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FISH AND WILDLIFE
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Cover photograph of a female Streaked Horned Lark at Damon Point by David Maloney and cover photograph of Miller Sands Island by Scott Pearson

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INTRODUCTION

The Streaked Horned Lark (*Eremophila alpestris strigata*) is a rare subspecies of the Horned Lark that breeds and winters in Oregon and Washington. Recent Streaked Horned Lark research has focused on documenting changes in the subspecies breeding range (Rogers 2000), inventorying and locating current breeding (Altman 1999, Rogers 1999, MacLaren and Cummins 2000, Pearson and Hopey 2004, 2005) and wintering (Robinson and Moore unpubl., Pearson et al. 2005) populations, identifying the important characteristics of breeding and foraging habitat (Altman 1999, Rogers 2000, Pearson 2003, Pearson and Hopey 2004, 2005), and experimenting with methods to improve Lark habitat (Pearson and Hopey 2005). In addition, British Columbia recently completed a status report on the Lark (Beauchesne and Cooper 2003), another has been drafted by Washington Department of Fish and Wildlife (Stinson 2005), and a range-wide population assessment and conservation strategy was written by Pearson and Altman (2005).

The goal of this work is to build upon our previous monitoring and habitat selection research and to investigate methods for improving Lark habitat and methods for creating new populations. The specific objectives of this research are:

1) Describe breeding phenology of birds in the Puget Lowlands, Coastal Washington and Columbia Islands.
2) Survey known and/or potential breeding locations along the Washington coast, lower Columbia River, and on Ft. Lewis for breeding larks.
3) Determine number of breeding territories at the following locations: Damon Point, Midway Beach, Whites Island, Gray Army Airfield, 13th Division Prairie, and McChord Air Force Base.
4) Assess nest survivorship rates for Damon Point, Midway Beach, Whites Island, 13th Division Prairie, McChord Air Force Base and Gray Army Airfield.
5) Use Conspecific attraction (broadcasting recorded Lark songs) to lure breeding larks into apparently suitable but unoccupied habitat.
6) Assess the effectiveness of herbicide and fire treatments for improving Lark habitat using an experimental approach.
7) Examine population trends

METHODS

Research Sites

In 2002, we mapped territories and assessed reproductive success from mid-April to mid-August, in four Puget lowland sites: Olympia Airport, 13th Division Prairie on Ft. Lewis, Gray Army Airfield on Ft. Lewis, and McChord Air Force Base (see research study site locations below). In 2003, fieldwork was conducted from early April to mid-August on 13th Division Prairie and Gray Army Airfield. In 2004 and 2005, fieldwork was conducted from March to mid-August at Gray Army Airfield, 13th Division Prairie and McChord Air Force Base, Midway Beach, Damon Point, and the east end of Puget Island known as Whites Island. All Lark territories were mapped on 13th Division Prairie, Olympia Airport, Midway Beach, Damon Point, and Whites Island. Territories were mapped on portions of Gray Army Airfield in 2002 and 2005 (See Pearson 2003 and Appendix I) and territories were mapped across the entire airfield in 2003 and 2004. In all years studied, we mapped territories only on the northeast portion of McChord Air Force Base.

Table 1. State, County, Latitude and Longitude values for all research and inventory sites used in this research.

Site	State	County	Legal	Inventory/ Research
Puget Lowlands				
13th Division Prairie - Ft. Lewis	Washington	Pierce	47° 01' N 122° 26'W	Research
Gray Army Airfield - Ft. Lewis	Washington	Pierce	47° 05' N 122° 34'W	Research
McChord Air Force Base	Washington	Pierce	47° 08' N 122° 28'W	Research
Artillery Impact Area (Range 74,76) – Ft. Lewis	Washington	Pierce	47° 02' N 122° 36'W	Inventory
Artillery Impact Area (MP 10) – Ft. Lewis	Washington	Pierce	47° 01' N 122° 37'W	Inventory
Johnson Prairie – Ft. Lewis	Washington	Pierce	46° 56' N 122° 37'W	Inventory
Point Salinas – Ft. Lewis	Washington	Pierce	47° 03' N 122° 32'W	Inventory
Olympia Airport	Washington	Thurston	46° 42' N, 122° 59'W	Research
Upper Weir Prairie – Ft. Lewis	Washington	Thurston	46° 56' N, 122° 36'W	Inventory
Lower Weir Prairie – Ft. Lewis	Washington	Thurston	46° 56' N, 122° 36'W	Inventory
Shelton Airport	Washington	Mason	47° 14' N, 123° 09'W	Inventory
Washington Coast				
Damon Point	Washington	Grays Harbor	46° 56'N, 124° 06' W	Research
Midway Beach	Washington	Pacific	46° 46'N, 124° 05' W	Research
Ledbetter Point	Washington	Pacific	46° 38'N, 124° 03' W	Inventory
Columbia River				
Whites Island	Washington	Wahkiakum	46° 08'N, 123° 18' W	Research
Coffeepot Island	Washington	Wahkiakum	46° 10'N, 123° 24' W	Inventory
Rice Island	Oregon/ Washington	Clatsop/ Wahkiakum	46° 15'N, 123° 43' W	Inventory
Miller Sands	Oregon	Clatsop	46° 15'N, 123° 39' W	Inventory
Pillar Rock Island	Oregon	Clatsop	46° 15'N, 123° 37' W	Inventory
Tenasillahe Island	Oregon	Clatsop	46° 13'N, 123° 26' W	Inventory
West Wallace Island	Oregon	Columbia	46° 07'N, 123° 15' W	Inventory
Crims Island	Oregon	Columbia	46° 10'N, 123° 09' W	Inventory
Sandy Island	Oregon	Columbia	46° 00'N, 122° 52' W	Inventory
Rivergate	Oregon	Multnomah		Inventory

In 2005, the following coastal and Columbia River sites were surveyed at least once to determine the presence of larks and to estimate number of breeding birds: Coffeepot Island, Crims Island, Graveyard Spit, Ledbetter Point, Miller Sands, Pillar Rock Island, Rice Island, Sandy Island, Tenasillahee Island, Wallace Island, and Rivergate. In 2005, the following Puget lowland sites were surveyed at least once to determine the presence of larks and to estimate number of breeding birds: Artillery Impact Area (Range 74,76), Artillery Impact Area (MP 10), Johnson Prairie, Olympia Airport, Point Salinas, Shelton Airport, Weir Prairie (Lower), Weir Prairie (Upper), McChord Airfield outside the intensive study area.

The Puget lowland sites are dominated by perennial grasses, occur on glacial outwash soils and were formally or are currently composed of native Puget prairie species. The Puget lowland airport sites are mowed to keep the grasses short and are dominated by non-native perennial grasses. In contrast, the Puget prairie sites (13^{th} Division Prairie and Range 74,76 of the Artillery Impact Area) are dominated by native and exotic perennial grasses. On the outer coast, the study sites consisted of accreted lands or erosional features along sandy shorelines with sparse to dense beachgrass cover. The Columbia River island sites consisted of sparsely vegetated sites created by the accretion of sandy soils or by the deposition of dredge spoils. All sites are grass and forb dominated habitats with very few or no trees and shrubs.

Inventory

Along the coast and Columbia River and in the Puget lowlands, we identified potential inventory sites by locating grassland habitat on aerial photographs, by visiting sites previously recorded as occupied (Rogers 2000), and by learning of potential Lark breeding sites from local birders and USFWS personnel. Surveys were conducted by hiking through appropriate habitat between sunrise and mid-afternoon. Birds were located visually or by detecting songs or flight displays. The duration of each survey varied depending on the amount of appropriate habitat to cover at each site. We recorded the age (adult or hatch year), sex, behavior and any evidence of breeding.

Territory Mapping

In 2005, 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 study sites. Individual birds were also mapped during relatively quick tours of the site. Along with the location of each bird, we recorded the following information 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. The information from all of the territory mapping activities was combined on 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).

Nest Survivorship

We searched for and monitored Streaked Horned Lark nests from April until mid- August (early July at Gray Army Airfield in 2005). 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 incubating or brooding adults, or by searching appropriate habitat. 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). We also report nest outcome as the proportion of successful nests, nests that failed, nests lost to predation, nests abandoned and nests lost to human activities (e.g., mowing, construction and recreation).

Clutch Initiation

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):

First date of incubation = date found - ((incubation period - number of days observed) ÷ 2)

Because one egg is laid per day, we then subtracted the number of eggs in the clutch from this value to determine clutch initiation date.

Conspecific Attraction Experiment

The goal of this experiment was to lure breeding larks into apparently suitable but unoccupied habitat using broadcasts of recorded Lark song. In late February of 2005 we set up two playback devices at Upper Weir Prairie (Ft. Lewis) and one at Mima Mounds Natural Area Preserve (Washington Department of Natural Resources). The playback devices consisted of a waterproof tape player system and speakers that broadcast a variety of Lark songs including flight songs and other vocalizations associated with territorial behavior. The playback devices were placed in suitable habitat at both sites, which consisted of large expanses of grassland with little Scotch broom cover and that was relatively sparsely vegetated. At Weir Prairie the playback devices were placed approximately 75 m from a dirt road. We placed the speaker near the dirt road because Larks in Prairie habitats (13^{th} Division Prairie) use dirt roads for foraging during the breeding season. At both sites, we walked a series of parallel transects and recorded all birds seen or heard. Transects were approximately 75 meters apart [75 m appears to be the detection limit for Larks (Pearson 2003) indicating that we more than adequately covered the habitat surrounding the playback devices] on Upper Weir and 50 m apart on Mima Mounds and covered all habitat within 225m of the devices (the extreme distance that the sound projected under ideal conditions). Transects were closer together at Mima Mounds because the mounded terrain limited our ability to visually detect Larks on the ground. Broadcasts started in late February and continued until the end of March. The timer on each device was set so that the recording started broadcasting just before sunrise and continued until sunset. The recording consisted of calls, flight songs and ground songs and was mixed with periods of silence.

Habitat Enhancement Experiments

Herbicide

We experimentally examined the effects of the herbicide Poast Plus® on grassland habitat from 2003-2005. 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*). Applying the herbicide to areas with a high cover of non-native grasses should result in a more sparsely vegetated habitat preferred by larks (Dinkins et al. 2003, Rogers 2000). Horned Lark densities increased in herbicide treated grassland in Maine (Vickery et al.1999). Six treatments and control plots (50 m x 50 m) were established at Gray Army Airfield in 2003 and two additional treatment and control plots were added in 2004. Vegetation within treatments and controls were measured in May of 2003 just prior to the herbicide application in early June using the point intercept method as described below. Vegetation was measured again in May of 2004 prior to a second application of herbicide in May of 2004 and again in June of 2005. Birds were monitored on control and treatment plots throughout the breeding seasons of 2003, 2004, and 2005 by walking transects through the control and treatment plots.

Fire

We examined the effects of fire on lark habitat and abundance at 13th Division Prairie, Fort Lewis, WA. The use of prescribed burns in Oklahoma tallgrass prairie created a mosaic of successional habitats that increased relative abundance of Eastern Meadowlark (*Sturnella magna*) (Rohrbaugh et al. 1999) and Grasshopper Sparrow (*Ammodramus savannarum*) (Heckert 1994). Johnson and Temple (1990) noted higher probability of nesting success for Grasshopper Sparrows and Western Meadowlarks (*Sturnella neglecta*) in recently burned prairie. On 13th Division prairie, bird habitat use is focused on dirt roads in the interior portions of the prairie and adjacent to Pacemaker runway, which suggests that birds prefer appropriate habitat adjacent to roads (Pearson 2003). We established replicated treatment and control plots (50 x 50 m squares) along roads (n = 6 treatments and n = 6 controls) and interior prairie not adjacent to roads (n = 6 treatments and n = 6 controls). Burns were conducted in early September 2004. Bird abundance was measured before and after burns by walking transects through the center of each plot. The results are presented as mean number of bird observations/visit for both control and treatment plots pre- and post-burn. Only 6 treatment plots were burned in September of 2004 and on two of the burn plots, the area burned was considerably larger than the plot size. We took advantage of these larger burns by randomly establishing three additional treatment plots within the burns and we also established unburned controls in adjacent unburned habitat. Because not all plots were burned and because the establishment of new plots was constrained by the location of the larger burns, we could no longer assess the relationship between the fire and roads.

<u>Habitat Sampling</u>

For each herbicide and fire treatment and control plot, vegetation variables were measured along transects that were 25 m long and crossed at their midpoints. The two transects in each plot were oriented north-south and east-west. We used the point intercept method (Bonham 1989) at each meter along these axes and recorded the plant species that intercepted the rod, maximum height of the vegetation, and whether or not the rod hit bare ground, moss or rock. For all analyses, total hits were averaged per plot and plant species were put into the following groupings before analysis: annual forbs, perennial forbs, annual grass, perennial grass, and shrubs and small trees.

<u>Population Monitoring</u>

Following the recommendation of Pearson (2003) we used belt transects where observers recorded the number of Larks detected within 75m of each transect. Each transect was visited between 5 and 13 times between April 9th and July 27th (Some have been visited every year for 4 years and others for only 2 or 3 years). Censuses were started within 1 hour of dawn and completed within 2 hours.

<u>Data Analysis</u>

An ANOVA was used to compare habitat variables between treatment and control plots before and after treatment (fire and herbicide). We did not use a repeated measures ANOVA because additional control and treatment plots were added to both the fire and herbicide experiment in the second year of the experiment. When analyzing bird count data, an alpha level of 0.10 was used because of small sample sizes and associated low power and because minimizing Type II error is important when making management decisions (Peterman 1990, Smith 1995, Schmiegelow et al. 1997). When analyzing habitat data, an alpha level of 0.05 was used because of larger sample sizes.

RESULTS & DISCUSSION

Clutch Initiation

During our four years of research in the Puget lowlands, clutches are initiated as early as April 22nd and as late as July 22nd. However, most clutches are not initiated until the second week of May. Nest building usually precedes clutch initiation by a week. The curve of clutch initiation for the Puget lowlands (Figure 1) suggests two peaks of clutch initiation, one from May 19th to the 23rd and another between June 13th and 27th. Our data from banded birds indicates that pairs can successfully produce two clutches during a breeding season but rarely do because predation rates are very high (see below).

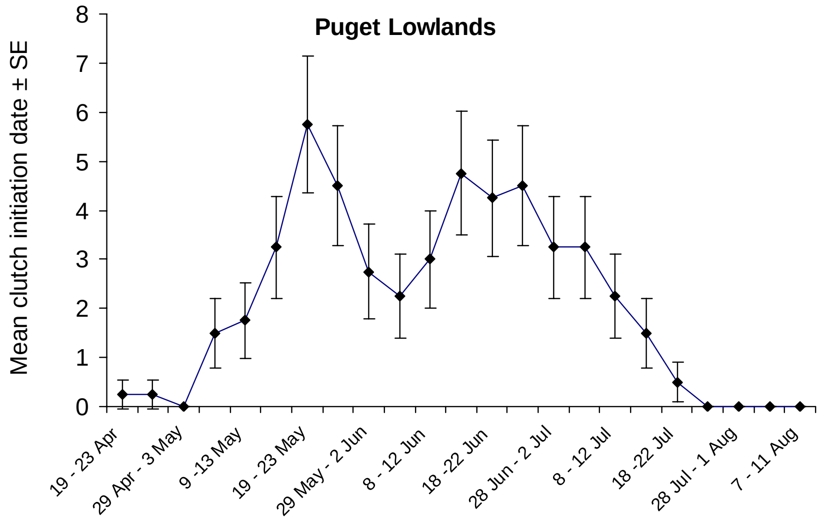

Figure 1. Mean number of Streaked horned lark clutches initiated in five-day intervals in the Puget lowlands during the 2002, 2003, 2004, and 2005 breeding seasons combined.

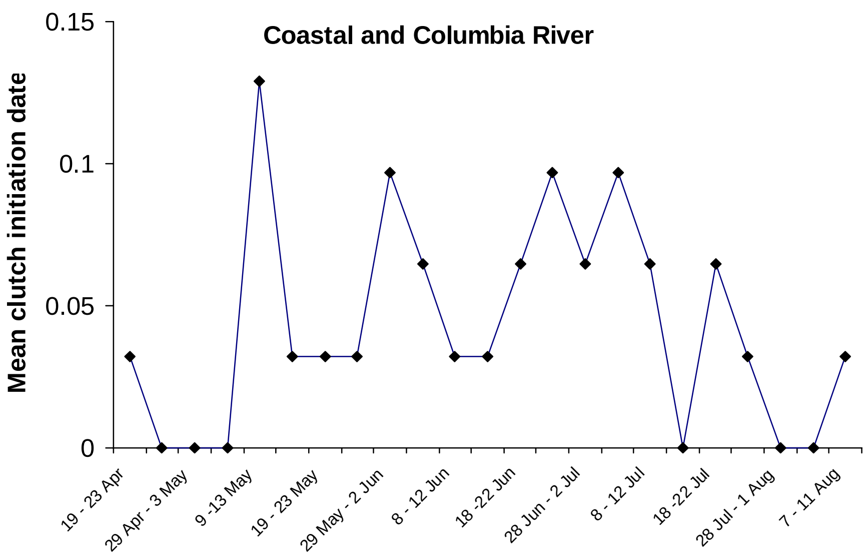

Figure 2. Mean number of Streaked horned lark clutches initiated in five-day intervals on the Washington coast and Columbia River during the 2004 and 2005 breeding seasons combined.

Along the coast and Columbia River, clutches are initiated as early as the 20th of April and as late as the 8th of August. There is a great deal of variability around clutch initiation dates along the coast indicating that clutches being initiated throughout the breeding season. Data from banded birds indicate that individual pairs will attempt as many as three clutches in a season but have never been observed successfully fledging young from three nests.

Coastal Washington and Columbia River Island Inventory and Territory Mapping

Inventory

In 2005, we visited nine Columbia River island sites [Tennasilahee Island, Coffeepot Island, Pillar Rock Sands (Jim Crow Island), Miller Sands, Rice Island, Sandy Island, Crims Island and Wallace Island] and one Columbia River shoreline site, "Rivergate", one or more times during the breeding season and counted the number of birds and estimated the number of territories at each site (Table 2). Evidence of nesting was discovered at several of these sites; active nests with eggs were observed at Rice Island on June 15 and Rivergate on May 10th, and recent fledglings or young of the year were observed at Rice Island, Pillar Rock Island and Sandy Island.

Table 2. Estimated numbers of territories and high lark counts from lower Columbia River island sites during the 2005 breeding season.

Location	# Territories[1]		# birds[2]		# visits[3]		Dates visited	
	2004	2005	2004	2005	2004	2005	2004	2005
Rivergate	-	6	-	6	-	2	-	10 May, 1 Aug
Coffeepot Island	2	0	4	0	1	1	12 May	17 July
Crims Island	-	1	-	2	-	1	-	20 June
Graveyard Spit	3	2	5	3	2	2	10 Mar, 1 June	21 May, 18 June
Ledbetter Point	2	-	2	-	3	-	13 June, 16 June, 13 July	-
Miller Sands	3	6	7	7	2	3	13 May, 1 Jul	22 June, 30 June, 11 July
Pillar Rock Is.	6	10	10	16	2	2	13 May, 1 Jul	23 June, 11 July
Rice Island	8-12	10	15	15	2	2	13 May, 1 Jul	15 June, 6 July
Sandy Island	-	3	-	7	-	1	-	5 July
Tenasillahee Is.	0	1	0	2	1	1	12 May	17 July
Wallace Island	1	1	2	1	1	1	27 April	8 June

[1] Number of territories based on number of singing males
[2] Highest total number of birds noted in any one visit to a site
[3] Visit duration varied from 1-6 hours depending on extent of habitat

In 2004, we visited five Columbia River island sites [Lark Island, Coffeepot Island, Pillar Rock Island (Jim Crow Island), Miller Sands, West Wallace Island, and Rice Island] one or more times during the breeding season and counted the number of birds and estimated the number of territories at each site (Table 2). Nests and evidence of nesting was discovered at several of these sites: 1) active nests were discovered at Miller Sands, and 2) recent fledglings or young of the year were observed at Rice Island, Pillar Rock Island, and Graveyard Spit.

Territory Mapping

For two coastal study sites and one Columbia River island site, we used composite maps of bird locations and behaviors (agonistic interactions, male singing and flight displays, male-female interactions) to delineate 37 territories in 2005 (Table 3). We defined a territory as the area actively defended by a single male. For all of the territories observed, it appears that each male successfully attracted at least one mate.

The number of territories at Midway Beach and Damon Point declined in 2005. The decline at Midway Beach may be the result of decreased sampling effort in 2005 relative to 2004. The sampling effort increased at Damon Point in 2005 yet the number of territories appears to have decreased. This decrease in the number of territories could be the result of changes in habitat conditions, increased human activities, over-winter population decline, or birds moving to other appropriate habitat along the coast or Columbia River. We did not notice an increase in human activities or a significant habitat change. At Whites Island the number of territories increased in 2005 (Table 3). The breeding habitat at Whites Island was created by the deposition of dredge spoils and more of the area is becoming suitable for breeding as the habitat moves from unvegetated sand to the sparsely vegetated condition preferred by Larks.

Table 3. Estimated number of Streaked Horned Lark territories by location, in the month of June 2004 and 2005. At all three sites, all appropriate breeding habitat was mapped.

Location	Territories 2004	Territories 2005
Midway Beach	21	12
Damon Point	17	12
Whites Island (Puget Island)	8	13

Puget Lowland Inventory and Territory Mapping

Inventory

In 2005, we visited 8 sites one or more times during the breeding season and counted the number of birds and estimated the number of territories at each site (Table 4). Birds were observed at the Artillery Impact Area (Range 74,76), Olympia Airport and Shelton Airport. Evidence of breeding was observed at these same three sites: fledglings observed at Olympia and Shelton Airports and Range 74,76, a nest was discovered at Olympia airport, and a male and female were observed carrying food at Range 74,76.

Table 4. Estimated numbers of territories and high lark counts from Puget lowland sites during the 2005 breeding season.

Location	# Territories	# Birds	# Visits	Dates Visited
Artillery Impact Area (Range 74,76)	15	23	3	16 May, 21 June, 2 Aug
Artillery Impact Area (MP 10)	0	0	1	21 June
Johnson Prairie	0	0	3	4 June, 29 June, 21 July
Olympia Airport	12	16	4	23 & 24 May, 11 June, 20 July
Point Salinas	0	0	3	4 May, 30 June, 22 July
Shelton Airport	9	13	2	24 May, 1 June
Weir Prairie (Lower)	0	0	3	4 June, 29 June, 21 July
Weir Prairie (Upper)	0	0	3	4 June, 29 June, 21 July

Territory Mapping

In 2005, we delineated 25-26 male territories at three research sites (Table 5). Twenty-four of these males successfully attracted a mate and one male at 13th Division Prairie was never observed with a mate and appeared to go unmated this season.

The entire population was monitored at 13th Division Prairie in 2002, 2003, 2004, and 2005. At Gray Army Airfield, a portion of the airfield was mapped in 2002 and 2005 (see Appendix I) and the entire airfield was monitored in 2003 and 2004. At McChord Air Force Base, we monitored the population of Larks in the northeastern portion of the airfield in 2002, 2004 and 2005. In 2004, we conducted a nearly complete survey of the McChord airfield and estimated that there were 16 additional territories outside our intensive study area for a total of 31 territories on the entire site. In 2005, we repeated this entire airfield survey on 1 June and 28 July and estimate that there were 21 additional territories outside the study area for a total of 28 territories for the entire airfield.

The number of territories at McChord AFB appeared to decrease within the intensive study area but not on the entire airfield suggesting that birds were moving away from the intensive study area. This movement may have been associated with several activities including an international military event (Rodeo) that occurred at the airfield during the breeding season and resulted in tents being set up within the study area and people/vehicles walking/driving across the study area. For all years studied, a falconer flew falcons to scare away birds that might collide with aircraft. In 2004, the falconer also used a dog to scare birds and in 2005 he used two dogs. This increased dog activity (especially in the study area) may have contributed to the movement of the birds onto grasslands adjacent to runways and taxiways where dogs were rarely used.

Table 5. Estimated number of Streaked Horned Lark territories by location, in the month of June 2002 - 2004.

Location	Territories 2002	Territories 2003	Territories 2004	Territories 2005
Gray Army Airfield	6[a]	30	31	11[a]
McChord AFB	13[a]	-	15[b] (31[c])	7[b] (28[c])
13th Division Prairie	8	10	18	7-8

[a]Intensive study area did not include the entire airfield in these years
[b] Intensive study area only
[c] Airfield survey outside the intensive study area

Nest Survivorship

Nest survivorship 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 survivorship. The Mayfield method accounts for potential biases associated with date of nest discovery by calculating a daily nest survivorship rate for each of the three nest stages independently. In Table 6, we report Mayfield nest survivorship estimates for the 2002-05 breeding seasons.

At three Puget lowland sites, overall nest survivorship was 27% in 2005. This overall nest survivorship rate is similar among all years of monitoring (Table 6). We did not statistically compare nesting success among locations because of small sample sizes (Hensler & Nichols 1981, Nur et al. 1999). In general, nest survivorship is lowest at 13th Division Prairie; however, the improved nest survivorship in 2005 is encouraging. At 13th Division Prairie, no young fledged from monitored nests in 2002, five fledged in 2003, 12 fledged in 2004, and 11 fledged in 2005. The unusually high nest survivorship at Gray Army Airfield in 2005 is likely the result of a small sample size (n = 5) and likely does not represent the site's actual nest survivorship rate.

Table 6. Streaked Horned Lark Mayfield nest survivorship estimates for the 2002, 2003, 2004 and 2005 breeding seasons at four Puget Lowland sites (n = 55 nests in 2002, n = 72 nests in 2003, and n = 39 nests in 2004, n = 26 nests in 2005).

Site	Egg laying 2005	Incubation 2005	Nestling 2005	Overall 2002	Overall 2003	Overall 2004	Overall 2005
Gray	-	0.6	1.00	0.31	0.23	0.30	0.61
13th Div.	1.00	0.38	0.76	0.07	0.15	0.07	0.23
Olympia	-	-	-	0.37	-	-	-
McChord	1.00	0.49	0.50	0.29	-	0.46	0.20
Overall	1	0.45	0.69	0.28	0.21	0.28	0.27

The Two coastal and one Columbia River island site studied in 2005 had a nest survivorship rate of 24% which is lower than 2004 by nearly 10% (Table 7). The highest nesting survivorship rate observed was 66% at Damon Point in 2004 but this trend was reversed in 2005 with only a 9% survivorship rate (Table 7). We observed a weasel (*Mustela sp.*) on numerous occasions at Damon Point in 2005 and predation evidence was consistent with mammalian predation.

Table 7. Streaked Horned Lark Mayfield nest survivorship estimates at two coastal and one Columbia River island site for the 2004 breeding season (n = 31 nests in 2004, n = 43 nests in 2005).

Site	Egg		Incubation		Nestling		Overall	
	2004	2005	2004	2005	2004	2005	2004	2005
Midway	1.00	1.00	0.34	0.62	0.82	0.45	0.21	0.24
Damon	-	1.00	0.64	0.22	1.00	0.68	0.66	0.09
Whites	-	1.00	0.44	0.71	0.60	0.63	0.21	0.40
Overall	1.00	1.00	0.43	0.46	0.86	0.59	0.33	0.24

The primary source of nest failure in all sites and years was nest predation (Tables 8 and 9), which appears to be the primary source of nest failure in most North American grassland systems (Best 1978, Johnson and Temple 1990). We did not observe any predation events in 2005. In past years, we observed two predators depredating nests, a garter snake (*Thamnophis sp*.) eating the nestlings from one nest in 2002 and an American crow depredating one nest in 2003 (*Corvus brachyrhynchos*) and again in 2004 when an American Crow was observed depredating a flightless fledgling at Gray Army Airfield. We also suspect that a killdeer may have pecked a hole in a lark egg in 2003. The relative contribution of these nest predators to overall lark nest predation is unknown. American Crow are more frequently observed on transects conducted at Gray Army Airfield than at any other breeding site (Pearson and Hopey unpublished).

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 cattus*) & 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. Brown-headed cowbirds (*Molothrus ater*) were noted on all lark breeding sites, and fledgling cowbirds have also been observed begging food from adult streaked horned larks at a Columbia River island site. No cowbird young or eggs have been observed in the 265 active lark nests located to date.

Other sources of nest failure are abandonment (25% of all failed nests, Table 10) and human caused failure including mowing, construction projects and recreational activities (6% of the failures at the Puget lowland and coastal sites combined, Table 10). Human activities may also 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.

Table 8. Streaked Horned Lark nest outcomes for three research sites in the south Puget lowlands in 2005.

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	29 Apr - ?	8	5	4	6	1	0	0	1
13th Division Prairie	14 May – 27 Jul	12	10	4	11	6	3	3	0
McChord Air Force Base	6 May – 27 Jul	10	9	4	8	5	4	1	0
Total (%)[8]		30	24	12 (50)	25	12 (50)	7 (58)	4 (33)	0

[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, construction or recreational 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.

Table 9. Streaked Horned Lark nest outcomes for two coastal research sites and one river island research site in Washington in 2005.

Location	Nest Activity[1]	Number of Nests[2]	Active Nests[3]	Successful[4]	Fledglings[5]	Failed[6]	Depredated	Abandoned	Human Caused Failure[7]	Unknown Outcome
Midway Beach	19 May – 13 Aug	9	8	1	1	5	5	0	0	2
Damon Point	7 May – 9 Aug	15	15	2	3	12	12	0	0	1
Puget Island (East)	29 Apr – 11 Aug	21	20	12	30	8	8	0	0	0
Total (%)[8]		45	43	15 (35)	34	25 (58)	6 (46)	6 (46)	1 (8)	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] Recreational 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.

Airfield mowing caused nest failures in 2002, 2003, and 2005. In 2004 at Midway Beach, recreational horse back riding was the cause of one nest being crushed during the incubation stage. Recreational activities such as dog walking, beachcombing, driving vehicles and horseback riding in lark coastal habitat may indirectly increase predation, nest abandonment and decrease overall nesting success.

Table 10. Streaked Horned Lark nest outcomes for five research sites in the south Puget lowlands for the 2002, 2003, 2004, and 2005 nesting seasons combined and for two coastal and one Columbia River island site for the 2004 and 2005 field seasons combined.

Location	Nest Activity[1]	Number of Nests[2]	Active Nests[3]	Successful[4]	Fledglings[5]	Failed[6]	Depredated	Abandoned	Human Caused Failure[7]	Unknown Outcome
Puget Lowlands	18 Apr – 13 Aug	235	191	75	162	118	80	27	8	0
Coast & Columbia	22 Apr – 21 Aug	80	74	33	63	38	12	12	2	3
Total (%)[8]		315	265	108 (42)	225	156 (59)	92 (59)	39 (25)	10 (6)	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

Conspecific Attraction Experiment

In late February of 2005 we set up two devices that broadcast Horned Lark songs at Upper Weir Prairie (Fort Lewis) and one device at Mima Mounds Natural Area Preserve (Washington Department of Natural Resources). The goal of the playback experiment was to lure breeding larks into apparently suitable but unoccupied habitat. This type of conspecific attraction has been used for years for colonial birds and recent research suggest that it may be effective for territorial birds (Ward and Schlossberg 2004, Schlossberg and Ward 2004).

We walked transects adjacent to the playback devices 10 times between late February and 22 March and we did not detect a single Lark. These sites were visited 3 additional times during the breeding season and no Larks were detected.

Habitat Enhancement Experiments

Herbicide treatment

We conducted an experimental study (n = 6 treatments and n = 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 roemeri*), native sedge (*Carex inops*), or native forbs (Dunwiddie and Delvin *in press*). 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 early June of 2003 and we measured bird and vegetation response pre- and post-treatment. We found no effect of the treatment on the vegetation or birds (Fig. 3, Table 11).

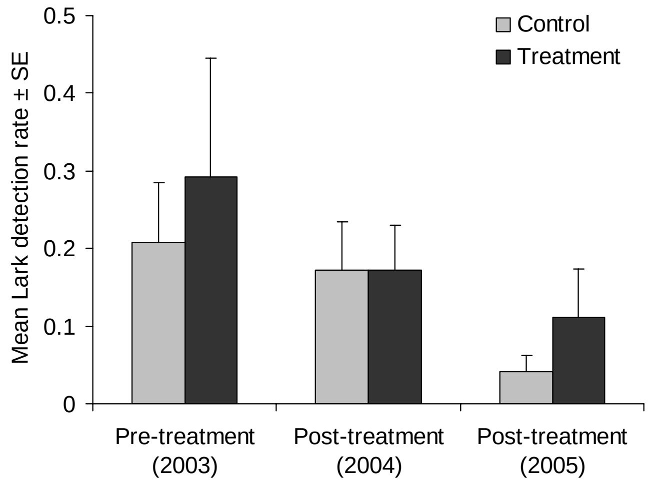

Figure 3. Mean bird abundance (± SE) on herbicide treatments and controls before (2003) and after (2004 and 2005) treatment with the herbicide Poast Plus® on Gray Army Airfield, WA. Detection rates are the mean number of Larks detected per transect per year.

Table 11. Habitat variables associated with herbicide treatment and control plots pre- and post-treatment on Gray Army Airfield. The first ten habitat variables expressed as mean (SE) percent cover, vegetated hits are the mean (SE) number of times the pin hit plant vegetation on a plot (multiple hits per drop were counted), non-vegetated hits are the mean (SE) number of pin drops per plot where the pin did not touch any vascular plant vegetation, and height is the mean (SE) vegetation height (cm) on each plot.

	Pre-treatment (late April 2003)		**Post-treatment 1** (late April 2004)		**Post-treatment 2** (mid-May 2005)	
Habitat Variables	**Control (n = 6)**	**Treatment (n = 6)**	**Control (n = 6)**	**Treatment (n = 6)**	**Control (n = 8)**	**Treatment (n = 8)**
Thatch	66.7 (5.3)	70.5 (5.2)	17.3 (2.9)	19.6 (7.9)	34.1 (5.9)	35.8 (7.6)
Moss lichen	92.6 (4.8)	95.8 (2.2)	84.0 (3.5)	80.1 (8.6)	63.2 (6.5)	62.3 (8.1)
Bare ground	2.6 (1.8)	2.9 (1.8)	1.6 (1.6)	2.9 (1.8)	1.4 (0.7)	1.7 (0.8)
Rock/Wood	3.2 (3.2)	1.0 (1.0)	1.0 (1.0)	0.3 (0.3)	0.0	0.0
Annual forb	37.2 (7.4)	30.4 (8.7)	46.5 (6.1)	48.4 (9.1)	45.9 (6.4)	55.3 (8.7)
Perennial forb	7.4 (2.3)	10.9 (3.8)	14.4 (3.5)	19.9 (3.2)	43.0 (3.2)	57.7 (3.3)
Annual grass	31.7 (10.7)	19.9 (9.5)	26.0 (7.2)	8.0 (5.0)	26.0 (6.1)	14.4 (4.2)
Perennial grass	34.9 (6.8)	38.8 (5.9)	36.5 (5.0)	26.0 (3.4)	73.6 (6.1)	68.7 (9.6)
Shrub	0.0	1.0 (0.4)	0.0	1.6 (1.6)	1.0 (1.0)	0.7 (0.7)
Unknown	4.2 (1.9)	0.0	0.3 (0.3)	1.9 (0.9)	1.4 (1.4)	7.5 (3.6)
Vegetated hits	61.0 (2.3)	56.0 (3.6)	67.2 (7.1)	58.7 (1.6)	109.8 (5.8)	110.0 (7.7)
Non-veg. hits	10.3 (1.7)	12.2 (1.7)	10.7 (1.7)	13.7 (0.7)	3.5 (1.1)	2.8 (1.1)
Height	-	-	3.5 (0.4)	4.1 (0.2)	9.9 (0.7)	10.5 (1.6)

The herbicide may have been applied too late in the season and, as a result, was not effective. Consequently, the treatment was repeated in May of 2004 (with 2 additional treatments and controls) and we again measure bird and vegetation response. Again, we found no effect of the herbicide on the vegetation or on the bird community (Figure 3, Table 11). The number of birds decreased on both treatments and controls in 2005 but the detection rate on treatments relative to controls was similar to that in the pre-treatment year (2003).

Controlled burn

We also experimentally examined the effects of fire on Lark habitat. Before burning the treatment plots, we found no difference in Lark abundance between treatments and controls ($p = 0.36$; Figure 4). Immediately after the early September fire of 2004, Larks were only detected on burned plots but the variability in the data was very high and, as a result, this difference was not significant ($p = 0.15$; Figure 4). In the breeding season following the fire, Lark abundance was significantly higher on the burned plots ($p = 0.10$; Figure 4).

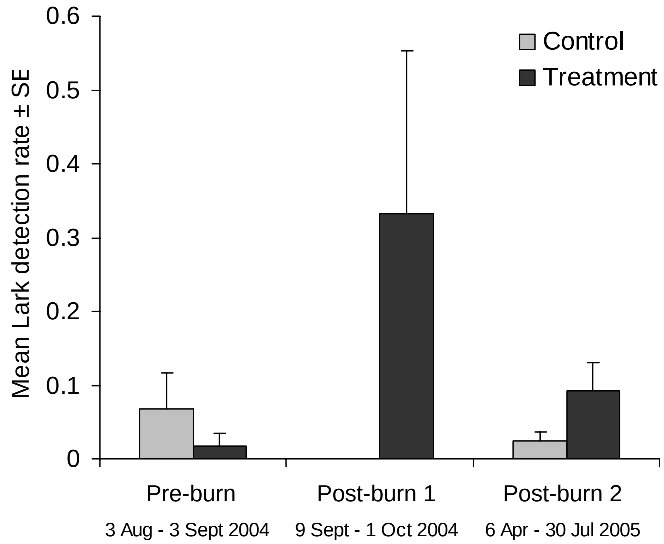

Figure 4. Mean (± SE) Streaked Horned Lark abundance on treatment and control plots shortly before and after a prescribed fire on Thirteenth Division Prairie and in the breeding season following the fire. Detection rates are the mean number of Larks detected per transect per year.

All of the vegetation variables changed significantly after the fire ($p < 0.05$) with a decrease in the amount of vegetation and thatch and an increase in moss/lichen and bare ground (Table 12). In the breeding season following the burn, there were still significant differences (p's < 0.05) in the vegetation with less thatch, fewer forbs, fewer total vegetation hits, more moss/lichen and bare ground on treatments (Table 12); there were no differences in the percent cover of annual and perennial grasses between treatments and controls (Table 12). The more open habitat (less vegetation and thatch) may be particularly important to a species that walks through its habitat (dense vegetation/thatch makes walking difficult) and selects sparsely vegetated sites for territories and for foraging.

Table 12. Habitat variables associated with fire treatment and control plots pre- and post-treatment on 13th Division Prairie. The first ten habitat variables expressed as mean (SE) percent cover, vegetated hits are the mean (SE) number of times the pin hit plant vegetation (multiple hits per drop were counted), non-vegetated hits are the mean (SE) number of pin drops per plot where the pin did not touch any vascular plant vegetation, and height is the mean (SE) vegetation height (cm) on each plot.

	Pre-burn (late June - early July 2004)		**Post-burn 1** (late Sept. – early Oct. 2004)		**Post-burn 2** (late June – early July 2005)	
Habitat Variables	**Control (n = 6)**	**Treatment (n = 6)**	**Control (n = 9)**	**Treatment (n = 9)**	**Control (n = 9)**	**Treatment (n = 9)**
Thatch	36.2 (1.5)	37.5 (5.0)	54.5 (4.4)	29.1 (2.4)	73.1 (4.8)	37.4 (4.5)
Moss lichen	10.3 (3.9)	15.4 (4.0)	32.7 (5.2)	51.3 (3.5)	22.2 (5.0)	42 (6.7)
Bare ground	59.0 (5.7)	51.0 (6.8)	10.5 (3.1)	19.2 (2.5)	4.5 (1.2)	19.0 (2.5)
Rock/Wood	1.3 (0.6)	1.9 (1.2)	1.5 (1.0)	0.2 (0.2)	0.0	0.0
Annual forb	29.5 (5.5)	23.7 (3.9)	25.0 (7.2)	10.5 (2.1)	83.8 (5.4)	65.8 (6.8)
Perennial forb	56.4 (4.8)	54.8 (1.6)	66.7 (7.1)	19.9 (3.0)	84.2 (6.9)	67.3 (3.1)
Annual grass	70.8 (6.7)	63.1 (4.2)	94.0 (10.3)	25.4 (4.2)	64.5 (3.6)	63.5 (4.1)
Perennial grass	48.4 (5.2)	43.6 (9.8)	76.5 (5.5)	50.9 (6.7)	106 (7.8)	97.2 (4.7)
Shrub	0.0	0.0	0.9 (0.9)	0.6 (0.5)	0.0	0.0
Unknown	5.1 (3.0)	2.6 (1.0)	18.6 (4.1)	29.9 (5.3)	0.2 (0.2)	0.4 (0.3)
Vegetated hits	119.8 (5.7)	109.7 (2.6)	154.0 (5.3)	74.4 (3.0)	205.7 (11.2)	171.2 (7.2)
Non-veg. Hits	2.0 (0.4)	2.0 (0.4)	0.3 (0.2)	7.3 (1.1)	0.0	0.3 (0.24)
Height	15.7 (0.8)	16.4 (1.4)	13.4 (0.8)	4.9 (0.7)	37.8 (4.0)	33.4 (2.9)

Population Monitoring

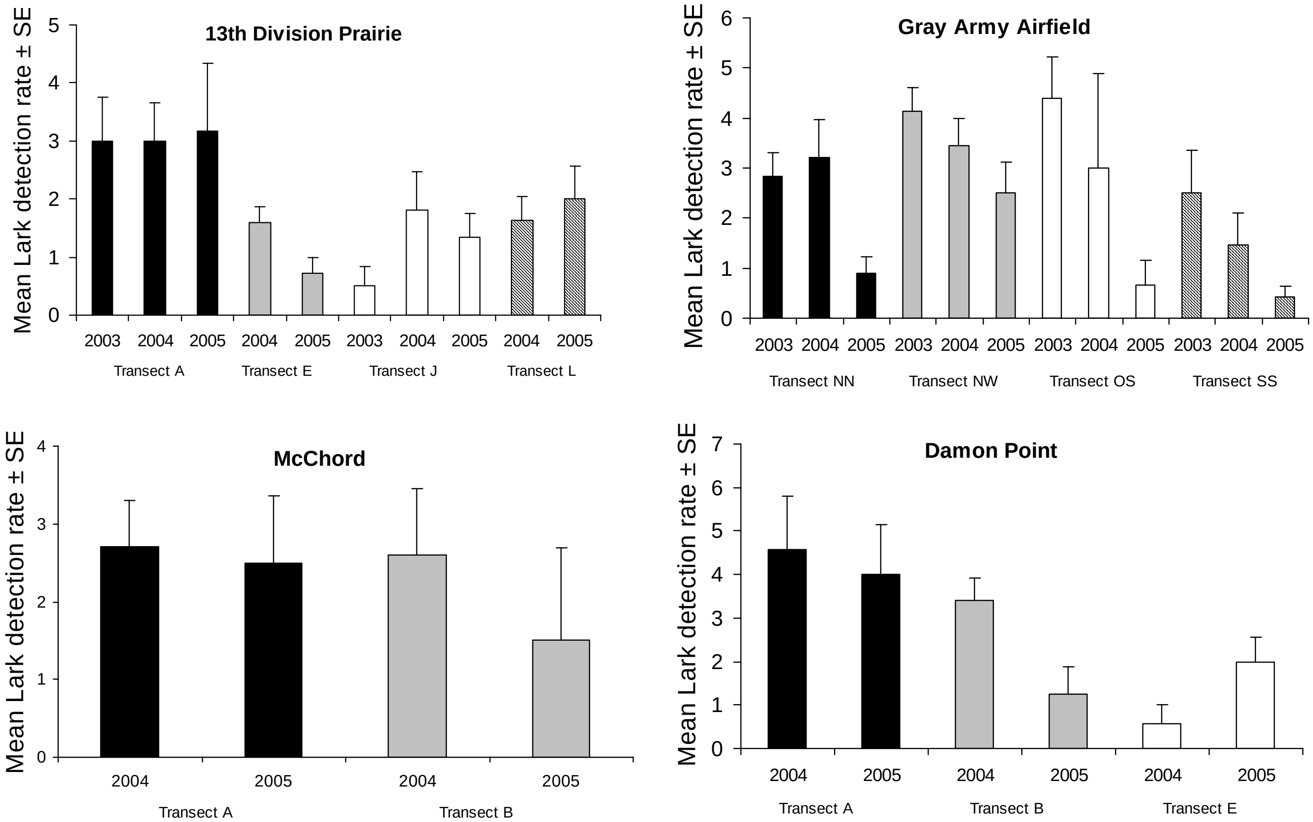

Figure 5. Streaked Horned Lark detection rates (Mean ± SE) on transects located at 13th Division Prairie, Gray Army Airfield, McChord Air Force Base, and Damon Point Washington. Detection rates are the mean number of Larks detected per transect per year.

We established permanent transects on four research sites to track changes in Lark abundance. For all sites other than Gray Army Airfield, there was no consistent change in Lark abundance (detection rate; Figure 5). For sites like McChord Air Force Base the detection rate has been fairly consistent over time. On sites like Damon Point, Lark abundance has decreased on some transects and increased on others suggesting a spatial population movement (Figure 5). At Gray Army Airfield, we monitored four transects for three years and the average number of birds detected per visit has declined dramatically on all transects (Figure 5). Looking at each transect, Lark abundance has decreased by 85%, 83%, 68% and 40% since 2003. The decline in abundance is consistent among transects. These transects are spatially well distributed, covering the south end, north end and in the triangle of habitat to the north of the airfield (but not the middle of the airfield) suggesting that this change in the population is not the result of a spatial redistribution of the population.

SIGNIFICANT FINDINGS

- Over the past two field seasons, populations of Larks were enumerated for the first time at Coffee Pot Island, Rice Island, Crims Island, Sandy Island, Tenasillahee Island, Whites Island, Wallace Island, and Rivergate.
- Fire proved to be a very effective tool for improving Lark breeding and non-breeding habitat
- The herbicide Poast Plus® was not effective in improving Lark breeding habitat.
- Transect data indicate that the Lark population at Gray Army Airfield has declined significantly. It was difficult to locate Lark nests this year suggesting that breeding activity may have also declined. In contrast to these results, nest survivorship rate was high this season (although the sample size was very small) and it was relatively high the previous season.
- Reproductive success at 13th Division Prairie was considerably higher in 2005 than previous years suggesting that habitat improvement activities may be effective.

RECOMMENDATIONS

For a complete list of management and research recommendations refer to Pearson (2003), Pearson and Hopey (2004, 2005), and Pearson and Altman (2005).

Research Recommendations

- Repeat the passive introduction (playback) experiment using both recorded song and model Larks. Animals that prefer to settle near conspecifics may be unlikely to settle in areas without conspecifics. Although our playback experiment failed to attract Larks to Upper Weir and Mima prairies, we only used recorded vocalizations. Visual cues such as bird decoy models may particularly important for consepecific attraction in open habitats (Schlossberg and Ward 2004). Conducting these conspecific attraction activities throughout the breeding season may be more successful than broadcasting song just in the early spring because birds (especially young of the year) may assess potential breeding sites in the late summer.
- Use monitoring results to develop a monitoring scheme that would detect a 10% annual population change over a 5-year period
- Investigate methods for reducing Lark nest predation rates. Overall Lark nest survivorship was low and predation rates high. Overall nest Lark nest survivorship is very low when compared to other grassland species.
- Identify source(s) of population decline at Gray Army Airfield
- Develop a metapopulation model (including populations in the Willamette Valley, lower Columbia River/Washington coast and Puget lowlands) to identify population sources and sinks. This model is critical to the development of recovery goals.

Management Recommendations

- Identify potential Lark introduction sites in the Puget lowlands
- Evaluate the feasibility of Lark introduction in the Puget Lowlands
- On Puget prairie breeding sites, control Scotch broom and invasive grasses

- Reinstate the use of late summer fire especially on the west side of the old Pacemaker airfield on 13th Division Prairie. We recommend burning portions of the prairie every two to three years but consider fire impacts to other prairie species and communities.
- Recommend scheduling activities that are likely to disrupt breeding Larks outside the breeding season (from early August to late March). Activities such as McChord's Rodeo and airshow events appear to be particularly disruptive to breeding Larks because they involve increased activity on and adjacent to breeding sites, percussion bombs, burning habitat during the breeding season, and pyrotechnics.
- Develop a temporally and spatially explicit plan for the deposition of dredge spoils that maintains well distributed habitats (numerous sites along the length of the lower Columbia River from the confluence with the Willamette to the River's mouth) in the appropriate habitat condition (see description above) over time.
- There are two non-native and invasive beachgrass species along the Washington coast that create densely vegetated habitat inappropriate for breeding larks and Snowy Plovers (*Charadrius alexandrinus*). We recommend creating openings (10 acre) adjacent to existing breeding populations just landward of the embryonic foredune. This approach has been used successfully by USFWS to improve Snowy Plover habitat at Leadbetter Point. We recommend that this activity be designed as an experiment with treatments and controls and where both Lark and Snowy Plover response are monitored.

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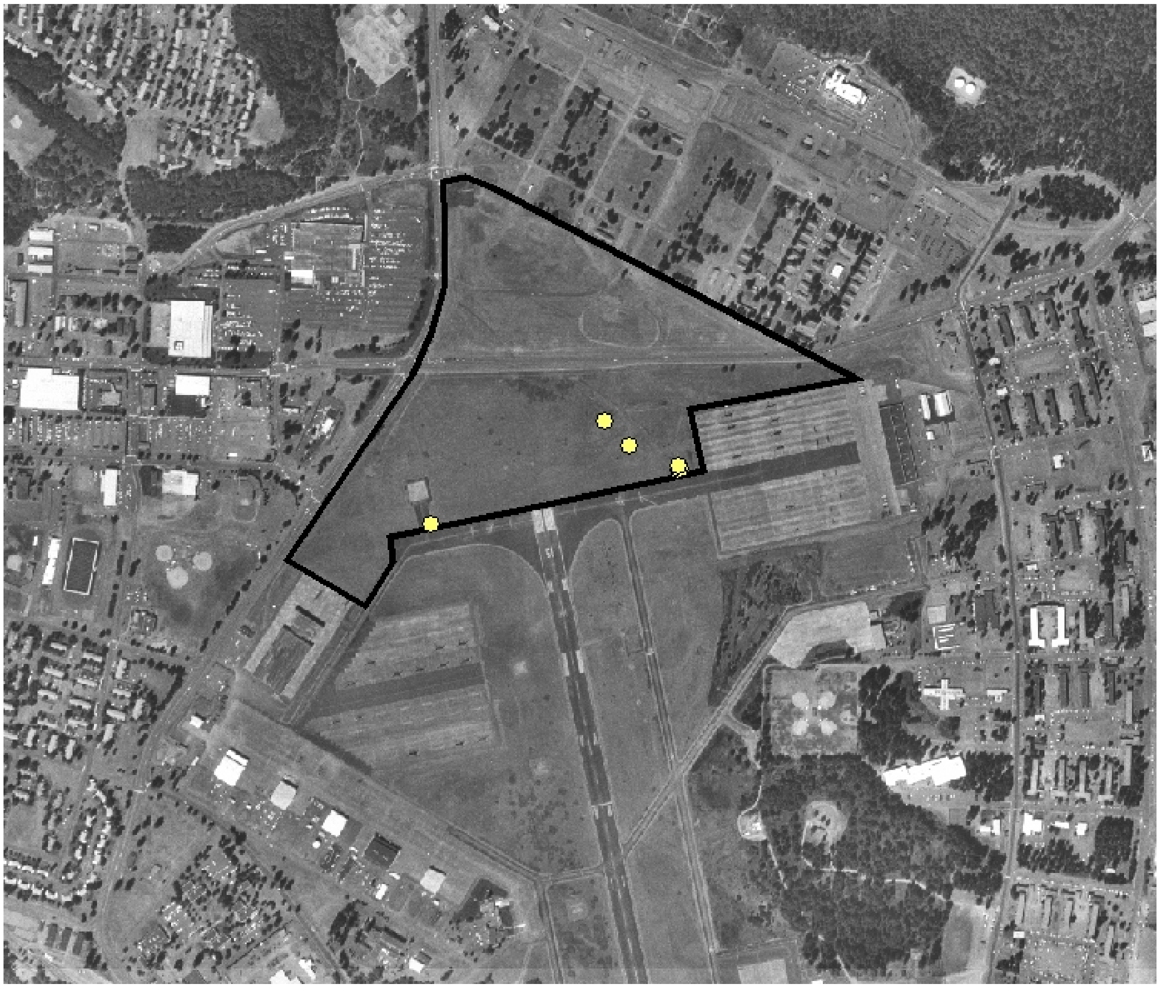
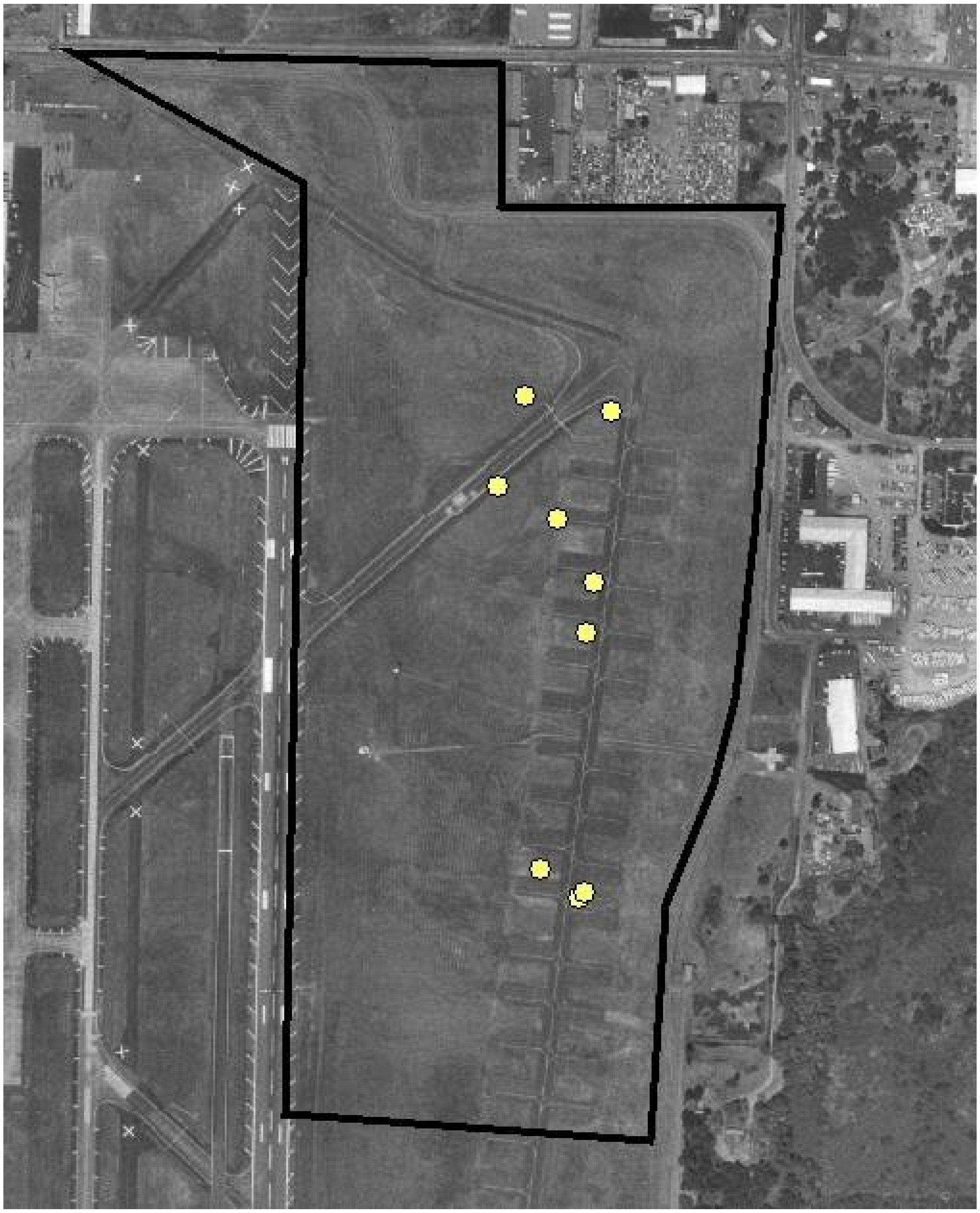
APPENDIX I

The following figures identify Streaked Horned Lark nest sites at Gray Army Airfield, 13th Division Prairie, McChord Air Force Base, Damon Point, Midway Beach, Whites Island, and Miller Sands Island. Nest locations are from the 2005 field season. All nest sites were GPSed at the end of the field season using a Trimble GeoExplorer CE with differential correction.

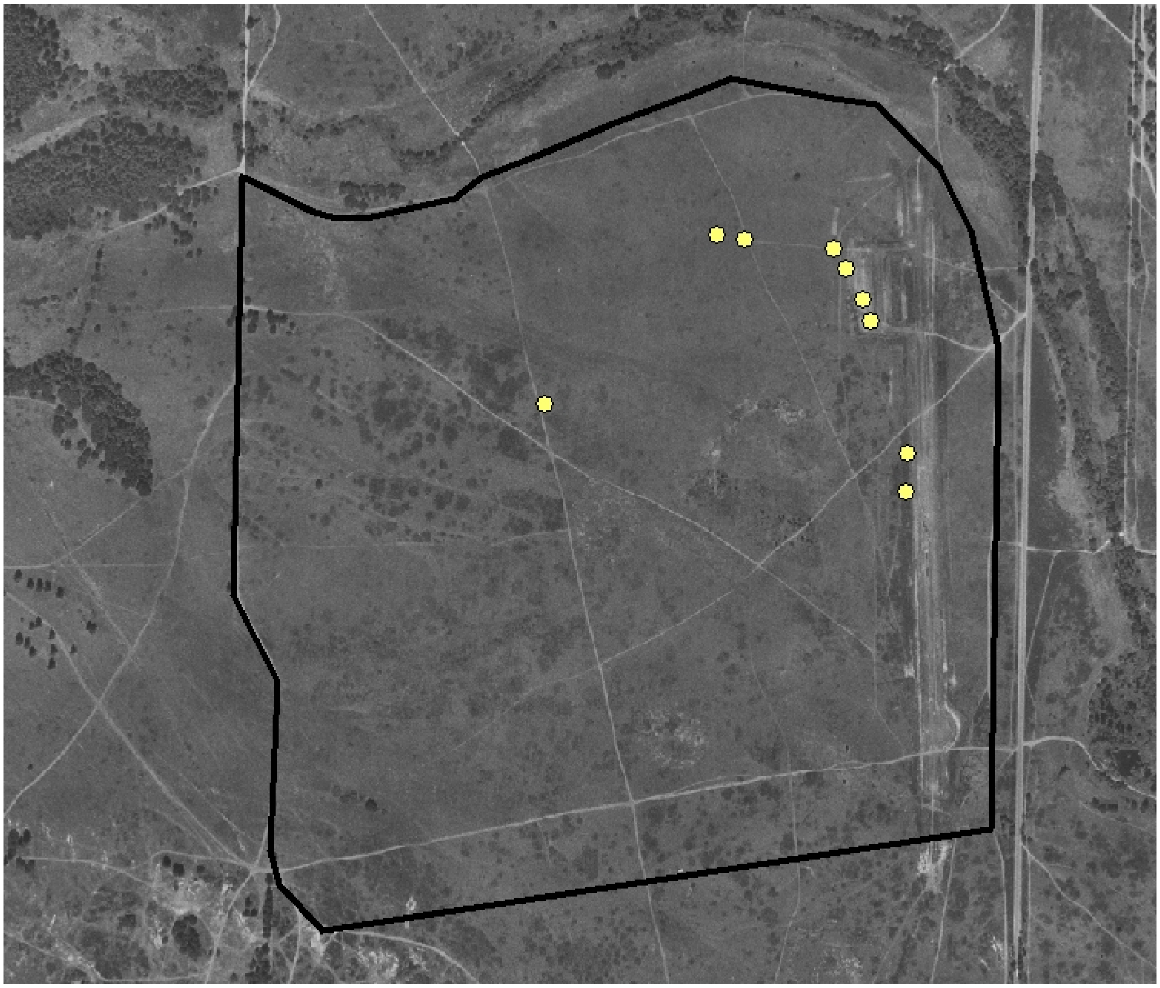
1) Gray Army Airfield nest locations



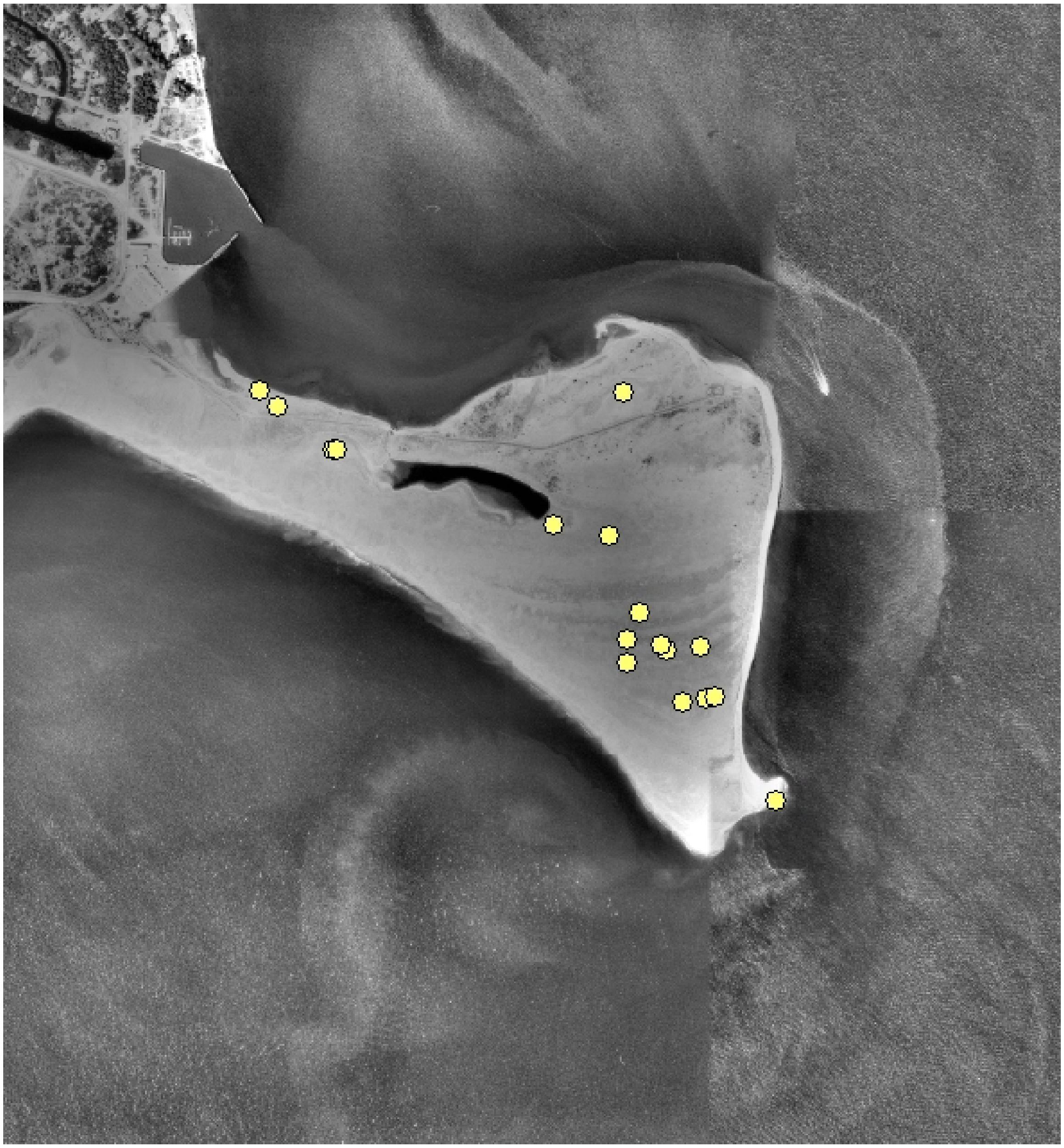
2) McChord Airforce Base nest locations



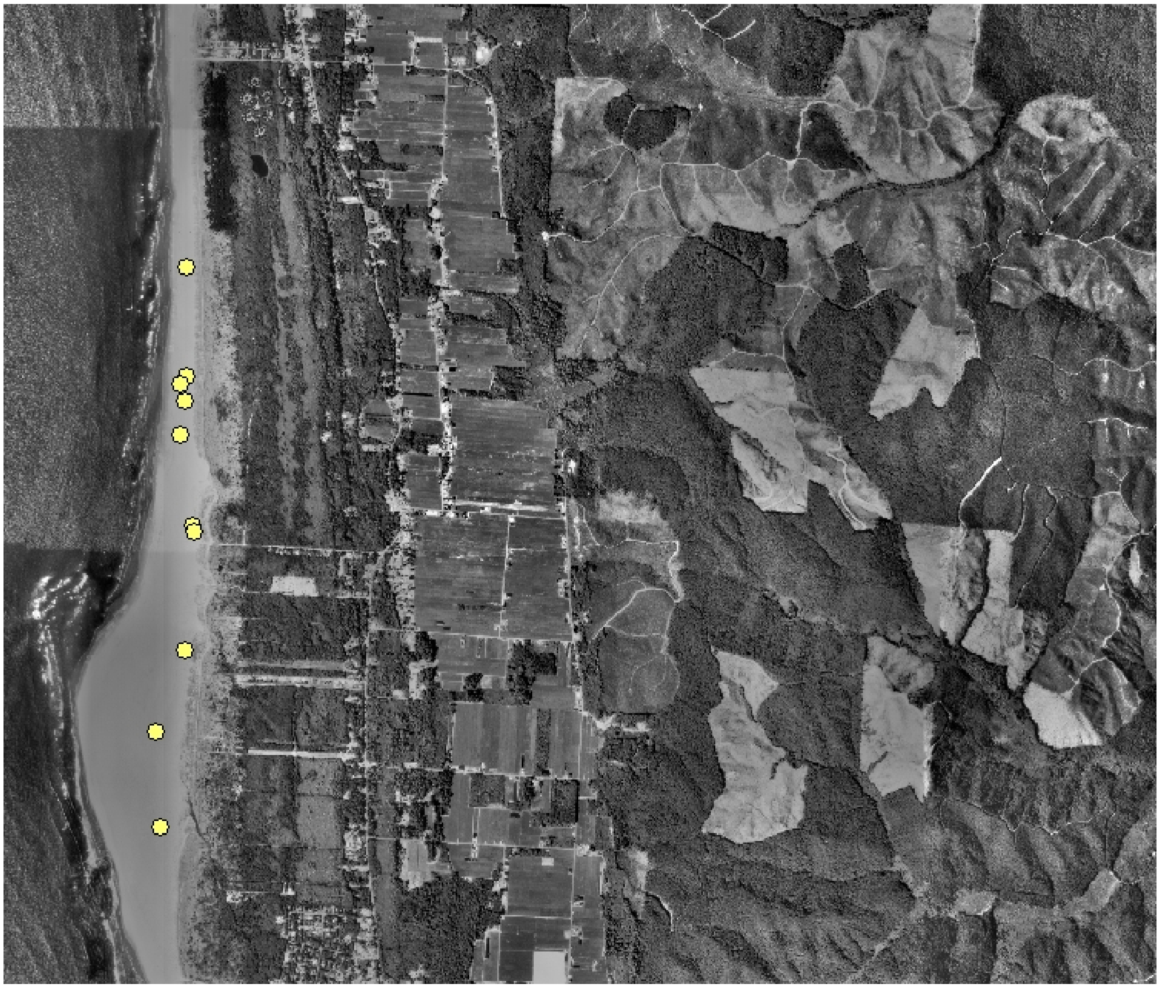
3) 13th Division Prairie nest locations



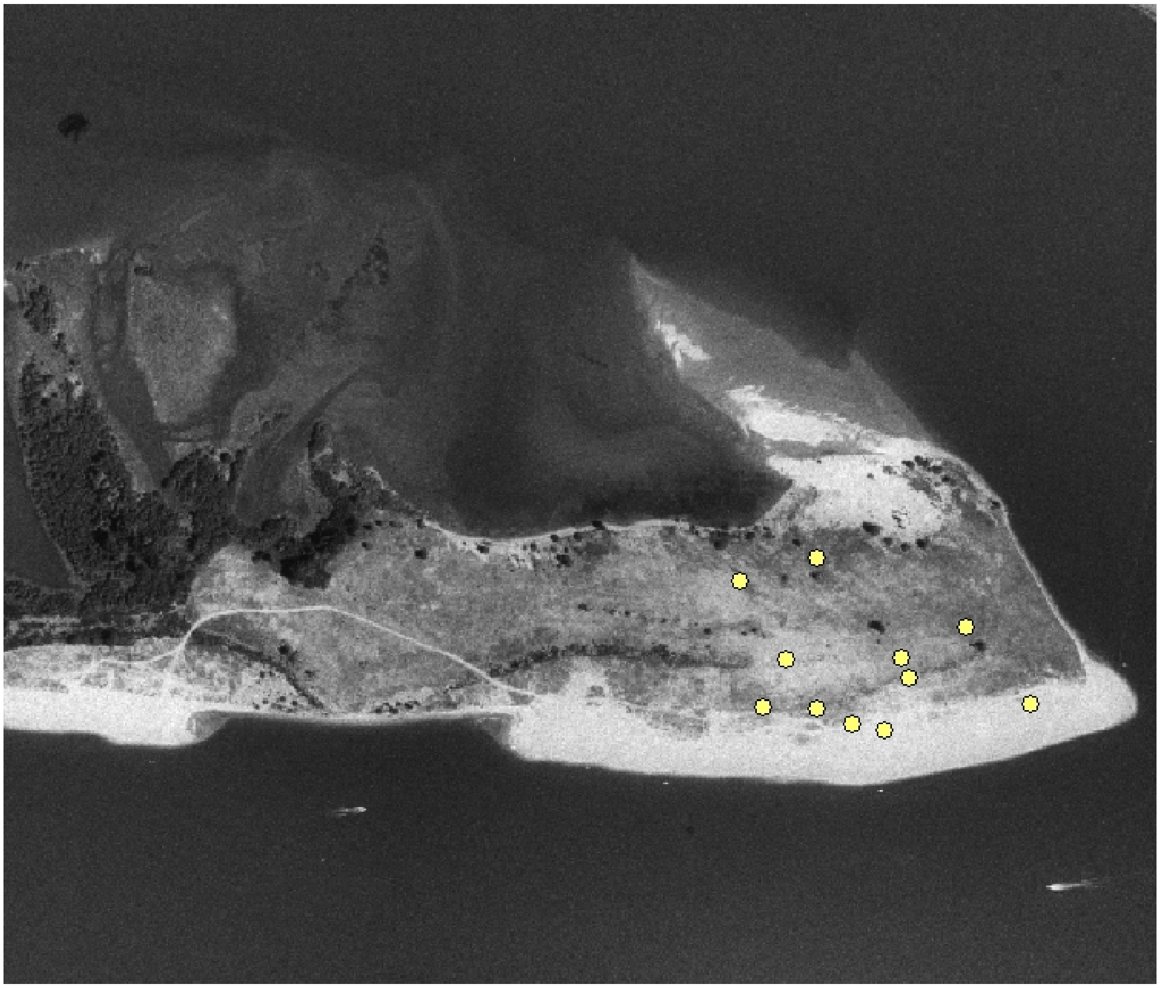
4) Damon Point nest locations



5) Midway Beach nest locations



6) Whites Island nest locations



7) Miller Sands nest locations

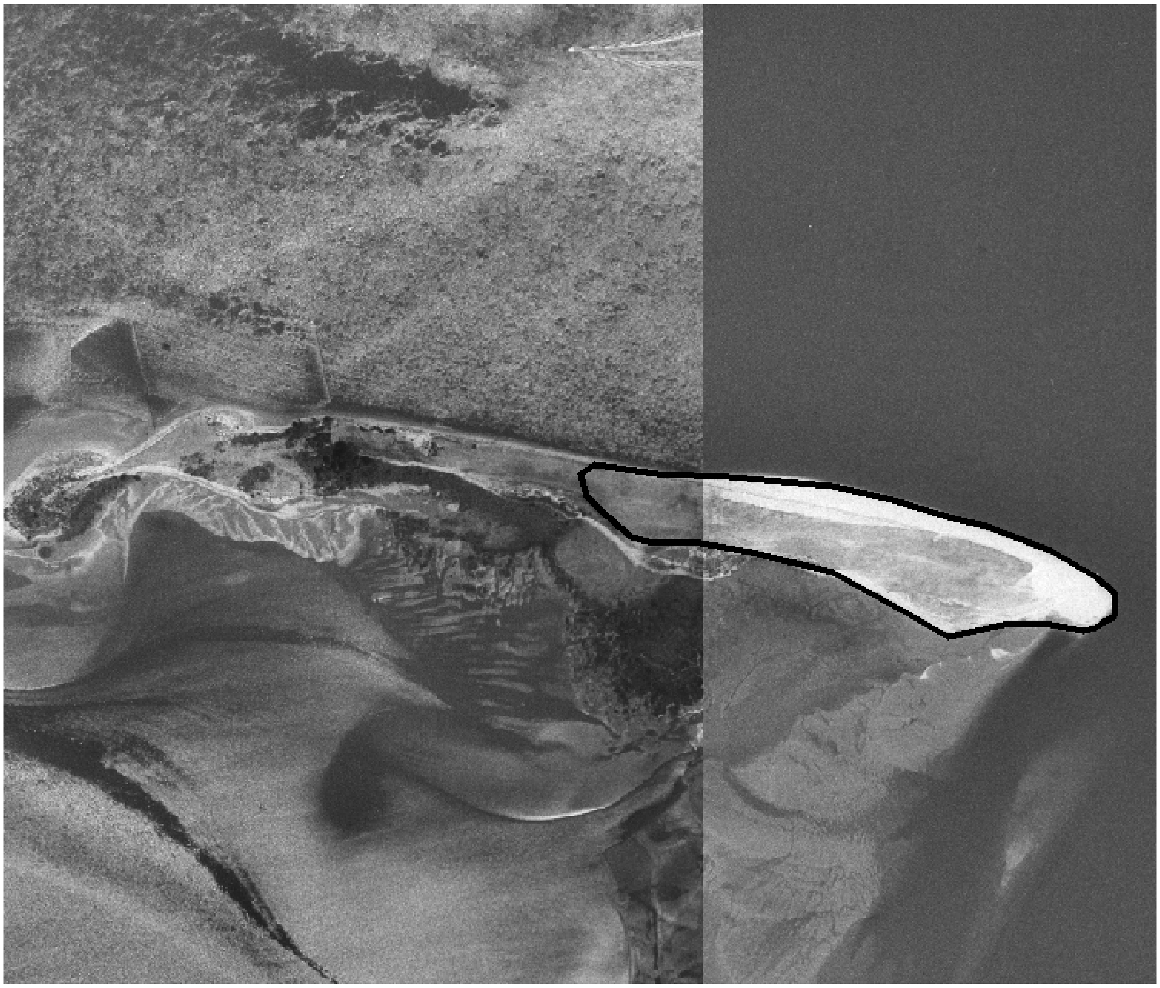
APPENDIX II

The following figures roughly identify Streaked Horned Lark breeding areas along the lower Columbia River.

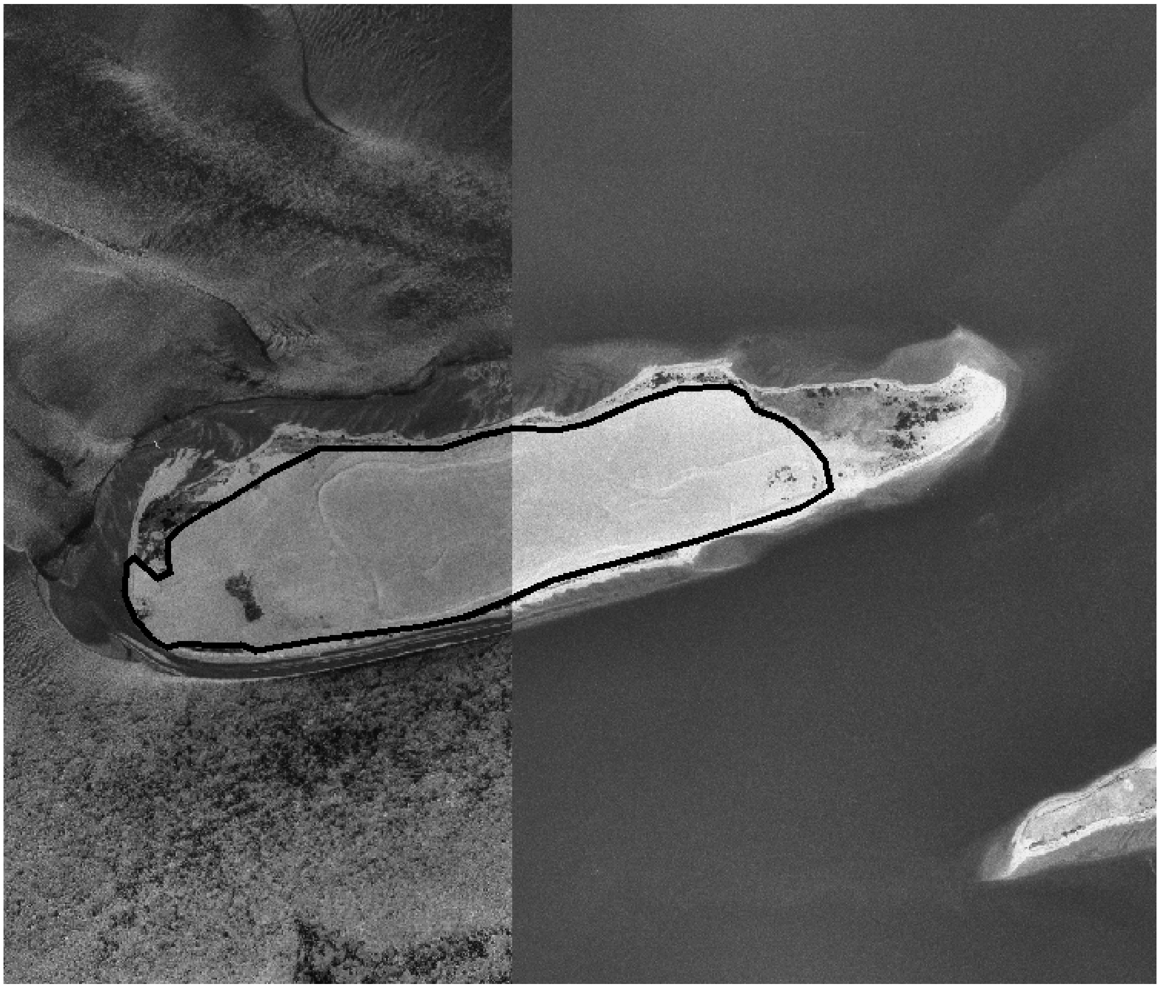
1) Coffee Pot Island breeding area

2) Crims Island Lark breeding area

3) Pillar Rock Island Lark breeding area



4) Rice Island Lark breeding area



5) Sandy Island Lark breeding area

6) Tenasillahe Island Lark breeding area

7) Wallace Island Lark breeding area