

Streaked Horned Lark Inventory, Nesting Success and Habitat Selection in the Puget Lowlands of Washington

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SUMMARY

The Streaked Horned Lark (*Eremophila alpestris strigata*) is a recognized subspecies of the Horned Lark (American Ornithologists' Union 1957) and is a federal and state candidate for listing under the state and federal Endangered Species Acts. In the spring and summer of 2004 we conducted research on this subspecies at two research sites and inventoried all appropriate habitat on Ft. Lewis Washington for breeding Streaked Horned Larks. The specific objectives of this research were:

- 1) Describe breeding phenology and clutch size
- 2) Conduct an inventory of all potential streaked horned lark habitat on Ft. Lewis for the presence/absence of larks
- 3) Map territories of all breeding larks on Ft. Lewis
- 4) Assess reproductive success at Gray Army Airfield and 13th Division Prairie
- 5) Identify habitat features important to breeding at the nest site and territory scales
- 6) Use the herbicide Poast Plus[®] to create potential lark breeding habitat
- 7) Assess lark flush distances

Where possible we compare data from 2002 field season (Pearson 2003) or, in the case of the habitat data, we combine data from both years to increase the sample size and strength of the overall habitat model.

In 2002, nest building activity was first observed on April 18th and the last active nest failed on August 8th with three eggs. In 2003, nest building activity was first observed on April 25th, the first clutch was initiated on May 4th and breeding was completed by August 9th.

We examined clutch in both 2002 and 2003. Using data from both years, we found that clutch size ranged from 1 to 5 eggs ($n = 126$ clutches) with a mode of 3 and a mean of 2.97 ± 0.07 (SE) (2002 and 2003 data combined).

In the four sites used in 2002, combined nest success was 28%. In the two sites used in 2003, combined nest success was 21%. In both years, predation was the primary (70%) source of nest failure. Other sources of failure were abandonment (20%) and human activities (10%).

Territorial Streaked Horned Larks selected habitats that were sparsely vegetated by relatively short annual grasses and with a relatively high percent of bare ground (particularly associated with gravel and cobbles). Territories were usually located adjacent to paved or dirt surfaces, and Larks avoided areas dominated by shrubs and non-native perennial forbs. At the nest site scale, females selected nest sites with more bunch

grasses than random locations and nests with more cover of annual grass were less likely to be depredated.

In 2003, we attempted to survey all “suitable” habitats on Ft. Lewis for Streaked horned larks. No larks were observed during visits to prairies/training areas outside the known population at 13th Division Prairie (TA 14). We also surveyed the Central Impact Area and Artillery Impact Area (AIA) by driving the perimeter and stopping at appropriate habitats. No larks were observed on the Central Impact Area but a new population of larks was located on Range 74 in the AIA. This population was visited 9 times and we located 2 nests, 2 young of the year, and we estimate that there are at least 10 territories at this location. The AIA is approximately 7,000 acres in size and there is a distinct possibility that other nesting pairs occur in areas that cannot be surveyed because the area is an actively used artillery range and may contain unexploded ordinances.

Finally, we initiated an experimental study (6 treatments and 6 controls) at Gray Army Airfield to examine the effects of the herbicide Poast Plus[®] on grassland habitat. Poast Plus[®] is a grass specific herbicide that apparently kills non-native pasture grasses but does not kill the native bunch grass (*Festuca roemerii*) or sedge (*Carex inops*). Consequently, applying the herbicide to areas with a high cover of non-native grasses should result in a more sparsely vegetated habitat preferred by larks. We did not expect to be able to detect a change in the habitat or bird population until the 2004 field season. We will present results from this study after the 2004 field season.

Specific management recommendations include:

- Human activities that are likely to disrupt Lark breeding should be minimized in areas being used by breeding Larks from early March until early August.
- Streaked Horned Lark habitat restoration should focus on creating habitats consisting of sparsely vegetated areas composed of short annual grasses and with a relatively high percent of bare ground (particularly associated with gravel and cobbles). Specifically, managers should maintain relatively short grasses and forbs [0-6 inches (Altman 1999); 7.9-10.4 inches (95% confidence interval from this study)] and a relatively high percent of bare ground [17% (Altman 1999); 7-15% (95% confidence interval from this study)]. We don't recommend conducting restoration activities for the Lark in areas where such activities are likely to negatively impact high quality prairie or other rare species.
- Creating and maintaining high quality prairie habitat is another way of managing for Streaked Horned Larks. High quality prairie habitat has more open space between plants than degraded prairie and consequently, is more likely to be used for breeding.
- In the Puget lowlands, we recommend that restoration activities focus on large open prairies (100s of acres in size) and away from suburban and forested edges.
- We recommend that restoration activities be treated as experiments so that the effectiveness of treatments can be evaluated.

- Streaked Horned Larks are not found in portions of grasslands with > 10% scotch broom cover and efforts should be focused on reducing the percent cover of scotch broom.
- Mowing to control broom can result in dense mats of short live broom plants that Larks appear to avoid. However, mowing broom is preferred to no broom control. On airports, Larks will establish territories in the spaces between mats if the broom plants are short. In addition, mowing can prevent seed set and the spread of broom. Ideally, mowing would be used in concert with other techniques (e.g., burning, herbicide treatment, pulling, and additional mowing) that kill plants.
- The colonization of Puget prairies by rhizomatous grasses (turf forming grasses) has resulted in densely vegetated grasslands. Control of these grasses should be a priority if the objective is to create native grasslands that might support Streaked Horned Larks.
- Airports are mowed regularly for safety purposes. To minimize the negative impacts of mowing on larks, we recommend that mowing occur during non-peak breeding times: before breeding starts in mid-April, the first week of June, and at the end of the breeding season (early August). We also recommend that mowing be very low before and after the breeding season and higher (≥ 8 inches or higher) during the breeding season.
- Predator numbers (especially corvids) increase in response to increased food supplies. We recommend eliminating potential sources of food surrounding breeding locations including uncovered garbage and food scraps.
- We recommend that most activities within 30 m of breeding larks be limited.

Limitations associated with this research and proposed management recommendations are:

- This study provides information on breeding phenology, nesting success and habitat selection for two breeding seasons. Consequently, the results described may or may not be typical and additional years of study are required to document the temporal variability.
- This work describes habitat features for four Puget lowland sites and the habitat variables associated with those sites are likely to differ from those associated with populations along the coast, on islands in the Columbia River, or in the Willamette Valley of Oregon.

Positive outcomes:

- Gray Army Airfield again modified their mowing regimes to avoid disturbing or destroying nests.
- Ft. Lewis did not renew a permit that allowed a model airplane club to use the area where Larks breed on 13th Division Prairie.
- Ft. Lewis put signs on 13th Division Prairie that prohibit all recreational activities near the nesting Larks.

- A new population of larks was discovered breeding on Range 74 in the Artillery Impact Area (native prairie).
- Non-breeding season mowing and/or controlled burns have been used to control Scotch broom at 13th Division Prairie in 2001, 2002, and 2003. Without such actions, the entire area used by Larks will eventually be colonized by broom and will no longer be suitable for breeding.

INTRODUCTION

The Streaked Horned Lark (*Eremophila alpestris strigata*) is a recognized subspecies of the Horned Lark (AOU 1957). The historic breeding range of the Streaked Horned Lark extended from southern British Columbia (Campbell et al. 1997) south through the Puget lowlands and outer coast of Washington (Jewett et al. 1953) and south through the Willamette Valley of Oregon (Gilligan et al. 1994, Gabrielson and Jewett 1940). It was historically considered to be a common to abundant breeder in appropriate habitats (Bowles 1900, Dawson and Bowles 1909, Gabrielson and Jewett 1940, Jewett et al. 1953, Browning 1975, Campbell et al. 1997).

The Streaked Horned Lark was historically described as a common breeder in the glacial outwash or Puget prairies of the south Puget lowlands (Dawson and Bowles 1909, Bowles 1900, Bowles 1898, Suckley and Cooper 1860). Crawford and Hall (1997) estimated the historic distribution of grasslands in the southern Puget lowlands by mapping grassland soils (Puget prairies only occur on gravelly, well drained soils or on soils derived from materials with low water holding capacity). They estimated that grasslands currently occupy about 22% of their historic distribution and that prairies dominated by native species occupy approximately 3% of the historic grassland distribution. The loss of these grasslands has been attributed to urban development (33%), forest invasion or conversion (32%) and agriculture conversion (30%; Crawford and Hall 1997).

This Streaked Horned Lark is apparently extirpated from British Columbia, the northern Puget lowlands of Washington and the Rogue Valley in Oregon (Rogers 2000, Altman 1999). Currently, there are only six known Streaked Horned Lark populations in the southern Puget lowlands and four of these are associated with airports (Rogers 1999 & 2000, MacLaren and Cummins 2000, Pearson 2003, this study).

Because there are few populations of this subspecies and because larks are no longer present at several historic breeding locations, the Streaked Horned Lark is: 1) a priority species for conservation by Oregon-Washington Partners in Flight (Altman 2000) and British Columbia Partners in Flight (Fraser et al. 1999); 2) listed as State Sensitive by the Oregon Department of Fish and Wildlife (Critical Status; Oregon Sensitive Species List, 1997); 3) listed as a candidate for listing under the Washington Endangered Species Act (Washington Department of Fish and Wildlife, 28 October 1998); 4) considered a Red list species in British Columbia; 5) listed as a federal Candidate species under the Endangered Species Act, U.S. Fish and Wildlife Service.

In the spring and summer of 2003, we conducted research on this species at two research sites in the southern Puget lowlands. The specific objectives of this research were:

- 1) Describe breeding phenology and clutch size
- 2) Conduct an inventory of all potential streaked horned lark habitat on Ft. Lewis for the presence/absence of larks

- 3) Map territories of all breeding larks on Ft. Lewis
- 4) Assess reproductive success at Gray Army Airfield and 13th Division Prairie
- 5) Identify habitat features important to breeding at the nest site and territory scales
- 6) Use the herbicide Poast Plus[®] to create potential lark breeding habitat
- 7) Assess lark flush distances

METHODS

Research Sites

In 2002, fieldwork was conducted from late February to mid-August, in four Puget lowland sites: (1) Olympia Airport (46° 97' N, 122° 90'W), (2) 13th Division Prairie on Ft. Lewis (47° 02'N 122° 44'W), (3) Gray Army Airfield on Ft. Lewis (47° 08'N 122° 58'W), and (4) McChord Airforce Base (47° 12'N 122° 45'W). In 2003, fieldwork was conducted from early April to mid-August and was conducted primarily on 13th Division Prairie and Gray Army Airfield. All sites are dominated by grasses, occur on glacial outwash soils and were formally or are currently composed of native Puget prairie species. The airport sites are mowed to keep the grasses short. These sites were selected because males and, in some cases, females were reported at all sites (Rogers 1999, 2000, MacLaren and Cummins 2000).

Territory Mapping

In 2003, locations of breeding birds were mapped on an orthographic photograph or detailed map of each research site when walking transects that covered most of the two study sites. Individual birds were also mapped during relatively quick tours of the site. Along with bird location, the following information was included on the map: sex and age (adult/fledgling) and behaviors such as agonistic interactions, singing, flight displays, courtship behaviors, etc. These maps represent a snapshot picture of bird locations and behaviors at a given research site. All locations were entered into GIS.

The information from all of the territory mapping activities was combined on to a single composite map for each site. For each site, locations of territorial behaviors such as agonistic interactions, singing, and flight displays were used to delineate territories following Robbins (1970).

Locating Nests and Determining Reproductive Success

We searched for and monitored Streaked Horned Lark nests from April until mid-August. Nests were located and monitored using standardized methodology (Martin and Geupel 1993). Nests were located by observing adults with nesting materials or carrying food, by flushing brooding adults, or by simply searching the vegetation. Date and status (presence of parents, eggs, nestlings) of each nest was recorded approximately every 3-5 days. Nest success and mortality was calculated using the Mayfield method (Mayfield 1961, 1975) as modified by Johnson (1979) and Hensler and Nichols (1981). Nest outcome was reported as the proportion of successful nests, nests that failed, nests lost to predation, nests abandoned and nests lost to human activities (mowing and construction activities).

Clutch Initiation Dates

Unless observed directly, we calculated clutch initiation date by backdating from known dates (hatching dates, estimated age of nestlings, or fledging dates). Backdating using known dates requires information on the time intervals associated with egg laying, incubation and/or nestling stages. Because our sample size was too small to compute these time intervals directly, we used the following time intervals from Beason (1995) to

calculate clutch initiation dates: egg laying = 1 egg laid per day (thus, the number of eggs = the length of the egg laying stage), incubation = 12 days, nestling = 9 days. Although not reported here, the intervals quantified for these nest stages during this study match closely the time intervals reported by Beason (1995).

When a nest found during incubation failed before hatching, we used the following formula to estimate the first date of incubation (Martin et al. 1997):

$$\text{First date of incubation} = \text{date found} - ((\text{incubation period} - \text{number of days observed}) \div 2)$$

We then subtracted the number of eggs in the clutch from this value to determine clutch initiation date.

Clutch Size

The average, median, and modal clutch size was calculated for all research sites and both years combined. We only included clutch sizes from nests that were seen with the same number of eggs at least twice during the incubation period.

Inventory

We attempted to survey all “suitable” habitats on Ft. Lewis for Streaked horned larks. To accomplish this, we first identified potential grassland sites by talking with those familiar with the Fort. Because larks appear to avoid areas with extensive broom cover, we then used the land condition mapping information to identify grassland areas with low Scotch broom cover (<10%). In high lark use areas, the percent cover of Scotch broom is approximately 2% suggesting that they avoid areas with extensive broom cover (data from this work). We then visited potential sites and established transects (100 – 400 m in length depending on extent of appropriate habitat) in relatively large areas with <10% broom cover and that contained patches of bare ground or rock. Using these criteria, we established 9 transect on 9 prairies/training areas (Table 1).

The Central Impact Area was surveyed on three visits (April 20, May 23, and June 16) by driving the perimeter road and stopping only at locations with suitable habitat. Similarly, we drove the perimeter road at the Artillery Impact Area (AIA) and stopped at locations that afforded long-range views of this extensive grassland.

Several training areas (TA) were evaluated for potential lark habitat and determined unsuitable and consequently not surveyed because they contained a high density of Scotch broom: TA12 “Dakto”, TA13 “Anzio”, TA 18 “Point de Hoc” and “Marion”, TA19 “Mytkina”, TA22, and TA23.

Habitat Sampling

Habitat variables were measured at the territory and nest site scale. At the territory scale, habitat variables were measured within territories delineated through territory mapping. Within territories, high use areas were identified (areas with high concentrations of bird

locations). Within high use areas, we randomly located two 25 m perpendicular transects (oriented north-south and east-west) that crossed at their midpoints. We used the point intercept method (Bonham 1989) at each meter along these axes and recorded species that intercepted the rod, maximum height of the vegetation, and whether or not the rod hit bare ground, rock or thatch. For all analyses total hits were averaged per territory or non-use site and plant species were put into the following functional groupings before analysis: ferns, annual forbs (non-native), perennial forbs (native), perennial forb (non-native), annual grass (native & non-native), perennial grass (caespitose), perennial grass (rhizomatous), perennial grass (tuft), and shrubs (native and non-native). Transects were also randomly located in grassland areas adjacent to those used by Larks but that were not used or rarely used (non-use sites). We used the same sampling protocol for nonuse sites as we did for use sites.

At the nest site scale, a 1m wooden frame and dowel was used to measure habitat variables following Barbour et al. (1980). Vegetation was measured within a 0.5 m radius of the nest center by centering the 1m long frame on the nest so that the axis was oriented north-south. We recorded every plant hit by a vertical dowel dropped through the frame at 10 cm intervals. We recorded the number of hits by species, maximum vegetation height and, when the dowel hit the ground, whether the dowel hit bare ground, thatch or rock. The frame was then oriented east-west and the same protocol was followed. For all analyses plant species were put into the following functional groupings before analysis: annual forbs (native and non), perennial forbs (native), perennial forbs (non-native), annual grasses (non-native), perennial grasses (caespitose), perennial grasses (rhizomatous), perennial grasses (tuft), and perennial shrubs (native and non-native). Differences in these species groupings from those measured at the territory scale reflect differences in the species present. For example, no ferns were recorded at the nest scale. Nonuse nest sites were located using a random distance (within 10 m of the nest) and random azimuth from the nest. These random nest sites were located within the same vegetation type (grassland) and likely fell within the same male's territory as the nest site. The same sampling protocol was used for nonuse nest sites as was used for nest sites.

Logistic regression was used to compare habitat variables between nest/territory plots and random plots (Hosmer and Lemeshow 1989). We used the following strategy to develop our multivariable models. As suggested by Hosmer and Lemeshow (1989), we made univariate comparisons of habitat variables between nest and random transects and between territory and random transects. All variables with $P < 0.25$ were included in an initial multivariate model. We controlled for multicollinearity by computing a correlation matrix among the remaining variables. No variables were significantly correlated ($r > 0.60$). The most parsimonious model was developed using a manual "step-down" method, minimizing Akaike's Information Criterion (AIC; Lebreton et al. 1992). Predictors were eliminated from the full model if their removal reduced the value of AIC. The final models were evaluated using the likelihood-ratio test comparing the full model with a constant only model, and the coefficient, t-ratio, p-value, and model log likelihood, chi-square, and Rho-squared values were reported.

Habitat Enhancement Experiment

We initiated an experimental study to examine the effects of the herbicide Poast Plus[®] on grassland habitat. Poast Plus[®] is a grass specific herbicide that apparently kills non-native pasture grasses but does not kill the native bunch grass (*Festuca roemeri*) or sedge (*Carex inops*). Consequently, applying the herbicide to areas with a high cover of non-native grasses should result in a more sparsely vegetated habitat preferred by larks. Six treatments and six control plots (50 m x 50 m) were established at Gray Army Airfield. Vegetation within treatments and controls was measured in May prior to herbicide application and in late July using the point intercept method as described for territories above. The herbicide was applied in May and birds were monitored on control and treatment plots throughout the breeding season.

Flush Distances

A 'flush' is a behavior, characterized as a reaction to disturbance, causing a bird to change its' position rapidly, presumably to a more secure location. Flush distance is defined as the distance between the disturbance and the fleeing bird. A bird may change its' behavior in response to a perceived disturbance but until it changes location, either by flight, running or walking, it is not recorded as 'flushing'. In the course of gathering data, flushes were recorded when observed opportunistically or in anticipation of a planned approach to a specific bird. After flush occurred, the distance flushed to a new location was recorded. We noted behaviors prior to and after flushing, direction of flush and the approach direction of disturbance.

RESULTS & DISCUSSION

Clutch Initiation

Information about the timing of Streaked Horned Lark breeding is important for determining when certain land management activities might impact Horned Lark reproduction. Consequently, we documented Horned Lark clutch initiation dates at four locations in 2002 (Pearson 2003) and two locations in 2003.

In 2002, nest building activity was first observed on April 18th, the first eggs in a nest were observed on April 30th and the last active nest failed on August 8th with three eggs (Pearson 2003). In 2003, nest building activity was first observed on April 25th, the first clutch was initiated on May 4th and breeding was completed by August 9th.

The graph of clutch initiation dates (Figure 1) suggests that there are at least two periods of clutch initiation. The first period begins in late April - early May and extends into late-May. This period appears to be followed by a period of re-nesting after failed attempts and second clutches (early June to late July). We base this description of clutch initiation periods on the relationship between nest failures and clutch initiation and on the relationship between first fledglings and apparent initiation of second nests.

Nesting dates reported here are similar to those reported for the Streaked Horned Lark by Bowles (1900). According to Bowles (1900), lark nesting near Tacoma begins in late April and nesting extends through the first week in July, with the height of the season about the middle of May.

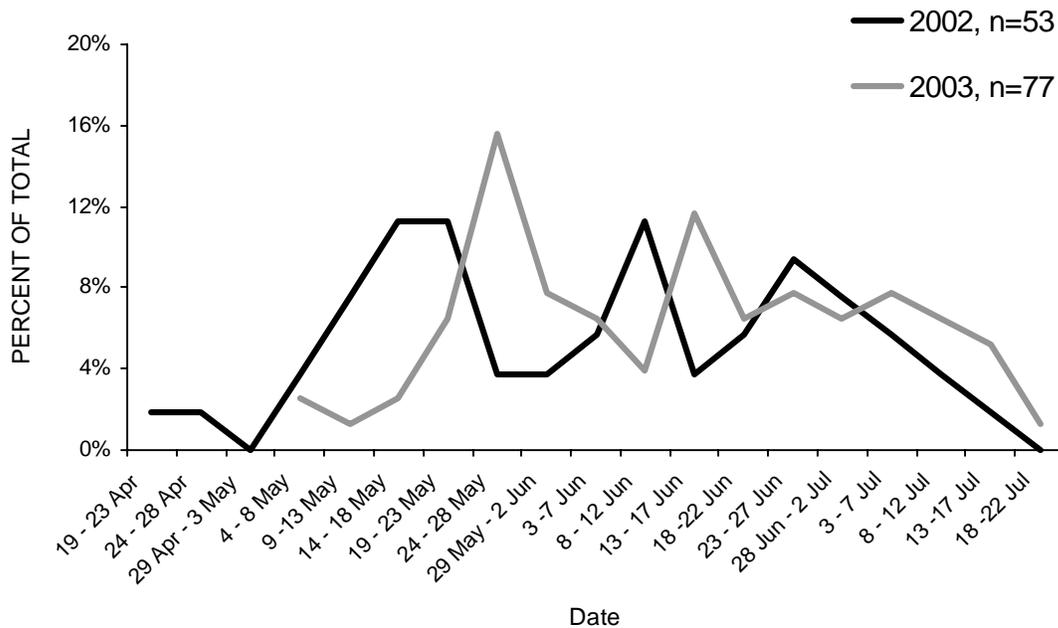


Figure 1. Clutch initiation dates (in five day intervals) for Streaked Horned Larks at four south Puget lowlands breeding locations in 2002 and two locations in 2003.

Clutch Size

For the 2002 and 2003 clutches combined, clutch size ranged from 1 to 5 eggs ($n = 126$ clutches) with a mode of 3 and a mean of 2.97 ± 0.07 (SE). Beason (1995) summarized what is known about Horned Lark clutch sizes throughout North America and reports a clutch-size range from 2 to 5 eggs; mean clutch size varies geographically [British Columbia and Washington = 2.4 ($n = 15$), Colorado = 3.0 ($n = 9$), Illinois = 3.3 ($n = 26$), and Northwest Territories = 3.5]. The average clutch size reported in this study is similar to those reported elsewhere for this species but larger than that reported previously for the Pacific Northwest. These differences in clutch sizes may be the result of differences in sample size ($n = 126$ for this study and $n = 15$ for other studies combined). In addition, our clutch size data is based on clutches produced throughout the breeding season. Work on a number of other passerine species suggests that clutch size decreases in replacement and second clutches.

Inventory

In 2003, we surveyed 9 transects on 9 prairies/training areas and detected 9 birds at range 74 (Table 1).

Table 1. Number of transects, number of visits to the transects and number of larks detected by location surveyed (does not include transects within known breeding populations).

Location	# Transects	# Visits	Ave. # Larks detected/visit
Training Area 7S	1	3	0
Training Area 8	1	3	0
Training Area 13	1	3	0
Training Area 15	1	3	0
Training Area 14 (outside known breeding population)	0	2	0
Point Salines (Training Area 6)	1	4	0
Lower Weir (Training Area 21)	2	3,2	0
Upper Weir (Training Area 21)	1	3	0
Range 74	1	3	3

The Central Impact Area was surveyed on three visits and no horned larks were observed. We drove the perimeter road at the Artillery Impact Area (AIA) during four visits and detected a population of larks at R74. The population at Range 74 was visited during 9 visits between April 20 and July 4. Two nests were located, 2 young of the year were observed and we estimate that there are at least 10 territories (20 individuals; Table 2). We also detected a singing male in the southwest corner of the AIA approximately 100-200m north of the road but we did not see the bird. No birds were detected during a follow-up visit to the same location on June 16. The AIA is approximately 7,000 acres in size and there is a distinct possibility that other nesting pairs occur in areas that cannot be surveyed because the area is an active artillery range and may contain unexploded ordinances. The AIA burns very frequently as a result of artillery explosions. Frequent fires may create appropriate nesting habitat (see discussion below).

Several training areas (TA) were evaluated for potential lark habitat and determined unsuitable and consequently not surveyed because they contained a high density of Scotch broom: TA12 “Dakto”, TA13 “Anzio”, TA 18 “Point de Hoc” and “Marion”, TA19 “Mytkina”, TA22, and TA23.

Territory Mapping

Using the composite maps and locations of agonistic behaviors, singing, flight displays and male-female interactions we delineated 45 territories on the four research sites in 2002 (Table 2) and 50 territories on three research sites in 2003. In 2002, we only used a portion of Gray Army Airfield and we used the entire airfield in 2003. This change in the amount of area covered resulted in an increased number of territories for the site.

A territory represents the area defended by a single male and it appears that each male successfully attracted at least one mate. Consequently, doubling the count of territories gives an approximate count of the number of birds at each location when the entire population was observed. The entire population was observed at Olympia Airport and 13th Division Prairie in 2002 and the entire population was observed at Gray Army Airfield, 13th Division Prairie and the Artillery Impact area in 2003. At McChord, we only used a portion of the airfield for our study in 2002. As a result, we do not have an estimate of the number of territories for the site.

Table 2. Estimated number of Streaked Horned Lark territories in June, 2002 and 2003 by population.

Location	#Territories 2002	#Territories 2003
Gray Army Airfield	6	30
Olympia Airport	18	-
McChord AFB	13	-
13 th Division Prairie	8	10
Artillery Impact Area (Range 74)	-	10
Total	45	50

Nesting Success

Nesting success associated with different nesting stages (egg laying, incubation, and nestling) varies from nest stage to nest stage. Nests are usually found at different stages of the nestling cycle. Consequently, biases associated with the relative number of nests found by nesting stage can influence overall estimates of nesting success. The Mayfield method accounts for potential biases associated with date of nest discovery by calculating a daily nest success rate for each of the three nest stages independently.

In Table 3, we report Mayfield nest success estimates for the 2002 and 2003 field seasons. We did not statistically compare nesting success among locations because of small sample sizes (Hensler & Nichols 1981, Nur et al. 1999).

Table 3. Mayfield estimates of Streaked Horned Lark nest survivorship during the 2002 and 2003 field seasons (n = 55 active nests in 2002 and n = 72 active nests in 2003).

Site	Egg laying		Incubation		Nestling		Overall	
	2002	2003	2002	2003	2002	2003	2002	2003
Gray	-	0.85	0.59	0.38	0.63	0.80	0.31	0.23
13 th Div.	1.00	1.00	0.31	0.31	0.09	1.00	0.07	0.15
Olympia	-	-	0.56	-	0.81	-	0.37	-
McChord	-	-	0.55	-	0.63	-	0.29	-
Overall	1.00	0.88	0.51	0.36	0.63	0.82	0.28	0.21

In the four sites used in 2002, combined Mayfield nest success was 28%. In the two sites used in 2003, combined Mayfield nest success was 21% (Table 3). In both years, more nests were lost during the incubation period than the nestling and egg laying periods (Table 3). Mayfield nesting success was lowest in 13th Division Prairie, where no young fledged in 2002 and only five fledged in 2003. We did observe an additional 8 fledglings on 13th Division prairie that apparently fledged from nests that we did not locate. Other than 13th Division, nesting success was fairly similar among sites (Table 3). Nest failure was greater during the incubation stage than the nestling stage for all sites except 13th Division in 2002. Differences in the number of nests discovered at 13th Division Prairie between years might reflect differences in the amount of effort spent looking for nests. Differences in the number of nests discovered at Gray Army Airfield between years likely reflects both differences in the amount of area searched for nests and the amount of effort spent looking for nests.

Table 4. Streaked Horned Lark nest outcomes for three research sites in the south Puget lowlands in 2003.

Location	Nest Activity ¹	Number of Nests ²	Active Nests ³	Successful ⁴	Fledglings ⁵	Failed ⁶	Depredated	Abandoned	Human Caused Failure ⁷
Gray Army Airfield	4 May – 9 Aug	72	56	20	45	36	28	6	2
13 th Division Prairie	17 May – 25 Jul	22	16	3	5	13	7	6	0
Artillery Impact Area	24 May – 10 Jul	2	1	-	-	-	-	-	-
Total (%) ⁸		96	72	23 (32)	50	49(68)	35 (71)	12 ()	2 (3)

¹ Period of time when birds were actively nesting (i.e., nest building, egg laying, incubating, and caring for nestlings)

² Total number of nests discovered

³ Of the total number of nests discovered, those that progressed at least to the egg-laying stage with known outcomes

⁴ Number of active nests that fledged at least one young

⁵ Number of young that successfully fledged from active nests

⁶ Number of active nests that failed to fledge nestlings

⁷ Mowing activities

⁸ Percent of active nests that fail or are successful or the percent of the failed nests that were depredated, abandoned or lost to human activities.

The primary source of nest failure in both years and at all sites was nest predation (Tables 4 & 5), which appears to be the primary source of nest failure in most North American grassland systems (Best 1978, Johnson and Temple 1990). We only observed two predators depredated nests, a garter snake (*Thamnophis sp.*) and an American crow (*Corvus brachyrhynchos*). In addition, we suspect that a killdeer may have pecked a hole in a lark egg. The relative contribution of these species to lark nest predation is unknown.

Table 5. Streaked Horned Lark nest outcomes for five research sites in the south Puget lowlands for the 2002 and 2003 combined.

Location	Nest Activity ¹	Number of Nests ²	Active Nests ³	Successful ⁴	Fledglings ⁵	Failed ⁶	Depredated	Abandoned	Human Caused Failure ⁷
Gray Army Airfield	4 May – 9 Aug	84	68	26	56	43	33	7	3
13 th Division Prairie	17 May – 25 Jul	30	24	3	5	21	15	6	0
Artillery Impact Area	24 May – 10 Jul	2	1	-	-	-	-	-	-
Olympia Airport		23	21	9	20	12	6	2	4
McChord		16	14	6	15	8	5	2	1
Total (%) ⁸		155	127	44 (34)	96	84 (66)	59 (70)	17 (20)	8 (10)

¹ Period of time when birds were actively nesting (i.e., nest building, egg laying, incubating, and caring for nestlings)

² Total number of nests discovered

³ Of the total number of nests discovered, those that progressed at least to the egg-laying stage with known outcomes

⁴ Number of active nests that fledged at least one young

⁵ Number of young that successfully fledged from active nests

⁶ Number of active nests that failed to fledge nestlings

⁷ Mowing activities

⁸ Percent of active nests that fail or are successful or the percent of the failed nests that were depredated, abandoned or lost to human activities.

Based on studies of nest predators in grassland systems (Pietz and Granfors 2000, Renfrew and Ribic 2003) other potential nest predators that are found in and around our study sites are: domestic cat (*Felis catus*) & dog (*Canis familiaris*), coyote (*Canis latrans*), northern raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), red fox (*Vulpes vulpes*), long-tailed weasel (*Mustela frenata*), Virginia opossum (*Didelphis virginiana*), black-tailed deer (*Odocoileus*), Northern Harrier (*Circus cyaneus*) and other hawks, various small mammals and song birds. Although brown-headed cowbirds (*Molothrus ater*) were noted in the area, no nests were parasitized. Cowbirds have been observed depredated a nest without parasitizing the nest (Pietz and Granfors 2000).

Other sources of nest failure include abandonment (Table 5: 20%) and human caused failure (Table 5: 10%; mowing activities and construction activities). In 2002, three of the four research sites were actively mowed throughout all or part of the breeding season. In 2003, only Gray Army Airfield was mowed once during the breeding season to minimize impacts on larks. Human activities may well be responsible for some of the observed nest abandonment. Activities that prevent females from returning to their nests for extended periods of time may cause them to abandon their nest. For example, during Armed Services Day tents we set up Gray Army Airfield next to nests preventing females from returning to their nests and nests were abandoned.

Habitat Selection

We compared habitat variables within male territories and surrounding nest sites with habitat variables associated with areas not used for territories or nests. This type of comparison is critical for identifying the habitat variables selected by breeding Horned Larks (Martin and Roper 1988). At the territorial scale, males avoided non-native perennial forbs and shrubs (Table 6, Figure 2) and selected sparsely vegetated areas with more rock (gravels and cobbles), annual grasses, and annual forbs than non-use areas (Table 6, Figure 2). The McFadden's Rho-squared, similar to r^2 , is relatively high (Table 6) indicating that the model accounts for a considerable amount of variability in the data. Horned Larks walk through the grass rather than hopping (Beason 1995), consequently dense, tall grass can be very difficult to move through. Other research indicates that Horned Larks are associated with areas composed of short, sparse vegetation (Dubois 1935, Stewart and Kantrud 1972, Owens and Myres 1973, Weins 1973, Davis and Duncan 1999, Dinkins et al. 2003).

Table 6. Results of the multivariate logistic regression comparing habitat variables associated with territories to those associated with areas not used for territories (n = 86 used and 83 sites that were not used for territories). All variables were averaged per territory and non-use site. The model with the smallest AIC value is presented.

Vegetation variable	Coefficient \pm SE	t-ratio	P value
Rock	0.24 \pm 0.10	2.38	0.017
Annual Forbs	0.04 \pm 0.02	1.87	0.062
Perennial forb (non-native)	-0.116 \pm 0.03	-3.40	0.001
Annual grass	0.02 \pm 0.01	3.19	0.001
Shrubs	-0.07 \pm 0.03	-2.17	0.030
Non vegetated	0.18 \pm 0.05	4.008	0.000
Model log likelihood = 109.9			
Model Chi-square P value < 0.001			
Model McFadden's Rho-Squared = 0.47			

The regression comparing habitat variables associated with nest sites to those associated with nearby random locations suggests that females are selecting areas with more native bunch grasses (Table 7) and nests with more annual grasses are less likely to be depredated (Table 8). These two models are significant but explain little of the variability in the data (Tables 7 & 8).

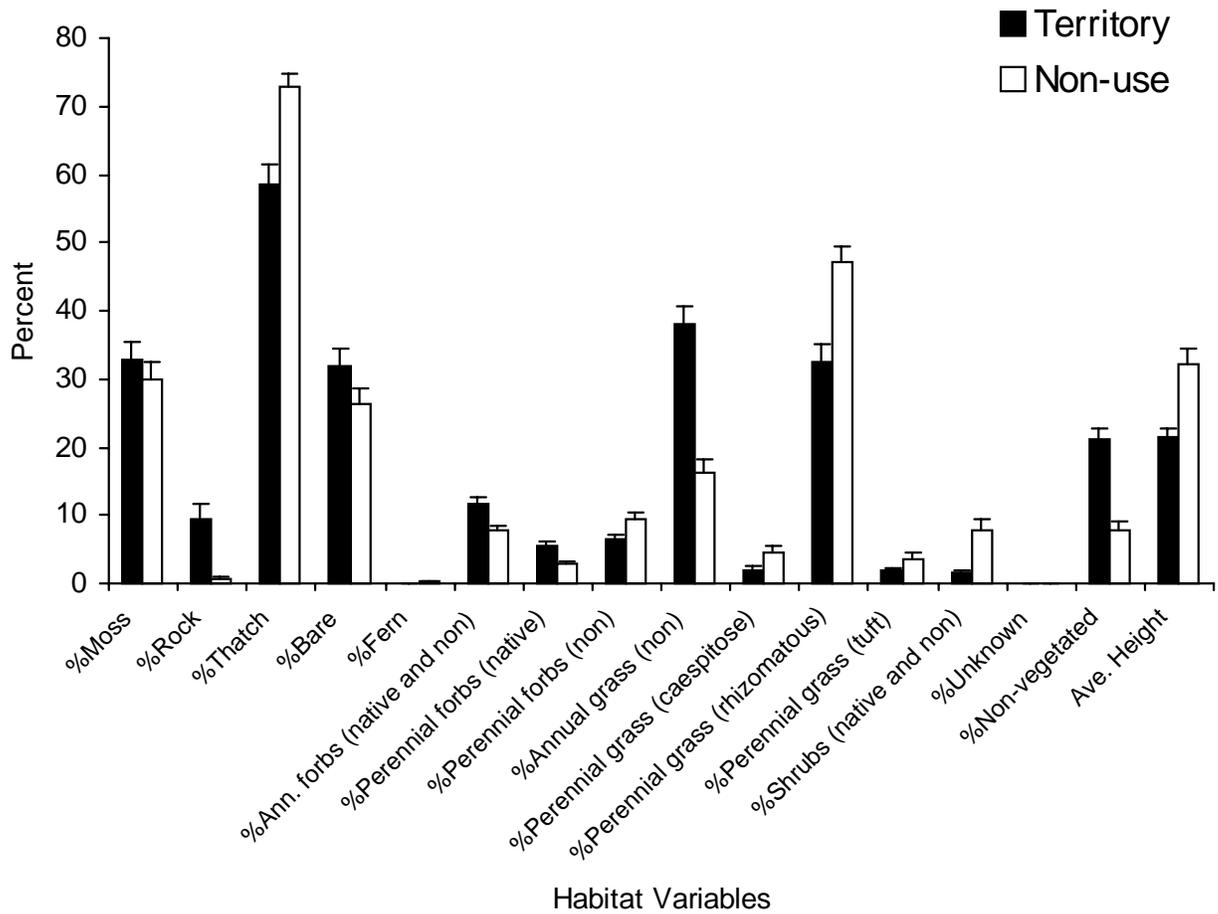


Figure 2. Percent cover of ground cover variables (percent of the total ground intercepts per territory or non-use site), vegetation variables (percent of total vegetation intercepts per territory or non-use site), percent non-vegetated (percent of total points sampled per territory or non-use site) and average vegetation height (cm) for Streaked Horned Lark territories and non-use areas located within adjacent grasslands.

Table 7. Results of the multivariate logistic regression comparing habitat variables associated with Streaked Horned Lark nest sites to those associated with nearby random locations. All variables were averaged per nest site and random locations (n = 142 nests and 142 random locations). The model with the smallest AIC value is presented.

Vegetation variable	Coefficient ± SE	t-ratio	P value
Perennial grasses (caespitose)	0.08 ± 0.04	2.36	0.016
Model log likelihood = -77.29			
Model Chi-square P value < 0.06			
Model McFadden's Rho-Squared = 0.02			

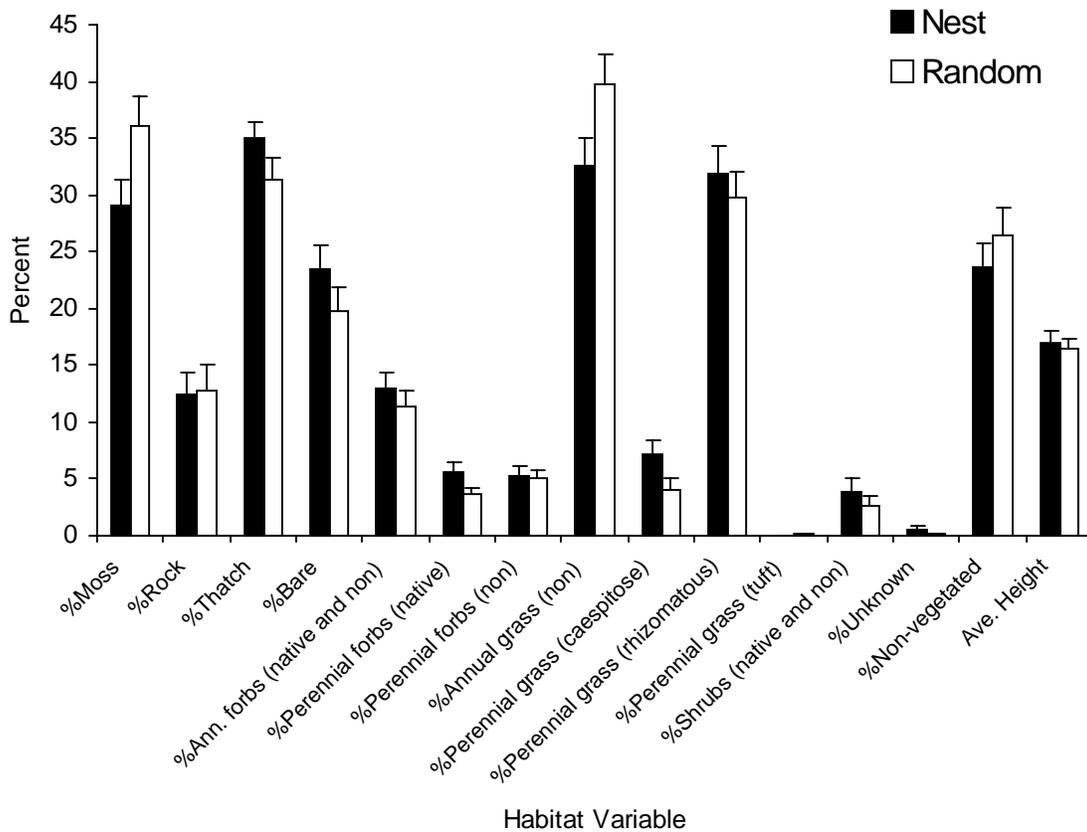


Figure 3. Percent cover of ground cover variables (percent of the total ground intercepts per nest or random site), vegetation variables (percent of total vegetation intercepts per nest or random site), percent non-vegetated (percent of total points sampled per nest or random site) and average vegetation height (cm) for Streaked Horned Lark nest sites and random sites located within adjacent grasslands.

Table 8. Results of the multivariate logistic regression comparing habitat variables associated with successful Streaked Horned Lark nest sites to those associated with depredated nest sites. All variables were averaged per nest site and random locations (n = 43 successful nests and n = 65 depredated nests). The model with the smallest AIC value is presented.

Vegetation variable	Coefficient ± SE	t-ratio	P value
Perennial grasses (caespitose)	0.04 ± 0.02	2.31	0.021
Model log likelihood = -69.70			
Model Chi-square P value < 0.016			
Model McFadden's Rho-Squared = 0.04			

Habitat Enhancement Experiment

We initiated an experimental study (6 treatments and 6 controls at Gray Army Airfield) to examine the effects of the herbicide Poast Plus[®] on grassland habitat. Poast Plus[®] is a

grass specific herbicide that apparently kills non-native pasture grasses but does not kill the native bunch grass (*Festuca roemerii*) or sedge (*Carex inops*). Consequently, applying the herbicide to areas with a high cover of non-native grasses should result in a more sparsely vegetated habitat preferred by larks. The herbicide was applied in May, and we did not expect a significant change in the habitat or bird population until the 2004 field season. We will present the initial results from this study after the 2004 field season.

Flush Distances

We recorded 81 flush events in response to our site surveys, nest checks or when birds responded to other pedestrians, helicopters or airplanes. On average, birds flush when the disturbance was 19 m away (ranged: 2 - 50m). In response to the disturbance, most birds flew (95%; n = 55) and flew 40 m on average. These data only include birds that flushed and do not include individuals that did not flush in response to a disturbance.

When examining flushing by nest period (Figure 4), birds flushed when disturbances were farther away (average \cong 30 m) during the egg laying period when compared to the incubation and nestling periods (average \cong 17 – 18 m). This result is not surprising because birds tend to become more committed to the nest with the amount of effort invested. The distance a bird flew or walked in response to a disturbance did not differ among nest periods.

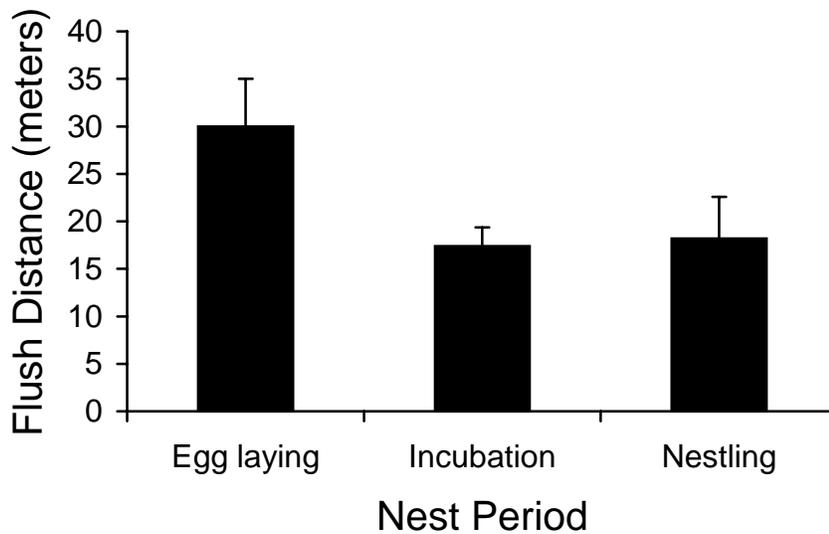


Figure 4. Mean flush distance by nest period (egg laying n = 3, incubation n = 40, nestling n = 10) at Gray Army Airfield and 13th Division Prairie in 2003.

It appears that aircrafts (helicopters and airplanes) caused birds to flush from a greater distance from the disturbance than flushing events caused by our research activities or by

other pedestrian traffic (Figure 5). However, it is very difficult to draw any conclusions from only 3 aircraft flushing events. Both of the observed helicopter flushing events were in response to very low flights (< 20 m above the ground). Birds do not always flush in response to helicopter activity at Gray Army Airfield and rarely flushed in response to airplane activity on McChord Airforce Base.

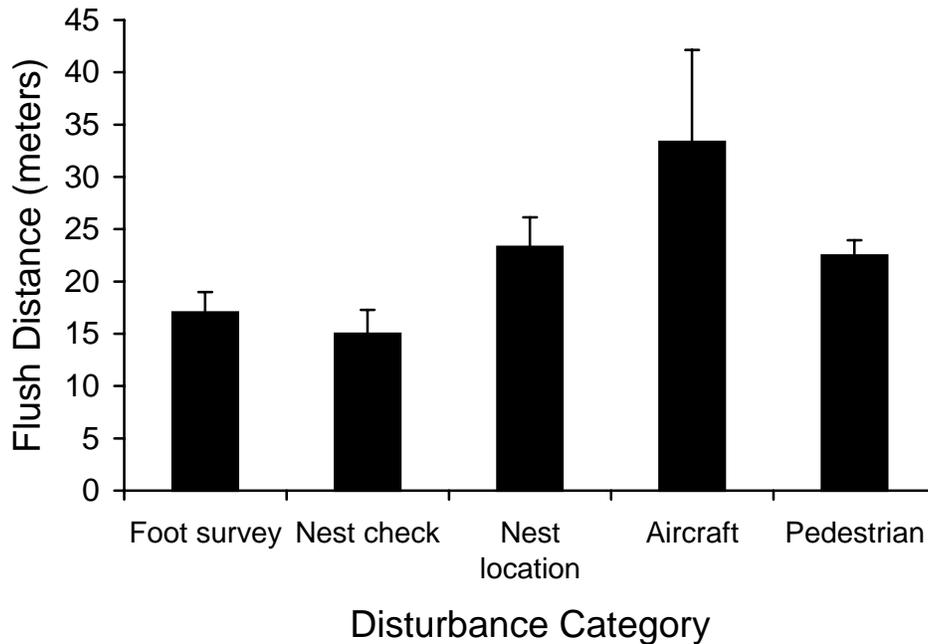


Figure 5. Mean flush distance by disturbance category (foot survey n = 19, nest check n = 22, nest location n = 27, aircraft n = 3, pedestrian n = 4) at Gray Army Airfield and 13th Division Prairie in 2003.

MANAGEMENT RECOMMENDATIONS

Timing of Activities

Streaked Horned Larks are actively establishing territories and breeding from mid-April to early August. Consequently, human activities that are likely to disrupt Lark breeding should be minimized during this time period. The following activities appear to influence Lark behavior by causing them to become alert, fly or the activities directly destroy nests: mowing, vehicle traffic (including ORVs), model airplane flying, dog walking, and gatherings of people and/or vehicles. If possible, the timing or location of these activities should be adjusted to avoid areas of Lark use, especially during the breeding season. Activities that keep larks away from nests for extended periods of time are particularly disruptive and may result in nest abandonment.

Disturbance

Flush distances depend on breeding stage and type of disturbance. In general, activities that occur within 30 m (mean + 1 SD of the mean flushing distance) are more likely to cause flush events than more distant activities. When possible, we recommend that most activities within 30 m of breeding larks be limited. When examining flush distances, we only recorded actual flush events. In many cases, birds did not flush in response to a disturbance. In our experience, birds are less likely to flush in response to a vehicle when compared to an approach by a person on foot at a similar distance.

If land managers are interested in a more comprehensive evaluation of the effects of human disturbances on Lark behavior, then we recommend an experimental approach that would quantify Lark behavior before and after a potential disturbance event.

Nesting Success

Nesting success was extremely low at 13th Division prairie and relatively low on all study sites. Altman (1999) reported 14% nesting success for Streaked Horned Larks in the Willamette Valley in Oregon; a number of these nests were associated with roads and sources of nest failure included predation, human disturbance and abandonment. It is difficult to determine why a female abandons her nest (human or predator activity, physiological condition, weather, or death). We can however, attempt to limit the potential human sources of failure and abandonment as described above. Because predation was the primary source of nest failure, we recommend efforts to identify the primary nest predators. Additional information on habitat variables associated with successful and depredated nests may help identify habitat features associated with successful nesting.

Predators

Predator numbers (especially corvids) increase in response to increased food availability. We recommend covering garbage cans and picking up food scraps near lark breeding locations to reduce potential predator food sources.

Habitat Management

On the sites studied, Streaked Horned Larks selected habitats that were sparsely vegetated by relatively short annual grasses, with a relatively high percent of bare ground (particularly associated with dirt, gravel and cobbles) and avoided areas dominated by shrubs and non-native perennial forbs (this study, Altman 1999). Consequently, efforts to remove non-native and invasive shrubs such as Scotch broom (*Cytisus scoparius*) and sod forming perennial grasses such as *Agrostis spp.* are recommended. Other specific recommendations for improving habitat conditions associated with territories include: maintaining relatively short grasses and forbs [0-6 inches (Altman 1999); 7.9-10.4 inches (95% confidence interval from this study)] and a relatively high percent of bare ground [17% (Altman 1999); 7-15% (95% confidence interval from this study)]. Altman (1999) recommended a higher percent cover of bare ground (31%) for Streaked Horned Lark nest sites. For foraging, Larks select sites with low vegetation (mean = 4.2 inches), and with low vegetation density (Rogers 2000). A review of the effects of management practices on the horned lark (Dinkins et al. 2003) also indicates that larks prefer areas with short, sparse herbaceous vegetation with little or no woody vegetation.

Today, Streaked Horned Larks are found on accreted soils along the coast and Columbia River, dredge spoils, gravel or dirt roads adjacent to grasslands (natural or human created) and agriculture fields, recently planted Christmas tree farms with bare soils, wetland mudflats, and airports (Altman 1999, Rogers 2000, Pearson 2003, this study). It is unclear what habitat conditions were historically selected by Streaked Horned Larks in the Puget lowlands because they no longer occupy high quality native prairie sites. However, three factors may have worked either independently or in concert to create appropriate habitat conditions. Short, sparsely vegetated conditions may have existed in areas (1) burned frequently, (2) with a poorly developed A horizon, and (3) with a high content of gravels and cobble content. Typically, Spanaway soils have a well developed A horizon (Pringle 1990). However, the width of the A horizon and the amount of gravel in the upper soil layer varies dramatically across the Puget prairie landscape (pers. obs.). Areas that are extremely gravelly/cobblely do exist on the landscape and are likely to have a higher component of bare ground. Plants growing under such harsh conditions are likely to be less vigorous. Poor plant growth would result in a less well developed A soil horizon.

Very frequent fire intervals could create areas that are sparsely vegetated. Frequent intervals would prevent the accumulation of thatch and if the fire burns hot (summer burns), it can volatilize soil nutrients leading to poor plant vigor. A frequent fire interval seems plausible given what is currently known about historic fire frequency. Areas subject to frequent fires were likely dominated by native Roemer's fescue (*Festuca roemerii*) and forbs with plenty of open space between plants. In known breeding areas, we recommend that controlled burns be conducted after the middle of August and before March to avoid interfering with breeding. Frequent fires at locations like the Artillery Impact Area may create good Lark habitat but if the fires occur regularly during the breeding season, then they may negatively effect nesting success.

We recommend focusing Lark restoration activities on degraded prairies that contain high gravel/cobble content in the upper soil horizon and that can be burned frequently. We do not recommend conducting restoration activities for the Lark in areas where such activities are likely to negatively influence high quality native prairies (high quality native prairies are extremely rare) or other rare prairie dependent species (e.g., Taylor's checkerspot). If attempts are made to increase the amount of gravels/cobbles in restoration areas, we recommend the use of native Spanaway gravels and cobbles over other materials such as crushed asphalt or concrete. Other materials may increase ground temperature (darker materials) or may make walking and running difficult (highly angled materials).

Creating and maintaining high quality prairie habitat is another way of managing for Streaked Horned Larks. High quality prairie habitat has more open space between plants than degraded prairie and consequently, is more likely to be used for breeding. We know that Larks historically bred on native prairie and were relatively abundant in discrete patches of appropriate habitat. According to Bowles (1898), Larks used areas "distant from water, where the soil is dry and sandy and the vegetation consists mainly of short grass, mixed with spars clumps of small prairie ferns, which grow to a height of six or seven inches in large patches" (Bowles 1898).

In the Puget lowlands, we recommend that restoration activities focus on large open prairies (100s of acres in size). We know of no studies that have investigated the relationship between habitat patch size and nest success for the horned lark. Bock et al. (1999) compared lark abundance between interior and edge locations and found lark abundance to be greater on interior plots. This result was not significant due to high variation in numbers of larks among plots.

We recommend that restoration activities be treated as experiments so that the effectiveness of treatments can be evaluated.

Human Disturbance

In 2002, we recommend that Ft. Lewis attempt to reduce the amount of recreational and military activity in the areas occupied by breeding Larks. In response to this recommendation, Fort Lewis prohibited model airplane flying, dog walking and vehicle traffic in the area occupied by breeding Larks at 13th Division Prairie. Pedestrians can have a number of negative effects on breeding bird communities (Fernandez-Juricic 2000, Lafferty 2001, Thomas et al. 2003) and these negative effects are increased if pedestrians bring dogs (Thomas et al. 2003).

Streaked Horned Larks breed in the triangularly shaped grassland just north of Gray Army Airfield (see Appendix I). We recommend both fencing off this area and conducting habitat restoration activities in this area.

Mowing

Mowing may be both a blessing and curse for the streaked horned lark. All of the airport sites are mowed for safety reasons and the mowing may be partially responsible for

creating suitable habitat at these sites. At the same time, mowing results in direct mortality of nests and may cause some nest abandonment. To minimize the negative impacts of mowing on larks, we recommend that mowing occur during non-peak breeding times: before breeding starts in mid-April, the first week of June, and at the end of the breeding season (early August). The curve of clutch initiation dates suggests that there is a break in clutch initiations between the first and second clutches, which occurs in the first week of June. We also recommend mowing very low before and/or after the breeding season and higher (≥ 8 inches) during the breeding season. We have noted that mowing with the mowing deck very close to the ground results in more nests being destroyed.

Mowing to control broom can result in dense mats of short live broom plants that Larks appear to avoid. However, mowing broom is preferred to no broom control. On airports, Larks will establish territories in the spaces between mats if the broom plants are short. In addition, mowing can prevent seed set and the spread of broom. Ideally, mowing would be used in concert with other techniques (e.g., burning, herbicide treatment, pulling, and additional mowing) that kill plants.

Future Planning and Research

In 2003, we initiated a study examining the effects of the herbicide Poast Plus[®] on grassland habitat and habitat use by larks. We recommend continuing this work. In 2004, we will initiate a study examining the effects of fire on grassland habitat and habitat use by larks. Again, we believe this study will provide valuable information about methods for restoring lark habitat. We recommend a study that attempts to identify nest predators. For two years, predators have been the primary source (70%) of nest failure. Unfortunately, we do not know which predators are primarily responsible for this predation.

Scope and limitations

There are several limitations to my study that should be considered before applying these results to management prescriptions, and that highlight the need for additional research:

- We describe breeding phenology, nesting success and habitat selection for two breeding seasons. There is likely to be temporal variation in all of these variables. Consequently, the results described may or may not be typical and additional years of study are required to document the temporal variability.
- This work describes habitat features for four Puget lowland sites and the habitat variables associated with these sites are likely to differ from those associated with populations along the coast or on islands in the Columbia River. With funding recently obtained from USFWS, we will be gathering this information in 2004.

POSITIVE OUTCOMES

- Gray Army Airfield again modified their mowing regimes to avoid disturbing or destroy nests.

- Ft. Lewis did not renew a permit that allowed a model airplane club to use the area where Larks breed on 13th Division Prairie. This group sponsored at least three gatherings last year that resulted in 30 vehicles parked on the roads where the Larks breed and forage, mopeds and mini-bikes driving across the prairie where Larks forage and breed in order to retrieve planes and planes flying directly over Larks causing the Larks to flee.
- Ft. Lewis put signs on 13th Division Prairie that prohibits all recreational activities near the nesting Larks.
- A new population of larks was discovered breeding on Range 74 in the Artillery Impact Area. The AIA is approximately 7,000 acres in size and there is a distinct possibility that other nesting pairs occur in areas that cannot be surveyed because the area is an active artillery range and may contain unexploded ordinances.
- Non-breeding season mowing and/or controlled burns have been used to control Scotch broom at 13th Division Prairie in 2001, 2002, and 2003. Although we have not noted a change in the area used by Larks in response to these management actions, these actions have likely helped prevent the spread of broom into areas used by breeding Larks. Without such actions, the entire area used by Larks will eventually be colonized by broom and will no longer be suitable for breeding. We will continue to monitor Lark response to these management actions.

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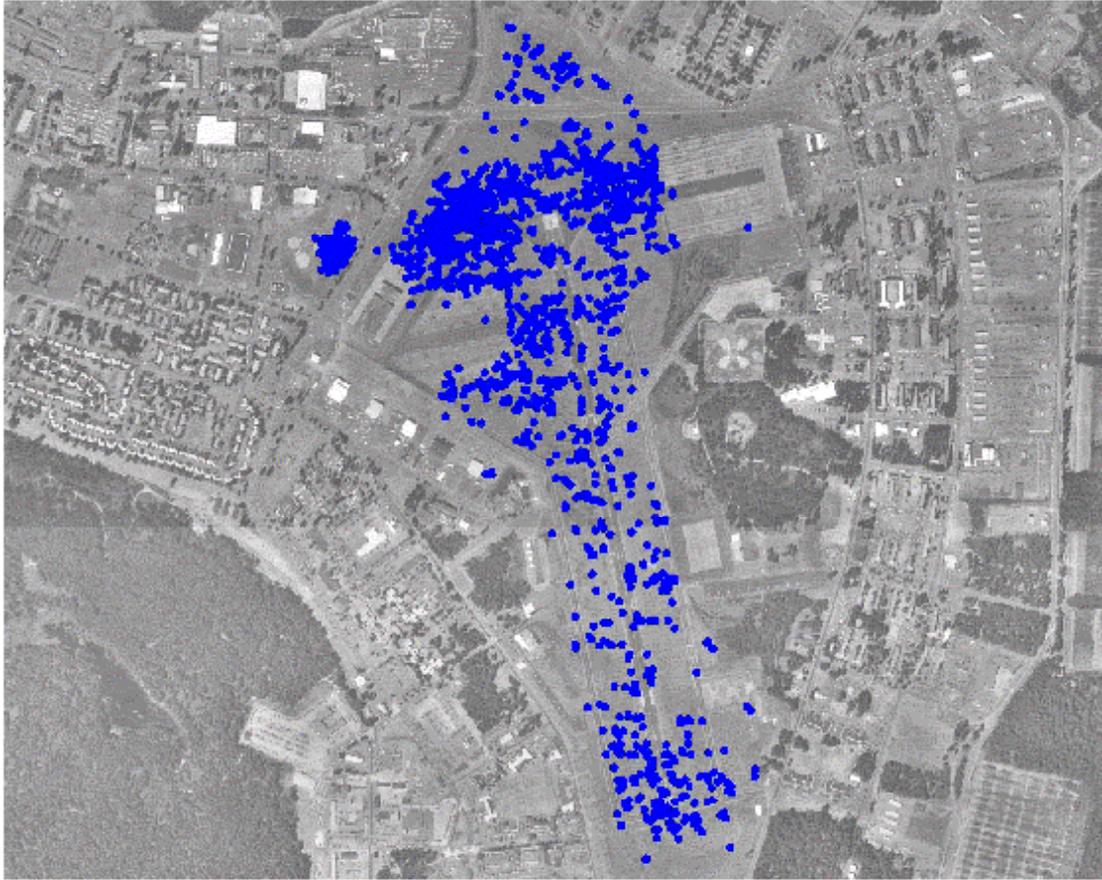
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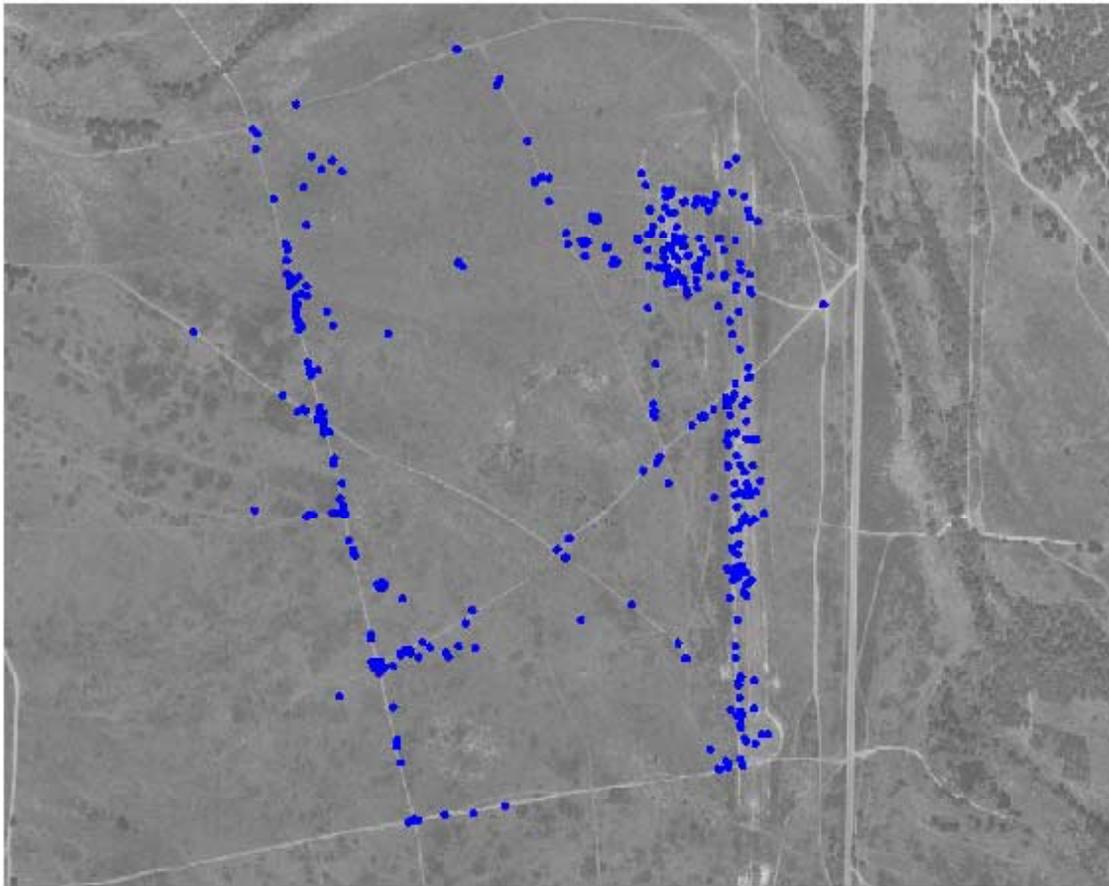
APPENDIX I

The following five figures identify Streaked Horned Lark bird locations and nest sites at Gray Army Airfield, 13th Division Prairie, and R 74 of the Artillery Impact Area. Bird locations were mapped throughout the 2002 and 2003 breeding seasons at each site using the methods described above. Consequently, many of the localities undoubtedly represent the same birds detected numerous times and should not be used to infer bird abundance or density. Nest locations are from the 2003 field season only. Nest locations were determined by GPSing all nest sites at the end of the field season using a Trimble GeoExplorer CE with differential correction.

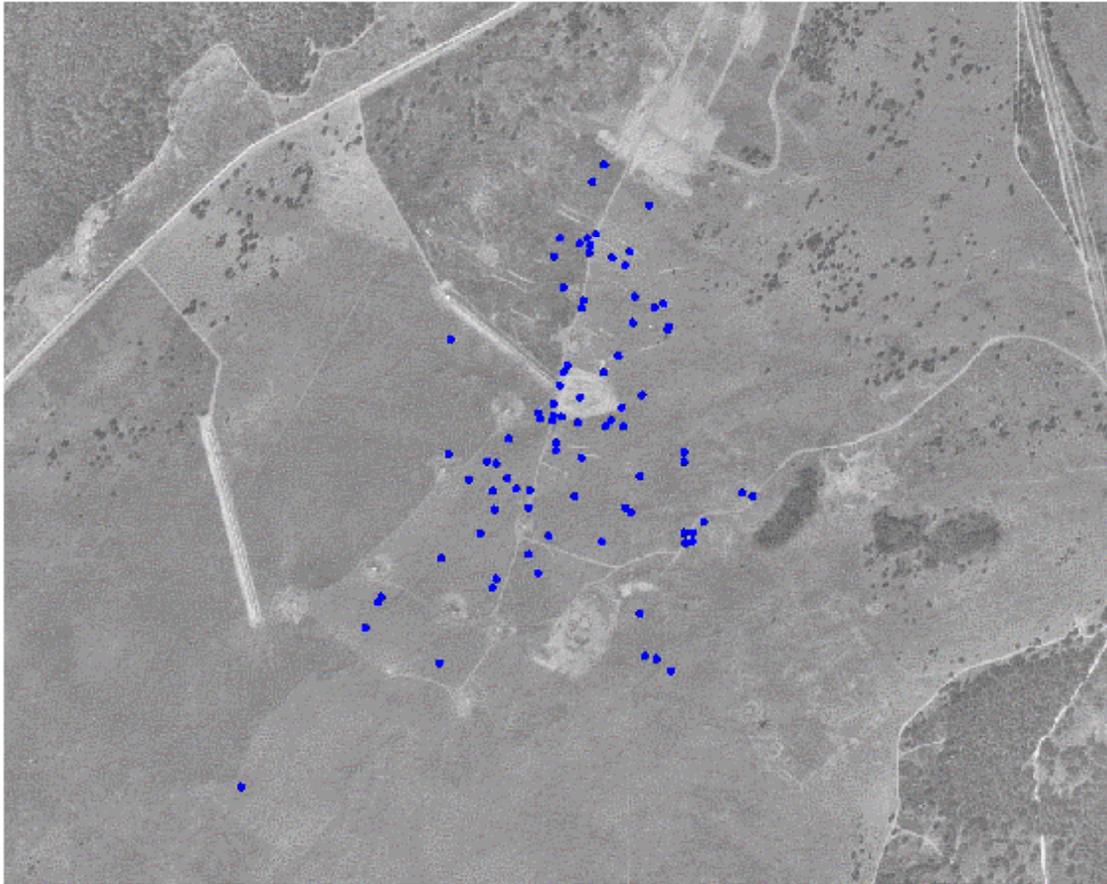
A) Grey Army Airfield bird locations (2002 & 2003 field seasons).



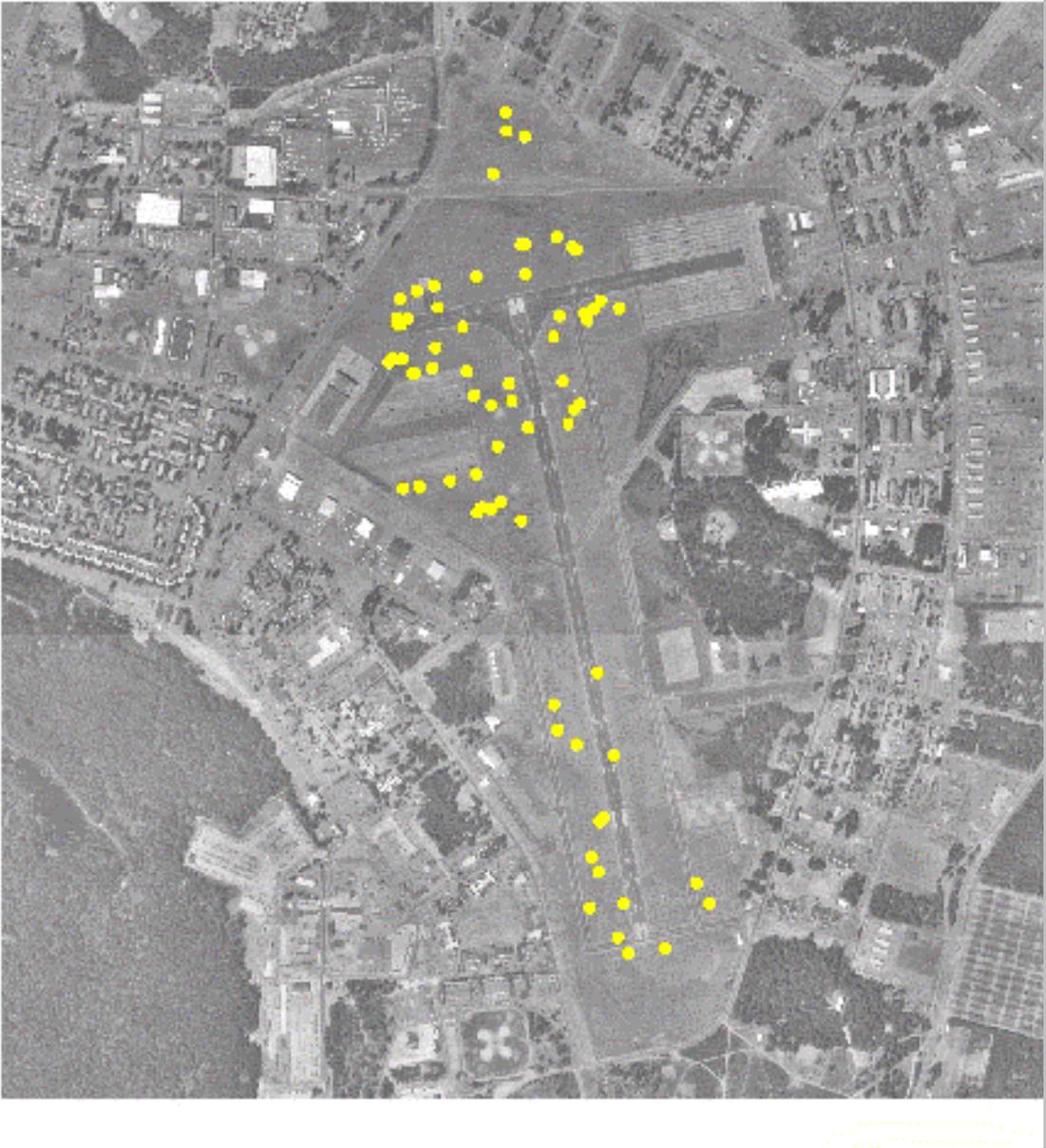
B) 13th Division Prairie bird locations (2002 & 2003 field seasons).



C) R. 74 of the Artillery Impact Area bird locations (2003 field season).



D) Grey Army Airfield nest locations (2003 field season)



E) 13th Division Prairie nest locations (2003 field season).

