products on nontarget predators and scavengers, as well as to provide insight into strategies that could be employed to reduce this risk.

1:25 **Integrated Pest Management Strategies for Round-Tailed Ground Squirrels**

Shaku Nair[1], Dominic Henry[2], Dawn H. Gouge[3]
[1]Maricopa Agricultural Center, University of Arizona, Maricopa, AZ
[2]National Park Service, Coolidge, AZ
[3]Department of Entomology, University of Arizona, Maricopa, AZ
nairs@email.arizona.edu

The round-tailed ground squirrel (*Spermophilus tereticaudus*) is a common resident of natural areas in throughout most of the desert southwest region of North America. These small-bodied mammals live in matriarchical colonies

of at least several adult animals and are diurnal during the active season that ranges from late winter until late summer. They are well adapted to desert life, and live in burrows they excavate in the ground, but will also modify and occupy burrows created by other animals. Round-tailed ground squirrels are frequently seen in many human community environments. Their burrowing is usually not a significant cause of concern, nor are they reported to cause severe damage to humans or their property and structures. However, they very often cause concerns due to human-wildlife interactions that may include the squirrels themselves, but also their predators such as rattlesnakes, coyote, feral dogs and other large mammals. Another cause for concern is that round tailed ground squirrels can be hosts for fleas and other parasites, and could vector plague or other diseases during human interactions. This presentation describes successful use of integrated pest management strategy at an archaeological site in AZ to manage activity of these rodents, using a combination of monitoring, trapping and repellents.

1:50 **Estimating the Number Rodents Killed by Barn Owls Nesting in Boxes on Winegrape Vineyards**

Dane St. George, Matthew Johnson
Department of Wildlife, Humboldt State University, Arcata CA
mdj6@humboldt.edu

To mitigate the economic and environmental costs of treating for rodent pests, winegrape producers in Napa Valley, California, have installed nest boxes to attract barn owls (*Tyto alba*) to their properties, but their effectiveness to control rodent pests in vineyards has not yet been thoroughly tested. A rigorous estimate of the number of rodents barn owls remove from the landscape is a necessary first step, and this study aimed to produce an index of rodent removal and prey species composition by using remote nest box cameras. Results indicate that each barn owl chick received 191 ± 10.01 prey items before dispersing from the nest box. Combining this estimate with the average clutch size (3.62 ± 1.40 chicks fledged) and estimates for the number of rodents killed and consumed by adults for self-maintenance (155 per adult), yields a total estimate of 1001 ± 290 rodents killed per occupied and successful barn owl nest box in a nesting season. Future research should work to ascertain how many of these rodents are removed specifically from vineyard habitats, and whether this figure is sufficient to meaningfully reduce rodent populations or contribute, with other methods, to an effective integrated pest management system.

2:15 **Use of Self-Resetting Traps for California Ground Squirrel (*Otospermophilus beecheyi*) Control**

Kenneth Gilliland
Department of Ecology, Evolution, and Marine Biology, University of California, Santa Barbara, Santa Barbara, CA
kenneth.gilliland@lifesci.ucsb.edu

California ground squirrels (*Otospermophilus beecheyi)* have been implicated in causing damage to anthropogenic structures, critical infrastructure, sensitive wildlife species, and agricultural areas in California. Current methods employed to reduce the abundance of California ground squirrels includes trap and kill, shooting, exclusion, fumigation, filling of burrows, natural predation, habitat modification, and use of rodenticides. Recent technological advances in rodent traps provide an opportunity to test CO2-powered, self-resetting traps to reduce California ground squirrel abundance. Goodnature® A24 automatic traps deployed in three 80 × 80-m trapping arrays reduced the relative abundance of California ground squirrels on average by 84.8% over a period of one week. When trapping arrays were compared to control arrays, Goodnature® A24 automatic traps also significantly reduced the relative abundance of California ground squirrels. Inspection of California ground squirrel carcasses indicated that Goodnature® A24 automatic traps successfully controlled all life stages and sexes of California ground squirrels. Although these data are preliminary, Goodnature® A24 automatic traps show promise as an effective and efficient means to reduce California ground squirrel abundance, potentially reducing the need to implement less efficient methods and methods that pose a risk to non-target wildlife in higher trophic levels, including rodenticides. Logistical issues, non-target wildlife effects, human safety concerns, and future directions of this research will also be discussed.

2:40 **Sustained Release Long-Life Lures and Bait Consumption Motivators for Rats**

Michael Jackson[1], Rob Keyzers[1,2], Wayne Linklater[3]
[1]Centre for Biodiversity and Restoration Ecology, Victoria University of Wellington, Wellington, New Zealand
[2]School of Chemical and Physical Sciences, Victoria University of Wellington, Wellington, New Zealand
[3]Department of Environmental Studies, California State University, Sacramento, CA
michael.jackson@vuw.ac.nz

All current vertebrate pest control and detection devices require a lure to be effective. Even advanced multi-kill and multi-species technologies that can work remotely for extended periods without maintenance require lures to be effective. Unfortunately, current vertebrate pest lures are almost exclusively foods like peanut butter that perish. They rapidly go rancid, rendering them unattractive and ineffective in a matter of days. In practice, therefore, either devices are frequently replenished with fresh lures at considerable cost or, most commonly, devices operate sub-optimally for substantial periods of time, especially in less accessible landscapes. The logistic and financial constraints perishable lures impose, therefore, substantially impacts management outcomes and pest control programme success. We have developed, over the past five years, several sustained release, long-life lures for controlling and monitoring rats. The lures contain blends of chemical compounds that we identified as attractive to rats. Our early prototype lures were effective at kill-trapping wild, free-ranging ship and Norway rats without lure replenishment for 6 months. We have since engineered other lures with different life-spans (1, 2, 3 and 6 months) and comprising different compound-combinations to suit different applications (e.g., kill-trapping and monitoring) and users (e.g., pest control and conservation). We are also currently testing our lures as bait consumption motivators. Early trials indicate that the presence of some lures near the bait increases the amount of bait consumed. This has the potential to increase the toxic load ingested by rats, reduce sub-lethal dosing and, therefore, increasing the efficacy of control operations. We are currently working with a range of international partners to transform our prototypes into products for international markets. The techniques we employed for this rapid advance to compound-based vertebrate lures are applicable to other pest-mammal species and we are researching the advance to multi-species, long-life lures.

3:20 **Carbon Monoxide (CO) to Control Gophers and Ground Squirrels: An Alternative to Anticoagulant Rodenticides**

Rebecca Dmytryk
Humane Wildlife Control Association, Moss Landing, CA
help@humanecontrol.com

Using traps to remove gophers and ground squirrels can be extremely time consuming. Anticoagulant rodenticides can pose a risk to children, pets and non-target wildlife. This presentation we will discuss the use of carbon monoxide gas to control burrowing rodents, and how this approach can be more sustainable, cost effective and humane than others.

3:45 **Evaluating Habitat Manipulation as a Strategy for Rodent Control in Agricultural Ecosystems of Pothwar Region, Pakistan**

Nadeem Munawar, Tariq Mahmood
Department of Wildlife Management, PMAS-Arid Agriculture University Rawalpindi, Rawalpindi, Pakistan
nadeemmunawer@gmail.com

Habitat manipulation is an important technique that can be used for controlling rodent damage in agricultural ecosystems. It involves intentionally manipulation of vegetation cover in adjacent habitats around the active burrows of rodents to reduce shelter, food availability and to increase predation pressure. The current study was conducted in the Pothwar Plateau during respective non-crop period of wheat-groundnut (post-harvested and un-ploughed/ non-crop fallow lands) with the aim to assess the impact of reduction in vegetation height of adjacent habitats (field borders) on rodent's richness and abundance. The study area was divided into two sites viz. treated and non-treated. At the treated sites, habitat manipulation was carried out by removing crop cache and non-crop vegetation's over 10 cm in height to a distance of approximately 20 m from the fields. The trapping sessions carried out at both treated and non-treated sites adjacent to wheat-groundnut fields were significantly different (F

2, 6 = 13.2, P = 0.001) from each other which revealed that maximum number of rodents were captured from non-treated sites. There was a significant difference in the overall abundance of rodents ($P < 0.05$) between crop stages and between treatments in both crops. The manipulation effect was significantly observed on damage to crops and yield production resulted in the reduction of damage within the associated croplands ($P < 0.05$). The outcomes of this study indicated a significant reduction of rodent population at treated sites due to changes in vegetation height and cover which affect important components i.e., food, shelter, movements and increased risk sensitivity in their feeding behavior, therefore, they were unable to reach levels where they cause significant crop damage. This method is recommended for being cost-effective and easy application.

Poster Session

Using Camera Traps to Assess the Effects of Predator Urine on Potential Nuisance Wildlife

Cara Yocom-Russell, Robin Verble
Missouri University of Science and Technology, Rolla, MO
yocomrussellc@mst.edu

Several companies market predator urines as a deterrent in human-wildlife conflicts. Using camera traps has proven to be a successful technique to assess the presence of species on the Ozark Biological Research Station. The Ozark Biological Research Station is a 10-acre natural area bordered by a 300-acre conservation area in the Mill Creek watershed, in South-central Missouri. In Fall 2019, eight bait stations were placed across the research station. A bait station consisted of one game camera and two bait piles (protein, carbohydrate). Each bait station was deployed for 21 trap nights. For the first and last 7 nights, baits were untreated. From days 8-14, predator urine was deployed next to baits. Bait piles were weighed and refreshed daily. Camera traps were assessed for battery power and card storage daily. At the end of the trapping session, photos were analyzed and daily species composition was recorded and compared among trap nights. This study will be repeated in the Spring 2020.

Benefits of Sewer Baiting to Decrease Norway Rat Population

Celina Guerra-Martinez, Elio Di Giuseppe, Reuben Lundvall
Alameda County Vector Control Services District, Oakland, CA
celina.guerra-martinez@acgov.org

We will reference the origins of the sewer bating program in Oakland CA with the changes and evolution that have occurred to improve the program. The current use of technology for accurate record keeping allows the management of this program to run more efficiently. The date collected can be shared with other agencies for a more proactive approach for rodent control.

Age Distribution of Urban Coyotes in Southern California: A Comparison of Tooth Wear and Cementum Annuli Methods

Ariana Mc Kenzie, Paul Stapp
Department of Biological Science, California State University, Fullerton, CA
arianammckenzie@csu.fullerton.edu

Although coyotes (*Canis latrans*) are a natural component of Southern California ecosystems, they are sometimes considered a nuisance because of their opportunistic habits and high tolerance for urban and suburban areas brings them into conflict with people. Recent attacks on people and pets have increasingly led to lethal control of nuisance animals, yet it is unclear whether the demographic distribution of these individuals are representative of the coyote population as a whole and is information that could be used to guide coyote management. I used two methods, cementum annuli analysis and tooth wear, to estimate the age from the mandibles of 100 coyotes collected as nuisance animals and as roadkills in southern California. Age estimates based on tooth wear, a non-lethal method, were broadly similar to those from cementum annuli analysis, although tooth wear estimates produced more variation and would tend to overestimate age, especially for younger individuals. The demographic structure of coyotes collected as nuisance animals was biased toward juveniles, young adults, and males, which is a pattern typical of exploited populations elsewhere. Although fewer roadkill individuals were examined, the fact

that younger animals were over-represented in the sample of euthanized individuals suggests that younger age classes (and males) may be more likely to be the target of control efforts, possibly due to how their behavior creates opportunities for greater conflict with people.

Avian Pests of Cereal Crops in Rainforest and Savanna Agro-Ecological Zones, Ondo State, Nigeria.
Oluwadunsin Adekola, Oluyinka Odewumi, Ebenezer Agbelusi
Federal University of Technology, Akure, Nigeria
dunsin4christ@gmail.com

The impacts of wildlife, especially birds, on agriculture cannot be underestimated, resulting into human-wildlife conflicts. This study identified avian pests of rice and maize in two agro-ecological zones of Ondo State, Nigeria. Information gathered from informal interviews and questionnaires administered to FADAMA farmers in local communities, together with direct observations made over exploratory transects, were used to survey avian pests. A total of 27 avian pest species of rice and maize belonging to nine families and three orders were recorded in the two agro-ecological zones in Ondo State. In the Savanna agro-ecological zone, a total of 18 avian pest species belonging to nine families and three orders were recorded whereas in the Rainforest agro-ecological zone, a total of 21 avian pest species belonging to eight families and two orders were recorded. Farmers revealed that bird damage is a serious problem which usually leads to reduction in yield, harvest quality and interest in production. Human bird scarers and scarecrows were reported as the most effective control measures against birds' infestation and damage. There should be synergized efforts towards Integrated Pest Management (IPM) involving farmers, crop scientists and ornithologists to ensure the survival of birds in agrarian areas as well as improve crop yield. This approach will not only help farmers but also conservationists.

What's in the Box? The Essentials for a Successful Barn Owl Nest Box
Rebecca Dmytryk
Humane Wildlife Control Inc., Moss Landing, CA
help@humanecontrol.com

Barn owls are efficient hunters of rats, mice, voles and gophers. They take readily to manmade nest boxes and often remain in an area their entire life, making them an excellent option for natural rodent control. But, there's more to encouraging barn owls to a property than simply installing a nest box. The author has extensive experience in barn owl nest box design, having installed over 100 nest boxes, many of which are monitored closely. This poster will explore various nest box designs and what criteria are essential to the health and well-being of resident owls and successful nest boxes.

The Effects of Feral Cat Feeding on Urban Wildlife and their Human Neighbors in Alameda County
Valerie Winters, David West, Stephanie Kurniawan
Alameda County Vector Control Services District, Oakland, CA
valerie.winters@acgov.org

Trap-Neuter-Release (TNR) as a practice began in the United Kingdom in the 1950's but was no popularized in the United States until the 1990's. TNR are cat colonies are "managed" by one or more individuals who set up feeding stations for the cats. These feeding stations vary significantly and may range from a handful of cat kibble thrown on the ground to elaborate bowls of multiple mixed foods with cat dwellings. Colony size can range from one or two cats to more than twenty cats. Although there have been numerous studies of the impact free-roaming cats have on birds and endangered prey species, the impact of freely available food on urban wildlife, skunks, raccoons and opossums has yet to be seriously discussed. This study was conducted to determine the effects that cat feeding stations may have on nuisance wildlife populations. To quantify food consumption at these colonies, various feeding stations located throughout Alameda County were monitored with wildlife cameras. The number of nuisance wildlife calls received by Alameda County Vector Control Services District was used to determine if the number of feeding stations per city had any influence on the wildlife population. This study found that the current and popular free-roaming cat management strategies fail to address common public health concerns: cat wastes on residential properties, flea infestations, and the elevated risk of scratches and bites to humans, especially children.

Skunk Exclusion at County of Santa Clara Vector Control District: A Demonstration Project

Beverly Perez
Santa Clara County Vector Control District, San Jose, CA
noor.tietze@cep.sccgov.org

Wildlife burrowing under homes and other structures is a major concern to residents in Santa Clara County. Skunks, opossums, and raccoons frequently burrow under structures in search of prey, as a daytime refuge, or for birthing a litter of pups. These burrowing animals can often damage structures, spread ectoparasites, and can behave aggressively towards pets and humans. Skunks are particularly problematic due to the offensive odor they release, that persists and permeates into the home. Property owners and residents need to properly secure homes from invasion of wildlife but may not know how to properly evict and exclude them. Animals burrowing under the Vector Control District headquarters presented a unique opportunity to demonstrate to the public how to deal with this issue, and staff collaborated in each step of the process that was chronicled for producing media and educational tools for the public. Vector control staff conducted eviction, monitoring for activity, material acquisition, site preparation, and installation of barrier screen around the Vector Control facility while capturing images and video for public education purposes. Beyond the initial outreach objectives of creating brochures, web content, and slides for presentations, District staff benefitted as well, gaining valuable hands-on experience in every aspect of exclusion work.

Keeping an Eye on Human Wildlife Conflict and Vertebrate Pests in Southern California: The Wildlife Watch Program

Alexander Heeren, Victoria Monroe, Dave Dodge, Kent Smirl
California Department of Fish and Wildlife, Rancho Codova, CA
alexander.heeren@wildlife.ca.gov

Understanding residents' perceptions and expectations surrounding vertebrate pests is an important element in designing socially acceptable management strategies. Human (*Homo sapiens*) and coyote (*Canis latrans*) conflicts in southern California illustrate the importance of incorporating the social sciences, particularly communication, in a coyote management strategy. The California Department of Fish and Wildlife has developed the Wildlife Watch program as a community-based approach to engage residents in coyote management across eight different cities in Los Angeles and Orange Counties. Wildlife Watch (based on the Neighborhood Watch crime prevention program) uses the principles of Conservation Coaching to empower residents to remove wildlife attractants in their neighborhoods and to haze habituated coyotes. Here, we will outline the main components of the Wildlife Watch program using the cities of Irvine, Culver City, Palos Verdes Estates, and Rancho Palos Verdes as case studies. These case studies suggest that successful programs have three components in common, such as 1) multiple methods (online, phone, etc.) for residents to report coyote encounters, 2) a policy that all incident reports receive an acknowledgement or response from the city, and 3) strong support from the city's police department. We will also present the results from a pilot experiment that tests different Wildlife Watch brochures and handouts to see whether different methods of framing the information influences support for the Wildlife Watch program. A flexible, community-based program, like Wildlife Watch, offers a valuable toolbox to managers for navigating the diverse array of human perceptions and attitudes surrounding human and wildlife conflicts and vertebrate pests.

Novel Methods for Barn Owl Hunting Within the Hawaiian Islands

Elizabeth Baxter, Alex Dutcher, Kyle Pias
Hallux Ecosystem Restoration LLC, Lihue, HI
lizzy.baxter333@gmail.com

In 1958, the barn owl (*Tyto alba*) was introduced to the Hawaiian Islands to control rodent populations in agricultural areas. Barn owl have been documented on multiple islands preying upon native ground-nesting seabirds. Lethal management of introduced barn owl populations is assumed to be essential to the recovery and sustainability of Hawai'i's seabird populations. Control efforts are currently focused along the Na Pali coast on Kaua'i, which is located on the north-western side of the island and encompasses habitat types ranging from rugged, steep montane forests to mesic coastal dunes. Due to the challenging and unique terrain in this coastal area, typical owl removal methods such as spotlighting or trapping proved ineffective along the Na Pali coast,

encouraging a more creative approach. In pursuit of a repeatable and effective removal method for barn owls, a two-person hunting team was developed, one acting as a spotter and the other the shooter. Using a barn owl decoy and a remote-controlled game caller, we are able to focus the attention and approach direction of the barn owl, bringing it within shooting range. The shooter wears a helmet-mounted night vision monocular unit with an infrared (IR) illuminator, and the shotgun is outfitted with an IR laser for aiming. So far, this novel method has yielded a high success rate in removal of detected barn owls per unit effort and remains an easily repeatable process.

Consumption of Rat Carcasses as a Pathway of Rodenticide Exposure of Wildlife in Southern California

Brandon Lotts, Paul Stapp
Department of Biological Science, California State University, Fullerton, CA
pstapp@fullerton.edu

The high toxicity and effectiveness of anticoagulant rodenticides has led to their widespread use for controlling rodent pests; however, significant concerns remain about the potential exposure of non-target wildlife species. Non-target species can be exposed by consuming the toxic baits directly, or indirectly, by scavenging rodenticide-killed prey (secondary exposure). To investigate opportunities for secondary exposure, we used Reconyx digital game cameras to quantify the fates of 20 rat carcasses placed in residential backyards of Master Gardeners in Orange County, California. Rats were anchored to the ground and their fates were followed for 7 days or until the carcasses were removed. We also recorded yard characteristics, e.g., yard area, vegetation cover, type of exterior barriers, to help explain the variation in carcass removal rates between yards. Rats were discovered fairly quickly, with 35% of carcasses visited within 24 hours. Thirteen carcasses (65%) were removed within 7 days, with opossums (*Didelphis virginiana*) and corvids removing the most carcasses (9/13). Coyotes (*Canis latrans*), free-roaming cats (*Felis catus*), and skunks (*Mephitis mephitis*) also consumed rats, which, by the end of the trials, had attracted scavenging arthropods that were also eaten. Yards from which carcasses were routinely removed had relatively low vegetation density, the presence of pets, water sources, and anthropogenic foods, and barrier types that permitted movement by wildlife into the yard. Our results improve our understanding of the routes by which native carnivores and scavengers are exposed to rodenticides in suburban settings and can be used to improve pest management practices.

Exclusive Residential Exclusion

Gary Kunselman, David West
Alameda County Vector Control Services District, Oakland, CA
gary.kunselman@acgov.org

Exclusion is the single best Integrated Pest Management tool to minimize or eliminate unwanted animals at your residence. Raccoons, skunks, opossum, rats, mice etc., can be a nightmare. Our poster will primarily deal with the yard surrounding your home. Modification of your property is essential so as not to invite unwanted guests that may decide to reside on your property. Items such as trees, shrubs, wood and compost piles just to name a few. Our objective in this poster will be to focus on several basic systems which require foresight and innovation to achieve your desired results.

Common roof rat (*Rattus rattus*) Plant Associations Observed in Alameda County California

Flora Kwan, Wade Lee, Bruce Kirkpatrick
Alameda County Vector Control Services District, Oakland, CA
flora.kwan@acgov.org

Alameda County is the 7th most populous county in California and historically has experienced established populations of both roof rats and Norway rats (*Rattus norvegicus*). Roof rats, an introduced species, are well adapted to the Alameda County landscape due to the availability of food, water, and shelter. From 2014 - 2018, roof rat requests for service received by the Alameda County Vector Control Services District have significantly increased. Roof rats utilize various habitats including rocks, wood piles, trees, residential buildings, and dense vegetation. They pose a public health risk by harboring disease in their waste, contaminating food, biting people,

or introduce disease indirectly by the ectoparasites they carry. This poster examines the plant species that provide harborage, food sources, and potential roof access that allow roof rats to thrive in Alameda County.

A Holistic Approach to Nuisance Wildlife.

Rebecca Dmytryk
Humane Wildlife Control Inc., Moss Landing, CA.
help@humanecontrol.com

A holistic approach considers the many factors contributing to a wildlife conflict, which results in solutions that are effective and lasting. This presentation will introduce the concept of a holistic approach and how it can be applied in the pest control industry, highlighting the most common non-lethal methods of resolving wildlife problems without the use of poison or traps, as well as a comparison of the holistic approach with a more conventional approach as for the investment of time and cost, as well as efficacy.