Updated Ethography for European Starlings (*Sturnus vulgaris*) in Central Coast Vineyards

A Senior Project

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by

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# Contents



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## Introduction

The Central Coast of California is well known for its diverse microclimates that are optimal for growing wine grapes and other berries. There are coastal regions such as the Santa Rita Hills, Santa Maria Valley, and Edna Valley American Viticultural Areas (AVAs) that are known for their production of high quality Pinot Noir, Chardonnay, and cool climate Syrah. In places such as the Paso Robles and Santa Ynez Valley AVAs the temperatures get much warmer so Rhone, Bordeaux, Italian and Spanish varieties can all be produced in these areas. This region has garnered the attention of wine enthusiasts worldwide for producing high-quality wines. To make high-quality wine the winemaker must first attain high-quality fruit and, unfortunately, the avifauna too has taken notice of this regions' potential. These optimal, diverse growing conditions located very close to one another create a sort of "wine grape buffet" for one of the area's primary avian pests, the European Starling (*Sturnus vulgaris*).

There are many bird abatement products available to growers. Some of them are more effective than others. Most of the products and methods available are still very labor intensive. In commercial agriculture the goal is to always minimize economic inputs while still achieving acceptable quality. The Bird Gard® is a device that offers electronic bird control. This device, if effective, could provide a relatively inexpensive and less labor-intensive approach to controlling the starling problem in the area. This study was designed to test the effectiveness of the Bird Gard® scaring device for reducing the presence of starlings and the crop damage they cause.

## Literature Review

The European Starling (*Sturnus vulgaris*) is a medium-sized song-bird with a length of about 20 cm, belonging to the family Sturnidae, sub-order Oscines, order Passeriformes (Bateson and Asher, 2010). Starlings are native to most of the temperate areas of Europe and western Asia. Northeastern populations migrate in autumn, with some birds over-wintering in Iberia and Africa (Bateson and Asher, 2010). Starlings were introduced to Australia (late 1800s), New Zealand (1862), North America (1891) and South Africa (1890); the species is currently estimated to inhabit 30% of the earth's land area, excluding Antarctica (Bateson and Asher, 2010). At a distance, starlings look black. In summer they are iridescent purplish-green with yellow beaks; in fresh winter plumage they are brown, covered in brilliant white spots. Habitat use in North America parallels that seen in Europe, with highest densities seen in agricultural and settled (disturbed) areas (Cabe, 1993). Starlings are not always migratory. Some will migrate up to several hundred miles. Others may remain in the same general area throughout the year. Outside the breeding season, starlings feed and roost in flocks. Each day, they may fly 15 to 30 or more miles from roosting to feeding sites. During winter, they roost in dense vegetation, such as coniferous trees, or in urban structures, farm buildings, and other areas protected from wind and weather. Some of these roosting areas are occupied by wintering starlings year after year (Johnson and Glahn, 1998).

The European Starling arrived in the United States in 1890(Lawrence, 1984). It was brought here by a drug manufacturer named Eugene Scheifflin. Scheifflin's goal was to bring all the birds mentioned in Shakespeare's works to the United States. Scheifflin and The American Acclimatization Society released the first 60 birds in 1890 into Central Park. In 1891 Scheifflin released 40 more birds. By 1942 the starling population had spread as far as California and can now even be found in Alaska (Lawrence, 1984).

Starlings have done well in the United States for a few reasons. First, they were introduced to an area that had been altered in much the same way that their native European environment had been altered. Second, starlings thrive where natural ecosystems have been disrupted such as is the case when cities are built. Starlings can nest in just about any cavity. They compete well for both nesting sites and food against native bird species and can produce two broods of young each year. They learn quickly and change their behavior readily to adapt to new circumstances. Finally, the individual starling benefits from being part of a flock as they share in the roles of food finding and protection (Lawrence, 1984). Cabe (1993) suggests that due to their close association with man and behavioral plasticity, starlings can inhabit a wide variety of areas if a few crucial needs are met. They forage in open country on short, mown, or grazed fields, which are abundant in urban areas and most types of agriculture. These areas also provide accessory food resources, nesting cavities, and water. In recent decades urban areas have begun to encroach on agricultural land creating an even more suitable environment for the success of the starling because it has more nesting sites available and several sources of food.

Conservative estimates based on the assumption that starlings cause $5 in crop losses per hectare of US cropland, the total loss due to starlings would be approximately $800 million per year (Pimentel, Lach, Zuniga, and Morrison, 2000). Starlings can cause damage to agricultural crops including cherries, blueberries, grapes and apples. They can pull sprouting wheat and other grains and eat the planted seed. Starlings can also affect other areas of agriculture.

Johnson & Glahn (1994) suggest that in livestock facilities, starlings both consume the feed and contaminate the feed and water with their feces. Sometimes when cattle feed is supplemented with a high protein additive the starlings can selectively feed on the more costly high-protein portion of the feed. A 1967 report indicated that 1 million starlings at a California feedlot resulted in losses of $1,000 per day because of food consumption and contamination, and starling interference with cattle feeding activity. . When feed and water is contaminated by the starlings the livestock eat it anyway and can contract diseases that the birds carry. These diseases can include various viral, bacterial, fungal, protozoal and rickettsial /chlamydial diseases that can be transmitted to humans and domestic animals (Lee, Stanczyk, and Berkowitz, n.d.). When livestock become infected with diseases they may have contaminated milk, they become less productive, meat can be rejected at market and they can contaminate other livestock. Often the disease results in death or destruction of the animal. This results in a large loss to the rancher. When the disease is treatable it is usually treated with vaccinations, medications, supplements, veterinary care or treatment for dehydration. Though the animal is not lost in these cases, the treatment is costly and those animals become less profitable because of the extra economic input to treat the animal.

In a recent article *in Crop Protection Journal*, it was found that in the state of California average losses to bird damage in wine grapes are $49,099,613. This is a $247 loss per hectare due to bird damage. These losses only account for 2.9% of the crop statewide, which may seem like minimal damage, but when considering that the benefits (yield savings) of bird control in fruit production can be $330,152,570 (low end) to $345,390,381(high end) state wide ( Anderson, Lindell, Moxcey, Siemer, Linz, Curtis, Carroll, Burrows, Boulanger, Steensma and Shwiff, 2013).

Unchecked, birds can destroy an entire crop. A flock of 5,000 starlings can consume up to 1 ton of food over a 10 day period (Fraser, Fisher and Frensch, 1998). This could be significant in the case of a grower who produces luxury level Cabernet Sauvignon. If he/she sells the fruit for $5, 000 a ton, then he/she should have a reliable bird abatement plan come verasion. If not, there could be thousands of dollars lost in just a matter of hours or days.

In order to construct an effective bird abatement or management plan what first must be understood is their foraging habits, what the damage will look like, and identifying patterns in the damage that they cause. Starlings eat plant matter and invertebrates, with the latter being favored during the spring and summer months, when they are readily available. Starlings feed on a wide variety of invertebrates, including beetles, millipedes, butterfly and moth larvae, grasshoppers, and crickets. Starlings forage in fruit orchards, especially in the fall (Linz, Homan, Gaulker, Penry, and Bleier, 2007).

Somers and Morris (2002) published a study of birds' foraging activity in vineyards. They suggest that starlings caused the greatest amount of damage on the edges of the vineyards and damage decreased with distance toward the center. In the study European starlings were the only species that was consistently present in substantial numbers (5-200 birds). They gathered on power lines or in deciduous trees. Periodically groups of birds would descend into the vines plucking one grape and returning to the perch to consume it. European starlings tended to gather in adjacent habitat features (perching areas) in larger numbers and descend into fields from the air, removing grapes from clusters high up on the vines (upper tier). Asymmetrical foraging on upper and lower-tier grape clusters by European starlings causes vertical stratification of ther damage. It was also found that damage began early on when grapes where unripe but the amount of damage significantly increased in the two week period prior to harvest. This study's findings are consistent with the ethogram that has been compiled over decades by grape grower observation.

Starlings often feed up to 20 miles away from their roosting site (Bateson & Asher, 2010). Starlings from the far north (above 40° latitude) migrate south between the months of September and December. These fall roosting flocks can range from several hundred to several thousand birds (Cabe, 1993). This increase in temporary population or just the presence of passing flocks could also be a reason why vineyards experience an increase in damage near harvest time.

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Most grape farmers would agree that bird abatement is important to avoid losses. Though they all agree that birds are pests that need to be controlled, farmers have different opinions on the efficacy of the control methods available today.

One of the most widely accepted bird exclusion techniques is the application of bird netting after veraison. There are two general types of bird netting, over the top netting and side panel netting. Both types of netting have an initial cost and, if properly maintained and stored, can last up to 10 seasons or more. Not only is there an initial cost, but there is also the cost of labor to apply it and take it down each year. Over the top netting was the first type of netting that was developed. One drawback of the over top netting is that plastic cups have to be purchased and put atop each line post to avoid tearing the netting. When applying this type of netting farmers have to purchase or rent an application trailer that has a high arm and loop or a mounted roller device in order to feed the netting over the vines, this is also used to help aid in the removal of the netting. The side panel netting does not have to be removed each season but rather it is bunched together underneath the vines and tied in place. Each year the side panel netting has to first be untied and then applied. Usually a labor crew is employed to do this type of hand work and even the fastest and most experienced crew of 8 people can only move at about 4 acres per day. This is a large labor cost and only seems to be practical if the producer is farming ultra-premium to luxury level fruit ($25or more a bottle of wine; this grading system is based on Jeff Newton's price point farming model).

Growers with larger acreages or who for a lower price point ($5- $15 dollar per bottle) usually have a bird control crew that uses ATVs and various frightening devices including pyrotechnics (e.g. shellcrackers, bird bombs), shotguns for noise and shooting, and propane exploder canons. Shotguns are used mostly as a dispersal technique rather than trying to reduce numbers. It is recommended to start scaring efforts early before birds form a strong attachment to the site and to be persistent until the problem is solved (Johnson et al., 1998). The propane exploders are usually effective at first, but birds tend to grow accustomed to the noise and eventually stop responding. Therefore, they have to be moved regularly. This technique has been around the longest and is considered traditional bird scaring.

One problem with these methods is that a worker is usually just scaring birds from one area of the vineyard into another. Safety is also a consideration. These employees must be well-trained and among the most trusted of the staff. Working with fast, off-road vehicles, fire arms, and pyrotechnics presents a significant source of risk and liability, not only because of the potential injury to workers, but also fire risk.

A biological control method that is popular with large-scale operations is falconry. Falconry is the use of highly trained birds of prey. Falcons partner with the Falconer (handler) to chase away pestiferous birds.  Falcons are chosen as the bird for the job because they are smaller and more nimble than any other bird of prey. They can dive into vine rows and negotiate obstacles. Certain species like the peregrine falcon can fly at speeds exceeding 200 miles per hour when in a stoop (nose dive). This form of control is only practical for large vineyards with substantial revenue because the service of falconry is expensive. To be effective the falconer and his/her falcons have to be on the property for several days at a time, otherwise the birds will return upon the falcon's departure.

Kross, Tylianakis and Nelson (2010) conducted an experiment in New Zealand that measured the value of a native, endangered species of falcon as a biological control of pest birds in vineyards. This strategy has two potential benefits- conservation of an endangered species and protection of grapes from bird damage. The falcons bred successfully in the vineyard setting. It was also found that there was a significant reduction in bird damage to grapes within 300 meters of the falcon feeding trays. It was determined that the presence of a falcon could result in savings of $234- $326 per hectare in grape damage depending on the variety.

Some other visual frightening devices are eye-spot balloons, hawk kites, and reflective mylar tape. Unfortunately all of these devices are only effective for a short time. Birds grow used to them and will infiltrate the vineyard once they know the devices are not a threat. A cultural method that is rather effective is spraying birds' roosting sites with water from a hose or sprinkler.

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Other bird abatement techniques include repellents, trapping and the use of toxicants. Deterrents consist of putting sticky materials or plastic spike products in areas that starlings may use as roosting sites. These products discourage them from. Trapping is an impractical control method due to the wide-ranging movements of starlings, the time necessary to maintain and manage traps, and the number of starlings that can be captured compared to the total number in an area.. However, trapping and removing starlings can be successful at locations where a static population is causing damage. Toxicants are usually not used in vineyards because of the risk of killing other non-target birds with the bait but products such as Starlicide Complete can be very effective in livestock and poultry operations (Johnson et al., 1998).

Auditory alarms are a bird abatement technology available to growers which has a lower initial that nets and may be as efficacious as traditional scaring methods. These are the auditory alarm and distress call speaker systems such as the Bird Gard Pro Plus® that was to be tested in this experiment. Auditory alarm system play digital recording of the distress calls of a number of bird species and the vocalizations of common predators. These calls are broadcast through weather resistant speakers and work as a deterrent for birds that approach the area. Berge, Delwiche, Gorenzel and Salmon (2007) compared the effectiveness of a similar device in conjunction with conventional scaring, conventional scaring methods, and exclusion methods (netting) in the Carneros AVA in three commercial Pinot Noir vineyards.  Damage data was collected over two seasons (year 1 control; year 2 broadcast tests).  Conventional methods paired with the broadcasting device yielded 5.7% bird damage. Bird damage in the areas using conventional methods was 13%.Netting yielded the least damage at 2.3%. The Bird Gard® system itself has been tested in multiple studies, once in Arizona in pecan orchards against crows and ravens (Call, 2011), another by Rutgers in New Jersey on a Dairy Farm against starlings, grackles, pigeons, cowbirds and sparrows (Lee, Stanczyk and Berkowitz, n.d.) and also in California in almond orchards against crows (Salmon, Gorenzel, and Pearson, 2000). In each of

**Formatted:** Indent: First line:  36 pt these studies the results showed evidence that the bird damage was significantly reduced when the Bird Gard device was employed.

The unit used in this experiment is the Bird Gard Pro Plus. The unit comes with two speakers. Each effectively covers a cone-shaped area approximately 300 x 200 feet. The control box is fully programmable, with adjustments for volume, specific sound combinations, daylight, night, or 24-hour operation. Every six seconds a randomly selected sound is broadcast at a randomly selected frequency out of a randomly selected speaker. There are four different random settings that vary the sound, the sound duration, length of time between sounds and the sound location so it reduces the chance of birds getting accustomed to the sound pattern (birdgard.com).

## **Star~~t~~ling Behavior**

There are several problems with controlling the European starling all relating to their behavior. The first is in the way that they learn. Starlings like most animals learn through causal agents or stimuli. These are things that the starling can see, hear, smell, taste or feel. Examples include the approach of a predator, the smell of prey or when night falls. These are all stimuli that require a type of learned behavior in response. They are also very observant creatures. A roosting flock can sit on a high perch and send a small exploratory element into a vineyard as the larger flock sits and watches for potential threats to the small element. If nothing happens to the lead element they see it is safe to proceed into the vineyard.

Starlings adapt their behavior to fit their current environment. Starlings are opportunistic and adaptable foragers, but forage predominantly on the ground in open areas of short grass. They are adapted for terrestrial foraging with powerful legs for walking and a strong, pointed bill for probing. They have a complex song, incorporating mimicry, and are open-ended learners extending their repertoire throughout life. (Bateson & Asher, 2010). Although insects are the main part for their diet, they will eat any number of fruit crops if they are available. One of the studies mentioned that starlings like to approach feeding areas from high perches. In one

**Formatted:** Indent: First line: 36 pt particular study area the starlings were present despite the absence of perch positions. This means that if they know there is food in a particular location they will take a less favorable avenue or approach to gain access to the location.

Starlings are very smart birds. Individuals can learn and reproduce the calls of up to 20 different species. Birds whose songs starlings often copy include the Eastern Wood-Pewee, Killdeer, meadowlarks, Northern Bobwhite, Wood Thrush, Red-tailed Hawk, American Robin, and Northern Flicker. In studies of starlings' sense of taste, scientists have discovered that they can taste salt, sugars, citric acid, and tannins. They can tell the difference between sucrose and other kinds of sugars – starlings lack the ability to digest sucrose. (Ehrlich, Dobkin, and Wheye, 1988). From an ethological standpoint and in the case of an indigenous starling population, if these birds are capable of distinguishing chemistry within the grape then they are just as adept with their sampling as we are when it comes to knowing when grape reach physiological maturity. They may not have refractometers or titration tests but what they can do is taste berries from early on in the season. They can track the progression much the same way growers do. At the same time the starlings might be paying attention to a grower's cultural practices throughout the season. They can see that the fruit is a bit sweet when that pesky netting is applied. The next year they can just eat insects and save themselves the experience of eating unripe fruit until they see the netting again. Starlings apply their intelligence in the assessment of threats as well. As discussed previously, they become habituated to control methods if they see them every day, in the same position or interval.

The European starling has been successful in the United States because of their ability to aggregate. They fly and migrate in large flocks because they know they have safety in numbers. Flocks of starlings normally fly in a loose pattern, but when such flocks in flight are attacked by a hawk they form a tight group, maneuvering as one bird to escape the enemy (Benton &Werner, 1966). In winter, the roosting flocks have been known to be large, often exceeding 1 million birds (Johnson & Glahn, 1994).

## The Original Experiment and Results

Bird abatement strategies in grapes are based on an ethogram of expected, normal behaviors. An ethogram is a catalogue or inventory of behaviors or actions exhibited by an animal used in ethology in the case of the European starling, it is known that it is a ground forager that likes to perch above its feeding area. When they do take grapes they pluck the whole grape from the cluster and retreat to consume it. Starlings and other birds do not penetrate deep into the vineyard they typically do most damage on the edges of the vineyard. Starlings feed sporadically throughout the day but much of their feeding takes place at daybreak and just before dusk. If left undisturbed starlings will consume a substantial amount of unprotected fruit. Based on this rather general ethogram an experiment was designed to monitor the effectiveness of the Bird Gard frightening device. The experiment failed because the starlings did not display the expected behavior. The results of this experiment were that the ethogram of expected behaviors for Starlings did not apply to this population. What follows is a narrative of what happened and why it might have happened. Using a number of observations and a detailed field note-taking system a new ethogram will be developed showing how the European starling's (Sturnus vulgaris) behavior has varied in this particular growing site from the ethogram that was previously accepted.

## Time Line

In the summer season of 2013 there was several changing of hands in the Trestle vineyard. There were different vineyard managers for winter and spring quarters. In late July Dr. Craig Macmillan joined the vineyard team as the vineyard manager and viticulture lecturer.

When Craig came to us we would have Monday morning staff meetings. These staff meetings usually covered projected work for the week, goals and upcoming projects. At some of these meetings he began asking if any of us have started thinking about our senior projects. I knew that I had not. When I told Craig I had no idea what I wanted to do for a project he agreed to help me develop some ideas. In the late weeks of July Craig had begun corresponding with another viticulture and entomology professor Dr. Michael Costello. Dr. Costello informed Craig that he had received two Bird Gard units from Terry Denzer as a donation. At the next Monday meeting Craig mentioned to me that the Bird Gard units were available and that he was curious about their effectiveness. He then suggested that this might be the direction that I should head in for my project. I was not very fond of the idea at the beginning because I was not very interested in birds and I felt that the best measure for control was exclusion using. Craig told me to begin research. I was instructed to find out if there had been any experiments conducted with the Bird Gard or similar devices and what the findings where.

I spent a few hours in the library looking through different publications and found that there were a few studies on this subject. One in particular was conducted by Davis researchers in Carneros region vineyards. This is the study that I felt I would model my project after. They set their project up so that is spanned two seasons, a control season and a treated season. I did not have two seasons to conduct my experiment so I had to think of a way to vary or randomize the conditions in one growing season.

Around the same time frame Craig had dropped off the two Bird Gard units off at the vineyard shop area. The vineyard crew opened the boxes and began contemplating what method we could use to power the units and where to place them. The first thing that came to mind was rigging them up to our John Deere tractor. We drove the tractor out to the large Pinot Noir block to see if it would work on the birds that were present in our earliest ripening block. This was early August and the fruit already had some color on it so there was some bird presence. The birds seemed to be confused by the machine and flew away. We drove our New Holland track tractor out to the Chardonnay block and set up the second unit on that tractor. We only wanted to test the units to see what they sounded like, the ease of use and to see if birds had any sort of reaction to the auditory calls. After a couple hours of running the machines we dismantled the equipment. I did not want the native population of birds, especially starlings and finches to habituate to the distress calls.

Once tested, I realized that the tractors would not always be available for my project. Taking this into consideration I began making plans to build a mobile cart that the Bird Gard could be mounted to that would also carry a 12 volt car or marine battery. I knew that the battery had to be a 12 volt but I did not know how long a battery would last while the machine was running. I was worried that the machine was going to kill the battery while the machine was working to deter birds during the project.

Craig put me in contact with Terry Denzer of Bird Gard who had donated the equipment. I asked Terry if he could forward me any literature on the Bird Gard and any studies that may have been conducted to test the effectiveness of the machine. He provided me with a few different studies that tested the equipment but most of them had to do with crows in nut orchards. I also mentioned my concern about the machine's power requirement to Terry. He assured me that the unit uses very little power and suggested that if it was a concern that I should think about a 20 watt solar panel to attach to the battery in order to recharge it during the day.

My next move was allocating a 12 volt battery. I came to a crossroads, I had to decide if I should use two inexpensive batteries and alternate use in order to recharge them or if I should buy a marine battery because it is weather proof and a solar panel to ensure it is always charged. Next Craig put me in contact with Dr. James Cooper our department head because he could fund the purchase of a battery and solar panel assuming that it would serve the vineyard long term. Luckily Dr. Cooper had some experience in installing solar panels so we ordered all the equipment together.

In the early part of September Craig and I began talking about the experiment design. Craig got permission from Dr. Cooper to use the Tempranillo block in order to execute this experiment. The Tempranillo block is about a 0.8 acre block located in the western most potion of the Trestle Vineyard. Each speaker of this particular model of Bird Gard® is supposed to be effective in covering a conical area of 300x200 feet. We decided that if placed in the middle of the block, one unit would be enough to cover this small area of land. We did not have two seasons to conduct this experiment so we had to figure out a way to create variance within one growing season. The only way we could do this is by varying the control method and time of exposure.

At this point in the season we had already applied the bird netting because verasion had taken place and the berries were already turning color. What we decided was that there would be several different treatments. These treatments would be called groups. Group 1 would be a treatment where the bird netting would be removed and there would be no Bird Gard® in place, basically leaving the fruit for the taking. The second would have the fruit exposed with the Bird Gard® active. The third would have the netting in place with no Bird Gard® active. The fourth application would be identical to the second and the fifth identical to the third. The sixth treatment would have the nets applied and the Bird Gard® active as well. We did not know how long it would take for damage to occur in the first treatment but what we thought is that if we started in the 19 -20° brix time frame that we would have about 6 weeks to conduct all six treatments, plus or minus a couple of days. If significant damage happened in less than a week then all treatments would be adjusted to that biofix day number.

That addressed the treatment variance but variance had to be created within the geographical area of the block. Taking into consideration that birds tend to have some edge effects a method of excluding the edges would have to be developed. The row numbering in this block goes from east to west 1-13. Rows 1, 2, 12 and 13 were excluded. An accurate vine count was taken so that the first five vines from the north and south sides of each row were excluded. The rest of the vines were split up into 5 vine "pods". In early September the pods where randomized and were ready to be marked. Craig randomized the pods, either using dice or some sort of randomizing mechanism. The pods were marked using flagging tape. Only 4 colors of flagging tape were available so two of the treatments had a combination of colors to make them distinct. The project was now ready to be executed.

There was some time in September before the experiment began where the Bird Gard® was activated in the early ripening varieties to observe if the machine would deter the birds from the ripening fruit. The battery and solar panel were never received so any vehicle that was available (the mule, New Holland and John Deere) was used to power the Bird Gard®. The unit seemed to confuse and deter the birds the first few days. It did not take long before it seemed to have no effect. I went out to check out the bird population a few times and I saw some dove foraging right under the machine and I also saw some house finches pilfering Pinot fruit just a few meters away from the machine. By what was observed in the weeks leading up to the experiment I was already constructing a hypothesis stating that the machine will have little to no effect in protecting the fruit from damage.

The fall quarter began and this marked the beginning of the experiment. I went out to the vineyard on the first Tuesday and luckily I had the help of Dan Rodrigues' class to help take down the netting on the first group/treatment/ time domain. The fruit was further along in its development and was at around 20° brix at the time the first group was initiated. At this point the fruit was very attractive to the birds. Just before the experiment started a damage-assessment was conducted on the fruit that was covered by nets that had already been damaged by birds. It looked like it was less than 1% of the total crop. The fruit was not checked after the nets had been dropped until Thursday of that week. I was expecting to see a significant amount of damage but that was not the case, in fact, the fruit on all the exposed pods was untouched. I went back out and checked the damage on Friday and still there was no sign of damage. While checking for damage I did see some starlings in the vineyard. The starlings were feeding on fruit that was covered by bird netting. I had always heard that starlings like to penetrate the canopy from the top to get to the fruit. What was peculiar is that I saw a group of about 10 birds that were on the ground looking like they were ground foraging but one or two at a time they would fly up toward the netting to pluck fruit. I informed Craig about the birds not taking the exposed fruit and we decided to let it go over the weekend.

I came back from the weekend to find that there was still no damage. I was puzzled as to why the birds were not feeding on the fruit that was just there for the taking, it just didn't make any sense. I began watching their behavior even more closely. On the south-western border of the vineyard there is a tree line made up of eucalyptus trees. This makes for a great roosting or a good perch site for the starlings. Just 150 yards west of the vineyard there are utility lines that run north-south where starlings perch. I noticed that the starlings do most of their feeding in the mornings and late afternoons when there is less activity in the vineyard. They can also feed throughout the day but in smaller, more scattered groups. It appeared to be that we receive visits from migratory bird flocks in the afternoons because on some afternoons as many as 300 starlings can be seen on the utility lines just outside the vineyard.

On Friday October 4th I went to check the damage on the fruit. I observed no significant damage. I happened to be checking for damage in the early part of the morning so I watched the starlings to see what I could learn about their feeding patterns. I noticed that there was often a large flock perched on the utility lines and from this flock a lead element was sent in as a scout unit. Once the scout element probed around a while and saw that there was no danger they would jump up into the vines and the main body would descend in groups of about 20 to 30 birds.

When this would happen they would start on the edges of the vineyard and slowly work their way inward. On that day and previous days I noticed that often times the birds would use the net as a perch while they pluck berries off of the clusters. Sometimes they hang almost upside down like bats using the net to their advantage to get to the berries. Other times they could be seen working in two bird teams, one weighing down the net while the other plucks berries.

On Monday October 7th Dan Rodrigues' class again assisted me but this time they helped take a quantitative damage assessment. We came to the conclusion that there was about 1-2% damage in all of the exposed pods. At this point I had long known that the experiment design had failed. There was no way I had enough time to replicate the same time domain for the rest of the groups. Oddly enough there seemed to be more damage on the netted fruit than on the non-netted fruit. The areas of the block that sustained the most amount of damage were the northwestern edge and the southwestern edge. It was bad enough that the birds were damaging the fruit but some of the partially eaten berries were drawing in yellow jackets which further exacerbated the situation. The next day, October 8th, we harvested the first ton of the Tempranillo. On Friday October 18th the rest of the Tempranillo was harvested.

The reason this project failed is because the design was modeled or based on the ethogram that had been established by decades of viticulturist experience. It seems as though some of the ethogram still remains true but starlings have changed their behavior in many ways. Starlings have been known to have a high level of variation in diet, habitat and behavior. It is because of this flexibility that they can find a niche in any type of ecological setting and are successful pest species. The problem is partly the species because of their ability to learn and adapt very quickly. The biggest problem here is the individual populations of starlings. These coastal areas tend to grow higher quality grapes, because their crop is higher quality the farmer tends to want to do all he/she can to protect the fruit from birds. For the last few decades bird netting has been considered one of the best methods of bird exclusion. The populations of starlings that inhabit these coastal areas have had decades to habituate to these control methods, so much so that it seems as though they use the netting in their favor to facilitate their feeding. This was clearly demonstrated by the birds' reluctance to eat the exposed fruit. Perhaps previous generations showed the current generation how to evade the netting to obtain the fruit. When fruit was exposed this could have confused the current generation of starlings because it is nothing they had experienced before. A greater problem could develop if the migratory birds learn from the native population and then transfer this learning over to their young. If this happens or if it is already happening then these flocks of 300 or more birds can cause an immense amount of damage.

Occasionally a bird gets caught in the net and dies but the frequency of this happening is a miniscule percentage when taking into account the amount of individuals that visit a vineyard each year. This indicates that they have also learned to resist and escape netting. This experiment was conducted in a vineyard that employed side panel netting, perhaps over the top netting is more effective because it may have a more draping affect. Over the top netting is more difficult and time consuming to secure at the bottom and considering the behavior of the bottom approach the starlings were demonstrating during the experiment this type of netting may not be effective either.

If the experiment would have gone the way it was planned I do not believe that the Bird Gard would have had much of an effect on keeping the birds out. From my observations in our early ripening blocks it seemed as though the starlings habituated to the device quite quickly. The problem with the machine is that starlings, like most animals learn and adopt behaviors as a reaction to certain stimuli. The predatory bird calls may have worried the birds at first as well as the starling distress call but once the birds saw that there was no predator present and no bird being attacked they soon ignored the device.

## **Updated Ethogram**

Compiling an ethography was not the original scope of this project but often science experiments fail but from these failures there is often still a valuable lesson learned. The lesson that has been learned here is that starlings learn quickly and adapt. They habituate to control measures very quickly. This changes the ethogram that was previously accepted. There were new and different behaviors observed during this experiment, enough to warrant compiling a new ethogram for this growing site. This growing site is not unique to this region. Most producers in this region grow similar varieties, have the same coastal climate, share similar surrounding vegetation and topography. Growers in this area share the same type of trellising system and have similar control measures. Knowing that vineyards in this area are very similar (only varying in size) and knowing how highly adaptive starlings are as a species, it is likely that this ethogram could be applied to all growing sites in this Central Coast region.

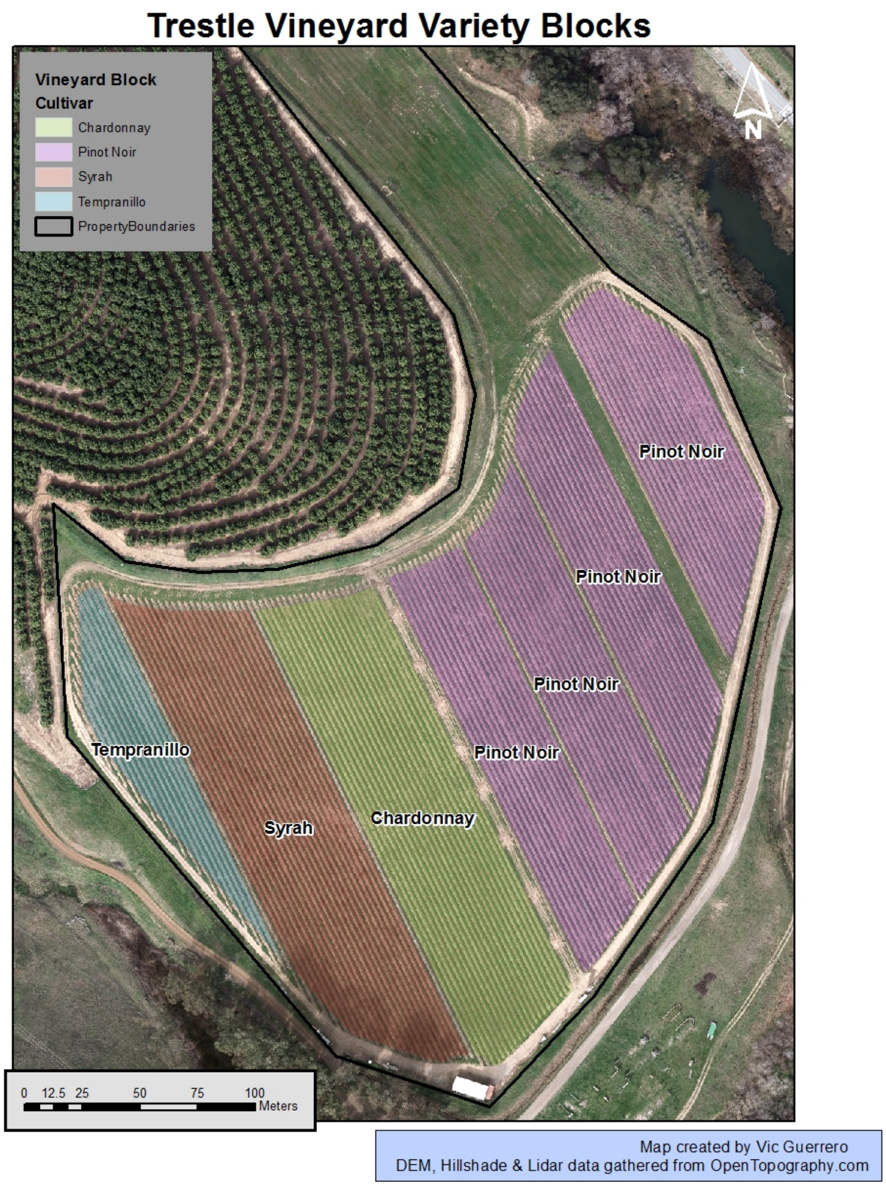
Like previously stated, there are some behaviors that remain constant with starlings in vineyards. Starlings continue to cause most damage on the edges of the vineyard especially on the edges near perch points. For the most part starlings pluck entire berries when feeding on grapes but partial berries are often left behind. Starlings continue to forage in large numbers. Starlings continue to utilize perch points that surround the vineyard in order to conduct reconnaissance and surveillance before descending to forage.

Farmers believed that starlings feed sporadically during the day, this still remains true but the groups of birds are much smaller and divided. When birds do decide to approach in the day, only a small group is sent in as scouts to ensure safe conditions for the main body of birds. Then and only then the main body might descend at once or in smaller fractions. It is difficult to determine with no video evidence but it is believed that larger bodies of birds choose late afternoon/evenings and early mornings as feeding times. The only evidence to support this is substantial new damage found the next morning upon arrival to the vineyard. In the later part of the season a few hundred birds could be seen waiting on the power lines in the late afternoon. These are believed to be migratory birds. It was previously believed that starlings descend directly from above into the canopy. Now they land on the vineyard floor under the vines and jump up into the vines to retrieve fruit. Side panel netting no longer deters starlings, in fact they almost seem to prefer it because they can perch on it or hang from it in order to pluck fruit from a cluster. Another observation that is impressive is that they sometimes work in teams to press down on the netting allowing another bird easy access to feed. It was previously believed that a starling would pluck a singular berry and retreat to its perch to consume it. Now it seems that they jump down to the ground consume the berry and continue to retrieve berries. Though the experiment was inconclusive when the auditory scaring device was employed in the early ripening blocks it seemed to have little effect on the presence of starlings. They quickly habituated to the calls and the lack of visual and situational stimuli.

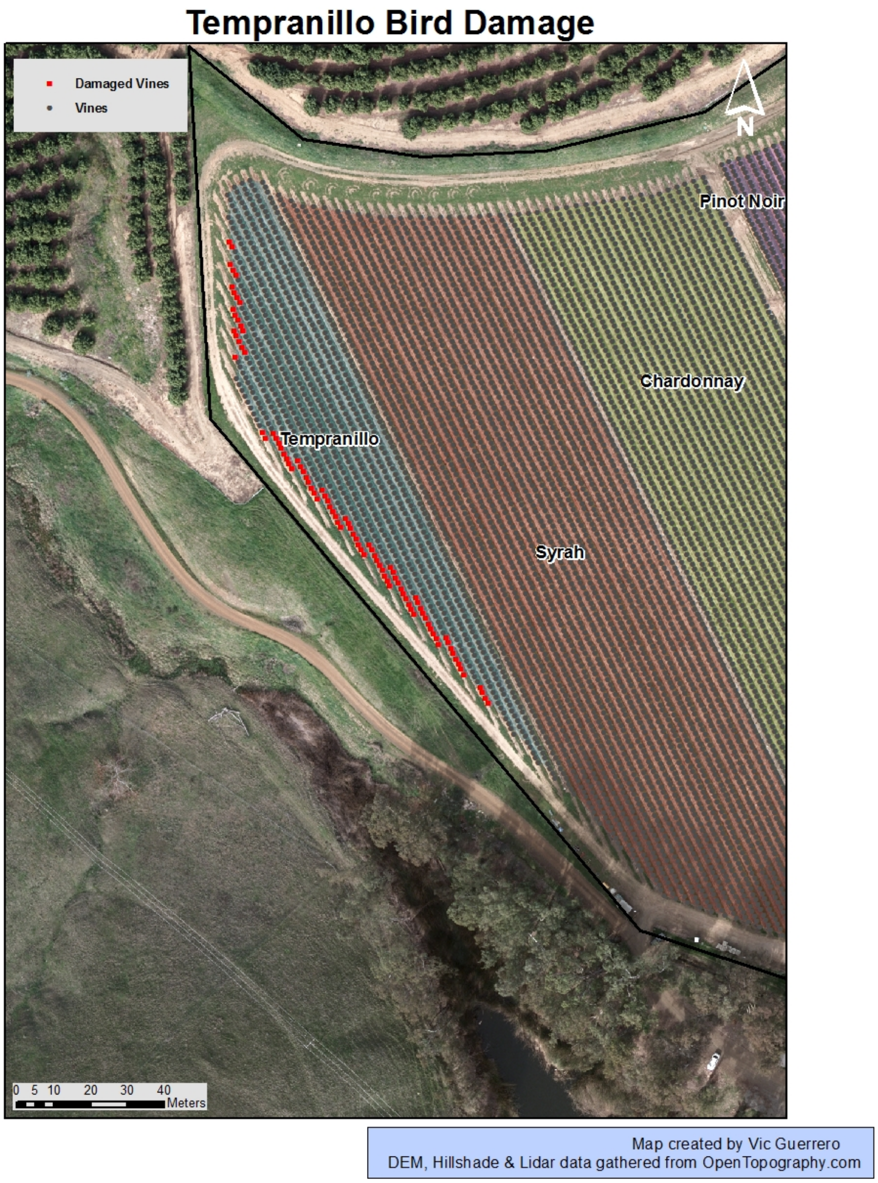
## Plan for Control

If this is considered a successful or accurate ethography for the starlings in Central Coast vineyards this may be a starting point for understanding how they operate and behave. This ethogram can be a record of their current typical behavior which may help to plan and conduct an integrated pest management program against the offending starlings. There is obviously no panacea for bird control. That is why there is the "integrated" in IPM because several different methods must be used to control starlings. By now it has been accepted that the reason that starlings are so successful is because they are highly adaptive and learn or habituate rather quickly. They have a very diverse diet and can live just about anywhere. They are strong fliers and have safety in numbers. They reproduce at a high rate. This type of flexibility makes starlings ecologically fit. They are not specified in anything that they do. Knowing that they are this flexible means that we have our work cut out for us. If they have gotten around our control efforts by just watching our next move and learning from it then there is no reason we cannot do the same. Integrated - combining or coordinating separate elements so as to provide a harmonious, interrelated whole. What can be gathered from this definition is that there are a lot of pieces that have to come together to solve a puzzle. If we take anything away from observing starlings it is that they have a high level of variation (diet, habitat, behavior) on their side. Can we be the same way? We need to stay constantly varied and functional if the goal is to eradicate these birds from growing sites. We relied on bird netting for decades as the best form of exclusion. Like the example of repeated use of the same insecticide or fungicide several times over a season and for years at a time. Eventually certain species will build resistance. That is essentially what has happened with starlings and bird netting. For years farmers put up nets and did little else to scare off starlings. Eventually they learned how to get around the net and now can even use it in their favor. One thing that may still hold true to the old ethogram is that most damage was found on the edges of the vineyard. If that is the case why net the inner most area of the vineyard? Refocusing labor used for putting up and taking down netting can be partially redirected to conduct patrols of the vineyard using conventional scaring methods. Any high perches around the property can be knocked down or cut down. If trees must remain in place maybe thinning the foliage a bit and laying down spike strips could make them less attractive for roosting or perching. A combination of shooting and roost disruption can discourage a native flock from staying near the vineyard. All of these cultural practices have to be constantly varied. Starlings, though considered a migratory bird, are not protected under the Migratory Bird Act. Another control measure that could be useful is chemical scaring agents like Avitrol. These chemicals are in bait formulations and cause feeding birds to act erratically and make them cry out with distress calls before their eventual death. This control method would be much like the Bird Gard® but it would also include visual stimuli that the Bird Gard® lacks. They can be taken at any time of the year. Shoot them with a shotgun one day, paintball gun the next, on the third day spray them with a hose or irrigation cannon. If we keep things varied we are less predictable and keep the starlings from catching on to any kind of modus operandi. Only then will we be able to consider this starling problem “controlled”.

## Appendix A:

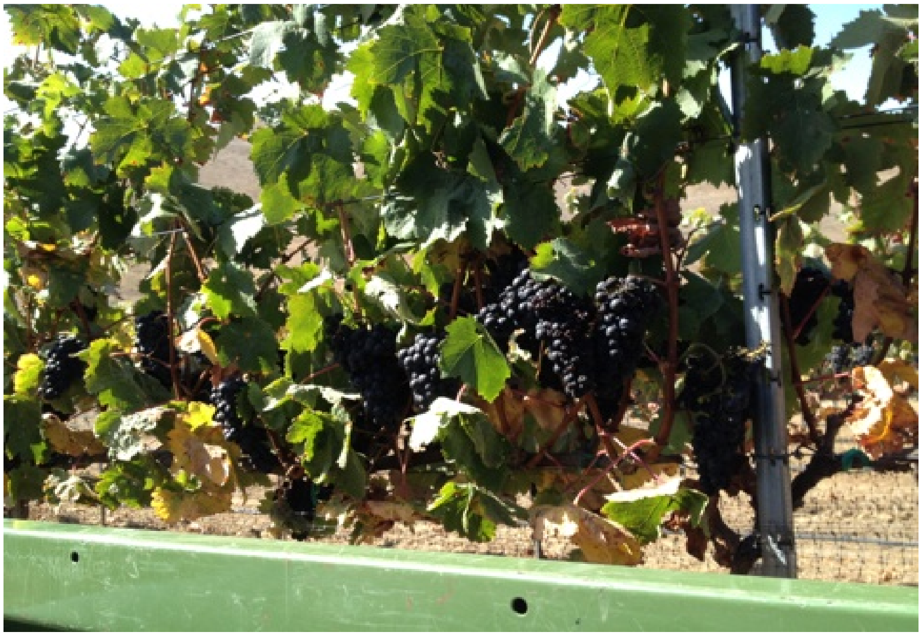


Trestle Vineyard Variety Blocks
Vineyard Block
Cultivar
Chardonnay
Pinot Noir
Syrah
Tempranillo
PropertyBoundaries
N
Pinot Noir
Pinot Noir
Pinot Noir
Pinot Noir
Tempranillo
Syrah
Chardonnay
0 12.5 25 50 75 100
Meters
Map created by Vic Guerrero
DEM, Hillshade & Lidar data gathered from OpenTopography.com

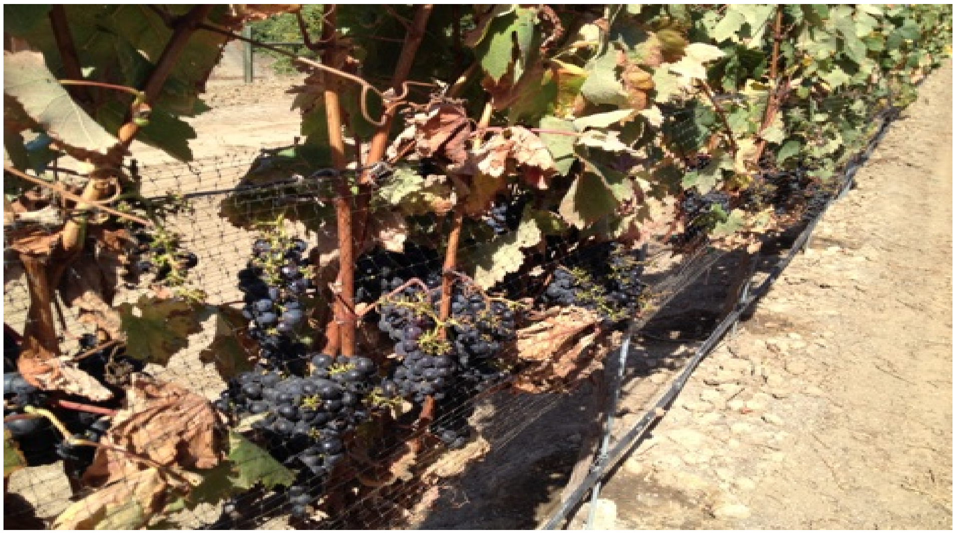



**Above:** The GIS map displays where bird damage was most heavily experienced. In the in the southwestern portion of the map three white lines can be seen, these are the utility lines. The tree line comprised of Eucalyptus trees can also be seen in the southwestern portion of the map.

## Appendix B:



**Above:** Both pictures were taken of exposed fruit 3 weeks into the experiment. Both photos feature minimal damage to the exposed fruit.



**Above:** These two photos feature the average damage experienced on the covered fruit near the edges of the vineyard 3 weeks into the experiment.

**Above:** This photo was taken the day of harvest. This vine is representative of the majority of vines on the most western rows of the Tempranillo block.

# Work Cited

**BOOKS**

Bateson, M. and Asher, L. (2010) The European Starling, in The UFAW Handbook on the Care and Management of Laboratory and Other Research Animals, Eighth Edition (eds R. Hubrecht and J. Kirkwood), Wiley-Blackwell, Oxford, UK.

Benton, A. H., and Werner, W. E. "Animal Behavior." Field Biology and Ecology. New York: McGraw-Hill, 1966. 330-49. Print.

Johnson, R. J. and Glahn, J. F., "EUROPEAN STARLINGS" (1994). The Handbook: Prevention and Control of Wildlife Damage. Paper 72. http://digitalcommons.unl.edu/icwdmhandbook/72

Lawrence, G., and Tyrol, A. "Starlings." A Field Guide to the Familiar: Learning to Observe the Natural World. Englewood Cliffs, NJ: Prentice-Hall, 1984. 84-89. Print.

Perrine, J. D., and Patton, J. L. "Letters to the Future." Field Notes on Science & Nature. Ed. Canfield, M.R. Cambridge, MA: Harvard UP, 2011. 211-50. Print.

**CONFERENCE PROCEEDINGS**

Clore, J., "COMMERCIAL PEST MANAGEMENT OF BIRDS IN GRAPES." Proceedings of the 7th Vertebrate Pest Conference. The 7th Vertebrate Pest Conference, California, Salinas. Lincoln: University of Nebraska, 1976. N. pag. DigitalCommons@University of Nebraska - Lincoln. Web. 17 Nov. 2013. <http://digitalcommons.unl.edu/vpc7/13/>.

Linz, G. M.; Homan, H. J.; Gaulker, S. M.; Penry, L. B.; and Bleier, W. J., "EUROPEAN STARLINGS: A REVIEW OF AN INVASIVE SPECIES WITH FAR-REACHING IMPACTS" (2007).Managing Vertebrate Invasive Species. Paper 24. http://digitalcommons.unl.edu/nwrcinvasive/24

**JOURNALS**

Anderson, A., Lindell, C.A., Moxcey, K.M., Siemer, W.F., Linz, G.M., Curtis, P.D., Carroll, J.E., Burrows, C.L., Boulanger, J.R., Steensma, K.M.M., and Shwiff, S.A. "Bird Damage to Select Fruit Crops: The Cost of Damage and the Benefits of Control in Five States." Crop Protection 52.October (2013): 103-09. Print.

Berge, A., Delwiche, M., Gorenzel, W. P. and Salmon, T., "Bird Control in Vineyards Using Alarm and Distress Calls." American Journal of Enology and Viticulture 58.1 (2007): 135-43. Print.

Boudreau, G. W., "Factors Related to Bird Depredations in Vineyards." American Journal of Enology and Viticulture 23.2 (1972): 50-53. Print.

DeHaven, R. W. and Hothem, R. L., "Estimating Bird Damage From Damage Incidence In Wine Grape Vineyards." American Journal of Enology and Viticulture 32.1 (1981): 1-4. Print.

Johnson, R. J. and Glahn, J. F., "Starling Management in Agriculture" (1998). Other Publications in Wildlife Management. Paper 34.

Kross, S. M., Tylianakis, J. M. and Nelson, X. J. (2012), Effects of Introducing Threatened Falcons into Vineyards on Abundance of Passeriformes and Bird Damage to Grapes. Conservation Biology, 26: 142–149. doi: 10.1111/j.1523-1739.2011.01756.x

Pimentel, D., Lach, L., Zuniga, R., and Morrison, D., "Environmental and Economic Costs of Nonindigenous Species in the United States." BioScience 50.1 (2000): 53. Print.

Saxton, V. P., Creasy, G. L., Paterson, A. M. and Trought, M. C. T., "Experimental Method to Investigate and Monitor Bird Behavior and Damage in Vineyards." American Journal of Enology and Viticulture 55.3 (2004): 288-91. Print

Somers, C. M. and Morris, R. D. (2002), Birds and wine grapes: foraging activity causes small-scale damage patterns in single vineyards. Journal of Applied Ecology, 39: 511–523.

Tobin M. 1984. Relative Grape Damaging Potential of Three Species of Birds. Calif Agr 38(3):9-10. DOI: 10.3733/ca.v038n03p9

**SCHOLARLY PROJECTS/REPORTS**

Call, R. E., Managing Bird Damage to Pecan Groves in Arizona with Bio-Acoustic Bird Distress Calls. Www.birdgard.com. Bird Gard, (2011) Web. 17 Nov. 2013.

Hambright, R. B. Control Of Starlings (Sturnus Vulgaris) And Linnets (Carpodacus Mesicanus) In California Central Coast Vineyards. Senior Project. San Luis Obispo: California Polytechnic State University, 1977. Print.

Lee, D., Stanczyk, C. and Berkowitz, J. Bird Control on Dairy Farms. Bird Gard. Rutgers University, n.d. Web. 17 Nov. 2013.

Salmon, T. P., Gorenzel, W. P. and Pearson, A. B., An Operational Crow Control Program Using Broadcast Calls. Rep. no. 96-0486-III. Davis: University of California, 2000. Print.

**WEB SITES**

Badyaev, A. V., Belloni, V. and Hill, G. E. 2012. House Finch (Haemorhous mexicanus), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/046

Cabe, P. R. 1993. European Starling (Sturnus vulgaris), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/048

Denzer, T. R., "Bird Gard Pro Plus." Bird Control. N.p., 2010. Web. 17 Nov. 2013. http://birdgard.com/product/Bird-Gard-Pro-Plus

Ehrlich, P. R., Dobkin, D. S. and Wheye, D., "All About Birds." European Starling, Life History,. Cornell University, 2011. Web. 14 Nov. 2013. http://www.allaboutbirds.org/guide/European_starling/lifehistory

Ehrlich, P. R., Dobkin, D. S., Wheye, D., Hill, G. E., Dunne, P. and Sibley, D. A., "All About Birds." House Finch, Life History,. Cornell University, 2011. Web. 14 Nov. 2013. http://www.allaboutbirds.org/guide/HOUSE_FINCH/lifehistory

Fraser, H. W., H. K. Fisher, and I. Frensch. "Bird Control on Grape and Tender Fruit Farms." Bird Control on Grape and Tender Fruit Farms. Ontario Ministry of Agriculture and Food, June 1998. Web. 12 Dec. 2013. <http://www.omafra.gov.on.ca/english/engineer/facts/98-035.htm>.

**Models**

Newton, J. "Price Point Farming Model." Chart. Buelton: Jeff Newton, n.d. N. pag. Print.