Final Report

Biological Alternatives to Rodenticides in Agriculture

Completed by Aves Alternatives (Team 2):

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1.0 Executive Summary

Rocky Point Bird Observatory has sponsored Aves Alternatives to assess the viability of using raptor nest boxes as an alternative to rodenticides. Northern Saw-Whet Owls and American Kestrels were chosen as target raptors for the project, as the nest boxes will be placed on agricultural land that serves as suitable habitat for these two species. This project set out to determine the environmental and economic costs of current pest control methods used on local farms. Nest boxes were installed in an attempt to increase raptor populations for the purpose of reducing rodent numbers and determining the ethicality of attracting raptors to the location in consideration of forming an ecological sink. This project used the following methods to obtain data: aliterature review, a nest box monitoring program,owl pellet dissections, and a series of interviews with local landowners, rodenticide experts, and avian experts.

The results from the literature review provided information on the successes and failures of the Boardman Tree Farm project in Oregon, which was the inspiration for this study. In addition, the possibility of adverse ecological effects resulting in an ecological sink was also considered, as well as the effects of rodenticides on target and non-target species.

The nest box-monitoring program consisted of eight nest boxes placed in four locations on Southern Vancouver Island, three in the Saanich peninsula and one in Colwood. Boxes were monitored for uptake weekly; also, owl pellets were collected from nearby sites and dissected to extrapolate the type of rodent species being preyed upon in the area. No nest box uptake from desired species occurred throughout the project, which led to a focus on the literature review, owl pellet and interview data when forming our discussion and recommendations.

A total of nine interviews were conducted between local landowners, rodenticide experts, and avian experts. Data from the interviews were used to assess the main types of rodents causing issues for landowners, the social acceptability of using raptors as alternatives to rodenticides, the effects of rodenticides in target and non-target species, and possible reasons for the lack of target species uptake in the nest boxes.

Data wereanalyzed and recommendations made on how to improve the success of future projects. Recommendations consist of increasing public awareness on the adverse effects of rodenticides, the use of larger raptor species, addressing potential risk through regular raptor monitoring, as well as various initiatives to improve raptor uptake, and continuing the study over a four year period to accommodate the natural flux in the population cycle of the Northern Saw-Whet owl, and finally, the relocation of the study area to a habitat closer resembling the Boardman Tree Farm.

The results of the literature reviews, nest box observations, and interview results confirm that rodents caused minimal damage to farms and rodenticide costs ranged from $100-500 annually.The lack of successful uptake from the desired species of interest determined the viability to be inconclusive. Due to the lack of information available, the potential for creating an ecological sink was also inconclusive and should be preceded with caution in the future.

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3.0 GLOSSARY OF TERMS

Rodenticide: A pesticide used to kill rodents (often containing anticoagulants) [1].
Anticoagulant: A chemical that acts by blocking the vitamin K cycle, resulting in inability to produce essential blood-clotting factors [1].
Raptor: For the purpose of this report, a raptor will be defined as a bird that hunts animals for food. Raptors described in this report include: Northern Saw-whet Owl, Kestrel, Barn Owl, and the Barred Owl.
Bioaccumulation: An increase or buildup of a pollutant within an organism's tissue [2a].
Biomagnification: An increase or buildup of a pollutant within an organism's tissue with the increase of trophic levels [2b].
Ecological Sink: Drawing otherwise healthy raptors into an area that will cause them to be unviable/ unsuccessful [3].
Owl Pellet: The indigestible remains of an owl's prey (bones, teeth, and fur), which is compacted internally and regurgitated by the owl [2c].

[1] Poché, 2012, [2] Anonymous, 2014, [3] Casini, 2012

4.0 Acronyms and Abbreviations

MNSO – Mount Newton Seed Orchard

NSWO - Northern Saw-Whet Owl

RPBO - Rocky Point Bird Observatory

RRU - Royal Roads University

BTF- Boardman Tree Farm

SVI - Southern Vancouver Island

TRS - Tamper-Resistant Station

5.0 INTRODUCTION

5.1 PROJECT SCOPE

Rocky Point Bird Observatory (RPBO) has sponsored Aves Alternatives (Team 2), which consists of Royal Roads University (RRU) students: Melinda Lue, Kara Foreman, Benson Ko, and Michel France, to assess the viability of using raptors as an alternative to rodenticides. This research project is a part of the requirement for a Bachelor of Science in Environmental Science at RRU. Research will be performed on the current uses and effects of rodenticides in regards to ecological and economic systems. Aves Alternatives will participate in a pilot study involving the placing and monitoring of nest boxes for the purpose of encouraging the presence of raptors in specific locations. Should uptake occur, data will be collected on the species that have nested, the number of offspring produced, and the associated prey consumption. Recommendations will be made with respect to the methods and procedures for future projects. This project began in January 2014 and will conclude in August 2014 with a final report delivered electronically to RPBO, and a final presentation delivered at RRU summarizing the report findings.

5.2 PROJECT OBJECTIVE

The objective of this project is to acquire baseline information and develop a standardized measuring protocol for use in future rodenticide-alternative programs.

This research sets out to answer the following questions:

- What are the environmental and economic costs of the current pest controls methods used on local farms?
- Does the provision of raptor nest boxes provide a viable alternative to rodenticides by reducing rodent numbers on farms and other properties in the area?
- Is it ethical to attractraptors to these locations, taking into consideration the potential of creating an ecological sink through predation or pesticides?

5.3 BACKGROUND INFORMATION

A literature review was performed on RPBO, the Boardman Tree Farm (BTF) research project, effects of rodenticides and howthey are regulated, as well as the target species and the potential for an ecological sink. This information will be used in conjunction with the nest box and interview data to form recommendations to RPBO on changes that can be made in future projects to improve success.

5.3.1 BACKGROUND ON RPBO

RPBO is the sponsor for this project and has been an official bird observatory society since 2000. RPBO is a member of a national network containing 25 monitoring stations across Canada, ranging from Vancouver Island to Newfoundland, which monitors bird migration. They have been monitoring the NSWOs since the fall of 2002, as well as hummingbirds, the Purple Martin, and the Fox Sparrow, and are actively involved in the conservation and public education of various bird species (RPBO, 2010).

5.3.2 BACKGROUND ON THE BOARDMAN, OREGON PROJECT

BTF is a poplar farm that is located in Oregon. In 1999, as a response to damage to the tree roots and irrigation lines caused by small rodents, raptor nest boxes were put in place as a method of pest control (Nightingale, Marks, McCullough, and Conway, 2012). Successful uptake and consumption of rodent prey from the Northern Saw-Whet Owl (NSWO) and the American Kestrel at BTF influenced our project to focus on these two species. Unwanted or invasive species, such as the Northern Flickers and the European Starling, were also found to occupy the nests in BTF and this reflects a similar issue that needs to be taken into consideration for this project (Nightingale *et al.*, 2012). The successes at BTF were measured by the amount of uptake by the desired species, the number of viable eggs produced, and the number of prey items found in the boxes. The failures at BTF were measured by the number of eggs lost from predation and the abandonment of nest boxes (Nightingale *et al.*, 2012).

5.3.3 Background on Rodenticides

Rodenticides are a chemical form of rodent control that is available for residential as well as commercial use. Typically, rodenticides act as blood thinners by binding to, and inhibiting vitamin K epoxide reductase, resulting in hemorrhaging of internal organs (Albert, Wilson, Mineau, Trudeau, and Elliot, 2010). There are two types of rodenticides: first generation anticoagulants, which include chlorophacinone, warfarin, and diphacinone; and second generation anticoagulants (SGAR), which include brodifacoum, bromadiolone, and difethialone (Albert *et al*., 2010).

SGARs were developed in the 1970s in response to widespread rodent resistance to first generation rodenticides (Albert *et al*., 2010). SGARs are more acutely toxic than first generation rodenticides in that a single dose is usually lethal and tends to be persistent in animal tissues due to its high affinity for liver tissue (Albert *et al.*, 2010; Thomas, Mineau, Shore, Champoux, Martin, Wilson, and Elliot, 2011).

Rodenticides can have a negative impact on the surrounding environment by making their way into non-target species, such as raptors. In one study conducted in British Columbia and the Yukon Territory, 164 owl livers were analyzed and 70% had residues of at least one rodenticide. Of this 70%, 41% had more than one rodenticide detected (Albert *et al.*, 2010).

In other studies, owls with concentrations as low as 0.1 mg/kg showed signs of hemorrhaging from organs like the heart, lungs, liver, brain, and subcutaneous areas (Thomas *et al*., 2011). There appears to be great variability in the amount of rodenticide it takes to kill different species of owls, as well as individuals of the same species (Thomas *et al*., 2011).

It can take several days for rodenticides to kill a rodent after the lethal dose is consumed. Often, the rodent will continue feeding during this time, which greatly increases the concentration in the rodent and changes its behavior to allow it to be preyed on more easily during this time (Albert *et al*., 2010).

Although the primary focus of this study is on the effects of rodenticides on non-target wildlife species, it is worth commenting on the adverse health effects it may have on humans. Toxicity information for humans was only available from data collected through accidental exposures, and thus caused lethal dose values to be indeterminable.

Symptoms of rodenticide exposure include: bleeding, anemia, and fatigue (Fishel, 2013). Warfarin has been used in the past for a blood-thinning treatment on pregnant women; it has been shown to cause birth defects and is considered teratogenic (Fishel, 2013). Thus, it can be shown, that rodenticides can also have harmful impacts on humans.

The initial rodenticide production for the control of rodent populations is proven to cause concerns tonon-targeted wildlife and human health. Furthermore, since rodents became resistant to the first generation rodenticides, more toxic SGARs were introduced, causing additional concerns. Althoughthe knowledge of negative impacts resulting from SGARs to non-target wildlife are still lacking, it is known that low concentrations can cause hemorrhaging(Thomas *et al*., 2011). The known impacts caused by SGARs on non-target wildlife, in conjunction with its teratogenic effects on humans,corresponds to the objective that alternative methods to control rodent populations would be beneficial.

5.3.4 Background on Raptors

The NSWO is a small migratory raptor with a migratory range from the high altitudes of central Mexico to the southern tip of Alaska (Yan, 2001). They prefer to inhabit areas with dense vegetation and mature forests with an open understory for foraging. They also favor deciduous trees for nesting, dense conifers for roosting, and a close proximity to riverside habitat(Yan, 2001). Their breeding season is between March and July, and they are commonly found in Southern Vancouver Island (SVI). They are extremely efficient nocturnal hunters that mainly prey on deer mice, white-footed mice, shrews, harvest mice, and voles (Yan, 2001). For these reasons, the NSWO is the primary raptor of interest for this research.

The American Kestrel is the smallest, most common, and widespread falcon found in North America. Their geographic range is between the southern tip of South America and Alaska

(Townes, 2004). They occupy a wide variety of habitats and they prefer open woodland with sparse trees, deserts, and meadows. Their breeding season is between April and June, and they also feed on shrews, mice, and voles. However, their diet also consists of insects, snakes, and other birds (Townes, 2004). The American Kestrel is a secondary raptor of interest since their habitat varies from the NSWO; this is likely to be beneficial in locations where the habitat is not suitable for the NSWO.

Barn Owls are a common owl found throughout the northern United States to the southwestern areas of British Columbia (Bachynski& Harris, 2002). They are found in various habitats, such as rural and urban areas, as well as abandoned barns, buildings, and dense trees. They are nocturnal hunters and generally hunt in marshes and grasslands (Bachynski& Harris, 2002). Their diet is similar to the NSWO as they mainly feed on rats, mice and voles (Bachynski& Harris, 2002). For the same reason of habitat variation from the NSWO, Barn Owls will also be a secondary raptor of interest.

5.3.5 Background on Potential Ecological Sinks

There are concerns that implementing a nest box project may attract raptors to agricultural areas where pesticide use is common and predation risks may also be high, leading to impacts detrimental to raptor populations.

For the purpose of this report, the definition of an ecological sink is when an animal makes a poor choice to inhabit an area of poor quality, even when good habitat is available, which leads to a decrease in survival rates, reproduction, and overall fitness of the animal. (Isaac, Cooke, Lerodianconou, and White, 2014). The reasoning for this phenomenon is thought to be because sink habitats appear to be more attractive and animals fail to differentiate between good and bad habitat quality due to faulty environmental cues (Battin, 2004). One study found the following features were commonly connected to ecological sinks: presence of exotic predators, open habitats (fields, meadows, wastelands), and areas subject to anthropogenic influences (Suvorov &Svobodova, 2013). Another paper suggested agricultural fields could be associated with ecological sinks due to "the potential spread of disturbance agents like fire, pesticides, fertilizers, pests, diseases, and alien species" (Zaccarelli, Petrosillo, Zurlini, and Riitters, 2008).

Other concerns over potential ecological sinks include drawing raptor species into areas with dense predator populations. A sink could be formed by drawing the NSWO into areas inhabited by Barred Owls or Great Horned Owls (GHO), which are both known to prey on the NSWO (Yan, 2001). The Barred Owl has been directly associated with the decline in small owl species, such as the Western Screech(Acker, 2012).

At present, information pertaining to the details of the formation of an ecological sink is limited. It is also worthy to note that proving the existence of an ecological sink is difficult to achieve (Isaac *et al*., 2014). However, ecological sinks continue to be an important concept to be aware of throughout a nest box projectto prevent the decline of raptor populations.

5.3.6 Background on Rodenticide Regulations in Agriculture

The following section includes the current practices allowed for rodenticide use in agricultural settings, as well as how Health Canada controls the dispersal of rodenticides to limit potential harm to the health of humans and the environment.

Application & Mitigation Measures

In regards to controlling Norway Rats, Roof Rats, and House Mice using rodenticides, Health Canada mandates the following restrictions for application:

- Outdoor and aboveground rodenticide use, in and around buildings and structures, must be in a "tamper-resistant station" (TRS)(Health Canada, 2012a).
- Bait cannot be accessible to children, or non-target species (pets, livestock, non-target wildlife)(Health Canada, 2012a).
- Areas not needing a TRS include: slotted floor gaps, burrows, between walls, and feed bales or stock – when it doubt, a TRS should be used (Health Canada, 2012a).
- Residential and/or outdoor use of rodenticides with certain main ingredients and concentrated chemicals are now banned (Health Canada, 2012a).The various types of rodenticides and where their placement is allowed are outlined in Table 1.

- Commercial outdoor use of rodenticides bans the use of concentrated products that are diluted into solid or liquid bait (Health Canada, 2012b).
- For non-field uses, bait must be placed within 15 m of a structure and within 100 m if along a fence with a bait station secured to a surface (Health Canada, 2012b).
- Bait for field use can be placed anywhere in fields, rangeland, other crop, and non-crop areas away from buildings without a bait station - as long as the public and non-targets are not exposed (Health Canada, 2012b).
- Use of where and how a rodenticide product is to be use must be stated on product labels (Health Canada, 2012b).

TABLE 1:RODENTICIDE PRODUCTS ALLOWED TO BE APPLIED ON FIELDS AND FARM YARDS, AND OTHER COMMERCIAL SETTINGS IN ORDER TO CONTROL RATS AND MICE (HEALTH CANADA, 2012A).

Active Ingredient		Bait Form (i.e., liquid or solid)	Use Areas			
			Indoors	Outdoors around buildings/ structures[1]	Landfills (garbage dumps)	Other outdoor areas (e.g., crop land, fields, nurseries)
Non-Anticoagulants	Bromethalin	Solid	✓			
	Zinc Phosphide	Solid	✓	✓		
First-Generation Anticoagulants	Warfarin	Solid	✓	✓		
	Chlorophacinone	Solid	✓	✓	✓	✓
	Diphacinone	Solid	✓	✓	✓	✓
		Liquid	✓			
Second-Generation Anticoagulants	Brodifacoum	Solid	✓			
	Bromadiolone	Solid	✓	✓		
	Difethialone	Solid	✓			

COMPLIANCE MONITORING

The Pest Management Regulatory Agency (PMRA) of Health Canada is responsible for promoting compliance of pesticide regulation in Canada by the following methods:

- Investigations and consulting over: the sale and product importation of rodenticides; on-site inspections detailing the usage and storage of rodenticides; and sampling soil, crop, and product to determine rodenticide levels.
- Educating individuals and local officials and growers.
- Issuing legal enforcement when deviations to Pest Control Products Act and regulations occur.

In British Columbia, the Ministry of Environment, Land, and Parksare responsible for issuing permits and classifying proper use of rodenticides(Health Canada, 2009).

6.0 METHODS AND MATERIALS

6.1 METHODOLOGY

Primary nest box data was collected from the boxes installed at the host farms. The habitat of the farm and its vicinity to man-made structures, such as a roadway, was taken into consideration during nest box installation. The boxes were monitored weekly and observation datumwas recorded. Interviews were also conducted to collect data on the social aspect for this research as well as additional raptor and rodenticide information.

6.1.1 NEST BOX PLACEMENT

Nest boxes were set up for NSWOs and American Kestrels; they were placed with multiple factors in mind, including: the species being selected for, the target species' preferred environmental conditions, and proximity to predators of the target species. The specific factors taken into consideration for each species were:

NSWO

- All nest boxes for NSWOs were placed facing a northern direction for protection from harsh weather exposure and to limit pesticides from being blown into the boxes from the surrounding agricultural area.
- NSWO prefer mature trees in closer proximity to dense stands (Migration Research Foundation Inc., 2014).
- Boxes were placed approximately 1.6 m above ground level.
- Trees were chosen with little to no branches near the base of the trunk in order to limit accessibility by other animals, such as raccoons and squirrels.
- Trees were also selected based on proximity to flyways and closeness to the edge of stands.

American Kestrels

- Locations chosen for American Kestrels were at the edge of dense tree stands next to open fields.
- The nest boxes were placed approximately 3 m above ground and on trees with few low hanging branches.

6.1.2 Nest Box Locations and Descriptions

The following section describes the locations of each of the nest box host sites, as well as information on the ecology. Nest boxes were set up at four locations on February 28, 2014 and were removed on July 22, 2014.

Location 1 - Mount Newton Seed Orchard (MNSO)

Three nest boxes were installed. Nest box placement was dependent on trees and areas that were perceived to encourage NSWO uptake. The orchard consists of highly managed groves of Douglas fir, Western Red cedar, Western White pine, and Western hemlock. The property has a large hill with a south-facing slope. Robins, crows, starlings, Red-winged blackbirds, chickadees, geese, and Red-tailed hawks have been seen on the property along with mice, voles, rats, rabbits, and deer.

Box 1: Set up on the top of a hill in a grove of pine trees planted by the farm.
Box 2: Located on same hill as Box 1, next to a small reservoir.
Box 3: Located at the bottom of the hill in a cedar grove.

Location 2 - Sea Cider Farm & Ciderhouse

This farm is located near a highway in the Saanich peninsula. Red-tailed hawks were expected to nest in this location as indicated by landowner observations and the presence of Red-tailed hawk eggs. Representatives from RPBO advised that the Red-tailed hawk is a natural predator of the NSWO; however, they would not be a problem for the American Kestrel (A. Moran, personal communication, February 28, 2014). Furthermore, robins, crows and starlings were also observed around the property. The landowner also witnessed mice, voles, deer, and rabbits frequently in this area.For these reasons, a nest box was placed to encourage American Kestrel uptake.

Box 4: Located at the edge of a densely forested area with the opening of the box facing the adjacent apple orchard.

Location 3 - RRU

Two boxes were set up to promote NSWO uptake. Low traffic areas were also chosen to prevent disturbance to the boxes. Two distinct ecological areas were chosen for each nest box. Both areas are expected to contain similar species, including: mice, voles, rats, deer, Bald eagles, Golden eagles, Barn and Barred owls, as well as various passerine birds.

Box 5: Located on top of a hill in a wooded area adjacent to walking and deer trails containing Douglas fir, cedar, Scotch broom, and Daphne.
Box 6: Located in a vernal pool on the southeast end of campus containing large amounts of Skunk cabbage and horsetail.

Location 4 - Saanich Seed Orchard

This property has two distinct ecological areas; one well-managed area of cotton, Western Red cedar and pine trees, and one more natural area made up of Western Red cedar, Douglas fir, Scotch broom, Daphne, Stinging nettle, and Himalayan blackberry. Two boxes were installed; an American Kestrel box in the well managed area on a cotton tree and a NSWO box in the forested area. Red-tailed hawks, Bald eagles, turkey vultures, mice, voles, rabbits, and raccoons were all noted in the area.

Box 7: Located higher up in a cotton wood tree in the well-managed area.
Box 8: Located lower on a Douglas fir tree at the edge of the forested area facing an open field.

6.1.3 Nest Box Monitoring

Nest boxes were monitored on a weekly basis for uptake. A description of the methods used to monitor nest boxes was developed early on in the project as a separate document, which can be found in Appendix I.

6.1.4 Research Methods

- Interviews were conducted by phone or in person and addressed questions outlined from the 'Landowner Interview Questions', 'Rodenticide Expert Interview Questions', and 'Avian Expert Interview Questions' documents listed in Appendix II.
- Current rodent control practices and issues faced by various agricultural stakeholders in southwest BC were identified.
- Economic impacts of rodents on agricultural operations were analyzed.
- Pest species causing problems on farms were identified.
- The environmental and economic effects of the rodenticides used on farms were determined.
- A "Monitoring Nest Box Protocol" was adapted from Blue Point Conservation Science (2014) for collection of data from nest boxes on landowner property, including: nest box uptake, amount of rodents in boxes, and rodent-caused damage.

6.1.5 Owl Pellet Dissection

Barn owl pellets were acquired from a barn opposite to the MNSO location. These pellets were dissected to derive an impression of the type of prey located in the area.

- Fifteen pellets were dissected in total.
- The pellets were dissected using scalpels and tweezers.
- Bones found in pellets were compared to the "Bone Sorting Chart" identification key found in The "Perfect Pellet" Kit Guide, located in Appendix III, to determine the type and size of prey species.

GHO pellets were acquired from an area off Grousewood Road in Colwood. These pellets were dissected to derive an impression of the size of prey being consumed by larger owl species.

- Three pellets were dissected in total.
- The pellets were dissected using scalpels and tweezers.
- Bones found in pellets were also compared to the same identification key as the Barn owl.

6.2 MATERIALS

6.2.1 Nest Box Construction

This section describes the materials used to build the nest boxes. Nest boxes were constructed by Brian Kemper based on bird box instructions found in Appendix IV.

- Pinewood used for nest box construction.
- White pine and arbutus shavings used for nesting material.
- Hinged top for easy access.
- Metal latch added to prevent scavengers.
- 16 bungee cords (2 for each box) used for installation.
- Nest box dimensions include:
    - 2.54 cm thick wood panels
    - 7.62 cm diameter entry hole
    - 35.56 cm entrance hole height above floor
    - 17.78 cm x 17.78 cm floor dimensions
    - 40.64 cm difference between floor to ceiling
    - 5 drainage holes in the floor and ventilation holes on box sides.
    - Exterior surface of the nest boxes left rough to look weathered.
    - The inside front of the boxes grooved to aid the young in climbing up to the entry hole.

6.2.2 OWL PELLET DISSECTION

Lab equipment used to analyze bird pellets are as follows:

- Autoclave
- Petri Dishes
- Thumb Forceps
- Tin Foil
- Paper Towels
- Latex Gloves
- Identification Key

6.2.3 Nest Box Monitoring

Field equipment used for monitoring nest boxes are as follows:

- Vehicles
- Nylon Rope
- Cloth/Sock
- Step Ladder
- 2.4 m Ladder

7.0 RESULTS

7.1 NEST BOX DATA

This section refers to the data collected during the nest box-monitoring component of the project, as described in the Nest Box Observation document, which is located in Appendix V, and includes such data as:

- Dates of uptake
- Uptake numbers
- Location
- Number of eggs observed
- Site/nest box observations

7.2 INTERVIEW DATA

Qualitative results collected through interviews from participating landowners, avian experts, and rodenticide experts are used to answer the research questions of this project. The findings from these interviews have aided in providing information that would most likely not exist in the literature review or background research.

LANDOWNERS

Preliminary data suggests some common themes between the landowner's pest issues. Few complaints were noted with regards to damage to goods and infrastructure from smaller rodents, such as vole and mice, with greater concern emphasized for rabbits, geese, and deer.

Most landowners seemed content with the effectiveness of their current method of pest control, but all were willing to consider raptors as an alternative, including the landowners currently using rodenticides. All landowners using rodenticides estimated costs associated to rodent damages to be negligible. They estimate $100 to $500 a year in damages and their primary concern is the time required in repairing equipment or infrastructure.

RPBO Avian Expert Interview - Ann Nightingale

Ann Nightingale suggested a low year in the natural four year population cycle of NSWOs as part of the reason for the lack of uptake found in the this study. She also pointed out that little is known about the four-year cycle except that it has lots of variability; however, it is expected that the population will be increasing over the next three years and she recommended running similar projects for the entire four year cycle in order to collect more data to discern a pattern.

While discussing other possible reasons for lack of uptake, Ann Nightingale did not believe that putting boxes up earlier than mid to late February would be beneficial since the boxes would likely be taken over by earlier nesting birds, such as Northern Flickers. She also suggested keeping the boxes up until June since the latest uptake of target species in this area would likely be in late May or early June.

Ann Nightingale remarked on how at BTF, NSWOs abandoned the nest shortly after, presumably due to a lack of wood chips in the nest box. For the current study, at least four inches of wood shavings were placed in each of the boxes and were replaced each week during monitoring; a lack of wood chips is not expected to have played a factor in uptake rate.

Some differences between the ecology of BTF and this study location were identified in the interview with Ann Nightingale. Boardman, Oregon has an abundance of sagebrush and prairie savannah and is surrounded by wheat and brush farms. There is limited usable vegetation for raptors for many kilometers around it. This causes BTF to act as an oasis for migrating birds such as the NSWO. The Poplar trees in BTF likely act as a windbreaker from the high winds that build up in the flatter surrounding areas. According to Ann Nightingale, this could explain the unusually high uptake numbers BTF has experienced over the years.

SVI should be more attractive to NSWOs compared to BTF, since the forests in SVIare more consistent with their preferred habitat. SVI has an abundance of trees with cavities of desired size for NSWO nesting. Ann Nightingale also suggested that the greater human presence on SVI in comparison to BTF could be a possible factor in the differences of uptake number between the two areas.

In order to suggest another type of raptor to use for a similar study, the risks of increasing another raptor's population numbers must be assessed. The effect of an alternative raptor species on other birds and mammals will need to be examined. An understanding of the risk to other species must be obtained before any species is encouraged.Ann Nightingale suggested both Barn and GHOs as two possible species that could have potential for use while attempting to target larger prey species. Barn owls have the ability to uptake larger prey up to the size of small rabbits; therefore, would be suitable to meet the needs of farmers that have problems with larger rodents. The GHO is larger than the Barn Owl, hence, hunt for larger prey. GHOs do not use nest boxes; instead, they take over the nests of other birds such as crows but are fairly flexible in the type of nest they occupy. Ann Nightingale suggested that constructing wire nests with twigs weaved into it can attract GHOs. Ann Nightingale pointed out that GHOs have been known to eat Barred owls, a fact that would need to be considered if one decided to attempt to increase their population numbers. When informed of our chickadee uptake at MNSO, Ann Nightingale made an interesting comment that, as far as she knows, no nest box project has ever found chickadee uptake in their owl boxes before.

RODENTICIDE EXPERT – SOFI HINDMARCH

Sofi Hindmarchsuggests that the actual threshold dose of rodenticide for rats and other target species is unknown. Furthermore, rodent'sresistance with SGARs is beginning to develop in European countries.

The most common rodenticides detected in owls in the interior of British Columbia werebrodifacoum and bromadiolone. The concentrations of rodenticides detected in owls ranged between 0.001 and 0.927 mg/kg, and 0.002 and 1.012 mg/Kg of brodifacoum and bromadiolone, respectively. Acceptable thresholds for rodenticides in owls have not been determined; however, the interview data suggested that the threshold concentration may be as high as 100 to 200 mg/kg. This value was much higher than expected and conflicts strongly with data found throughout the literature review.

Rodents ingesting rodenticide concentrations beyond their lethal dose is a major concern for raptors. Rodents may survive for several days or weeks after ingesting a lethal dose; furthermore, they may continue feeding on the rodenticide for several days after the original dose. When rodents are exposed to rodenticides they exhibit an altered state of behaviour. This altered state may consist of: spending more time in open areas, staggering, and sitting motionless before death. This altered state of behaviour allows raptors to hunt them with greater ease and as a result, increasing the transfer of rodenticides into non-target species that prey on rodents.

Sofi Hindmarchadvised that the levels of rodenticides found in raptors have been consistent for some time andnot to be concerned with causing an ecological sink. Sofi Hindmarchsuggested thatat present, there is not enough information and recommended more research to collect additional data.

7.3 OWL PELLET DATA

Barn owl pellets were obtained from below a Barn owl nest across the road from one of the host farms. Fifteen pellets were dissected in the lab and the contents were identified to distinguish rodents from shrews and birds using a general identification key. Both rodents and shrews were identified from skeletal remains in the pellets with numbers of 28 and 14, respectively.

GHO pellets were obtained from below an area on Grousewood Road in Colwood. The dissection of three pellets revealed three rodents that were estimated to be three times the size of the rodents from the Barn owl pellets based on comparisons of hip bones and hind legs.

8.0 DISCUSSION

8.1 ENVIRONMENTAL AND ECONOMICAL COST OF RODENTICIDES

Rodenticide regulations have recently been improved as of 2013 and the Pest Management Regulatory Agency promotes compliance of pesticide regulations through multiple initiatives to help reduce environmental costs; however, the effectiveness of these regulations hasnot been thoroughly researched (Health Canada, 2009; Health Canada 2012a; Health Canada, 2012b). The primary environmental concern for this study is the effects that rodenticides have on non-target species, specifically, raptors that prey on rodents. Ann Nightingalesuggested rodents that ingest amounts above lethal doses result in themselves being an ideal prey target; more importantly, this would transfer a greater amount of rodenticides to the non-target raptors. The lethal rodenticide concentration for raptors was said to vary and presently, research data is scarce. Studies performed byrodenticide experts in the interior of British Columbia concluded that the concentrations found in raptors were potentiallywell below lethal concentrations. This suggested that the amount of rodenticides currently used in British Columbia may not have a severe effect on raptors. However, due to the lack of data, additional research needs to be conducted to collect more information on this topic.

The interview data suggested that economic impacts of rodenticide use are considered to be minimal. Landowners that use rodenticides as a form of rodent control generally spend about $100 per year. However, the economic impact caused by rodents was shown to be more costly and created an inconvenience to the landowners. When incorporating the time it takes to locate and repair rodent-caused damages, the damage may be valued up to $500 per year. The cost of damages may increase substantially during years of heavy rodent infestation or if rodent populations are not regularly controlled. As conveyed by one landowner, incidents of heavy rodent infestation may result in crop failure,which would likely cost up to thousands of dollars; however, it was also indicated that this is not a probable situation.

8.2 Raptors as a Viable Alternative for Rodenticide Use

Due to the absence of uptake by raptors in nest boxes, the viability of raptors as an alternative to rodenticide use was assessed using interview and pellet dissection data as well as a literature review.

Interview data suggested that farmers in the area use rodenticides mainly to control larger rodents, such as rats. Larger rodents will likely be too large for the target raptor species (NSWO and the American Kestrel); however, the pellet dissection data showed that smaller rodents are present in the area and are being successfully being preyed upon by Barn owls.

The literature review showed some success in using raptors as an alternative to rodenticides at BTF, which was a similar project but on a much larger scale. The data suggested that although smaller rodents are in the area, the main issues landowners were having with pests came from the larger rodents, such as rats and rabbits. For this reason, it is likely that the target raptor species are too small to be an effective alternative to rodenticides in the area. A number of GHO pellets were collected from the Colwood area and dissected. Data collected from the pellets showed that this larger owl species tends to prey on larger rodents, as demonstrated by hip and hind leg bones that were approximately three times the size of the samebones of rodents found in Barn owl pellets. This data could be used in recommending larger raptor species to prey on the larger rodents,which was identified as a major issue for landowners during the interview process.

8.3 Ethical Questions and Potential Ecological Sinks

A literature review and two interviews have been used to assess whether or not it would be ethical to attract raptors using nest boxes to SVI over concern of forming an ecological sink.

Multiple papers recognized open and human-modified areas, such as agricultural fields and urban areas, to be most commonly associated with ecological sinks due to multiple disturbance factors, such as pesticides, fertilizers, and exotic predators (Suvorov and Svoboda, 2013; Zaccarelli*et al.*, 2008). There is potential for SVI to form ecological sinks, as the region contains many agricultural fields and open urbanized areas. The region is also newly inhabited by the Barred owl, and though it is not an exotic species, since the population has naturally expanded from the east, it shares the same generalist tendencies common to many exotic species (Government of Canada, 2007; U.S. Fish and Wildlife Service, 2012). There is a concern that the Barred owl could be the cause of a sink for the NSWO, as it has been linked to major declines in the Western Screech owl due to predation (Acker, 2012). Based on this research, it appears that there is potential for an ecological threat to form; however, determining whether or not an ecological sink is occurring is difficult to achieve (Battin, 2004; Isaac *et al*., 2014).From the data gathered from the literature, no distinct conclusion can yet be made that connects an owl nest box project to the creation of an ecological sink.

Experts were also questioned about the potential for an ecological sink to occur. It could not be conclusively stated if an ecological sink would form from establishing an owl nest box project as an alternative to rodenticides. In regards to whether it would be ethical to set up nest boxes, somewhat contrasting views were provided. Some cautions were advised upon implementing this project and it was suggested that an understanding of the risk to other species must be obtained before any raptors are encouraged. However, it was also suggested that not enough data are currently available to determine if a sink would occur, and it was recommended that the study be continued to allow for further data to accumulate.

Based on the information provided by the interviews and the literature review, there appears to be potential for the formation of an ecological sink, but the likelihood of one occurring is difficult to determine. Whether it is ethical to implement the project, in spite of the potential to create an ecological sink, also appears to be a difficult question to answer, without trial and error experimentation. It should also be asked whether or not this situation calls for the use of the Precautionary Principle.

8.4 FACTORS INFLUENCING NORTHERN SAW-WHET OWL UPTAKE

According to background research on the NSWO, the owls prefer areas of old growth and dense vegetation(Yan, 2001);however,looking at the study done at BTF in Oregon, successful uptake of the NSWO occurred in trees that were a minimum of six years old with little to no branches or leaves, according to Ann Nightingale. These findings support the NSWO preference for mature trees, but the denseness of vegetation surrounding the area varies. From the interview with Ann

Nightingale, a reason for the successful uptake in Oregon could be the location of the farm. NSWOs are migratory birds and BTF is located on their migratory path; the poplar farm could have been seen as a safe-haven for the NSWO. Even though there are a few trees in the surrounding areas and the climate is dry at BTF,Ann Nightingale suggests they are still drawn to the area because there are limited alternative places for the NSWO to go. Although no uptake of the NSWO was observed in the study areas, there are many suitable habitats for them on SVI.

The results of the data gathered are still inconclusive because there are many other factors that could influence successful uptake. BTF has conducted their NSWO study since 1999 and are still unsure of the exact population cycle. According to Ann Nightingale, NSWOs are believed to be on a fluctuating four-year cycle, which could in part be influenced by rodent populations. Although BTF farm is maintained and has a fairly stable climate, the rodent population still fluctuates for unknown reasons. Another important factor that Ann Nightingale stressed to consider is that small farms may see a difference in rodent populations, but most farms have an acceptable rodent threshold. It is likely that owl populations would not impact prey populations extensively, but may bring the prey population to an acceptable number. From this data, it can be understood that certain factors, such as nest box location and rodent densities are important for influencing raptor uptake. It is also important to recognize that low NSWO uptake may occur in ideal conditions, but this could be more related to a low year in their population cycle.

9.0 RECOMMENDATIONS & CONCLUSION

9.1 RECOMMENDATIONS

The following recommendations include initiatives to increase the possibility of a successful raptor nest box project, such as educating the public in regards to rodenticide use and implications, suggesting alternative raptor species, and ways to monitor risk that may be inflicted upon the targeted raptor species.

9.1.1 IMPROVEMENTS TO INCREASE UPTAKE

The following recommendationsare intended to build on the pilot study and include suggestions to increase uptake of raptors in the nest boxes as per advice from bird experts and from observations gathered throughout the duration of this project:

- It is suggested to place nest boxes on poles. It has been reported that higher rates of raptor uptake, particularly with owls, may occur when nest boxes were attached to poles (Hindmarch, S., personal communication, June 2014). Additionally, it has been recognized that the tree stands at BTF resemble poles in that they contain few branches, which could possibly be linked to the success BTF has experienced.
- Installing more nest boxes is advised to increase the probability of uptake. BTF used over 120 nest boxes and, on a low cycle year, would sometimes only have 11 uptake events.
- If possible, it is recommended to check nest boxes at least twice a week prior to uptake, as this will help aid in preventing uptake from non-target species.
- It is also suggested that nest boxes be put up slightly earlier than what was done in this pilot study if future nest box initiatives were to continue focusing on the NSWO. However, boxes should not be put up too early, as it increases the odds of uptake occurring by non-target species, for example, the Northern Flicker (Nightingale, A., personal communication, July 2014). The first week of February is the recommended period for initial nest box installation for the NSWO. For other raptor species, nest boxes should be installed at the beginning of the raptor's nesting period.

- Another recommendation to determine the viability of the NSWO would be to continue the study throughout their four-year cycle to develop a pattern and measure the changes in peak years compared to low, of the cycle; future years may produce successful uptake.

It is important to realize that uptake may still not occurin areas that meet the habitat conditions for the NSWOs. There are many unknowns in this type of study so it is important to collect as much data as possible. An important question to keep in mind is how the attraction of the NSWO would benefit these areas ecologically.

9.1.2Matrix for Success

It is recommended to use and build on this basic Matrix for Success to help collect and analyze nest box data in future projects. Due to the lack of raptor uptake in the pilot study, it was difficult to develop a detailed Matrix for Success. However, the following indices have been established as important measurements for tracking if the nest boxes are attracting and sustaining raptor populations and decreasing rodent populations:

- Amount of nest box uptake
- Amount of abandoned boxes
- Total rodent numbers found in nest boxes
- Estimate of rodent-caused damage each year
- Number of eggs laid
- Number of eggs hatched
- Number of chicks fledged
- Amount of returning raptors

This data would be gathered annually and compared to subsequent years for trends. Additionally the amount of prey found in the boxes and the amount of rodent-caused damage would be correlated. A continual trend of greater raptor numbers, lower prey items, and lower rodent-caused damage over time, would indicate that the nest box project has been successful.

9.1.3 Rodenticide Education

The interview results provide evidence that landowners are receptive to the idea of installing nest boxes for the use of raptors as a biological alternative to rodenticides. However, the landowners' interestswere determined to be a result of their curiosity of the projectrather than a genuine interest for reducing rodenticide use. The landowners in many cases were unaware of the type of rodenticides they used and its effects. Furthermore, rodenticides are inexpensive, effective, and easy to use, therefore, a practical option for rodent control. In order to promote a genuine interest in a biological alternative to rodenticides, public education is essential.If education on how to properly use them was enforced it would decrease the possibility of harming non-targeted species. If they knew the side effects, effectiveness or lack thereof, such as built up resistance overtime, an alternative could seem more appealing, stable, and safe. It would be beneficial to educate landowners on the environmental and human health effects of rodenticides. It would also be valuable to guide landowners on how biological alternatives may be incorporated into the British Columbia Integrated Pest Management Plan.

9.1.4 Larger Raptors

Data collected from interviews with local landowners has shown to be less of a problem with smaller rodents, such as deer mice and voles, than anticipated. Landowners in the area have consistently stated that larger rodents, such as rats and rabbits, are the main pests of concern in relation to this project. For this reason, recommendations were based around trying to reduce the number of the aforementioned larger rodents. One recommendation for reducing larger rodent numbers would be to encourage higher population levels of larger raptors in the area. While making this recommendation, the ecological effects of attempting to increase the population size of certain species needs to be considered. In order to suggest another type of raptor for this study, the effect of the alternative raptor species on other birds and mammals of the study area will need to be examined carefully. An understanding of the risk to other species must be obtained before any species is encouraged in order to prevent ecological damage. Through an interview with an avian expert, it was determined that there is only one reasonable alternative raptor, the GHO, could be used for future studies in the area, providing that the risk to other species in the area is identified first.

GHO are very large owls and can take large prey, including rabbits. GHO do not use nest boxes, so the study would have to be modified to accommodate the new possible species. GHOs tend to take over existing nests, such as the nests of crows, but are highly flexible in the type of nest they can occupy. A study using GHOs as the raptor of choice would need to encourage owl uptake by constructing wire nests and weaving twigs into them.

Since interview data has shown that larger rodentsare more of a concern to local landowners;one possible recommendation would be to switch the current target raptor species to something larger that can handle the bigger rodents. The GHO has been identified as a possible alternative raptor; however, research needs to be performed to determine the ecological risk of increasing the population numbers of this species in the area.

9.1.5 Risk Monitoring

To increase our understanding of the likelihood of creating an ecological sink, it is advised that the impacts of pesticides on raptor populations be considered when implementing a nest box project. Should additionalowl nest box projects be implemented,it is recommended that the pesticide levels in raptors be measured through blood samples and that raptor populations betracked throughbanding initiatives. Collecting this data throughout the duration of a nest box project would contribute to the current knowledge base regardingecological sinks and improve the understanding on the probability of their occurrence.

9.2 Conclusion

The viability of using raptor nest boxes in SVI as an alternative to rodenticide use in agriculture has been assessed. Based on literature reviews, nest box observations, owl pellet dissections, and interview results, the economic and environmental costs of rodenticides have been described. It was found that many of the landowners in SVI are mainly experiencing rodent issues from larger rodents, such as rabbits and rats. Additionally, the damages caused by the rodents were seen to be more costly than the cost of purchasing rodenticides. The types of rodenticides used for pest control by the landowners were usually not specified, but the costs were said to be minimal, averaging around $100 per year; however, damages to farm products and infrastructure can range from hundreds to thousands of dollars each year depending on the level of rodent infestation. In regards to environmental costs, specific impacts to non-target species from secondary exposure to rodenticides were difficult to determine given the lack of information available pertaining to lethal exposure limits. As well, the current Health Canada regulations and restrictions pertaining to rodenticide use have recently been revised to reduce potential risk to non-target species. How strictly these regulations are followed and enforced is not known as it falls outside the scope of this project. Due to the lack of nest box uptake, it is difficult to determine whether the desired raptor species would control the rodent numbers to a desirable level. However, the landowners appear to be genuinely interested in this project, and Ann Nightingale suggested that continuing this research throughout the NSWO four-year population cycle may provide valuable information; therefore, further research would be beneficial. Whether it is considered ethical to attract raptors to the areas where an ecological sink is possiblewas considered questionable. It was determined that caution must be exercised if the project is to expand and continue into future years due to the lack of available information. Multiple recommendations have been made to encourage and enhance the use of raptor nest boxes in place of using rodenticides in agriculture, such as, increasing the amounts of raptor nest boxes, fostering public education, and using larger raptors as an alternative to the NSWO. Building on the basic Matrix for Success,whileusing raptor nest boxes, was also included as a recommendation, which outlines indicators essential to determining the success of future raptor nest box projects.

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11.0 APPENDICES

APPENDIX I - MONITORING NEST BOX PROTOCOL

Approaching the nest box:

Approach the nest box area slowly and quietly so as to not startle potential inhabitants. Carefully listen for any movement. If initial movement is heard within the nest box, please contact Michel France at 250-888-3709 or michel.france@royalroads.ca

Checking the surrounding area:

	Observation of owl pellets
	Observation of displaced wood shavings (this signals the presence of Flickers*)
	Other observations: ____.

Checking inside the nest box:

1. Prior to opening nest box, stuff opening with a sock (with minimum 15 ft. string attached) to ensure any raptor inside cannot escape. Leave the box alone for 10 minutes so as to not alarm the raptor.

2. Pull down spring latch and carefully open hatch to check for uptake:

    a. If grass observed in nest box, take out of box (this signals the presence of Starlings*).
    b. If raptors are observed in nest box, close hatch quietly and wait approximately 5 minutes until the raptor has settled.

3. Extend string to its limit before pulling the sock out.

4. Please contact Michel France by either phone or email as stated above.

* It is important to regularly check for signs that starlings or flickers may be occupying the nest boxes. Once uptake has occurred by any bird species, it is often illegal to disrupt the nests.

Section 34 of the Wildlife Act explicitly states that a person commits an offense if a person handles any birds or eggs. Please visit http://www.bclaws.ca/ for more information.

Excerpt from Wildlife Act [RSBC 1996] Chapter 488 – Section 34

Birds, nests and eggs

34 – A person commits an offence if the person, except as provided by regulation, possesses, takes, injures, molests or destroys

(a) a bird or its egg,

(b) the nest of a bird not when the nest is occupied by a bird or its egg.

APPENDIX II – INTERVIEW QUESTIONS

LANDOWNER INTERVIEW QUESTIONS

1. What is the approximate size of your farm?
2. What does your farm produce?
3. What is the growing season for your product(s)?
4. What time of year do you notice most rodent pests?
5. What kind of rodents?
6. What kind of damage is being done to your farm by rodents or other small pests? (ex. infrastructure, produce, feedstock)
7. What is the approximate cost of the damage yearly?
8. What is your current method of pest control?
9. If you use rodenticides (rat poison), what kind do you use? How do you apply it?
10. Do you have any concerns with using rodenticides?
11. How much do you spend annually on rodenticides?
12. How much do you spend on other methods of control?
13. How efficient do you feel your current method(s) is/are?
14. Have you considered using a biological alternative to pest control, such as owl nest boxes?
15. Do you have issues/concerns with using birds of prey as an alternative to rodenticides?
16. Do you notice birds of prey on the farm? Do you happen to know what types?
17. Do you know anyone else that might be interested in interviewing with us about this topic?

RODENTICIDE EXPERT INTERVIEW QUESTIONS

1. What do you think of the feasibility of alternatives to rodenticide use?
2. Do you foresee any potential problems with uptake of raptor based pest control?
3. What are sustainable limits of rodenticides in birds/ owls?
4. What kinds of rodenticides are being used most?
5. Which agricultural sectors have the most intensive rodenticide use in B.C.?
6. Do you feel there is potential for an eco sink while using raptors as an alternative to rodenticide (via ambient rodenticide levels)

7. Are you aware of good sources we can use to find sources of information on the usage of rodenticides in BC and the effects of those rodenticides in the receiving environment?
8. Are we seeing resistance to second generation rodenticides?
9. How much rodenticide is needed to kill and average size deer mice, other mice we are concerned with?
10. How long does it take at that dosage to kill them?

Avian Expert Interview Questions

1. Which raptors could you see being successful alternatives in this area?
2. Do you have any ideas as to why we didn't get uptake?
3. Other similar projects and their successes/failures?
4. Saw-whet cycle?
5. Updates about Boardman project this year?
6. How long has Boardman been studying saw whet; did you see success immediately? (How long was success? timeframe for project, when should we stop our project, better area?)
7. What time of year do you set up and clean out boxes?
8. What are some of the differences you see between Boardman and here?

APPENDIX III - Identification Key for Various Rodents

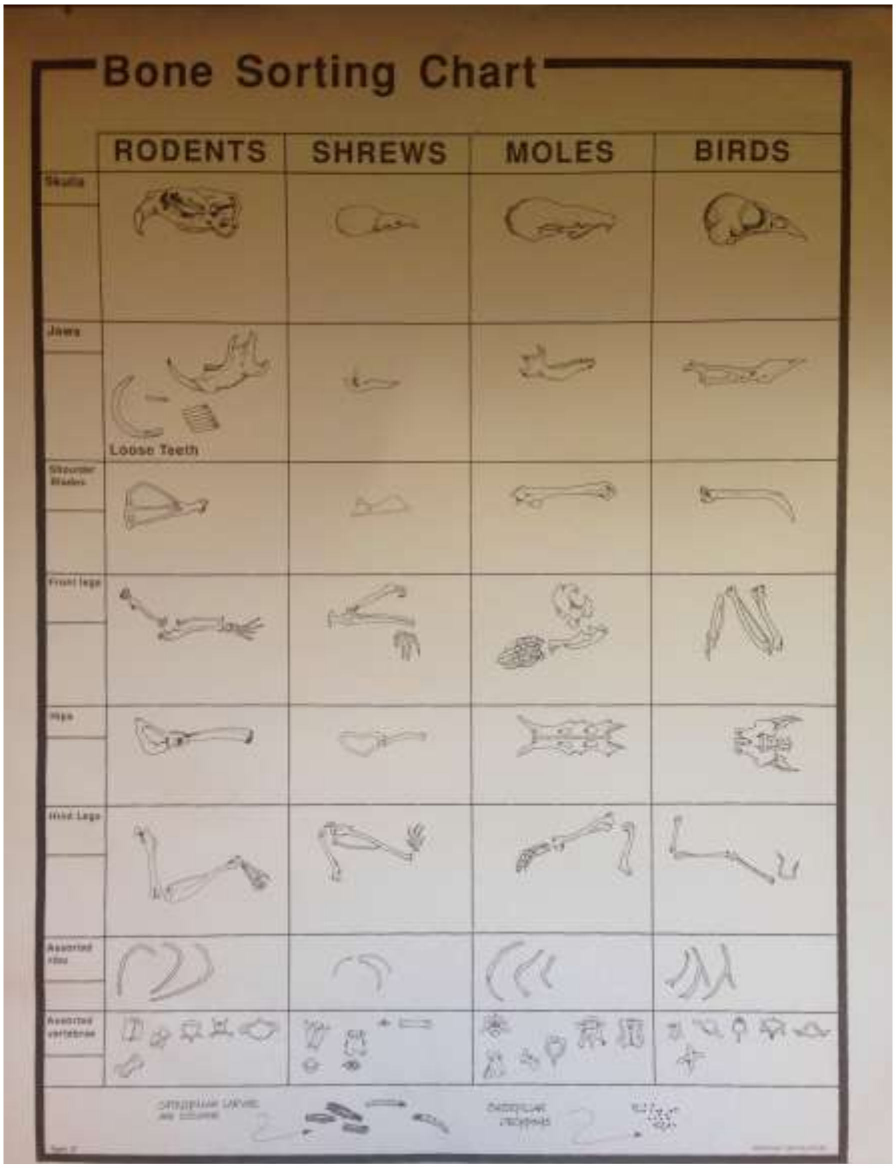

FIGURE 1: IDENTIFICATION KEY FOR VARIOUS RODENTS, SHREWS, VOLES, AND BIRDS TAKEN FROM THE "PERFECT PELLET" KIT GUIDE TEACHER'S GUIDE PROVIDED IN THE LAB AT ROYAL ROADS UNIVERSITY.

APPENDIX IV - NEST BOX CONSTRUCTION

Important nesting & nest box information for cavity nesting owls

	Western Screech-Owl	Barn Owl	Northern Saw-whet Owl
Entrance hole diameter	3″	6″	2″
Entrance hole height	12″ above floor	Near floor	14″ above floor
Floor dimensions	8″x8″	10″x8″	7″x7″
Distance from floor to ceiling	15″	16″	16″
Mounting height for box	10′ or higher	12′ or higher	10′ or higher
Number of eggs laid	2-5	5-7	5-6
Color & size of eggs	White; 1.4″	White; 1.7″	White; 1.2″
Egg Incubation Period (days)*	21-30	30-34	27-28
Chick-rearing Period (days)*	28	52-56	27-34

*Owls have a long breeding cycle (nest building, egg laying, incubation, and chick-rearing) that lasts 2-3 months.

FIGURE 2: DIMENSIONS REQUIRED TO BUILD NEST BOXES FOR VARIOUS RAPTORS, FOCUS IS ON NSWO. TABLE TAKEN FROM THE POINT BLUE CONSERVATION SCIENCE WEBSITE(POINT BLUE CONSERVATION SCIENCE, 2014).

APPENDIX V - NEST BOX OBSERVATIONS

Table 2 shows the dates, site locations, site observations, and box observations. Eight nest boxes were built and installed at RRU, MNSO, SCFC, and SSO by February 28, 2014. There were nosigns of uptake or box disturbance at any nest box location at the end of quarter 2. Uptake occurred in 2 out of the 8 nest boxes. A chickadee nest with 7 eggs and a chickadee with no nest were found at MNSO on May 13, 2014. Seven hatchlings in the chickadee nest at MNSO were observed on 27 May 2014. Starling nests were evicted multiple times at various locations. The nest boxes were checked weekly.

TABLE 2: SUMMARY OF WEEKLY NEST BOX OBSERVATIONS HIGHLIGHTING PERIODS OF HIGH ACTIVITY ANDCHANGES IN VEGETATION.

Date	Site location	Site observation	Box observation
28-02-2014	RRU, MNSO, SCFC, SSO		8 boxes installed
Week 11-03-14 to 22-04-14	RRU, box 5	Muddy, vernal pool, Skunk cabbage, no wildlife	No sign of disturbance
	RRU, box 6	Dry, no wildlife, Daphne, Scotch broom	No sign of disturbance
Week 29-04-14 to 06- 05-14	MNSO, box 1	No sign of debris, pesticides sprayed on farm	Feathers (chickadee)
	MNSO, box 2	Shavings outside box	Feathers (chickadee)
	MNSO, box 3	Shavings outside box	Starling nest (evicted)
	SCFC, box 4	Shavings outside box	Starling nest (evicted)
	RRU, box 5	Approx. 4ft horsetail, holly	No sign of disturbance
	RRU, box 6	No sign of debris, Daphne	No sign of disturbance
	SSO, box 7	Shavings outside box	Starling nest (evicted)
	SSO, box 8	No debris outside box	No sign of disturbance
13-05-14	MNSO, box 1	No debris outside box	Chickadee observed
	MNSO, box 2	No debris outside box	7 white eggs, chickadee
	MNSO, box 3	No debris outside box	No sign of disturbance
	SCFC, box 4	No debris outside box	Starling nest (evicted)
	RRU, box 5	Approx. 4ft horsetail, holly	No sign of disturbance
	RRU, box 6	No debris outside box	No sign of disturbance
	SSO, box 7	No debris outside box	No sign of disturbance
	SSO, box 8	No debris outside box	No sign of disturbance

APPENDIX VI - PROJECT AGREEMENT

Biological Alternatives to Rodenticides in Agriculture

Currently, farmers and landowners require environmentally harmful chemical rodenticides for pest control.A proposed biological alternative is to use the natural predator - prey relationship between raptors and rodents. Rocky Point Bird Observatory (RPBO) is interested in the feasibility of this proposal. As a result, Aves Alternatives has been recruited to assist in the research portion of a pilot study; this team consists of Michel France, Kara Foreman, Melinda Lue, and Benson Ko. This research project is part of the requirement for a Bachelor of Science in Environmental Science at Royal Roads University (RRU). The faculty advisor and sponsor will be Jonathan Moran and Alison Moran (RPBO), respectively.This research will determine whether nest boxes for Saw-Whet Owls, American Kestrels, and Barn Owls can be used as a viable alternative to rodenticide use on farmland in Southern Vancouver Island, British Columbia. Viability of this pilot study will be measured based on economic and environmental considerations.

Objectives and Research Questions

The objective of the project is to acquire baseline information and developa standardized measuring protocol for use in future rodenticide-alternative programs.

This research project sets out to answer the follow questions:

- What are the environmental and economic costs of the current pest control methods used on farms?
- Does provision of raptor nest boxes provide a viable alternative to rodenticides in reducing rodent numbers on farms and other properties?
- Is it ethical to attract the birds to these locations, in consideration to the potential of ecological sinks through pesticides or predation?

Approach

The general approach of this project will be to collect rodenticide related information from farmers in the area with respect to the feasibility of using raptors as a biological alternative to rodenticides. The researchers will be involved in nest box placement and data collection regarding nest box activities at 4 locations in the area, including two farms in central Saanich, and the RRU campus.

Ethical Review Timeline

The research conducted for this project involves human interaction through the use of interviews: thus, an ethical review evaluation is necessary. The following timeline outlines the ethical review process needed for this project:

- Review rough draft of ethical review form and included documents with faculty advisor, Jonathan Moran – Jan 21st
- Submit rough drafts of interview questions, research consent form, and completed ethical review form to Rick Kool for editing – Jan 21st
- Review second draft of ethical review form and attached documents with faculty advisor, Jonathan Moran – Jan 28th
- Submit interview questions, research consent form/privacy agreement, telephone script and edited review form for evaluation for the ethical board – Jan 28th

Methodology

The methodology for this project is as follows:

- To participate in a limited nest box pilot study (using nest boxes appropriate for Saw-Whet Owls, American Kestrels, and Barn Owls) with a few specified partners.
- Potential interviewees (farmers and land owners interested in taking part in the project) will be provided by John Costello of RPBO.
- Interviews will be conducted by phone or in person.
- Identify current rodent control practices and issues faced by various agricultural stakeholders in southwest BC.
- Analyze the economic impact of rodents on agricultural operations.
- Identify the types of pests causing problems on farms.
- Determine the environmental and economic effects of the rodenticides used on farms.
- Develop a monitoring protocol for measuring success of the nest box program, including nest box uptake, amount of rodents in boxes, and rodent-caused damage.

Data Collection and Analysis

Qualitative data will be collected to create a standardized measuring process for use in future rodenticide-alternative programs. This will involve qualitative techniques, including interviews, analyses of nest box, farm, and research data, and a descriptive statistical analysis. If uptake occurs, owl pellets will be dissected to accumulate predation data; this will require the use of laboratory equipment, such as the autoclave for sample sterilization, and tools used in dissection.

MAJOR PROJECT TIMELINE

Table 1 shows the major milestones for completion of this project.

Table 1: Timeline of the major milestones for the rodenticide project, including submission dates of reports and financial statements for Aves Alternatives (Team Two).

Type	Date	Description
Draft Project Agreement	02/09/2014	Submission of draft project agreement including; budget, timeline,etc.
Agreement Sign-off	03/07/2014	Ensure all parties sign-off on final agreement
Table of Contents	03/09/2014	Provide an initial framework/ outline for the major project report
First Quarter Presentation	3/21/2014	Present current progress of Major Project to RRU
Quarter 2 Self/ Peer Evaluations	04/04/2014	Evaluations of self and peer performance
Interim Report including Progress Report	06/03/2014	Progress report to ensure project is on track
Financial Statement / Budget Sheet	06/03/2014	Edit and update budget
Quarter 3 Presentation	6/13/2014	Present current progress of Major Project to RRU
Quarter 3 Self/ Peer Evaluations	6/27/2014	Evaluations of self and peer performance
Draft Final Report	7/15/2014	First submission of report
Corrected Final Report	08/12/2014	Second submission of report

Project Financial Statements	8/22/2014	Final Budget
Quarter 4 Presentation	8/28/2014	Present final project findings to RRU and RPBO
Quarter 4 Self/Peer Evaluation	8/29/2014	Evaluations of self and peer performance

Communication Plan

The following communication plan will be applied to all aspects of the project:

- Correspondence between team members will be primarily via email, in-person communication in class, and arranged meetings each Tuesday.
- Kara Foreman will be responsible for e-mailing sponsors and the faculty advisor, Jonathan Moran, for updates and arranging meetings.

Deliverables to Department

The following deliverables are to be submitted to the Department of Environmental Science:

- Annotated Table of Contents
- Presentation each quarter
- Self / Peer Evaluations each quarter
- Interim Report including Progress Report
- Financial Statement / Budget Sheet with Billable Hours
- Draft Final Report
- Corrected Final Report
- Project Financial Statements

Deliverables to Sponsor

The following deliverables are to be submitted to Alison Moran (RPBO):

- A final presentation summarizing the project.
- A final report to host on the RPBO website to include the following:
    - Findings on the possibility of using raptors as an alternative pest management method;
    - Identification of benefits and barriers to using alternative pest control methods;

- A ‘Matrix of Success’: a rating system that measures social willingness to participate, physical uptake of birds, and environmental damage from pesticides to be used as a recommendation in future projects and research;
- A description of the current environmental and economic costs of pesticide use; as well as
- Information on the survivability of owls to certain areas, taking into consideration the possibility of creating an ecological sink from high rodenticide use and a trophic cascade effect.

Expectation of Sponsor

In order for this research to be completed by August 2014, the sponsors are expected to show dedication and cooperation in this project. Aves Alternatives will perform and act with the highest degree of professionalism and expect the RPBO representatives to show this same courtesy in return. The researchers also ask the representatives to commit to the following:

- Timely communication.
- Availability for meetings.
- Provide contact list of potential interviewees.
- Expected initiative of having nest boxes built and placed.
- Supply nest box locations to proceed with project.
- Handling of birds and sharing of applicable data in relation to the birds and nest boxes.

Draft Budget

The total cost to RPBO for this research project is $400, which includes $200 for an administrative fee and $200 for the students' expenses. The expenses mainly consist of travel to and from the participating farms, as well as minor printing expenses. The theoretical hourly wage for each team member is $25/hour, to serve as an exercise in establishing pay rates. This project benefits both parties since RPBO is a not-for-profit organization and the students will gain valuable research experience throughout the project. In addition, the students' field of study is consistent with RPBO's mission; therefore, will form a synergistic relationship and together provide solutions to ecological conservation. (See attached Budget Proposal)

Request for Approval

Thank you for considering this proposed project agreement involving biological alternatives to pesticide use on Southern Vancouver Island. This Terms of Reference is subject to change with mutual agreement. Aves Alternatives requests your approval for this document by signing below:

Aves Alternatives - Team 2

Major Project Budget Proposal

Date	Description				Expenses	Funding
01-Dec-13	Admin Fee (billed at start of project)			RPBO		$200.00
07-Mar-14	Total Project Funding			RPBO	$200.00	$400.00
Expenses:		**Mileage**	**0.45/km**	**Projected Quantity**		
Jan - Aug, 2014	Field trips to Sea Cider and Puckle Farm	220		4 Trips	$99.00	**$400.00**
Jan - Aug, 2014	Field trips around the Saanich peninsula area	200		4 Trips	$89.00	$311.00
Jan - Aug, 2014	Printing				$12.00	$299.00
						$299.00
						$299.00
						$299.00
						$299.00
						$299.00
				Total Expenses:	$200.00	

Estimated Billable Hours

Date	Description	Hours	Qty	Notes	Amount
21-Mar-14	2nd Quarter Billable Hours	320	1		320.00
13-Jun-14	3rd Quarter Billable Hours	320	1		320.00
28-Aug-14	4th Quarter Billable Hours	320	1		320.00
				Total Estimated Billable Hours:	**960.00**

Aves Alternatives Signatures

Michel France, Lead Researcher Date

Melinda Lue, Co – ResearcherDate

Kara Foreman, Co – ResearcherDate

Benson Ko, Co – ResearcherDate

RRU Major Project Advisor:

Jonathan Moran, Faculty Advisor Date

Major Project Sponsor:

Alison Moran, RPBO Date