Efficacy of bird deterrent devices in agricultural areas of the Fraser Valley of British Columbia: a pilot study

---

January 2009

Prepared for:

The Ministry of Agriculture and Lands (MAL),
Province of British Columbia
and
The Fraser Valley Regional District (FVRD)

Principal Investigator:

Professor Karen M.M. Steensma
Co-director, Environmental Studies Program
Assistant Professor, Department of Biology
Trinity Western University

Student assistants:

Amanda Edworthy, Katherine Hartline, Denise Wong,
Becky Kern and Amy Gardner

Executive Summary

A series of bird count stations were set up in the Sumas Prairie region of British Columbia, Canada in June 2008 in order to gauge the efficacy of bird deterrent devices over a single blueberry harvest season. Birds were counted in the early morning and late afternoon at six different stations for two weeks prior to the installation of deterrents in July. Three stations remained as control count sites throughout the study. The remaining three sites each had a different deterrent installed: an auditory bird distress caller, a propane cannon, and a hawk kite. Counts continued through August with deterrents in place, and on through September after all deterrents were removed. Statistical analysis revealed that both the hawk kite and the propane cannon showed significant decreases in starling population numbers initially, but starlings slowly returned to higher numbers after the initial introduction of these deterrents. The hawk kite deterrent effect lasted longer than the propane cannon effect within this pilot study. The bird distress caller showed no statistically significant deterrent effect although problems at the particular site apparently skewed results for that deterrent trial, as initial starling populations at that site were significantly higher than the control populations. Though the overall study was of a pilot nature and extremely limited in scope, the results point to some possible recommendations for starling management and to the potential value of further research on this topic.

List of Figures and Tables

List of Appendices

Introduction

The invasive European Starling (*Sturnus vulgaris*) reproduces prolifically and is highly adaptable, which has resulted in nuisance populations across North America (Currie et al. 1977). Known for their intelligence, these glossy black birds also spread diseases, such as gastroenteritis, foot and mouth disease, salmonella, avian tuberculosis and histoplasmosis (Feare 1984, Johnson and Glahn 1994). Starlings can be found in flocks of up to 1.5 million birds and cause an estimated $800 million in damage in the United States annually (Norris et al. 2003).

Starlings pose a serious threat to the agricultural industry, especially berry farmers. Starlings descend on berry fields, consuming the ripe fruit and sometimes destroying entire crops (Pritts and Hancock 1992, Gough 1994, Sweeney 2003). In the Pacific Northwest, which produces a third of the world's blueberry supply, farmers report losses of up to 30% annually (Whatcom Farm Friends 2008). Other sectors of agriculture, most notably dairies and orchards, are also affected by these birds. With dairy commodity barns and stored forages providing winter feed and blueberries providing summer feed, starlings particularly thrive at berry-dairy interface areas in this region (Gilkeson and Adams 1996, 2000; Steensma et al. 2007).

Numerous methods of starling control have been attempted, but none has proven to be the ideal solution. Auditory deterrents, such as air cannons or electronic distress calls, and visual repellents such as reflective tape, have been used to frighten starlings away, but the birds may quickly return once they realize they are not harmed (Johnson et al 1985; Bomford 1990; Bomford and O'Brien 1990; Johnson and Glahn 1994; Gilkeson and Adams 1996, 2000; Harris and Davis 1998; Norris et al. 2003). Additionally, auditory devices increase the potential for and incidence of conflicts with neighbours (Pritts and Hancock 1992, Gough 1994, Johnson and Glahn 1994). Traps can be used to legally remove starlings, but they are only effective against a few birds rather than entire flocks (Pritts and Hancock 1992, Harris and Davis 1998). Chemicals, such as Methiocarb and Avitrol, can efficiently eliminate starlings (Conover 1982, Conover 1984, Tobin and Dolbeer 1987, Brugger et al. 1993, Sweeney 2003) though naphthalene shows no repellency (Dolbeer et al 1998). These chemicals are not available for use on fruit crops due to toxicity to humans and other non-target species. Reflective tape can be somewhat effective against similar birds, in certain instances, but birds may become habituated to this technique (Dolbeer et al 1986). Netting of fields can be an effective method of preventing crop loss, but it is expensive and interferes with harvester equipment (Conover 1982; Johnson and Glahn 1994; Gilkeson and Adams 1996, 2000; Flint and Dreistadt 1998; Norris et al. 2003; Sweeney 2003).

Concerns about damage to agricultural production in the lower mainland of British Columbia, combined with the conflicts posed by auditory deterrents used in a region of high urban-rural residential growth, have created a demand for accurate information on the efficacy of various bird deterrent devices in the region. The purpose of this pilot study was to assess background starling populations and then test the effectiveness of three particular devices – an audible bird distress caller, a propane cannon, and a hawk kite – in deterring starlings and other birds from agricultural areas of the Fraser Valley.

Methods

The Fraser Valley Regional District and the BC Ministry of Agriculture approved funding based on a proposal for this project in spring 2008. Faculty, students and staff of Trinity Western University (Langley, BC) and interns with the international conservation group A Rocha, assisted in the design and data collection for the project.

A timeline of events in the project occurred as follows:

- March-April 2008: A Rocha intern Becky Kern conducted volunteer literature research
- May-June 2008: TWU student Katherine Hartline and I conducted further literature research, began contacting landowners, mapped potential experimental treatment sites, and mapped the crops grown in the surrounding areas using a GIS (Geographic Information System). TWU student Denise Wong joined in conducting initial bird counts (all species) in the region for background information on bird populations and their habits as sites were chosen.
- July 2008: Denise and I completed landowner contacts and protocol was established at 7 sites: 4 control sites, 1 site with a Purivox Triple-John propane cannon set on lowest

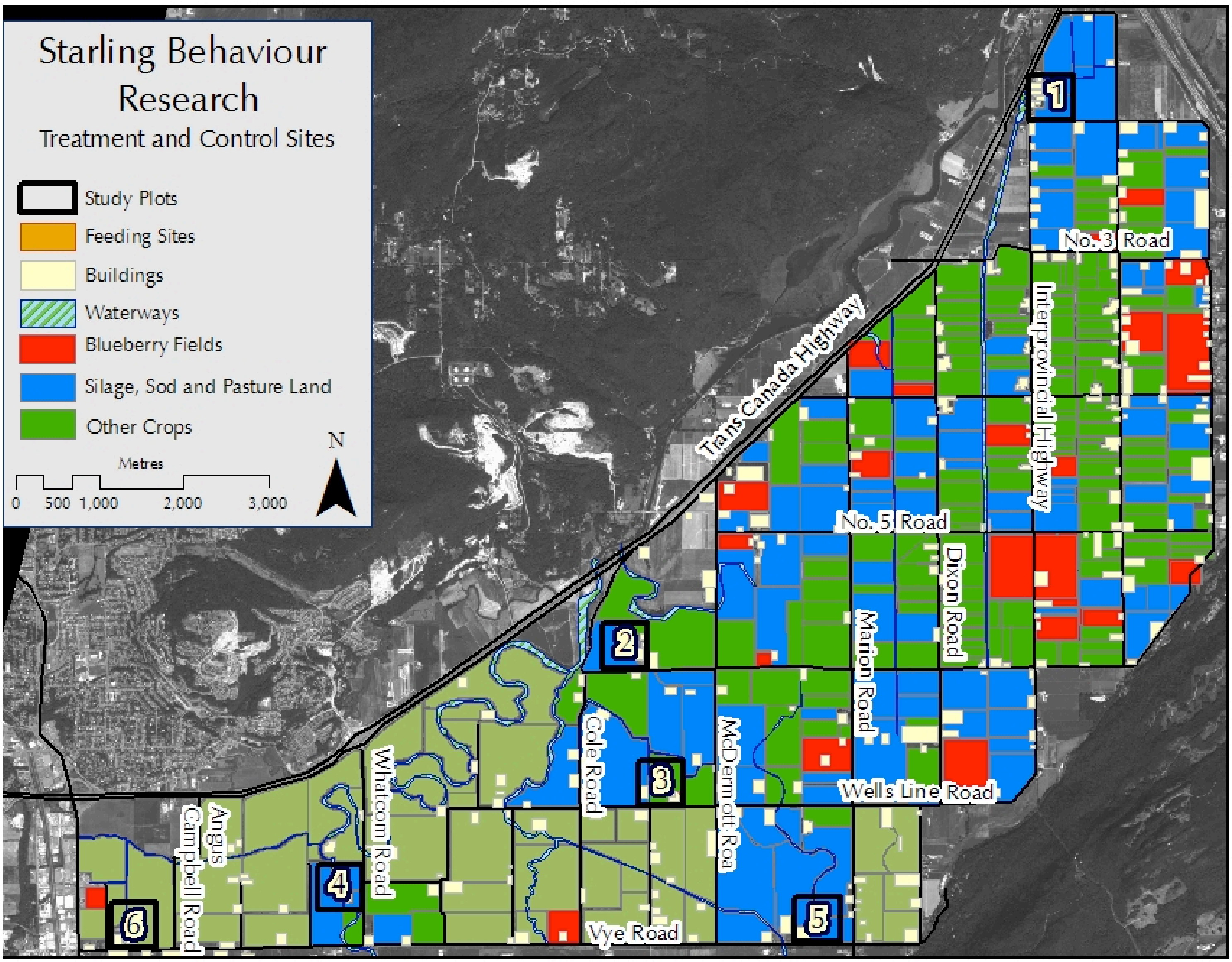
setting, 1 site with a BirdGard brand audible distress caller, and 1 site with a hawk kite. All sites were provided with additional food sources (beyond what they would forage from the surrounding area). Starlings and other incidental species were counted for at least 2 weeks prior to introduction of deterrent devices to establish baseline population numbers. Sites were counted twice per day, once in the early morning, and once in the late afternoon/early evening. At least 10-15 minutes were spent at each site visit.

- August 2008: Denise and TWU student Amanda Edworthy, and volunteer A Rocha intern Amy Gardner, conducted counts during the busiest portion of the blueberry harvest season. Counts continued with deterrent devices in place at 3 of the 7 locations. Data entry to spreadsheets began.
- September 2008: Amanda and Amy continued to do the counts. Deterrent devices were stopped the weekend of September 5, as the blueberry season was winding down. Counts continued through September 24, to gauge both seasonal bird behaviour and effect of deterrent removal.
- October 2008: Data entry was completed by Amanda and spreadsheets were reformatted for statistical analysis. We consulted with statisticians at both TWU and University of British Columbia in conducting the analysis.
- November 2008: Raw data were converted for entry into a statistical analysis program at UBC. Graphs and charts summarizing statistical results were developed. Mapping of Sumas Prairie was finalized.
- December 2008: Draft final report was written.

Initial land use analysis and bird surveys during the late spring and early summer showed that dairy farms and berry farms were most likely to harbour large populations of starlings. Due to the confounding factors presented by blueberry growers' own use of deterrents, and variable attractiveness of blueberry crops in different fields, treatment sites were deliberately chosen away from existing blueberry farms (Fig. 1). Seven sites were initially chosen and landowner permission was obtained. All but one of these sites were on dairy farms; the seventh was on a sod farm. As the sod farm site did not show an appreciable bird population, the site was eventually dropped from the study.

Figure 1. Sumas Prairie, BC starling behavior study sites

1 = Cedarwal; control site
2 = Driessen; control site
3 = Driessen; BirdGard site
4 = Meier; hawk kite
5 = Luymes; control site
6 = Kielstra; propane cannon site



A sheet of plywood was placed on the ground at each site, in proximity to bird roosting areas and to a water source. The plywood was kept evenly covered with a scattering of cracked corn and blueberries to serve as a stable food source for the birds. During each site visit, the observers would drive up to within 15-20 m of the feeding station and remain in the vehicle, using the vehicle as a blind so as not to alarm the birds (as per Holmes 1993). Birds on and within a 100 m radius of the feeding station were counted using binoculars and bird guides to identify species. Any unusual individual or flock behaviours were also noted.

At the time of deterrent introduction, three sites had devices installed as follows: 1) the BirdGard was set up at a distance of 20 m from the bird feeding station and set according to dealer specifications to make noise at a frequent time interval during daylight hours; 2) the propane cannon was set up at a distance of 50 m from the bird feeding station and was set according to dealer specifications to fire at the least frequent time interval from 6:30 am until 8:00 pm; 3) the hawk kite was set up at a distance of 20 m from the bird feeding station. All deterrents were left unchanged in their position and in the frequency setting of noise from the time of initial set-up to the time of removal.

Data were organized for presentation showing mean daily starling counts grouped into periods of nine to twelve days, showing trends and transitions resulting from adding and removing the deterrents. The propane cannon and hawk kite sites had two pre-deterrent periods (July 9 to July 29), four periods while the deterrent was deployed (July 30 to September 7), and two post-deterrent periods (September 8 to September 24). The BirdGard was removed slightly earlier (September 1) due to battery failure, and thus had only three deterrent-deployed periods. We compared data from the deterrent sites to data from the three control sites, which were averaged to show background trends in starling abundance. In addition, deterrent sites were compared to control sites at each time period using a t-test. Analyses and graphics were done using the statistical package R (R Version 2.4.0; R Development Core Team 2006) at UBC.

Percent difference was used to assess the overall degree of change in starling abundance at each of two transition points: 1) The pre-deterrent to deterrent-deployed transition time, and 2) the deterrent-deployed to post-deterrent transition time.

Results

The vast majority of birds seen frequenting the treatment sites were European starlings, although occasional redwing blackbirds, robins and other birds were seen. As well, occasional predator birds such as bald eagles, red tail hawks, harriers, and merlins were seen in the vicinity.

Of the three deterrents used, the BirdGard audible distress caller (Fig. 2) appeared to show the least effect. In fact, the site had a high starling population to begin with, and this became a statistically significant difference just prior to deterrent introduction. Midway through the use of the deterrent, the starling numbers actually climbed to 110, much higher than both control and pre-deterrent numbers. Bird populations did begin to drop after mid-August. Another feature to note was that an onsite manure lagoon around which the starlings were congregating was pumped out on August 27th, at which time the bird count dropped to fewer than 20 birds. Thus, during the time it was operating, it appeared that the overall trend was for the BirdGard to actually attract birds to the site initially, followed by a precipitous mid-deterrent drop. However, the data here should not be considered valid after the date of the pumping incident since that apparently removed a major food source that had been attracting the birds.

The propane cannon showed an effect on starling numbers at the site tested, with peak effect occurring within the first 15 days after introduction of the deterrent (Fig. 3). Though starling numbers remained lower than background control numbers, they did begin to climb again after 15 days, showing no significant difference from the control after the peak effectiveness.

The hawk kite showed the strongest effect of the three deterrents (Fig. 4). Starling numbers took the steepest dive during the period in which the kite was introduced, with peak effect occurring 15 days after kite introduction, and bird numbers remaining significantly lower than background starling population levels for 10 more days. Numbers continued to remain lower than controls and did not fully overlap with control numbers until about 15 days after the kite was removed.

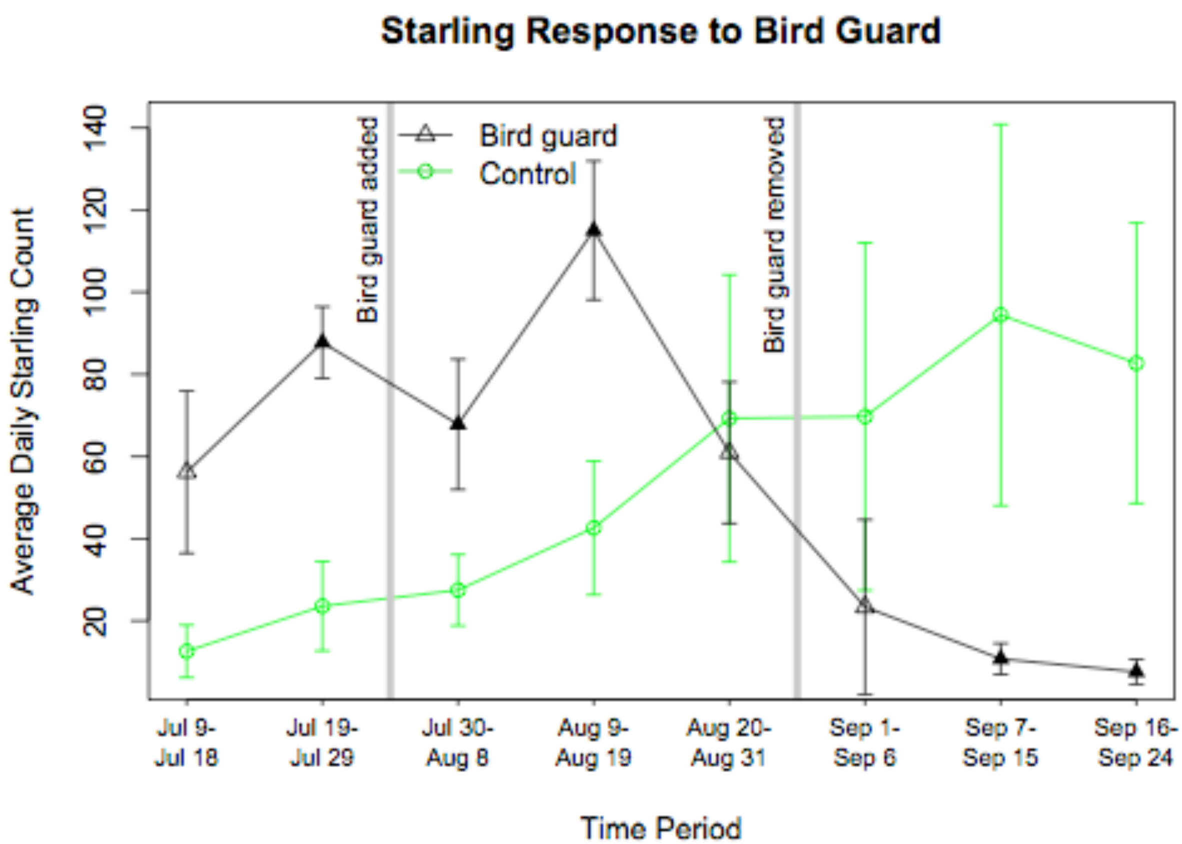


Figure 2. Starling population numbers in response to introduction of a BirdGard audible distress caller at a site in Sumas Prairie, BC. Filled triangles = significant difference from control, open = not significant.

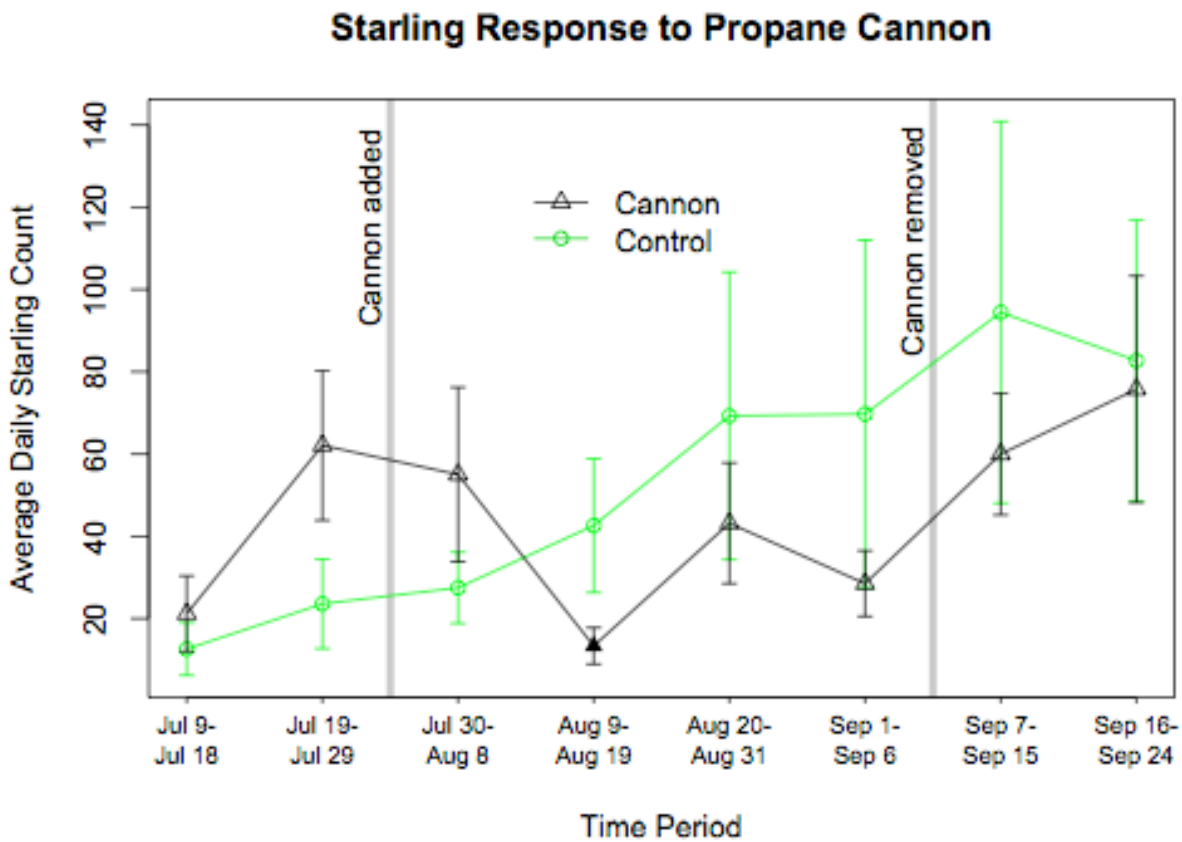


Figure 3. Starling population numbers in response to introduction of a propane cannon at a site in Sumas Prairie, BC. Filled triangles = significant difference from control; open = not significant.

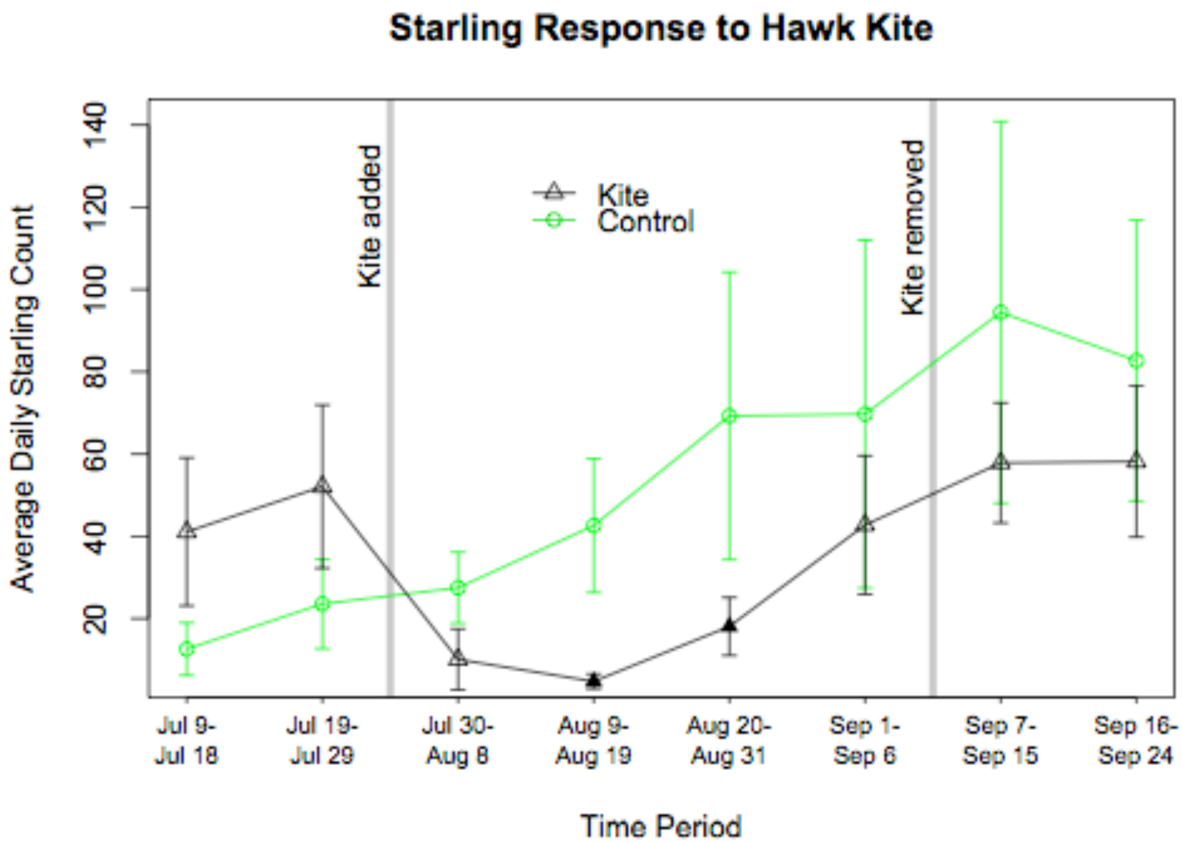


Figure 4. Starling population numbers in response to introduction of a hawk kite in Sumas Prairie, BC. Filled triangles = significant difference from control; open = not significantly different.

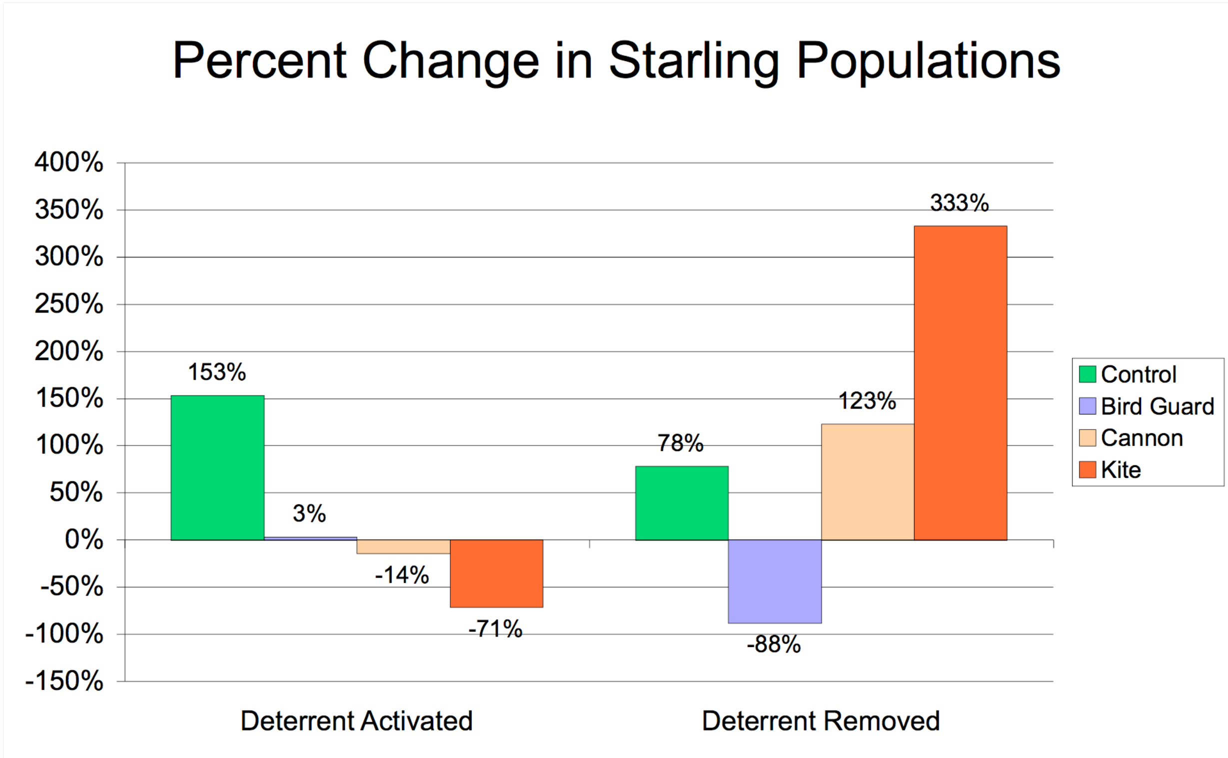


Figure 5. Percent difference in bird numbers at transition points for introduction and removal of various deterrent techniques at sites in Sumas Prairie, BC.

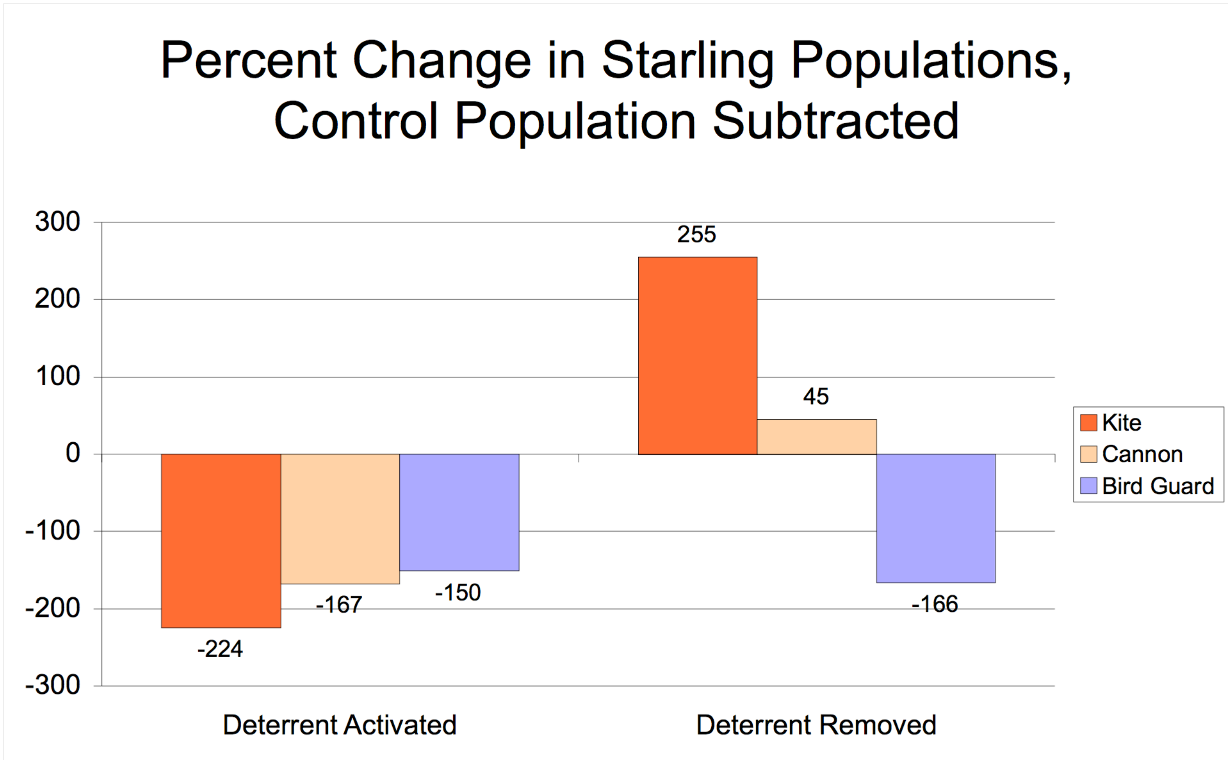


Figure 6. Percent difference in bird numbers at transition points for introduction and removal of various deterrent techniques at sites in Sumas Prairie, BC, with control population changes subtracted.

Percent differences in starling populations at the different deterrent sites are shown in Figures 5 and 6. The apparent lack of effect, or seemingly positive initial effect of the BirdGard on starling numbers, may relate to confounding factors mentioned above. Using percent change numbers illustrates even more strongly the success of the hawk kite, and also shows that bird decreases in response to the cannon may have been muted somewhat by the general increase in the control population. No statistical testing of percent difference values was possible due to the small scale of the study.

Trends in nine-to-twelve-day means (as shown in Figs. 2,3, and 4) were more interesting than actual t-tests for significant difference, though the test helps give meaning to error bars and gives an idea of how much of a difference is needed for significance. The t-tests would have been more meaningful if pre-deterrent starling abundance had been statistically identical for control and deterrent sites. Control sites showed consistent gradual increases in starling numbers as the season progressed. The three control sites, when taken together, form an indication of background trend in bird numbers, which was useful for comparison to trends at sites where deterrents were introduced. Deterrent effects can also be examined by simply noting the changes in population levels pre-deterrent, deterrent, and post-deterrent in Figures 2-4.

Discussion

The relatively simple techniques used in this study, and the limited scope of the study due to time and budget constraints, should be strongly considered when one attempts to interpret results. In particular, the lack of multiple replications of each deterrent technique in a greater number of locations, and over a number of growing seasons, with complete randomization of locations, makes statistical inferences difficult (Bomford and O'Brien 1990).

However, given the pilot-study nature of this research, several strengths of our study that have been lacking in many previous bird deterrent research studies, should be noted:
1) Control areas were established far enough from deterrent areas to minimize potential of "scared" birds moving into control plots. Control and treatment sites do not need to be matched, although ideally both should be replicated (Bomford and O'Brien 1990). Only the

controls were replicated here. 2) Deterrent plots did not have their effects confounded by surrounding farmers' deterrent use. 3) Results of the study were not tied to crop damage measurements, which can be highly variable based on field productivity and other confounding factors. 4) Since the "before" or pre-deterrent phase is not a control on the "after" or post-deterrent phase (Bomford and O'Brien 1990) due to seasonal changes in background bird populations and behaviors, the establishment of control sites is important and allows comparison of deterrent site trends to background trends. Our controls were not surprising in showing overall upward trends in starling numbers as the season progressed, since starlings typically fledge several clutches of young birds throughout the season, which then join the flocks (Bent 1950, Elliot 1964). Thus the information gained from our study has merit for examining *single-case effects of deterrents in these particular locations over time*, even though replication of deterrent plots was not possible.

Lack of effectiveness, or even apparent counter-effectiveness, of audible distress callers, corresponds with previous research indicating limited success and great variability of this technique (Johnson et al 1985, Feare 1989, Bomford and O'Brien 1990, Conover 1994, Harris and Davis 1998). In particular, Conover (1994) found that distress calls are effective only for a short time at best, and are ideally combined with an actual predator-caused fatality, which was not implemented in our study. Since introduction of actual native predators such as sharp-shinned or Cooper's hawks, merlins, or kestrel falcons was not conducted, there is no way to measure whether this combination of deterrents would have worked.

It is worth noting that the operator of the dairy farm at which the BirdGard was placed, indicated near the end of our project that he had previously tried using a BirdGard in a nearby location a few years earlier. He found it to be effective for a time but determined that the effectiveness decreased to nil after a few months. It is possible that residual older birds from that time were still present at the time of our study, and may have been resistant to the BirdGard as a result. Overall the problems at the BirdGard site, including the manure pump-out, limit conclusions that can be drawn regarding audible distress callers on this single study.

Habituation of birds to propane cannons has been documented in previous studies (Bomford and O'Brien 1990, Harris and Davis 1998). In our study the relatively infrequent use of the cannon (firing frequency of no more than 3 times/hour) may have increased the length of its effective period, as has been documented elsewhere (Harris and Davis 1998). The comparison of firing frequencies, however, was beyond the scope of this study. Propane cannon effectiveness can also be increased if it is moved randomly around the field and combined with visual deterrents such as artificial predators or pop-up scarecrows (Cummings et al 1986, Bomford and O'Brien 1990). As with the distress callers, however, the best increase in effectiveness of cannons comes when they are coupled with actual predator-caused deaths or shooting deaths of birds (Bomford and O'Brien 1990, Conover 1994). Shooting is not an option within or around blueberry fields, however, because of the risk of contaminating fruit with shot. Older research has shown cannons to be effective at least in the short term (Stickleya et al 1972, Decalesta and Hayes 1979, Potvin and Bergeron 1981).

Effectiveness of hawk kites, as well as eventual habituation of birds to the kites, has been shown previously (Conover 1982, 1984; Nakamura 1997; Harris and Davis 1998). Increased randomization of hawk kite placement, which was not done in our study, keeps pest birds from becoming habituated to the kites. Ideally the kites should be moved frequently and irregularly, and combined with other deterrents (Bomford and O'Brien 1990, Harris and Davis 1998). This was beyond the scope of our simple pilot study but would certainly be of interest in pursuing non-auditory options for effective bird control. For example, hawk kites in conjunction with reflective tape, actual shooting fatalities, or falconry may be highly effective. Considering the simplicity of our experiment with the hawk kite, its success in this locale was remarkable.

Success of any technique, whether auditory (distress caller, cannon) or visual (hawk kites, reflective tape) is dependent on the attentiveness and skill of the operator and requires randomization of intervals, location, and combinations of technique (Bomford and O'Brien 1990, Harris and Davis 1998). Our results agree with large-scale surveys of various techniques that rank effectiveness (Table 1). Professional falconry, conducted by an expert falconer onsite throughout daylight hours, is a virtual guarantee of eliminating bird damage (Harris and Davis 1998). However this is an expensive alternative. A clear understanding of bird biology and habitat related to the uniqueness of each individual site, as provided by a professional biologist, is an important step to effective bird control. Habitat recommendations, such as provision of predator perch sites and nest boxes, can then be implemented (Harris and Davis 1998).

Table 1. Summary of effectiveness of bird control techniques

Not recommended	Limited recommendation	Highly recommended
High intensity, infra- or ultra-sound	Hawk kites and other visual predator simulations	Habitat modification to encourage natural predators such as birds of prey
Lasers	Distress and predator callers such as BirdGard	Falconry
Lights	Propane cannons	Active shooting of pest birds
Microwaves	Reflective tape	Habitat modification to discourage pest birds
Smoke	Scarecrows	Netting, when feasible (as in small, handpicked fields)

(adapted primarily from Harris and Davis 1998. Recommendations and effectiveness are based on operation by skilled personnel with an understanding of biology of both pest and predator birds)

.

The best possible deterrent for pest birds is natural presence of native predator birds (Flint and Dreistadt 1998, Daly 2002, Steensma 2008), which may explain the relative effectiveness of the hawk kite here. Several studies have shown that the American kestrel (*Falco sparverius*) can effectively prey on, or territorially defend against, the European starling (Balgooyen 1976, Ashkam 1990, Village 1990, Suhonen et al. 1994, Bechard and Bechard 1996, Parrish 2000, Dover 2008). As the kestrel is native to the Pacific Northwest but declining in numbers in Western Washington and the BC Lower Mainland over the past 20 years (Wahl 1995, Ireland 2008; Pike 2008), enhancement of nesting, foraging and perching habitat for this species could provide a low-cost alternative control measure against starlings (Toland and Elder 1987, Dawson and Bortolotti 2000, Valdez et al 2007). A pilot kestrel release program has shown initial success in Washington State (Steensma 2008) and is planned for expansion into British Columbia.

Summary and Recommendations

Based on both our literature and field research, we would summarize and make the following preliminary recommendations regarding bird deterrent techniques:

- **Bird distress callers such as the BirdGard may be effective in some situations but were not shown to be of use in this particular setting and application due to site problems**
- **Propane cannons can be of use in shorter-term applications**
- **Hawk kites can be of use in shorter-term applications**
- **Combinations of audible distress techniques and actual shooting of pest birds are more effective than audible distress alone.** Shooting is not an option within or adjacent to blueberry fields, however, due to the risk of contaminating fruit with shot.
- **Hawk kites in combination with actual shooting or predator-caused fatalities are more effective than hawk kites alone**
- **All of the above techniques are enhanced through randomization and combination/integration of audible and visual devices**
- **Falconry and presence of natural predators are considered highly effective deterrents**
- **Enhancement of native birds of prey through habitat improvement, and release of young birds of prey should be a top priority for cost-effective bird control research**

Acknowledgments

This study was made possible by a joint grant from the British Columbia Ministry of Agriculture and the Fraser Valley Regional District, and special thanks are given to Director Dick Bogstie and Ms. Siri Bertelson of FVRD, and to Mr. Mark Sweeney and Mr. Bert vanDalfsen of MAL . We are grateful for the graciousness of the following farms in allowing our presence during the course of the study: Cedarwal Farms, Driessen Farms, Bos Sod, Meier Dairy, Luymes Dairy, and Kielstra Dairy. The assistance of Mr. Mark Sweeney in obtaining plywood and feed was very much appreciated. The co-operation of Hi-Tech Distributors in providing and setting up the deterrent devices was appreciated. Ms. Melissa Oakes of TWU and A Rocha Canada provided budget oversight and Dr. Tracy Stobbe of the TWU School of Business consulted on the statistical analysis. Mr. Patrick Lilley of Raincoast Applied Ecology and Mr. Glen Carlson of A Rocha Canada provided initial advice on study design. Finally, various members of our families provided company on survey days and patience throughout the process.

Literature cited

Askham, L.R. 1990. Effect of artificial perches and nests in attracting raptors to orchards. Proceedings from the Fourteenth Vertebrate Pest Conference in Lincoln, Nebraska.

Balgooyen T.G. 1976. Behavior and ecology of the American kestrel [dissertation]. Berkeley, California: University of California.

Bechard M.J. and J.M. Bechard. 1996. Competition for nest boxes between American kestrels and European starlings in an agricultural area of southern Idaho. *In*: Raptors in human landscapes. 1st ed. San Diego, California: Academic Press Inc.

Bent C. 1950. Life histories of North American wagtails, shrikes, vireos, and their allies. U.S. National Museum Bulletin 197.

Bomford, M. 1990. Ineffectiveness of a sonic device for deterring starlings. Wildlife Society Bulletin.

Bomford, M. and O'Brien P. 1990. Sonic deterrents in bird damage control: a review of device tests and effectiveness. Wildlife Society Bulletin 18: 411–422.

Conover, M.R. 1994. How birds interpret distress calls: implications of applied uses of distress call playbacks. Proc. Sixteenth Annual Vertebrate Pest Conference. Lincoln, Nebraska.

Currie F.A., D. Elgy and S.J. Petty. 1977. Starling Roost Dispersal from Woodlands. Forestry Commission Leaflet 69.

Daly M.A. 2002. American Kestrel: The Barnyard Friend. College Park, Maryland: University of Maryland Cooperative Extension.

Dawson D.R. and G.R. Bortolotti. 2000. Reproductive success of American Kestrels: the role of prey abundance and weather. Condor 102:814-822.

Dover B.S. 2008. Owner, Orchard Guard, Yakima, Washington. Personal communication.

Elliot H.N. 1964. Starlings in the Pacific Northwest. Vertebrate Pest Conference Proceedings Collection: Proceedings of the 2nd Vertebrate Pest Control Conference, U. S. Bureau of Sport Fisheries and Wildlife, Portland, Oregon.

Feare C. 1984. The Starling. Oxford, England: Oxford University Press.

Flint M.L. and S.H. Dreistadt. 1998. Natural enemies handbook. Berkeley, California: University of California Press.

Gilkeson L.A. and R.W. Adams. 1996. Integrated pest management for structural pests in British Columbia. 4th ed. Vancouver, British Columbia: British Columbia Ministry of Environment, Land, and Parks; Pollution Prevention and Pesticide Management Branch.

Gilkeson L.A. and R.W. Adams. 2000. Integrated pest management manual for landscape pests in British Columbia. 3rd ed. Vancouver, British Columbia: British Columbia Ministry of Environment, Lands and Parks; Pollution Prevention and Remediation Branch

Gough R.E. 1994. The highbush blueberry and its management. 1st ed. New York, New York: Food Products Press.

Harris R.E. and R.A. Davis. 1998. Evaluation of the efficacy of products and techniques for airport bird control. LGL Limited *for* Aerodrome Safety Branch, Transport Canada.

Holmes E.L. 1993. Responses of wintering grassland raptors to human disturbance. Wildlife Society Bulletin 21**:**461-468.

Ireland, J. 2008. Director, Reifel Bird Sanctuary, Delta, BC. Personal communication.

Johnson, R. J., P. H. Cole, and W. W. Stroup. 1985. Starling response to three auditory stimuli. J. Wildlife Management 49:620-625.

Johnson R.J. and J.F. Glahn. 1994. Prevention and control of wildlife damage: European starlings. *In*: Wildlife Damage Management Handbook. 2nd ed. Lincoln, Nebraska: University of Nebraska.

Nakamura, K. 1997. Estimation of Effective Area of Bird Scarers. J. Wildlife Management. 61(3): 925-934

Norris R.F., E.P. Caswell-Chen and M. Kogan, editors. 2003. Concepts in integrated pest management. 1st ed. Upper Saddle River, New Jersey: Prentice Hall.

Parrish J.W. 2000. Possible prevention of European starling nesting by Southeastern American Kestrels at a power substation in southern Georgia. J. Raptor Research 34:152.

Pike D. 2008. Master Falconer, Lynden, Washington. Personal communication.

Pritts M.P. and J.F. Hancock, editors. 1992. Highbush blueberry production guide. 1st ed. Ithaca, New York: Northeast Regional Agricultural Engineering Service.

Steensma, K.M.M. 2008. Advances in bird deterrent methods for agricultural areas of southwest British Columbia and northwest Washington. Invited presentation, WSU Western Washington Small Fruit Workshop, Dec. 16, Lynden, Washington.

Steensma, K.M.M., B. Dover and K. Hartline. 2007. Use of kestrels for biological control of starlings on fruit and dairy farms. Invited presentation, WSU Western Washington Small Fruit Workshop, Dec. 5, Lynden, Washington.

Suhonen J., K. Norrdahl, and E. Korpimaki. 1994. Avian predation risk modifies breeding bird community on a farmland area. Ecology 75(6):1626-34.

Sweeney, M. 2003. An overview of the BC highbush blueberry industry. Abbotsford, British Columbia: British Columbia Ministry of Agriculture, Food and Fisheries, Industry Competitiveness Branch.

Toland B.T. and W.H. Elder. 1987. Influence of nest-box placement on abundance and productivity of American Kestrels in central Missouri. Wilson Bull. 99:712-17.

Valdez U., S. Robertson, B. Robertson and K.L. Bildstein. 2007. Nestbox use by American kestrels (*Falco sparverius*) and European starlings (*Sturnus vulgaris*) in eastern Pennsylvania. Pennsylvania Birds 14(3):150-53.

Village A. 1990. The kestrel. London, England: T and A Poyser.

Wahl, T.R. 1995. Birds of Whatcom County: status and distribution. Bellingham, WA: TR Wahl. 184 pp.

Whatcom Farm Friends. 2008. Starling control. February Farm Flash.

Appendix 1. Landowner contact letter

TRINITY WESTERN UNIVERSITY

30 June 2008

To: Select landowners in the Sumas Prairie area

As you are likely aware, the presence of starlings has increased in our area in recent years. The resulting damage to farm crops, and the efforts to deter these birds through various devices such as propane cannons and other means have created some controversy in the community.

The Ministry of Agriculture and the Fraser Valley Regional District have commissioned me to carry out a study this summer, to survey the overall bird population in the Sumas Prairie area, and to test the usefulness of several starling deterrent techniques.

Assisted by senior-level Trinity Western University environmental studies and biology students, and by volunteers with specific expertise on starlings, I will undertake the following approach:

- Identify locations in which starlings are particularly numerous
- Deliberately create feeding stations to attract starlings regularly
- Count numbers of starlings frequenting the stations
- Introduce various deterrent techniques to some of the feeding stations
- Continue to count starling numbers at all stations through September
- Analyze results statistically to determine effectiveness of these deterrents

This is a pilot study, and part of a larger overall study in the Fraser Valley and northwest Washington State, that is seeking solutions to starling problems. The goal is to identify solutions that are workable for farmers, farm neighbors, and the natural environment.

Your land may provide a suitable location for one of the feeding stations, if you are willing to participate in this research. If you are interested in allowing us space for the project, we will attempt to minimize disruption to your property, and the study will be concluded by mid- to late September.

Thank you for your consideration, and please feel free to contact me with any questions.

Karen M.M. Steensma
Assistant Professor of Biology
Co-director, Environmental Studies Program
steensma@twu.ca

Other partners: BC Blueberry Council, Whatcom Farm Friends, Washington Department of Fish and Wildlife, Washington State University Cooperative Extension, A Rocha Canada & USA, and various BC & Washington dairy and blueberry farmers

7600 Glover Road
Langley, BC V2Y 1Y1
Canada
Tel: (604) 888-7511

Appendix 2. Sample data collection sheets

Luymes
Time: 9:21 am
Weather: Gray skies, cool breeze
Feed Added? None

Table 7: Avian Observation on July 23rd 2008				
Species		Number		Other Observations
Latin Name	Common Name	On feed	Within a 100 m radius	No birds seen on feed. All blueberries are still present on feed.
	House Sparrow	0	12	
	Rock Pigeon	0	3	
	Robin	0	1	
	European Starling	0	25	

Kielstra
Time: 7:50 am
Weather: Cold, cloudy, no precipitation
Feed Added? None

Table 13: Avian Observation on July 31st 2008				
Species		Number		Other Observations
Latin Name	Common Name	On feed	Within a 100 m radius	Cannon fired, birds fled yet within a minute of the last blast birds returned (20 returned to the powerline)
	European Starling	0	102	
	Female Brewer's Blackbird	0	2	
	Rock Pigeon	0	18	
	House Sparrow	0	3	

Appendix 3. Summary of t-test values for time periods shown in Figs. 2, 3, 4

Characteristics of starling populations at deterrent and control sites throughout the experiment

Site	Deterrent status (time period)	mean ± SE		Test statistic	*df*	*p**
		Deterrent	Control			
Kite	Off (1)	41.1 ± 18.0	12.6 ± 6.4	1.55	5	0.18
	Off (2)	52.1 ± 19.8	23.6 ± 10.9	1.37	6	0.22
	On (3)	10.1 ± 7.4	27.5 ± 8.7	-1.93	14	0.07
	On (4)	4.7 ± 1.8	42.6 ± 16.3	-3.96	21	**0.00**
	On (5)	18.1 ± 7.1	69.3 ± 34.9	-2.33	19	**0.03**
	On (6)	42.8 ± 16.8	69.7 ± 42.3	-0.91	13	0.38
	Off (7)	57.8 ± 14.6	94.4 ± 46.4	-1.20	22	0.24
	Off (8)	58.2 ± 18.3	82.7 ± 34.1	-0.91	17	0.38
Cannon	Off (1)	21.2 ± 9.2	12.6 ± 6.4	0.86	7	0.42
	Off (2)	62.1 ± 18.2	23.6 ± 10.9	2.00	6	0.09
	On (3)	55.0 ± 21.2	27.5 ± 8.7	1.26	8	0.24
	On (4)	13.4 ± 4.4	42.6 ± 16.3	-2.81	26	**0.01**
	On (5)	43.2 ± 14.7	69.3 ± 34.9	-1.03	20	0.32
	On (6)	28.5 ± 8.0	69.7 ± 42.3	-1.60	13	0.13
	Off (7)	60.0 ± 14.8	94.4 ± 46.4	-1.12	22	0.27
	Off (8)	75.8 ± 27.6	82.7 ± 34.1	-0.21	11	0.84
Bird Guard	Off (1)	56.2 ± 19.7	12.6 ± 6.4	2.17	5	0.08
	Off (2)	87.8 ± 8.7	23.6 ± 10.9	5.99	11	**0.00**
	On (3)	67.8 ± 15.9	27.5 ± 8.7	2.42	9	**0.04**
	On (4)	115.0 ± 16.9	42.6 ± 16.3	3.74	10	**0.00**
	On (5)	60.9 ± 17.2	69.3 ± 34.9	-0.31	18	0.76
	Off (6)	23.4 ± 21.2	69.7 ± 42.3	-1.43	11	0.18
	Off (7)	10.8 ± 3.8	94.4 ± 46.4	-3.09	18	**0.01**
	Off (8)	7.6 ± 3.0	82.7 ± 34.1	-3.77	18	**0.00**

*Values bolded if $p \leq 0.05$; indicates significant difference between deterrent and control means.