The Impacts of Shrubsteppe Fragmentation by Agriculture on Nest Predation of Songbirds
Preliminary Results

Project Background and Rationale

Increased agriculture in the Okanagan and Similkameen valleys has created a highly fragmented environment. The shrubsteppe habitat that exists there is one of the most imperilled habitats in North America due to habitat alteration and fragmentation ((Knick *et al*. 2003). Grassland songbirds that inhabit the shrubsteppe are one of the most imperilled groups of birds (Paige and Ritter 1999). Previous studies have found that the edges of agricultural lands can provide predators with an advantage in nest predation (Shake *et al*., 2011). This study is aimed at examining the impact of agricultural edges on songbirds by comparing predation rates between edge habitats and similar inland habitats.

Updated Project Description

Study Site

The study took place in the southern Okanagan and Similkameen valleys of British Columbia. The study was in shrubsteppe habitat, which is scattered throughout the valleys in the bunchgrass and ponderosa pine biogeoclimatic zones (Meidinger and Pojar 1991).

Nine pairs of 160 m by 100 m study plots were selected. Each pair consisted of one plot adjacent to agriculture (edge plot) and one plot 300 – 600 m into shrubsteppe habitat away from agriculture or other fragmentation (interior plot). Birds that had some of their territory within the plot were monitored and nest searched even if the area extended beyond the plot borders. Weather permitting, each plot pair was visited every four days.

Methods

The following types of data were collected to compare between edge and interior plots, and to landcover composition at a landscape scale:

1. Songbird Distribution: Eight ten-minute point counts with a 100 m radius were conducted from the centre of each study plot. Species, activity, and location of all birds present were recorded.
2. Nest Success: Each plot was searched for nests for approximately two hours every four days using a combination of behavioural and systematic searching techniques. Vesper Sparrow nests proved difficult to find, therefore, in order to have a larger sample size and more robust data, nests of other species of sparrows were also catalogued including Chipping Sparrows (*Spizella passerina*), Brewer's Sparrows (*Spizella breweri*) and Lark Sparrows (*Chondestes grammacus*). Nests were checked during every plot visit for a nest-check frequency of every four days. All nests of other passerine or semi-passerine species discovered during nest searching were also flagged and monitored.

   Due to the difficulty of nest finding, all territories that were searched on a regular basis were also monitored for fledglings as a secondary measure of nest success.

   Artificial nests containing Zebra Finch (*Taeniopygia guttata*) eggs were deployed. Five artificial nests were randomly distributed in each study plot, twice during each field season. Each round of artificial nests was left out for 24 days to simulate the nesting period of a Vesper Sparrow. Nests were checked every four days during site visits and any marks on the plasticine egg of depredated nests were compared with marks left by predators identified on camera.

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3. Nestling Condition: Nestling condition was assessed when Vesper Sparrow nestlings were six days old. The nestlings were weighed on an electronic scale, tarsus was measured using calipers and fat was scored visually on a scale of 0 – 7.
4. Nest Predator Identification: Bushnell Trophy Cam cameras were deployed on the majority of the targeted species nests to determine the frequency of predation by each of the predator groups. Cameras were only deployed on nests with complete clutches to avoid abandonment. Cameras were camouflaged with sage and grass, and dummy cameras were deployed throughout each plot to reduce detection by corvids.
5. Nest Predator Abundance:
    a. Avian predators: During the ten-minute point count at the beginning of every second plot visit, corvids, raptors, and icterids were detected within an unlimited radius.
    b. Snake predators: During 45-60 minute systematic searches for snakes in each plot, field technicians recorded species, time, location and activity of all snakes encountered and took a GPS co-ordinate.
    c. Small mammal predators: Track tubes were set out on a grid at every 30 m in each study plot. Each track tube was baited with peanut butter, and contained a strip of removable paper and inkpads at each entrance so that small mammals leave footprints on the paper. Track tubes were set out twice throughout the field season for four days at a time.
    d. Mesopredators: Track stations were set out at the four corners of each study plot. Each station consisted of one 1 m by 1 m squares of landscape cloth covered with a layer of sand treated with mineral oil. There was a round white disc at the center of each station that acted as a novel object to attract medium-sized mammals. Mesopredator stations were left out throughout the field season and monitored every four days. Tracks other than ungulates (especially deer and cows) were photographed and catalogued.
6. Vegetation: At each plot, four shrub intersect transects were laid along the 100 m width of each plot. At each territory monitored, two 100 m transects were also laid out at a random declination and intersecting at 50 m at the territory centre. Species, cover, and height of all shrubs that intercepted each transect were recorded. Daubenmire plots were used every 10 m along each transect to estimate percent vegetative cover by species and non-vegetative cover by type.

    After each nest was complete, the following was measured: grass/forb height at nest, dominant grass species, litter height at nest, height of nearest shrub, ground slope and aspect, and percent visibility from four cardinal directions.

Preliminary Data Trends

1. *Songbird Distribution*

    Edge plots (n=9) had higher bird density and avian species richness than interior plots (n=9; Figure 1). Interior plots, however, had higher grassland obligate songbird (Vesper Sparrow, Brewer's Sparrow, Lark Sparrow, Clay-coloured Sparrow (*Spizella palida*), Western Meadowlark (*Sturnella neglecta*)) density. When agricultural type was included, vineyard edge plots (n=5) had higher bird density, avian species richness and grassland obligate songbird density than orchards (n=4).

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2. *Nest Success*
    a. *Natural Nests*
    Forty nests of nine avian species were found and monitored (Table 1). More nests of all species and grassland obligate species were found at interior plots with the fewest nests found at vineyard edges (Figure 2). Predation rate was slightly higher at edge plots and in orchards, and is reflected in daily nest survival rate with less variability at interior plots (Figure 3).
    b. *Fledglings*
    Fifty-three territories of Lark Sparrows, Chipping Sparrows, and Vesper Sparrows were monitored for fledglings. Birds at interior plots fledged more successful broods per monitored territory than birds at edge plots.
    c. *Artificial Nests*
    Contrary to my hypothesis and the results from natural nests monitored, artificial nests had slightly lower rates of predation and higher daily nest survival rates at edge plots.

3. *Nestling Condition*
Eight nests of Vesper Sparrows containing 25 nestlings were measured for fat score, tarsus length, and mass. Nestlings at edge plots (n=2) were in better condition than nestlings at interior plots (Figure 4). Lower density of Vesper Sparrows at edge plots could explain higher fitness, however Vesper Sparrows at edge plots had smaller territories than Vesper Sparrows at interior.

4. *Nest Predator Identification*
Due to difficulties setting nest cameras close enough without causing nest abandonment, few nests found, and low nest predation rates, predator identities were obtained for only five predation events (Table 2).

5. *Nest Predator Abundance*
    a. Avian predators
    More avian predators were detected during point counts at vineyard edge plots than orchard edge or interior plots (Figure 5).
    b. Snake predators
    Orchard edge plots had more snake sightings per hour. A Spearman-rank correlation test shows a significant relationship between snake abundance and predation rate at the study plot level (r_{17}=0.519, p = 0.033; Figure 6).
    c. Small mammal predators
    There were no differences in small mammal detection frequency between plot types.
    d. Mesopredators
    Although insignificant due to a low sample size, more mesopredators (coyote (*Canis latrans*), black bear (*Ursus americanus*), dog (*Canis lupus*), raccoon (*Procyon lotor*), cat (*Felis catus*), and weasel (*Mustela* sp.)) were detected with track stations at orchard edge plots.
6. *Vegetation*
Vegetation data was collected at all study plots, territories, nests, and is currently being analyzed.

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Discussion

Although no formal statistical analysis has been performed yet, data from this first field season indicate there are differences between agricultural edges and habitat interior at both the individual territory and avian community levels. At the individual territory level, edge territories were smaller, fledged fewer broods, and experienced higher levels of predation. Many studies (e.g. Shake *et al*. 2011; reviewed in: Paton 1994, Andrén 1994, Hartley and Hunter Jr. 1998, Lahti 2001, Chalfoun *et al*. 2002, Sisk and Battin 2002) have found that nest predation was higher near agricultural edges than in natural, mature forest edges which is consistent with the data collected here. The fragmentation of habitat due to agricultural processes can create an environment where predators and brood-parasites such as Brown-headed Cowbirds are at an advantage to prey on nests (Vander Haegan 2007). Foraging opportunities for nesting birds may be worse at edge plots, forcing the female to leave the nest more often and remain away longer thereby providing predators with more time to attack the nest (Low *et al*. 2010). The terrain itself may also force songbirds to build nests in less hidden locations thus being more obvious to visual predators. Goddard and Dawson (2009) found that nest success increased with the amount of vegetative cover in sharp-tailed grouse.

The hypotheses for this study predicted that nest predator abundance would predict nest predation rates, with edge plots having more predators and predation. Although a small sample size, natural nest predator identifications indicate that snakes, particularly Yellow-Bellied Racers, are responsible for the majority of grassland songbird nest predation in this system. Snakes were seen more often at agricultural edges, and particularly at orchard edges where predation rates are highest. Snakes have been found to prefer edges in forested habitats (Chalfoun *et al*. 2002) perhaps because they provide better thermoregulatory opportunities (Durner and Gates 1993, Blouin-Demers and Weatherhead 2001), but not in a more open coastal sage-scrub habitat (Morrison and Bolger 2002).

Artificial nests do not detect snake predation (Marini and Melo 1998), which may explain why artificial nests here showed the opposite trend of natural nests, with higher rates of predation at interior plots. Nest placement could also be responsible for this unexpected result, as natural ground nests are built in very well hidden areas while the fabricated nests were often placed more in the open. The amount of camouflage on artificial nests has been found to greatly affect predation rates elsewhere (Matessi and Bogliani 1999). Due to the inconsistency between the results from artificial and natural nests, it is unlikely we will deploy artificial nests in subsequent years of this study.

At the avian community level, differences were seen between edge and interior plots, and between orchard and vineyard edge plots. Edge plots have higher species richness and abundance, in agreement with Leopold's original edge effect theory (1933). The suite of grassland obligate songbirds that are of conservation interest, however, appear to be edge avoiders (Ries and Sisk 2010) and have higher abundance at interior plots.

Between agricultural types, vineyard edges had higher density of all birds and grassland birds. Proposed mechanisms for edge effects include differences in food availability and vegetation structure (Chalfoun *et al*. 2002), both which are factors that vary between orchards and vineyards. Angelstam (1986) suggested that an edge effect might be most prominent when there is a steep gradient in primary productivity across the edge, such as is seen across an orchard/shrubsteppe interface.

Although it is unlikely many of the trends discussed above are statistically significant due to small sample size, this initial field season provides some interesting questions to pursue. With

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a larger sample size provided by an additional year of data, we hope to be able to draw some conclusions about edge effects of agriculture on grassland songbirds at the territory and community level, and the major nest predators in the shrubsteppe habitat.

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Table 1. Number, species, and type of nests found using behavioural and systematic nest searching techniques on study plots (n=18) in the shrubsteppe habitat of the southern Okanagan-Similkameen, British Columbia.

Species	**Functional group**	**Nest Type**	**Number of nests found**
American Robin (*Turdus migratorius*)	Generalist	Shrub	4
Brewer's Sparrow (*Spizella breweri*)	Grassland obligate	Shrub	1
California Quail (*Callipepla californica*)	Non-passerine	Ground	4
Chipping Sparrow (*Spizella passerina*)	Generalist	Shrub	7
Common Nighthawk (*Chordeiles minor*)	Non-passerine	Ground	4
House Finch (*Carpodacus mexicanus*)	Generalist	Shrub	1
Lark Sparrow (*Chondestes grammacus*)	Grassland obligate	Ground	4
Vesper Sparrow (*Pooecetes gramineus*)	Grassland obligate	Ground	14
Western Meadowlark (*Sturnella neglecta*)	Grassland obligate	Ground	1
TOTAL			40

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Table 2. Nest characteristics and species of nest predators identified consuming eggs or nestlings of shrubsteppe-nesting birds in the southern Okanagan-Similkameen, British Columbia.

Nest Species	Nest Type	Nest stage	Partial or full predation	Predator	Certainty
Lark Sparrow (*Chondestes grammacus*)	Ground	Nestling	Full	Raccoon (*Procyon lotor*) or Cat (*Felis catus*)	75-95%
California Quail (*Callipepla californica*)	Ground	Egg	Full	Weasel (*Mustela* sp.)	75-95%
Vesper Sparrow (*Pooecetes gramineus*)	Ground	Nestling	Partial	Yellow-bellied Racer (*Coluber constrictor*)	>99%
Vesper Sparrow (*Pooecetes gramineus*)	Ground	Nestling	Partial	Yellow-bellied Racer (*Coluber constrictor*)	>99%
Brewer's Sparrow (*Spizella breweri*)	Shrub	Egg	Full	Yellow-bellied Racer (*Coluber constrictor*)	75-95%

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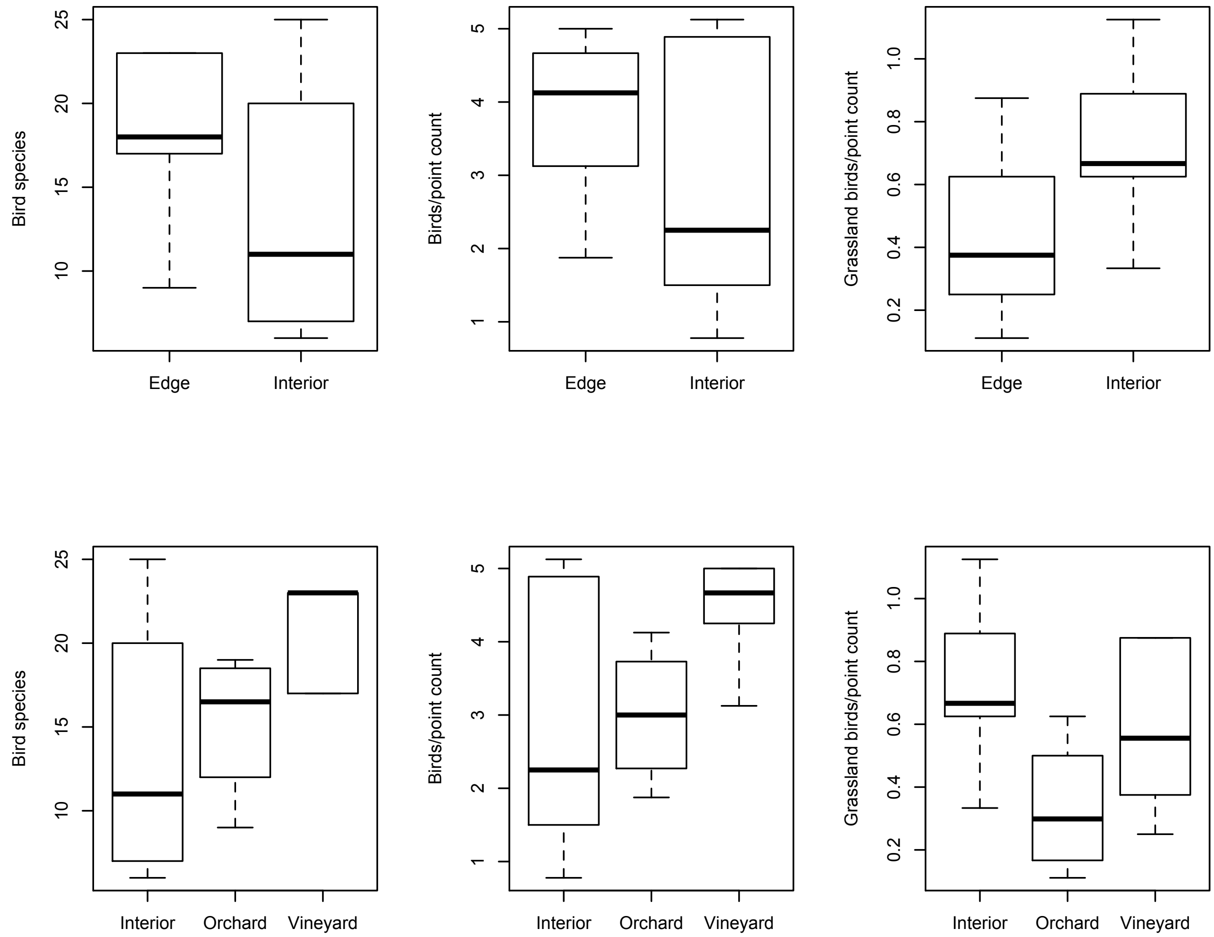

Figure 1. Total number of species and mean number of birds per point count observed during ten-minute point counts at study plots (n=18) in the shrubsteppe habitat of the southern Okanagan-Similkameen, British Columbia. Nine study plots were located at vineyard (n=5) or orchard (n=4) edges and nine study plots were in the habitat interior approximately 500m away. All points counts were performed within one hour of sunrise. Grassland birds include Vesper Sparrow (*Pooecetes gramineus*), Brewer's Sparrow (*Spizella breweri*), Lark Sparrow (*Chondestes grammacus*), Clay-coloured Sparrow (*Spizella palida*), Western Meadowlark (*Sturnella neglecta*).

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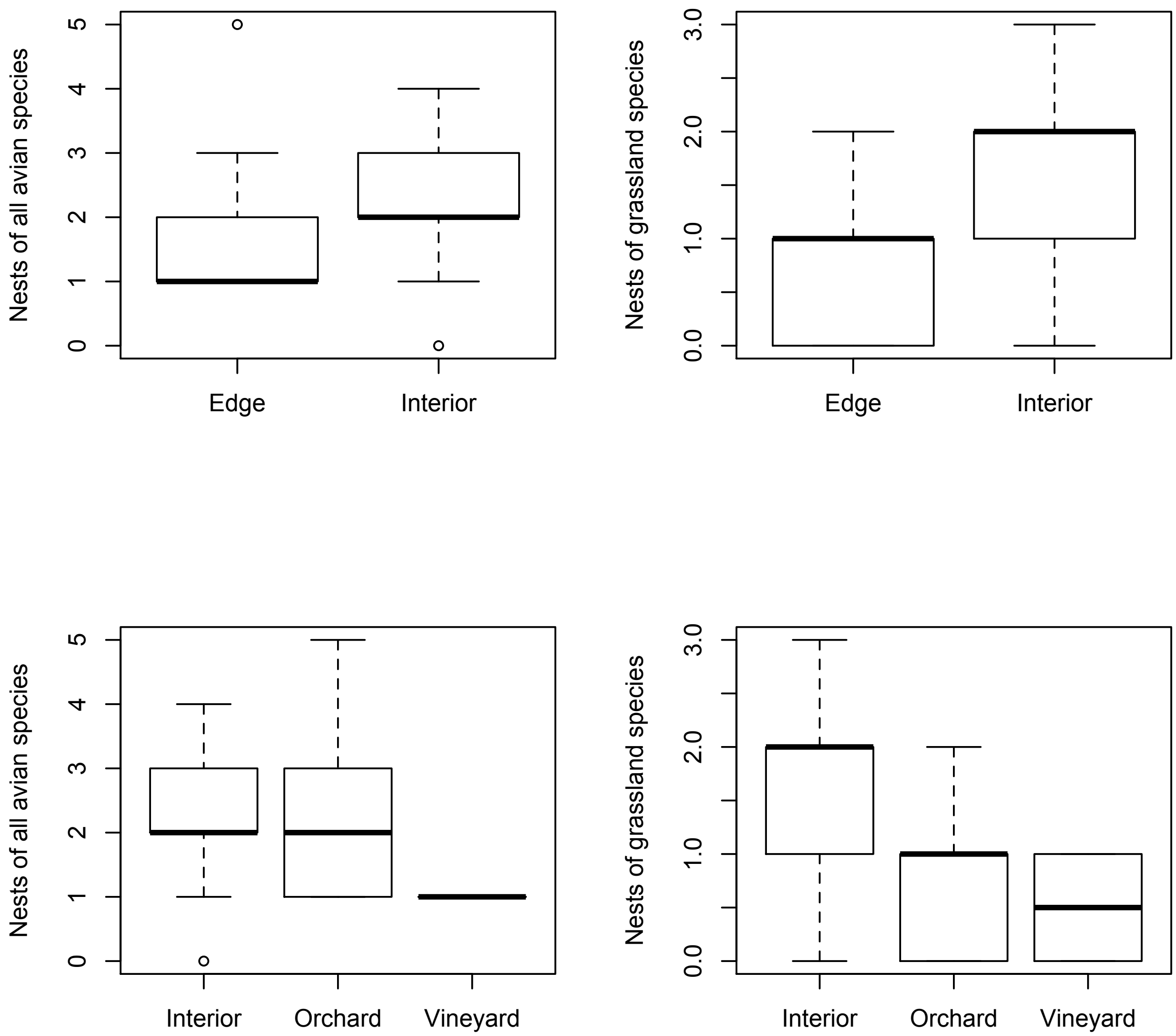

Figure 2. Number of nests per plot found using behavioural and systematic nest searching techniques on study plots (n=18) in the shrubsteppe habitat of the southern Okanagan-Similkameen, British Columbia. Nine study plots were located at vineyard (n=5) or orchard (n=4) edges and nine study plots were in the habitat interior approximately 500m away. Grassland birds include Vesper Sparrow (*Pooecetes gramineus*), Brewer's Sparrow (*Spizella breweri*), Lark Sparrow (*Chondestes grammacus*), Clay-coloured Sparrow (*Spizella palida*), Western Meadowlark (*Sturnella neglecta*).

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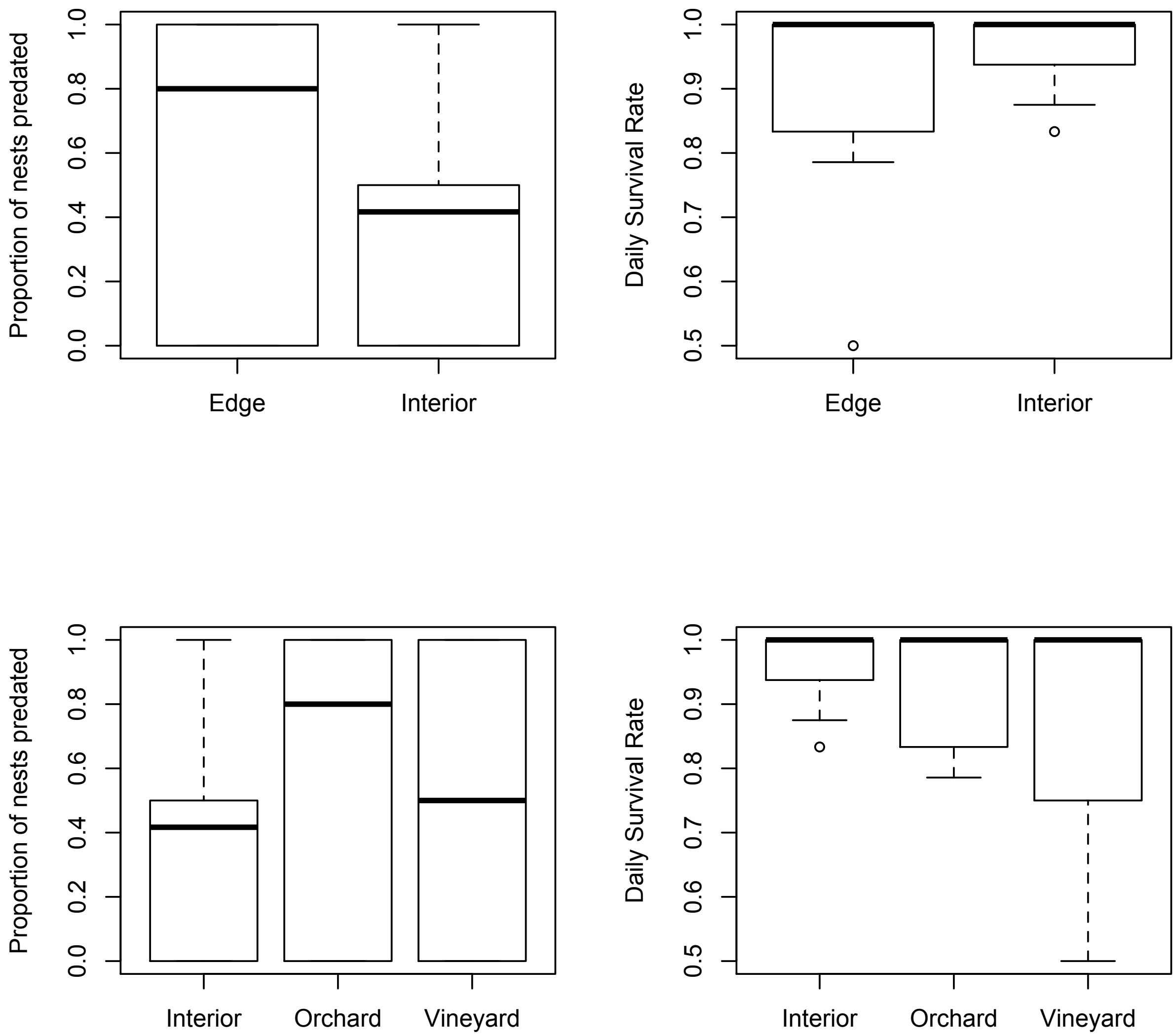

Figure 3. Proportion of nests per plot predated, and daily survival rate of nests found using behavioural and systematic nest searching techniques study plots (n=18) in the shrubsteppe habitat of the southern Okanagan-Similkameen, British Columbia. Nine study plots were located at vineyard (n=5) or orchard (n=4) edges and nine study plots were in the habitat interior approximately 500m away.

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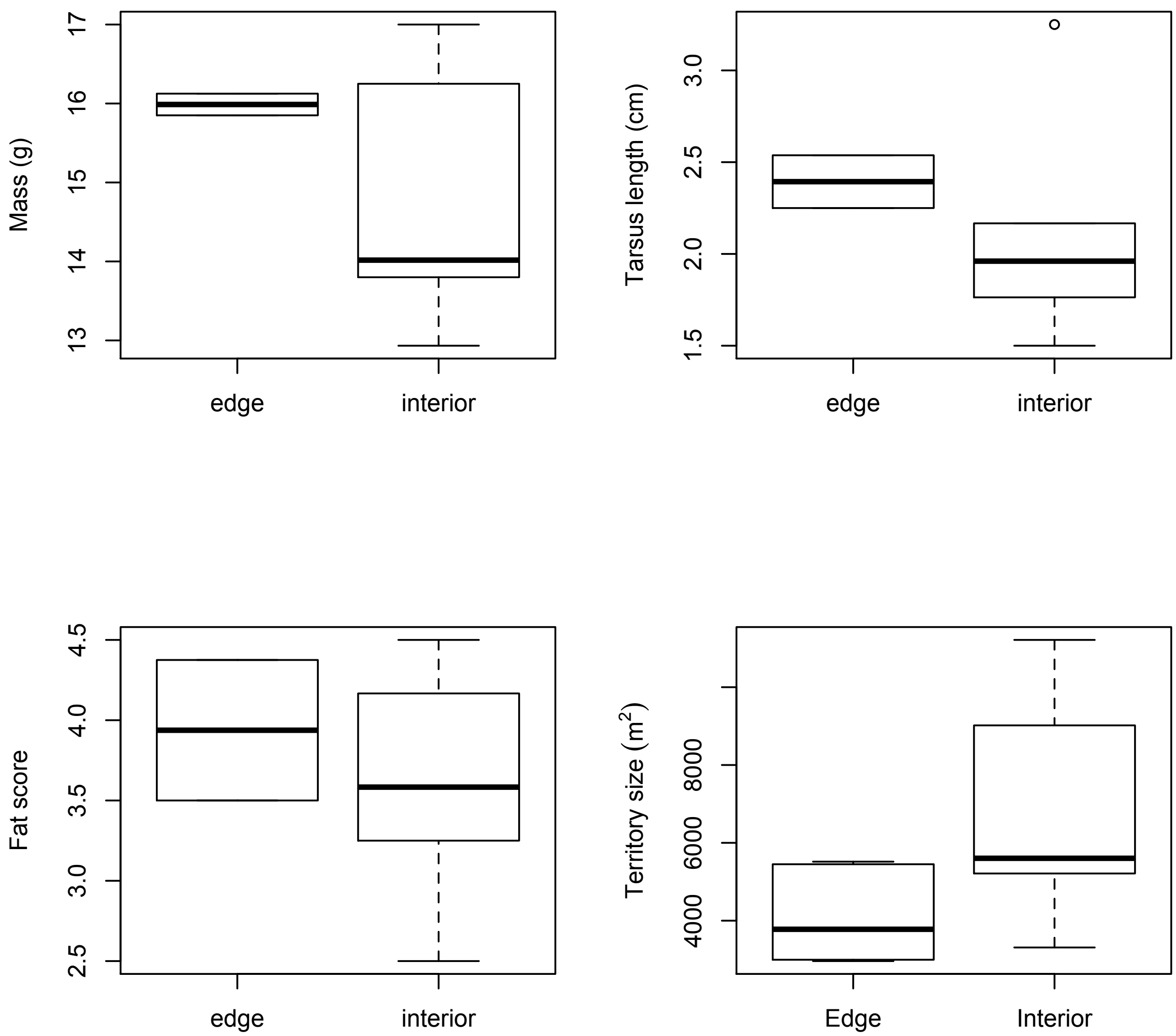

Figure 4. Mass, tarsus length, and fat score of six-day old Vesper Sparrow (*Pooecetes gramineus*) nestlings at study plots adjacent to agricultural edges (n=2) and plots in the shrubsteppe habitat interior approximately 500m away (n=6) in the southern Okanagan-Similkameen, British Columbia. Territories of Vesper Sparrows nest searched at nine pairs of study plots were mapped and calculated for area using ArcMap.

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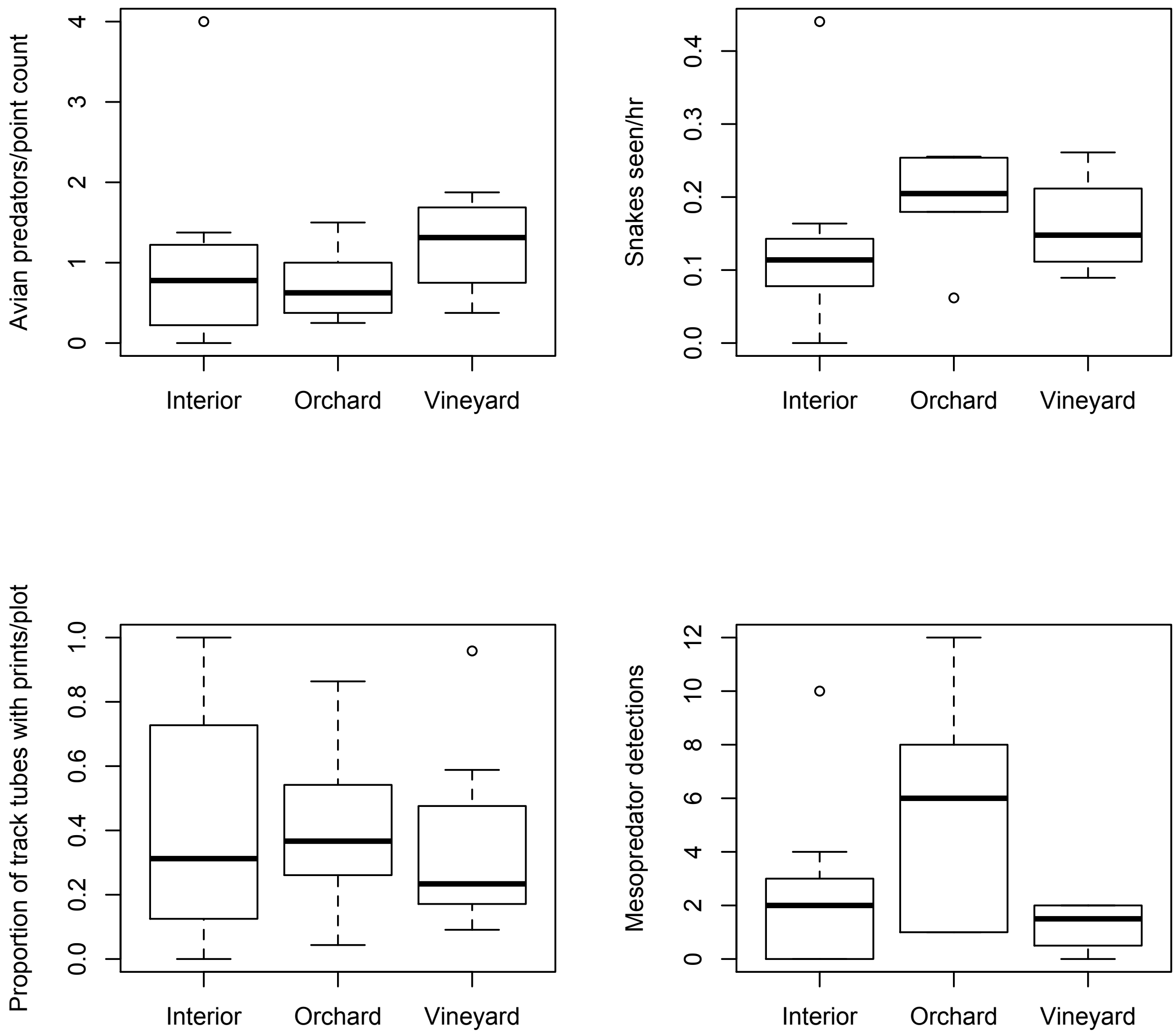

Figure 5. Relative abundances of four common types of predators of grassland songbird nests as surveyed at three types of study plots: orchard edges (n=4), vineyard edges (n=5), and habitat interior approximately 500m away (n=9). Avian predators were counted during ten-minute point counts with an unlimited radius. Snake predators were counted during systematic searching of each plot. Small mammal prints were collected using a grid of 24 track tubes at each plot, twice during the songbird breeding season. Mesopredator tracks were collected using track stations located at the four corners of each study plot that were checked and reset every four days. All study plots were located in the shrubsteppe habitat of the southern Okanagan-Similkameen, British Columbia.

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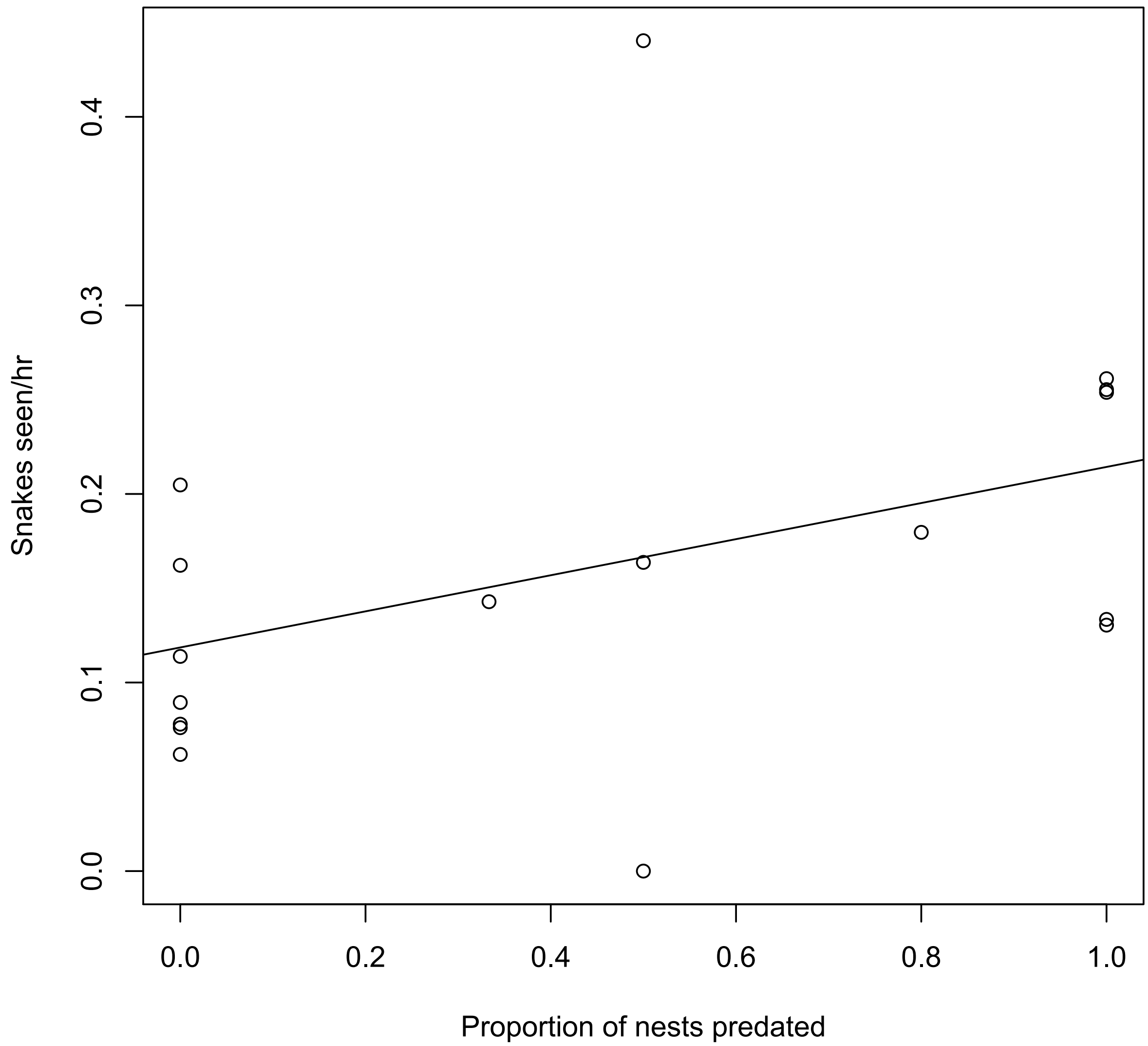

Figure 6. Proportion of songbird nests predated and the number of snakes seen per hour during systematic searches at study plots (n=17) in the shrubsteppe habitat of the southern Okanagan-Similkameen, British Columbia. A Spearman-rank correlation test shows a significant relationship between snake abundance and predation rate (r_{17}=0.519, p = 0.033).

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