CENTER for PRODUCE SAFETY

CPS 2017 RFP
FINAL PROJECT REPORT

Project Title
Use of raptors to prevent wild bird and rodent intrusion into fresh produce fields

Project Period
January 1, 2018 – December 31, 2019

Principal Investigator
Paula Rivadeneira
University of Arizona
Yuma Agricultural Center
6425 W. 8th St
Yuma, AZ 85364
T: 928-919-2611
E: thinklikeatortoise@yahoo.com
(New contact information: Humane Society of Central Texas, 2032 Circle Rd, Waco TX 76706, cell 254-447-0368)

Objectives

1. *Determine if the use of falconry at critical times in the growing season (post-sprouting and pre-harvest) decreases fresh produce crop loss due to food safety hazards from wild bird intrusion.*
2. *Establish wild native owl and kestrel programs that promote site fidelity (including rehabilitated released native owls and kestrels) to decrease rodent populations near fresh produce fields, thereby reducing food safety risks related to rodent intrusion.*
3. *Determine if the use of falconry is a cost-effective approach to bird and rodent deterrence compared with traditional methods.*

Funding for this project provided by the Center for Produce Safety through:
CPS Campaign for Research
FINAL REPORT

Abstract
Wild animals carry foodborne pathogens that may be a threat to fresh produce crops. Rodents are documented carriers of *E. coli*, *Salmonella*, and *Campylobacter*, and can amplify the prevalence of these in the environment. Birds are another important risk to food safety since they can travel long distances carrying foodborne pathogens, including *Salmonella* and *E. coli*, from sources to destinations that may include agricultural areas. Current wildlife control measures include sound and visual scare tactics, perception altering chemicals, and even unmanned aerial vehicles. None are 100 percent effective at preventing animal intrusion so growers sometimes turn to lethal methods. These techniques are in direct contrast to the public's call for wildlife stewardship and the Food Safety Modernization Act's support of co-management techniques.

The use of falconry can be a cost effective, highly successful way to deter birds and control rodents in agricultural settings. In fact, it is already in use for some produce commodities, such as wine grapes. The use of trained birds and native wild owls can provide protection from nuisance animals over significantly larger areas than traditional methods. They do not require the setup required for traditional bird deterrents, or the upkeep of rodent traps. The use of falconry can eliminate the need for rodent control using poison, and can diminish or eliminate the need for lethal traps. In addition, falconry and the use of nest boxes to manage and deter wildlife are viewed by the public more positively than traditional methods.

This project aims to 1) Determine if the use of falconry at critical times in the growing season (post-sprouting and pre-harvest) decreases fresh produce crop loss due to contamination of crops from wild bird intrusion; 2) Establish wild native owl and kestrel programs that promote site fidelity to decrease rodent populations near fresh produce fields; and 3) Determine if the use of falconry on a large scale can be a cost-effective approach to bird and rodent deterrence compared with traditional methods.

The use of falconry to protect the crops in our multi-billion dollar fresh produce industry could have important impacts on our growers, consumers, and the environment. Fresh produce growers are not only charged with providing safe clean food to our communities all over the country, but they are stewards of their land and the fragile desert environment where they grow our food. They sometimes must take drastic measures to keep crops safe from wildlife, using poisons and other lethal measures as a last resort. The use of falconry will eliminate the need for these, and instead will use the natural instincts of animals to prevent bird and rodent intrusion into fresh produce fields. This will result in fewer negative impacts to the environment, fewer person hours deterring animals through trap placement and cleanup, fewer animal intrusions, and therefore, less risk of foodborne pathogen contamination to crops.

Background

Wild animals carry foodborne pathogens that may be a threat to fresh produce crops through contamination of fields with feces, and by direct destruction of crops [1, 2]. Rodents are documented carriers of E. coli, Salmonella, and Campylobacter, and can amplify the prevalence of these in the environment [3, 4]. Fresh produce growers have a zero tolerance for rodents near their fields because of the possibility that their feces may harbor these foodborne pathogens, and because small rodents could be accidentally harvested with the crops. To enforce this policy, growers use rodent poisons during the off seasons, and lethal

traps while crops are growing (personal communication, Fatima Corona, JV Farms). These measures are far from ideal because the use of poisons could have repercussions for 2 animals that consume the rodents, and placement and collection of traps require extensive person hours.

Birds are another important risk to food safety since they can travel long distances carrying foodborne pathogens, including Salmonella and E. coli, from sources to destinations that may include agricultural areas [4-8]. Current bird control measures include sound cannons and sonic broadcasts [14, 15], visual scare tactics [16, 17], perception altering chemicals [18], lasers [19], and unmanned aerial vehicles [20]. None are 100 percent effective at preventing bird intrusion so growers sometimes turn to lethal methods. These techniques are in direct contrast to the public's call for wildlife stewardship [9] and the Food Safety Modernization Act's support of co-management techniques. The use of falconry can be a cost effective, highly successful way to deter birds and control rodents in agricultural settings. In fact, it is already in use for some produce commodities, such as wine grapes [10-12]. Modern day falconry is a much more scientific, complex, and targeted technique than it ever has been before. The use of captive bred trained birds and wild native owls and kestrels, along with new technological advances that support the process, can provide protection from nuisance animals over significantly larger areas than traditional methods, and with lasting effects. Falconry does not require the labor-intensive, costly setup required for traditional bird deterrents, or the upkeep of rodent traps.

The use of falconry can eliminate the need for rodent control using poison, and can diminish or eliminate the need for lethal traps. In addition, falconry and the use of nest boxes to manage and deter wildlife are viewed by the public more positively than traditional methods [13]. This project is important and timely because fresh produce growers are frustrated with their constant battle against birds and rodents. The costs they incur to deter them because of their potential to contaminate crops with foodborne pathogens is high, and still, every season fresh produce farmers lose acres of crops and tens, in some cases hundreds of thousands of dollars. They have tried countless measures to deter these animals from their fields and have resorted to time-consuming, labor-intensive, costly, and lethal means to protect the public from food safety hazards that they may cause. Growers are looking for a reliable, cost effective, environmentally friendly way to minimize birds and rodents in their fields. With the new food safety regulations imposed on fresh produce growers by the Food Safety Modernization Act (FSMA), now is a critical time to research and implement new methodologies like falconry that are already proven to be effective in protecting other agricultural commodities.

Research Methods and Results

This project took place over 3 seasons, and included 8 experimental fields and 5 control fields (Table 1).

Falconers provided their services at experimental fields from sunrise to sunset every day during the produce growing season, except for season 1 when they checked on the fields just a few times each day. The proposal indicated that falconers would provide their services only 2 weeks post-sprouting and 2 weeks pre-harvest, but we changed that to cover the entire growing season due to season-long bird pressure. Control fields continued to use traditional bird deterrents, while experimental fields used only techniques implemented by the falconers.

Falconers flew trained hawks and falcons in response to the presence of nuisance birds *or to prevent their arrival.* During season 1, falconers documented the species of trained birds that they used, the number and species of nuisance birds that were present using standardized bird counts, and if flights were successful at deterring nuisance birds, with success indicated

by the absence of nuisance birds in the protected field. Falconers counted birds using a protocol of a 5 minute bird count every hour throughout the day. In season 2, falconers continued to document the flights of trained birds but bird counters documented the number of nuisance birds at experimental and control fields using a protocol of a 5 minute bird count followed by a 10 minute break for 2 hours every morning and every evening. We made this change because most birds were present in the morning and evening so we only did bird counts during peak times of day instead of all day. This also took the onus of bird counting off of the falconers so they could concentrate on protecting the fields. In season 2, falconers began using drones, bangers, and screamers, along with trained birds to deter nuisance birds, and they occasionally used dogs in neighboring fields to scare up birds taking cover there.

At the end of each season, growers documented the amount of crop loss they experienced in experimental and control fields specifically due to bird intrusion.

Outcomes and Accomplishments

Season 1 - Spring 2018
Falconers: Tiffany, Ricky, Karl
Farms: JV

Season 1 was a test case with 2 experimental fields and no control fields. We did this to determine the best way to manage the logistics of future seasons. The falconers were deployed in the fields from the time the sprinkler pipes were pulled through the end of harvest. Karl is considered an expert falconer, and he had experience in agricultural abatement so he worked on the project for 2 weeks to help train Sonoran Desert Falconry team members, Ricky and Tiffany. The PI's intention was for the falconers to be in the fields all day since we know that falconers working at other farms do spend the entire day in the field, but Karl was only in the field sporadically throughout the day, and he trained Ricky to do the same. UA staff who went to check on the falconers reported that Ricky spent most of his time in the SCATT Lab, an RV that we had stationed in the field where the falconers could live during the project. During harvest, Tiffany spent the entire day in the field protecting crops. She noted that harvest is the most challenging time because the birds appear to be on a feeding frenzy where the crops are recently harvested. The second most challenging time is during the 2 weeks post-germination.

Falconers noted that thousands of banded doves were living at the granary located across the street from the fields that needed protection. Ricky reported seeing horned larks right before harvest, which is also when he abandoned the field and left the project. However, throughout the project, the main problem species were killdeer and barn swallows.

In this first season, bird counters were out all day, from sun up to sun down, to determine the peaks of bird activity. We found that birds were present early in the morning and late in the afternoon so in future seasons, we limited bird count activity to those times of day.

Also during the first season, it was clear that the falconers had no idea what they were doing – they had no bangers or screamer, they had no drone or other types of deterrents, and the trained birds were not doing what the falconers wanted. It was the first time they were doing agricultural abatement so they were working by trial and error. Tiffany just wanted her Harris

hawk, Dracarys (a broad wing bird) to sit on the car so the nuisance birds would not come into the field. Her peregrine falcon, Zeke (a long wing bird), went into the air only once to deter horned larks. There was so much unpredictability because Zeke and Tiffany were both inexperienced with agricultural abatement. Zeke also had some issues with his wings at the time, he needed a lot more practice, and he ended up getting bumble foot because he was being perched on inadequate perching materials. Ricky flew a peregrine falcon named Heinz and a Harris hawk named Holly (HH). Heinz only flew a few times because he died before coming back to Yuma on one of his trips up to Phoenix, the headquarters of Sonoran Desert Falconry.

Due to the unpredictability of the birds and their sensitivity to heat, as well as the varying skill levels of the falconers, they decided to bring in drones during the second season because they needed to make sure they had something that would do exactly what they wanted. They also had ongoing personnel issues, with newer and beginning falconers in training not always being where they claimed to be. There seems to be a pervasive issue with falconers not always doing the job they are hired to do since falconry is more of a well paying hobby than a career for most falconers.

Season 2 - Fall 2018

Falconers: Tiffany, Brad, Jeff, Chet for one day, Nick for one day, Amy for one day, Ricky came back but didn't do any work and left again
Bird counters: Angela (student intern) and UA staff and students
Farms: Amigo, GC, JV

During season 2, the falconers decided to use drones, bangers, screamers, and aplomado falcons instead of Harris hawks. They worked from sun up to sun down every day at 3 different experimental fields. Based on bird pressure, Tiffany sometimes pulled falconers so that all 3 were at one field (we will call it Field 20) because the other fields were safe. The falconers had to drive back and forth to continue to check the other fields though so they spent a significant amount of their budget on gas. Field 20 had 8 blocks, and it was near a pond and an alfalfa field, which made it a prime location for bird activity. The field was bombarded with pipits (which farmers were mistakenly calling horned larks), red winged blackbirds, grackle, and meadowlarks. This field was also subject to intrusion by other wildlife, such as deer, coyotes, and javelina, all of which breached the electric fences and were un-phased by the sound cannons and live shooters.

Falconers found that direct pursuit of nuisance birds with a drone was most effective in keeping those birds away from the field, when generally patrolling the area with Harris hawks, aplomado falcons or other birds of prey was helpful. The most important thing you can do to keep birds out of the field is to have watchers stationed everywhere with good communication. Everyone should have a walkie talkie and they should all communicate with one drone pilot. Having falconers in the area is a good start to an abatement program and they are great for backup, but utilizing a drone allows you to manipulate the flock. The great thing about Sonoran Desert Falconry is that Tiffany was willing to take a risk and bring in technology to find out what works by combining old school falconry with expert use of drones.

It is important to note that there are levels of falconers and levels of drone pilots. Jeff flew drones as an expert pilot with an in-depth knowledge of falconry and bird behavior. Having him work alongside Angela, who was adept at identifying bird species, made them a unique and highly successful team. They also used expert equipment, including their binoculars and drone goggles. The bottom line is that if you have all the right equipment, expert people, trained birds, all-terrain vehicles, and effective technological communication, it works!

Drones and birds are both effective at agricultural abatement but in different ways and under different circumstances. It is a lot of work to use falconry effectively, and we learned that you can do it with half the effort if you also use drones. Live predatory birds are hard to take care of, you have to keep them at the right weight to do their job, your truck smells all the time, working them is dependent on temperature and humidity, and you have to keep a constant supply of raw meat to feed them, which goes against food safety guidelines if you are going to feed them near fresh produce fields. Conversely, drones don't fly away, you don't have to feed them, you don't need to keep the air conditioner on in the truck for them, and they don't get tired. You just need an expert pilot, a specialized drone repair person, batteries, chargers, and an excellent team.

Another way using drones is helpful is in collecting data. In most cases, you can't see birds that land in the field, especially if they are hunkering down under vegetation. In such a case, visual counting is useless, even with binoculars. But if you have a drone, you can send it in to scare up the birds and make a relatively accurate estimate using drone goggles.

We found that birds are habitual. They would go to same places every day, so we had to be aggressive in getting them out of the area. Patrolling using car hawking with a trained bird following or hanging out on the car is fine, but a drone pilot with the right equipment is much more effective. Using top of the line amateur equipment, or the lowest level of professional equipment, you can survey 2 miles of fields. While working on the project, Jeff would meet a lot of growers in the areas he patrolled, including growers for fields he was not officially covering. As a favor to them, he would send videos of birds in their areas so they could better manage them. He felt strongly that he was there to help all farmers, not just those he was being paid to help.

During season 2, the falconers learned that they had to walk the fields instead of working from car and they learned is the importance of bird identification because different birds respond differently to different tactics. They learned to listen for nuisance birds because some make noise and give away their position even if you don't see them. Some of them fly solo (such as killdeer) so tracking a single bird won't matter, but for other species, if you see two of them, then you know there are a lot more nearby so you follow them to the others. They learned that red winged blackbirds are super noisy until they know you are a threat; then they are silent so silence doesn't mean that there are no birds around.

The falconers gained a whole new understanding of how to fly a drone to deter nuisance birds. Anyone can get rid of killdeer with any type of drone – they are easy. But clearing a field of northern pipet takes the right abatement personnel with the right equipment. The person, the trained bird, the drone, and the timing, are critical. You have to fly low and slow like a harrier hawk at 5 ft above the field to get rid of meadowlark, but if you move the drone

any faster, they won't leave.

The direction in which they pushed nuisance birds with falconry and drones became more purposeful in season 2, and they learned that ingress and egress of birds was important. They needed to be tactical about where they sent them, which is why shooters who are not purposeful in their actions don't work. The only way to effectively deter birds with handheld devices is using a double shot launcher by putting a banger on top of screamer. Despite farmers' belief that birds are afraid of sound which explains their constant use of sound cannons, birds are more afraid of visual deterrents than audio sound, so things that approach them are much more effective. Using a banger will get the birds off the ground, but following up with a screamer coming in their direction sends the sound closer to them and is a much more effective deterrent. For the cost of a banger and a screamer ($2) and just a little bit of time, you can do what 2 people with bangers can do over 2 hours at a cost of $100. The falconers advise that farmers should get rid of all of the bangers and shooters that are randomly using those tactics in their fields, and instead hire a Dream Team for Bird Deterrence: Reliable trained shooters/spotters with a supply of bird banger/screamer combos and bird kites on ATVs who can radio an expert drone pilot, one full time expert drone pilot per 1.5 mile area, and one on-call Master Falconer. They recommend tracking a single bird no matter what they do because when they get tired, they will bring you to their friends. One more technique that the falconers used successfully was running trained dogs sorghum, alfalfa, barley, and sudan fields that border fresh produce fields because birds often hunker down for protection in those fields before and after visiting the neighboring fresh produce fields.

Season 3 - Spring 2019

Falconers: Tiffany, Jeff, Brad for a few weeks
Bird counters: UA staff and students
Farms: Smith, Barkley, Griffin

Two of the trained aplomado falcons died in the second season, so the falconers went into the third season with Jeff's new drone (Mavic 2) plus 2 other drones and only 1 aplomado falcon.

When preparing the proposal for this project, farmers told us that they only care about protecting their fresh produce fields for 2 weeks post germination and 2 weeks pre-harvest. During the first season, we learned that falconers need to be present throughout the growing season to protect the fields. They worked 7 days per week for the entire project so they were getting burnt out by the third season since they had so few personnel. We learned that birds won't come back if someone stays there to keep them out using the techniques we learned in season 2. The problem is that farmers want birds out of their own fields but they land in neighboring fields so we learned that we need to cover neighboring fields as well.

In the third season, the falconers started pairing their trained birds with the drones so the birds would follow the drone. We wanted to see if the two techniques working together would be even more effective than working each individually. Falconers reported that when you have the drone flying properly and a good falconer with excellent communication between them, they can be 100% effective.

One of the farmers called us to request falconers after there was already bird damage at the time of planting. The nuisance birds ate the planted seed right out of the ground, which resulted in bald patches throughout the field. The falconers worked the field every day for a month, and eventually got the horned larks under control that were taking cover in the neighboring wheat field. But the birds were relentless so the falconers had to spend every waking moment at the field to protect it. Since we falsely believed that grant funds were running low, they had to abandon the field, and tell the grower to bring their shooters back for the middle of the season. They were supposed to go back out two weeks pre-harvest, but they started harvesting another section of the field and due to a miscommunication and the presence of shooter, Tiffany left the field.

Data

Bird counters collected 1,898 observations, and recorded 33 different bird species (Table 2). Trained hawks and falcons were deployed 385 times, compared with the use of screamers and bangers (652 times) and deployment of drones (628 times).

During season 1, falconers reported that their use of trained birds was successful about half the time (47.3%), but that was due to falconers' inability to determine if nuisance birds were in fact really gone from the field. In 50% of cases, they reported being unsure if the deterrent was successful. Despite this marginal success rate, growers reported no crop loss due to birds during that season. During season 2, the success rate increased to 99.4%, and one grower reported that the use of falconry saved them an estimated $400,000 due to the intense bird pressure that season. In the third season, there was a 91.0% success rate, likely due to the large area that had to be covered with only two falconers remaining on the project.

Summary of Findings and Recommendations

Does falconry work? It depends! If it is used as one tool in our giant toolbox of techniques, and you have a well trained group of people implementing those techniques, then yes, falconry can be very successful. If you run the project data by season, I believe that's exactly what you will see noting that we started using falconry in combination with other methods in the second season. However, I believe that the likelihood that any grower or group of neighboring growers will have a team consisting of an expert drone pilot with knowledge of bird behavior, a Master Falconer who knows how to fly the appropriate birds, and support staff that are fully trained and outfitted with screamers, bangers, ATVs, and high level communication is extremely unlikely.

Another aspect of implementing falconry that is challenging to most growers is the cost. Experienced falconers can charge $1000 per day of work. If you need falconers in your field for 14 days at the start and end of the season plus a few days in the middle, and you need more than one falconer because you have a lot of land, then your bill could easily climb to $100,000 for one season. If you will save $500,000 worth of crops, then it might be worth it, but to be completely effective, you will need the entire team with all of the technology and equipment described earlier. Most fresh produce growers would have a hard time justifying that cost.

APPENDICES

Publications and Presentations *(required)*

1. Rivadeneira, Paula. 2018. “Falconry as a Natural Alternative to Deter Nuisance Birds.” *CAPCA Applicator Alerts Newsletter*. https://issuu.com/capcaadviser/docs/201808-capca_applalerts_aug2018_web/8
2. The New Food Economy, “Could Falcons Prevent the Next *Salmonella* Outbreak?” by Naomi Tomky, 2018, https://newfoodeconomy.org/falcons-protect-lettuce-farms-bird-feces-bacteria/
3. KYMA, KSWT, KECY local Yuma, “New Project Tests Falcons in Yuma Ag Fields” by Caitlin Slater, 2018, https://www.kyma.com/news/new-project-tests-falcons-in-yuma-ag-fields/718408791
4. Rivadeneira, Paula. “Update on Falconry Project.” *Center for Produce Safety Symposium*. June 2018.
5. Rivadeneira, Paula. “Decreasing Food Safety Risks in Fresh Produce Fields with Falconry.” *Arizona-Nevada Academy of Science Annual Conference*. April 2018.
6. Rivadeneira, Paula. “Uso de Halcones Como Alternativa de Control de Aves Que Afectan En La Inocuidad de Hortalizas.” *XXI Del Congreso Internacional En Ciencias Agrícolas*. October 2018.
7. Rivadeneira, Paula. “Managing Wild Birds in Fresh Produce Fields in Relation to FSMA.” *California Pest Control Advisors Continuing Education Course*. October 2018.
8. Rivadeneira Paula. 2019. Protecting Wildlife and Agriculture through Co-Management. *The Arizona Wildlifer: The Voice of the Arizona Chapter of The Wildlife Society*. 2:4-7.
9. Rivadeneira, Paula. 2019. *Field Demonstration: The Use of Falconry to Deter Nuisance Birds from Produce Fields*. *Southwest Ag Summit*. Yuma, Arizona: Yuma Fresh Vegetable Association.
10. Rivadeneira, Paula, Armando Baranda, Yulissa Cabrera, Genesis Franklin, Hannah Hasty, Bryant Mendez, Chris Meza, Ana Sanchez, Daniel Sierra, and Rebecca Urzua. 2019. *Community Forum on Food Safety and Wildlife Research in Yuma, Arizona*. *Arizona-Nevada Academy of Science Annual Conference*. Yuma, Arizona: University of Arizona’s Haury Program.
11. Rivadeneira, Paula. “Managing Wildlife in Fresh Produce Fields: A Natural Approach.” *Colorado Fruit & Vegetable Growers Association Annual Conference*. February 2019.
12. Rivadeneira, Paula. “Use of Falconry to Deter Nuisance Birds in Agricultural Fields.” *Center for Produce Safety Annual Symposium*. June 2019.

Budget Summary *(required)*
I do not have access to this information.

Tables and Figures *(optional)*

Table 1. Field sites

Season	# experimental fields	# control fields	Distance between fields
Spring 2018	2	0	3.2 km
Fall 2018	3	3	16.1 km
Spring 2019	3	2	37.5 km

Table 2. Bird species observed by bird counters

American kestrel	House sparrow
American pipit	House wren
Barn swallow	Killdeer
Black-throated swallow	Kingfisher
Brewer's blackbird	Meadowlark
Canada goose	Mockingbird
Cooper's hawk	Mourning dove
Cormorant	Osprey
Duck	Prairie falcon
Eurasian collared dove	Raven
Flycatcher	Red-tailed hawk
Grackle	Red-winged blackbird
Great blue heron	Savannah sparrow
Great egret	Starling
Gull	Turkey vulture
Harrier hawk	Yellow-throated warbler
Horned lark	

Table 3. Percent success in deployment of trained birds (success=no nuisance birds present)

Was falconry successful?	Spring 2018	Fall 2018	Winter 2018/ Spring 2019
Yes	47.33	99.43	90.97
Not sure	50.67	0.57	7.21
No	2.00	0.00	1.82

Suggestions to CPS *(optional)*
None.

Literature Cited

1. Canavelli, S.B., et al., Multi-level analysis of bird abundance and damage to crop fields. Agriculture, Ecosystems & Environment, 2014. 197: p. 128-136.
2. Persad, A.K. and J.T. LeJeune, Animal Reservoirs of Shiga Toxin-Producing Escherichia coli. Microbiology Spectrum, 2014. 2(4).
3. Meerburg, B.G. and A. Kijlstra, Role of rodents in transmission of Salmonella and Campylobacter.
Journal of the Science of Food and Agriculture, 2007. 87(15): p. 2774-2781.
4. Nielsen, E., et al., Verocytotoxin-Producing Escherichia coli in Wild Birds and Rodents in Close Proximity to Farms. Applied and Environmental Microbiology, 2004. 70(11): p. 6944-6947.
5. Pedersen, K., et al., Prevalence of shiga toxin-producing Escherichia coli and Salmonella enterica in rock pigeons captured in Fort Collins, Colorado. Journal of Wildlife Diseases, 2006. 42(1): p. 46-55.
6. Pedersen, K. and L. Clark, A review of Shiga toxin Escherichia coli and Salmonella enterica in cattle and free-ranging birds: potential association and epidemiological links. USDA National Wildlife Research Center - Staff Publications, 2007.
7. Gaukler, S.M., et al., Escherichia coli, Salmonella, and Mycobacterium avium subsp. paratuberculosis in Wild European Starlings at a Kansas Cattle Feedlot. Avian Diseases, 2009. 58(2): p. 544-551.
8. Carlson, J.C., et al., The role of starlings in the spread of Salmonella within concentrated animal feeding operations. Journal of Applied Ecology, 2011. 48(2): p. 479-486.
9. Linz, G.M., et al., Limitations of population suppression for protecting crops from bird depredation: A review. Crop Protection, 2015. 76.
10. Erickson, W.A., R.E. Marsh, and T.P. Salmon, A review of falconry as a bird-hazing technique. Proceedings of the 14th Vertebrate Pest Conference, 1990.
11. Leggett, M., Managing populations of the Australasian harrier (Circus approximans) to reduce passerine bird damage in vineyards. 2012, Lincoln University. 13
12. Kross, S.M., J.M. Tylianakis, and X.J. Nelson, Effects of Introducing Threatened Falcons into Vineyards on Abundance of Passeriformes and Bird Damage to Grapes. Conservation Biology, 2012. 26(1): p. 142-149.
13. Herrnstadt, Z., et al., Consumer preferences for 'natural' agricultural practices: Assessing methods to manage bird pests. Renewable Agriculture and Food Systems, 2015.
14. Berge, A.J., et al., Sonic Broadcast Unit for Bird Control in Vineyards. Applied Engineering in Agriculture, 2007. 23(6): p. 819-825.
15. Swaddle, J.P., et al., A sonic net excludes birds from an airfield: implications for reducing bird strike and crop losses. Ecological Applications, 2016. 26(2): p. 339-345.
16. Fukuda, Y., C.M. Frampton, and G.J. Hickling, Evaluation of two visual birdscarers, the Peaceful Pyramid® and an eye-spot balloon, in two vineyards. New Zealand Journal of Zoology, 2008. 35(3): p. 217-224.
17. Santilli, F., et al., Evaluation of an aerial scaring device for birds damage prevention to agricultural crops. Rivista Italiana di Ornitologia, 2012. 82(1/2).
18. York, D.L., et al., Evaluation of Flight Control™ and Mesurol® as repellents to reduce horned lark (Eremophila alpestris) damage to lettuce seedlings. Crop Protection, 2000. 19(3): p. 201-203.
19. Gorenzel, W.P., et al., Evaluation of lasers to disperse American crows, Corvus brachyrhynchos, from urban night roosts. International Journal of Pest Management, 2002. 48(4): p. 327-331.
20. Grimm, B.A., et al., Autonomous unmanned aerial vehicle system for controlling pest bird population in vineyards. ASME 2012 International Mechanical Engineering Congress and Exposition, 2012.