

Evaluating the Effectiveness of Vernal Pools and Swales in Prairie Restoration for Streaked Horned Larks in the Willamette Valley, Oregon 2022-2023



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Background

The Streaked Horned Lark (hereafter lark) is an Oregon Conservation Strategy species (Oregon Department of Fish and Wildlife 2016) and a Threatened species under the U. S. Endangered Species Act (Federal Register, October 2013, 78 FR 61452 and affirmed Federal Register, April 2022, 87 FR 21783). Most of its range-wide population (<2,000 birds) occurs in the southern Willamette Valley, Oregon (U.S. Fish and Wildlife Service [USFWS] 2021a).

Larks evolved as an early-successional open landscape-dependent species with a unique niche at the initiation end of the gradient of early-successional habitat. The key features are a large landscape of low-statured herbaceous vegetation with significant areas of sparsely-vegetated and bare ground. This occurs in the Willamette Valley on mostly private agricultural lands, especially grass seed fields, but also anywhere suitable conditions occur such as along the edges of fields, roads, and ditches, and in swales and vernal pools (Altman 2011).

An essential lark recovery objective is to secure more populations on dedicated conservation lands where habitat management and other conservation actions can be prioritized for them (USFWS 2019). The two study sites in this project are on former agricultural lands in the southern Willamette Valley where wildlife and prairie habitat restoration are occurring. This includes the creation of vernal pools or the maintenance of existing swales that have the potential to provide lark habitat. However, the effectiveness of these habitats to contribute to lark recovery has not been verified.

Project Goal and Objectives:

The project goal was to assess the effectiveness of created vernal pools and natural swales as lark habitat within the context of habitat restoration at two sites (Erion's Wetlands and Herbert Farm) over a two-year period (2022-2023). Specific objectives were to:

- 1) document the occurrence and abundance of larks,
- 2) document lark use of vernal pools and swales relative to use of other habitat conditions,
- 3) provide continuity to long-term monitoring at each site,
- 4) provide recommendations to inform lark recovery strategies.

Sites

Erion's Wetlands

Erion's Wetlands is a 320-acre private property owned by Scott Erion and located in the southeastern Willamette Valley in Linn County. It is currently under a Safe Harbor Agreement with the USFWS (USFWS 2021b) to contribute to lark recovery. The property is adjacent to MDAC, another conservation site that supported a large lark population during the conversion from agricultural land to prairie (USFWS 2021c), and within a large open landscape of mostly agricultural fields that supports some of the highest lark densities in the Willamette Valley.

The property is being taken out of agricultural production (i.e., grass fields since 1958) and converted to native habitats with an emphasis on wildlife and endangered species conservation. Approximately 120 acres is being converted to wildlife and prairie habitat, with approximately 65 acres of that managed specifically for larks (Figure 1; Lark Focus Area [LFA]). Within the LFA five vernal pools have been created totaling approximately 10.4 acres. Additional lark habitat is currently available within the remaining 55 acres of the Waterfowl Focus Area (WFA) which includes four larger and deeper vernal pools totaling approximately 16 acres. The vernal pools in the WFA are planted to various waterfowl food crops and provide some breeding season lark habitat depending on several factors including water levels and the type of food crop.

Figure 1. Erion's Wetlands wildlife and habitat focus areas including Streaked Horned Lark Focus Area and associated vernal pools.



Suitable habitat for larks was initially provided through habitat restoration in the CREP Focus Area (CFA) in fall, 2017 (Figure 1). Although the long-term emphasis in the CFA is expansion of the riparian zone through tree and shrub plantings (i.e., non-lark habitat), the first two-years of restoration provided lark habitat with the creation of seven vernal pools. By 2020, vegetative succession resulted in most of the CFA becoming unsuitable habitat for larks, except for a limited amount of vernal pool habitat that remained sparsely-vegetated during the early part of the lark breeding season. However, initiation of construction of two of the proposed six vernal pools in the LFA in fall of 2019, and the remaining four in fall 2020 resulted in most of the 65 acres of the LFA being highly suitable lark habitat since 2021. Design of the habitat restoration in the LFA included staggered vernal pools in terms of size and depth to potentially extend the availability of suitable habitat throughout the nesting season.

The history of lark occupancy on the property is unknown, although they have been detected in the recent past during roadside surveys. Just prior to the initiation of habitat restoration in 2017, there were 1-2 pairs along the field road within the property (J. Jebousek, pers. comm.). Lark monitoring did not occur in 2018, but in 2019 there were 2-3 pairs and four nests were located and monitored, two of which were successful (Altman 2019). In 2020 there were 3-4 confirmed nesting pairs, and occasionally 1-2 other males with unknown nesting status (Altman 2020). Four nests were located and monitored, two of which were successful. There were 2-3 fledglings observed on most visits in July-August. In 2021 there were 7-9 confirmed pairs during the early nesting season into mid-June, and then 12-14 pairs during the second

nesting season in late June through July (Altman 2021a). Three nests were located and monitored, two of which were successful. The most fledglings observed on any visit was 17, although it is likely that most of the 16 additional unknown birds seen on that same date were fledglings.

Herbert Farm

Herbert Farm and Natural Area is a 221 acre conservation property just south of Corvallis, in Benton County, Oregon. It is owned by the City of Corvallis with a conservation easement facilitated by the Oregon Department of Fish and Wildlife and Bonneville Power Administration. The property is bordered by the Marys River and Muddy Creek and has remnant flood channels and swales formed by the rivers during previous floods. The property is less than one mile from Corvallis Airport, which supports the largest known population of larks in the Willamette Valley.

There has been recent conversion from agriculture (i.e., grass seed fields) to prairie on approximately 109 acres on the east end of the property. A 25-acre section which had been in chemical fallow since 2014, was seeded in fall 2018 and 2019 to create a mosaic of bare ground and sparse, low-statured vegetation. This field had two berms created by the USFWS Partners for Fish and Wildlife Program to flood swales and potentially create more suitable lark habitat during the breeding season. An additional 84 acres was put into chemical fallow in 2017-2018. Thirty-five acres of this area was seeded in fall 2020, and the remainder was in chemical fallow through 2021.

Larks were known to have nested at Herbert Farm prior to 2014 in sparsely vegetated areas of natural swales, roadside ditches, and field borders of the grass seed fields (R. Moore personal communication). However, from 2014-2018, there were only a few sightings and no known nesting (Altman personal observations). This coincided with a substantial drop in the local population of larks in 2014, likely due to an extreme weather event in December 2013, which resulted in the Corvallis Airport population being reduced by approximately 50 pairs of larks (R. Moore personal communication).

In 2014, there were regular sightings in June and July of a pair of larks in a habitat restoration field west of the restoration field in this project. It is likely they attempted to nest given the amount of time on site, but no fledglings were observed. In 2015, there were no sightings until July when a pair was detected in that same field that included a male banded at the Corvallis Airport in 2012 as a nestling (Altman 2015). These late season sightings were likely birds displaced from nesting attempts elsewhere. In 2016, there was one territorial pair prior to the nesting season, and sporadic occurrences of at least five individuals but no nesting was documented (Moore 2016). In 2017, there was only a single bird detected on one occasion (Moore 2017). Artificial conspecific attraction using playbacks and decoys was conducted from 2018-2020 (Lapinski and Bahm 2018). In 2018, there were only three sightings in April in advance of the breeding season. However, in 2019 there were 2-3 nesting pairs (Altman 2019), and 3-4 nesting pairs in 2020 (Altman 2020). Artificial conspecific attraction was discontinued in 2021 with the establishment of a population. In 2021 there were three confirmed nesting pairs, although there were an additional 1-2 males throughout May suggesting at least a fourth pair (Altman 2021b). Four lark nests were located and monitored, two of which were successful fledging five birds.

Methods

Lark surveys were conducted using a combination of transects and targeted follow-up of detections to georeferenced locations. This method results in systematic coverage of the area through the transects with the freedom of movement off transect to document locations of each bird. Detected birds were followed and subsequent movements were recorded if the flights were within the boundary of an adjacent transect. There were four transects at Erion's Wetlands (Figure 2) and three at Herbert Farm (Figure 3), each approximately 75 meters apart.

Surveys were conducted once a week during the breeding seasons (May-July) and twice a month during the post-breeding season (August) of 2022 and 2023 (except post-breeding 2023 at Herbert Farm). Visits were at least five days apart, conducted during morning hours when birds are most active (i.e., before 11 am), and only under favorable weather conditions (i.e., no rain or high winds). The starting transect was alternated each visit to minimize time of morning bias. The gender, age, and georeferenced location of all larks was recorded along with whether they were in or out of a vernal pool or swale.

Figure 2. Location of transects at Erion's Wetlands.



Figure 3. Location of transects at Herbert Farm.



Lark population size at each site was estimated based on high counts of males for both the early nesting season (through mid-June) and the late nesting season (mid-June through July). The recognition of two nesting seasons is based on personal observations over many years that larks are multi-brooded and there is regular within-season movement between sites based on changes in habitat suitability that occur due to vegetation succession and/or land management activities that disrupt nesting.

Results

Erion's Wetlands

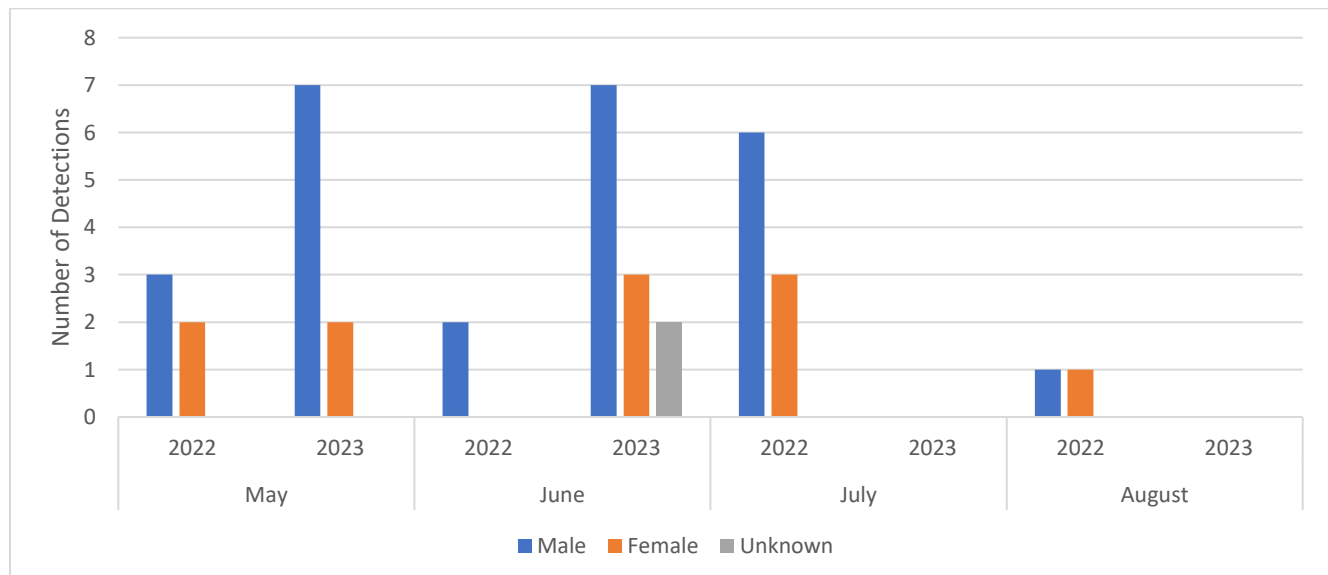
There were 399 georeferenced locations of larks including 218 in 2022 and 181 in 2023 (Table 1, Appendices A and B). Males accounted for 64.4% (n=257) of those detections and females 27.1% (n=108). There were 59 detections (14.8%) in vernal pools. Males accounted for 57.6% (n=34) of those detections and females 27.1% (n=16). There were 39 detections in vernal pools in the LFA (9.8% of all detections and 66.1% of detections in the vernal pools). Males accounted for 66.7% (n=26) of those detections and females 28.2% (n=11).

Table 1. Streaked Horned Lark georeferenced locations by gender at Erion's Wetlands, 2022-2023.

	All Detections			Detections Vernal Pools			Detections Vernal Pools in LFA		
	2022	2023	Totals (%)	2022	2023	Totals (%)	2022	2023	Totals (%)
Male	145	112	257 (64.4)	15	19	34 (57.6)	12	14	26 (66.7)
Female	58	50	108 (27.1)	10	6	16 (27.1)	6	5	11 (28.2)
Unknown	15	19	34 (8.5)	5	4	9 (15.3)	0	2	2 (5.1)
Totals	218	181	399	30	29	59 (14.8)	18	21	39 (9.8)

The monthly pattern of use of all vernal pools was different in the two years (Figure 4). Most lark detections occurred in the late nesting season (July-August) in 2022 (61.1%, n=11), and all lark detections occurred earlier in the nesting season (May-June) in 2023 (100.0%, n=21).

Figure 4. Monthly detections of Streaked Horned Larks in vernal pools within the Lark Focus Area at Erion's Wetlands 2022-2023.



The percent of lark detections in vernal pools (14.8%) was less than percent of that habitat type available (22.0%) (Table 2). However, the percent of lark detections in vernal pools in the LFA (71.2%, n=42) was greater than the percent of that habitat type available (35.0%).

Table 2. Streaked Horned Lark detections in vernal pools at Erion's Wetlands, 2022-2023.

Habitat Type	Acres (%)	Lark Detections (%)		
		2022	2023	Totals
Vernal Pools	26.4 (22.0)	29	30	59 (14.8)
Non-vernal Poll	93.6 (78.0)	189	151	340 (85.2)
LFA Vernal Pools	10.4 (35.0)	18	21	42 (71.2)
Non-LFA Vernal Pools	16.0 (65.0)	11	9	17 (28.8)

The estimated lark population size was 17 (early season) and 15 (late season) in 2022, and 13 (early season) and 9 (late season) in 2023 (Tables 3 and 4, Figure 5). The 2022 population represents the peak over the last five years (Figure 5).

Table 3. Streaked Horned Lark estimated population size by visit and georeferenced locations outside and within vernal pools at Erion's Wetlands, 2022.

Date	Estimated Population Size ¹				In: Out ²	Detections in Vernal Pools (%)			
	Male	Female	Unknown	Fledgling		Male	Female	Unknown	Fledgling
05/03	10	4	0	0	0:21	0	0	0	0
05/09	10	4	0	0	2:12	1	1	0	0
05/17	15	9	0	0	0:28	0	0	0	0
05/25	17	7	1	0	7:17	4	3	0	0
05/31	13	5	0	0	5:20	4	1	0	0
06/07	14	5	3	0	6:21	3	1	2	0
06/13	14	3	0	0	3:14	2	1	0	0
06/23	15	4	4	0	4:16	2	1	1	0
07/02	10	0	1	0	0:5	0	0	0	0
07/08	9	2	1	0	0:5	0	0	0	0
07/14	5	1	1	2	0:6	0	0	0	0
07/21	8	4	0	0	9:9	6	3	0	0
07/28	9	1	1	0	2:4	2	0	0	0
08/18	1	1	4	4	1:10	0	0	1	0
08/30	2	1	1	0	0:9	0	0	0	0
					30:188	18	8	4	0

¹ Includes only suspected unique individual birds.

² In = detections within boundary of vernal pool; Out = detections outside boundary of vernal pool; ratio can include same birds recorded multiple times.

Red = no gps coordinates were mapped.

Table 4. Streaked Horned Lark estimated population size by visit and georeferenced locations outside and within vernal pools at Erion's Wetlands, 2023.

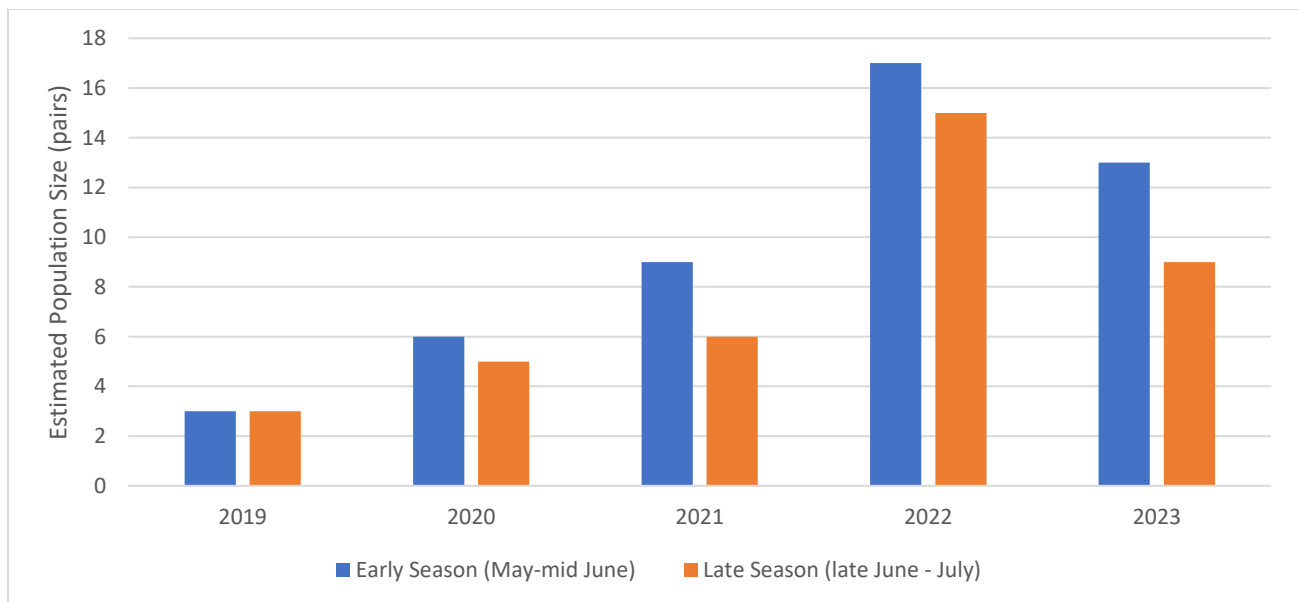
Date	Estimated Population Size ¹				In: Out ²	Detections in Vernal Pools (%)			
	Male	Female	Unknown	Fledgling		Male	Female	Unknown	Fledgling
05/03	6	3	0	0	0:7	0	0	0	0

05/10	13	8	0	0	1:24	1	0	0	0
05/17	8	6	1	0	2:18	1	1	0	0
05/25	5	3	1	0	0:7	0	0	0	0
05/31	10	6	0	0	5:15	3	2	0	0
06/06	7	1	1	0	1:9	1	0	0	0
06/10	12	4	0	0	1:13	1	0	0	0
06/19	9	0	0	0	0:11	0	0	0	0
06/27	8	2	0	2	0:8	0	0	0	0
07/05	8	1	0	0	4:7	3	1	0	0
07/09	9	3	1	0	6:8	4	2	0	0
07/20	8	2	0	1	0:8	0	0	0	0
07/28	9	3	5	5	9:15	2	2	5	4
08/13	1	1	4	3	nr	0	0	0	0
8/26	0	0	0	2	0:2	0	0	0	0
					29:152	16	8	5	4

¹ Includes only suspected unique individual birds.

² In = detections within boundary of vernal pool; Out = detections outside boundary of vernal pool; ratio can include same birds recorded multiple times.

Figure 5. Estimated population sizes of Streaked Horned Larks at Erion's Wetlands 2019-2023.



The percent of lark detections within vernal pools relative to all georeferenced lark detections was greater in 2023 (16.0%, n=29, Table 4) than 2022 (13.8%, n=30, Table 3), although the difference was not significant (p=0.82).

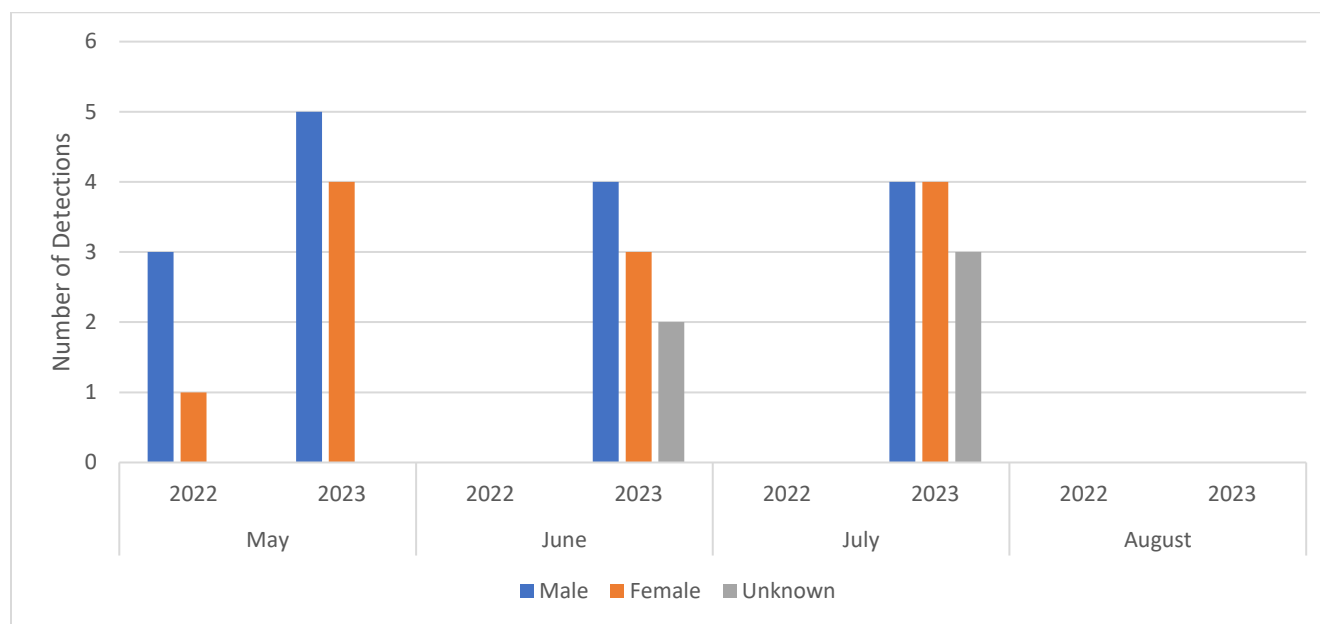
Herbert Farm

There were 101 georeferenced locations of larks including 43 in 2022 and 58 in 2023 (Table 5, Appendices C and D). Males accounted for 59.4% (n=60) of the detections and females 27.7% (n=28). There were 32 detections (31.7%) in the vernal pool and swales, although 88.0% (n=28) occurred in 2023. Males accounted for 53.1% (n=17) of those and females 31.5% (n=10). Among detections in just the vernal pool (n=26), males accounted for 61.5% (n=16) and females 23.1% (n=6).

Table 5. Streaked Horned Lark georeferenced locations by gender at Herbert Farm, 2022-2023.

	All Detections			Detections Vernal Pool/Swales			Detections Just Vernal Pool		
	2022	2023	Totals (%)	2022	2023	Totals (%)	2022	2023	Totals (%)
Male	30	30	60 (59.4)	4	13	17 (53.1)	4	12	16 (61.5)
Female	10	18	28 (27.7)	0	10	10 (31.3)	0	6	6 (23.1)
Unknown	3	10	13 (12.9)	0	5	5 (15.6)	0	4	4 (15.4)
Totals	43	58	101	4	28	32 (31.7)	4	22	26 (25.7)

The monthly pattern of use of vernal pools and swales was different in the two years. (Figure 6). There were only four detections in 2022 and 28 in 2023. All the detections in 2022 occurred in May, but were equally spread out in 2023 among May, June, and July.

Figure 6. Monthly detections of Streaked Horned Larks in vernal pools and swales at Herbert Farm 2022-2023.

The percent of lark detections in the vernal pool and swales (5.6%) was close to the percent of that habitat type available (6.1%) (Table 6). However, the percent of lark detections in the vernal pool (81.3%, n=26) was much greater than the percent of that habitat type available (2.8%).

Table 6. Streaked Horned Lark detections in vernal pools at Herbert Farm, 2022-2023.

Habitat Type	Acres (%)	Lark Detections		
		2022	2023	Totals (%)
Vernal Pool and Swales	6.1 (5.6)	4	28	32 (31.7)
Non-vernal Pool and Swales	102.9 (94.4)	39	30	69 (68.3)
Vernal Pool	3.0 (2.8)	4	22	26 (81.3)
Swales	3.1 (2.9)	0	6	6 (18.8)

The estimated lark population size at Herbert Farm was 3 (early season) and 2 (late season) in 2022, and 2 (early season) and 2 (late season) in 2023 (Tables 7 and 8, Figure 7). The 2020 and 2021 populations (5 and 4, respectively) represent the peak over the last five years, and the 2023 population is the lowest (Figure 7).

Table 7. Streaked Horned Lark estimated population size by visit and georeferenced locations outside and within vernal pools or swales at Herbert Farm, 2022.

Date	Estimated Population Size ¹				In: Out ²	Detections in Vernal Pool and Swales (%)			
	Male	Female	Unknown	Fledgling		Male	Female	Unknown	Fledgling
05/07	2	0	0	0	0:2	0	0	0	0
05/10	3	2	0	0	0:10	0	0	0	0
05/16	0	0	1	0	0:1	0	0	0	0
05/23	2	1	0	0	1:4	1	0	0	0
05/30	3	1	0	0	0:3	0	0	0	0
06/06	2	1	0	0	0:3	0	0	0	0
06/14	2	0	1	0	2:6	2	0	0	0
06/24	1	0	0	0	0:1	0	0	0	0
07/01	1	1	0	0	0:2	0	0	0	0
07/07	1	1	0	0	0:2	0	0	0	0
07/12	1	1	0	0	0:2	0	0	0	0
07/19	1	0	0	0	0:1	0	0	0	0
07/26	3	0	0	1	1:2	1	0	0	0
08/21	0	0	0	0	0:0	0	0	0	0
08/29	0	0	0	0	0:0	0	0	0	0
					4:39	4	0	0	0

¹ Includes only suspected unique individual birds.

² In = detections within boundary of vernal pool; Out = detections outside boundary of vernal pool; ratio can include same birds recorded multiple times.

Red numbers indicate birds detected in the road or the adjacent filbert field.

Table 8. Streaked Horned Lark estimated population size by visit and georeferenced locations outside and within vernal pools or swales at Herbert Farm, 2023.

Date	Estimated Population Size ¹				In: Out ²	Detections in Vernal Pools and Swales (%)			
	Male	Female	Unknown	Fledgling		Male	Female	Unknown	Fledgling
05/02	0	0	0	0	0:0	0	0	0	0
05/09	2	1	1	0	0:4	0	0	0	0
05/15	2	1	1	0	4:5	3	1	0	0
05/22	2	1	0	0	3:3	3	0	0	0
05/30	1	1	0	0	2:1	0	2	0	0
06/05	2	1	0	0	3:3	2	1	0	0
06/11	2	1	0	0	3:2	1	2	0	0
06/24	2	1	1	1	3:5	2	0	0	1
06/30	2	2	0	3	0:0	0	0	0	0
07/07	2	1	0	2	0:4	0	0	0	0
07/12	1	1	0	3	4:3	0	1	0	3
07/17	1	1	0	0	6:0	3	3	0	0
07/24	1	0	0	0	0:0	0	0	0	0

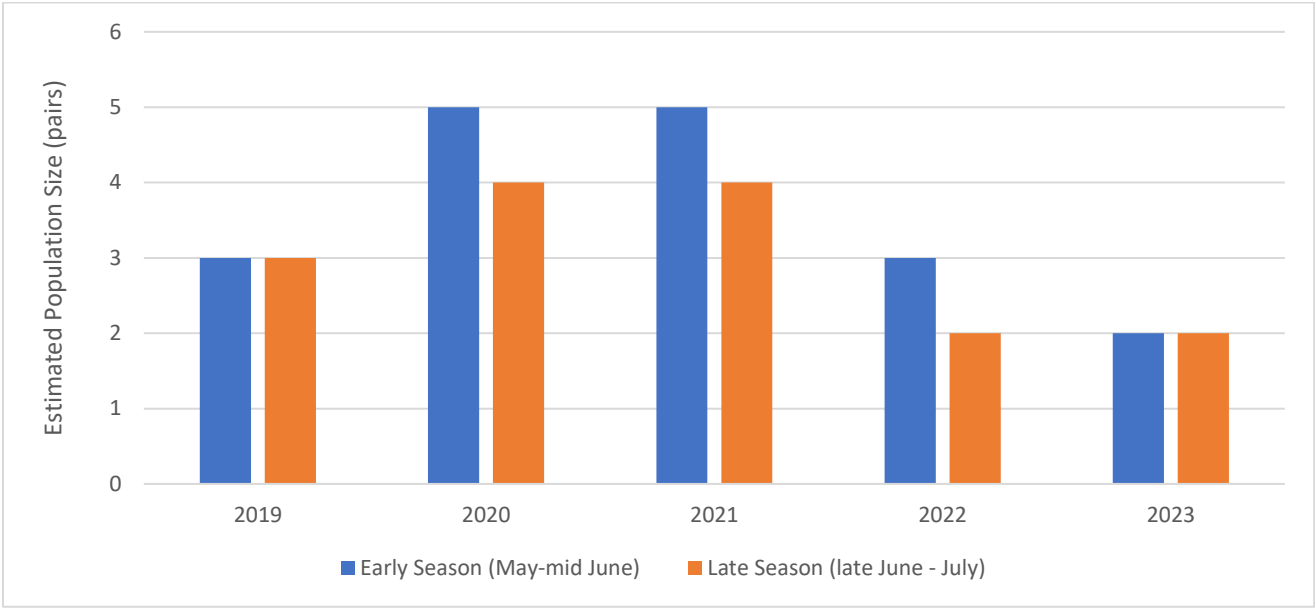
					28:30	14	10	0	4
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¹ Includes only suspected unique individual birds.

² In = detections within boundary of vernal pool; Out = detections outside boundary of vernal pool; ratio can include same birds recorded multiple times.

The percent of lark detections in vernal pools relative to all detections was much greater in 2023 (48.3%, n=28, Table 8) than 2022 (9.3%, n=4, Table 7).

Figure 7. Estimated population sizes of Streaked Horned Larks at Herbert Farm 2019-2023.



Discussion

Lark Habitat and Vernal Pools: The Concept

Both Erion’s Wetlands and Herbert Farm are in the developing stages of prairie and wildlife habitat restoration from former agricultural grass seed fields. Anecdotal observations from many other sites in the Willamette Valley indicate that these types of sites have the potential for lark colonization after the initial ground disturbance that results in substantial bare and sparsely vegetated ground. Although larks have high breeding site fidelity which limits recruitment to these newly created habitats, in the Willamette Valley there is regular displacement of larks both between and within nesting seasons because of vegetation succession moving a site out of suitability, or disturbance from equipment operations in the fields where they are nesting (Altman 2022). Both Erion’s Wetlands and Herbert Farm are within large agricultural landscapes dominated by grass seed fields, which are managed and harvested during the lark breeding season resulting in regular displacement of birds.

After the initial ground disturbance and creation of suitable lark habitat, there is typically a 2-3 year period when prairie vegetation becomes established and the habitat becomes less suitable for larks. The ability to maintain a population is dependent on the natural or created presence of areas that hold water longer in the spring and inhibit plant growth as they dry-out. As the water recedes in spring, these areas potentially provide sparsely vegetated suitable habitat for nesting and foraging larks. The concept of creating vernal pools within habitat restoration fields to provide some annual and potential long-term lark habitat was based on many observations of larks in “drown outs” in natural depressions or swales in grass seed and other agricultural fields that retain water throughout the winter and inhibit plant growth.

Vernal Pools and Lark Conservation Challenges: The Reality

Quantifying the potential value of created vernal pools or natural swales, the objective of this project, is limited by and/or dependent on numerous factors as described below. Drown outs in agricultural fields get the same tillage and chemical applications as the rest of the field and the retained water and chemical applications result in limited plant growth even after these areas dry out in the spring and summer. Conversely, vernal pools created as part of habitat restoration that could potentially mimic the agricultural drown-outs typically get seeded with emergent and other water tolerant plants and receive no chemical applications. Thus, when the water recedes, plant growth can take advantage of the exposure and quickly grow to fill in the area and render it less suitable or unsuitable for larks.

Vernal pools have limited temporal availability during the lark nesting season. Lark habitat only becomes available as the water evaporates and recedes providing exposed areas with the potential for sparsely vegetated conditions. This lack of availability while the pools still have retained water is especially important at the start of the nesting season in early May and is highly dependent on the timing of the draw-down of the water (e.g., wet winter/spring versus dry winter/spring).

The challenges of temporal availability of vernal pools due to weather were distinctly evident during this project. The two years of the project were completely opposite in terms of water levels in vernal pools. Oregon State Climatologist Larry O'Neill stated that "between April and June 2022, Oregon received the most rain during that period than it ever had before in recorded history going back to 1895." Conversely, spring of 2023 was warm and dry with many record-breaking temperatures during that same time frame, especially in May. Consequently, there was limited use of vernal pools and swales in 2022 during the early nesting season due to high water levels, but extensive use in 2023 when standing water was limited or absent. This was especially true at Herbert Farm. At Erion's Wetlands the differences were not as profound, but most noteworthy was the almost absence of use of vernal pools in the LFA in the late nesting season in 2023. Anecdotal observations suggest that the long, dry spring and summer may have resulted in limited foraging resources in the LFA vernal pools since larks were mostly detected in the deeper pools of the WFA (or offsite) where some moisture might have provided better foraging opportunities. This same phenomenon was also noticed at another lark site in 2023 with no vernal pools where the larks had mostly moved off site by early July (contrary to all previous years) presumably to seek moister fields with better foraging opportunities.

Temporal availability also is a factor during winter when vernal pools are entirely under water and unavailable as habitat. If the pools were not present those areas may have been above the surface water levels and have provided suitable foraging habitat.

Further complicating availability of vernal pools during the nesting season is the high variability in the rate of revegetation in exposed areas where water has receded. This is dependent on the soil and seed sources, the latter of which changes over time through flooding and deposition of new sediment. Some sites maintain sparsely vegetated conditions for part of the nesting season, but others quickly become revegetated and often in a dense, mat-like condition. This was most noticeable in the swales at Herbert Farm which have been seeded similar to the rest of the prairie. My extensive observations of created vernal pools over the last 5-10 years indicates there have been many examples of restored prairies with vernal pools or swales that mostly went out of suitability for larks, and a few examples that maintained a population of 1-2 pairs.

Because of the challenges of soil seed sources and rapid revegetation in the Willamette Valley, vernal pools also require regular assessments (often multiple within the nesting season) of actions needed to ensure sparsely vegetated conditions throughout the nesting season. Thus, a commitment to regular habitat management is usually necessary to maintain suitable conditions for larks in vernal pools.

Another significant factor in the value of vernal pools is the suitability of habitat for larks in the immediate vicinity of the vernal pools. The presence of suitable habitat in the immediate vicinity provides a greater opportunity for recruitment of birds to sites with vernal pools. In this project we had clear differences between sites with almost no suitable habitat in the mature prairie at Herbert Farm and much suitable habitat at Erion's Wetlands in both the LFA outside the vernal pools and the remainder of the property in the initial stages of conversion to wildlife habitat (i.e., WFA). There were few lark detections at Herbert Farm in the former, whereas most of the lark detections at Erion's Wetlands were in the latter. This availability of extensive habitat outside the vernal pool may be a factor in attracting larks and maintaining a population at the site (i.e., density-dependence paradigm). Thus, isolated vernal pools amid much non-lark habitat (e.g., mature prairie), even with some suitable habitat conditions for larks in vernal pools or swales, may be less attractive for settlement than larger expanses of suitable habitat. Further, it needs to be recognized that these small populations at vernal pools have limited value in terms of regional population status and no value in terms of the establishment of core sites, an essential component of lark recovery (USFWS 2019).

Vernal Pools and Swales: Erion's Wetlands and Herbert Farm

Erion's Wetlands

The last few years have seen abundant lark habitat at Erion's Wetlands due to lark-specific management objectives on part of the site (i.e., LFA), initiation and ongoing habitat management which included creation of the vernal pools in fall of 2019 and 2020, scattered regular spray-outs of undesirable invasive vegetation, plowing and disking within the WFA, and a short period of cattle grazing in April 2022 in the WFA. The latter was a short-term tool that inhibited plant succession and retained suitable lark habitat further into the spring.

The abundance of suitable habitat resulted in lark detections throughout much of the site. The presence of many vernal pools did not result in greater habitat use than the non-pool area during the two years of this project. However, vernal pools in the LFA did have greater use than those in the WFA and in proportion to their availability. This was expected since vernal pools in the LFA were designed and are maintained specifically for larks. Conversely, vernal pools in the WFA are deeper and are planted in different wildlife crops that may or may not provide suitable lark habitat when the waters recede.

Herbert Farm

Habitat restoration at Herbert Farm is different than at Erion's Wetlands in that the priority for the entire site is establishment of mature prairie. Consequently, availability of lark habitat is mostly limited to along the road or near the edge of the adjacent filbert field next to the road (34% of detections) or within the one created vernal pool and one existing swale (approximately 32% of detections) (appendices C and D). The remainder of the lark detections were scattered near those features where suitable lark microhabitat conditions occurred. Additionally, there were several observations of larks in the filbert field adjacent to Herbert Farm that were not georeferenced due to private property issues. A few years ago, when Herbert Farm was in a similar stage as Erion's Wetlands the population was slightly larger (3-4 pairs), most detections of larks were outside the swales and vernal pool (personal observation) where suitable lark habitat occurred before prairie vegetation establishment and dominance.

The vernal pool and swales at Herbert Farm will likely see future reductions in lark habitat suitability from the seeding of emergent and wetland prairie vegetation which will become more established over time and can result in rapid revegetation after water recession. Further, the depth and long period of water retention in the vernal pool reduces its temporal availability as suitable lark habitat, especially in spring and early summer as was observed in 2022. For example, although approximately one-third of the

detections were in the vernal pool or swales, almost all of those (88%) occurred in 2023 when spring water levels were low.

Site Comparisons

The difference in use of vernal pools at the two sites over the two years clearly supports several of the conservation challenges associated with vernal pools as described above. There was a much greater percent use of the vernal pool and swales relative to what was available at Herbert Farm, however, there is little suitable habitat outside vernal pool and swales at Herbert Farm and much suitable habitat outside of vernal pools at Erion's Wetlands. Additionally, the temporal availability of vernal pool habitat for larks was highlighted by the near absence of sightings in vernal pools at Herbert Farm in 2022 during record-breaking spring rainfall and water levels. At Erion's Wetlands this pattern was not as evident, but the vernal pool at Herbert Farm is deeper than at Erion's Wetlands and holds water much longer.

Lark Populations: Erion's Wetlands and Herbert Farm

Erion's Wetlands

The lark population at Erion's Wetlands has annually increased since the initiation of habitat restoration in 2019, reaching its peak in 2022 with a drop in 2023. This is slightly different than the typical pattern following initiation of habitat restoration as described above with an approximate 1-2 year lengthening of the suitable habitat window due to the phased approach to restoration across the site and the regular habitat management in both the LFA (as prescribed for larks) and in the WFA (e.g., annual disking and planting).

Changes in population size between the first and second nesting seasons were expected. The larks high site fidelity limits use of the expansive habitat in the early part of the nesting season to mostly birds from the previous year (surviving adults and first-year birds). However, as described above, displacement of birds due to natural vegetative succession or disturbance from agricultural operations and seeking suitable habitat is likely high, especially during the second half of the nesting season when displacement of birds due to agricultural operations is high.

It is likely that suitable lark habitat at Erion's Wetlands was near its peak during this project with expected and typical declines as there is less need for habitat management as the site matures. However, unlike Herbert Farm and most other habitat restoration sites where lark populations drop back to pre-restoration levels as the vegetation matures, the commitment to maintaining some lark habitat at Erion's Wetlands (e.g., the LFA) should result in maintaining a lark population even as much of the remainder of the site becomes more established in vegetation. Further, the landowner's regular habitat management efforts in the WFA are likely to provide some additional suitable habitat for larks, and there is one more phase of conversion of agricultural land which will provide additional lark habitat for a couple of years. Once all the habitat restoration is completed, it is likely that Erion's Wetlands has the potential to support 10-15 pairs of larks based on the size of the property, the emphasis on maintaining lark habitat in the LFA, and the continuing habitat management that occurs outside the LFA.

Herbert Farm

The lark population at Herbert Farm appeared to reach its peak in 2020 and 2021 and has declined each of the last two years during this project. This is similar to the typical pattern following the initiation of habitat restoration, and 2-3 years in advance of Erion's Wetlands due to an earlier initiation of habitat restoration and an emphasis on revegetation of the prairie, not lark habitat suitability.

Habitat restoration is mostly complete at Herbert Farm except for annual attempts to manage undesirable invasive species incursions. These efforts have the potential to provide scattered but short-term lark habitat within the prairie through spot-spraying of patches of invasives. It is likely that the future

population size will be 1-2 pairs mostly associated with the habitat along the road and the adjacent field and some late season use of the vernal pool and swales. This is consistent with what the population was during the agricultural field phase and prior to the habitat restoration.

Productivity

An assessment of lark productivity was not a part of the project. However, inferences on productivity can be made from the detections of fledglings in July and August and the outcomes of nests that were incidentally found and monitored. At Erion's Wetlands, the number of fledgling sightings approximately doubled in 2023 over 2022. However, fledgling detections in both those seasons (6 and 13, respectively) were much less than in 2021 (34) prior to this project. Thus, the populations in 2022 and 2023 need to be tempered by what appears to be reduced productivity. At Herbert Farm, there was only one detection of fledgling in 2022 but nine in 2023 (with no visits in August). However, populations this small are tenuous independent of productivity especially when habitat is also limited.

At Herbert Farm a single nest was located in 2022 on the adjacent filbert property within one meter of the road but failed due to equipment operation that crushed nestlings. At Erion's Wetlands, one nest was located within a vernal pool in 2023, but it failed.

Conclusions

This project provides important empirical data to enhance our understanding of the potential role of vernal pools and swales within the context of habitat restoration to contribute to lark conservation and recovery in the Willamette Valley. The practice of vernal pool creation is being conducted regularly and the results from this project support extensive anecdotal observations from numerous other sites over the last 10 years.

The most salient conclusion of this effort, and supported by other observations throughout the Willamette Valley, is that vernal pools and swales that occur in a landscape of other lark populations and are regularly maintained to ensure their suitability for nesting larks can provide lark habitat for a small population in the context of integration with other primary ecological goals at a site (e.g., prairie restoration). However, the potential value is limited by and/or dependent on the vagaries of weather and temporal availability of vernal pool habitat due to water levels, changing seed banks in the soil and high revegetation rates in the fertile soils of the Willamette Valley, the presence and amount of suitable habitat in the immediate vicinity of the vernal pools to attract a population, and the need for a strong commitment to annual habitat management to maintain lark habitat. Further, when the primary objective at a site is lark conservation or recovery (i.e., not integration with other ecological objectives), creation of vernal pools is unnecessary and counter-productive to providing suitable habitat throughout a site and throughout the nesting season. Vernal pools are underwater for some of the fall, all the winter, and some of the spring nesting season depending on weather. Those areas would be available for lark use with no vernal pools and the primary objective is lark habitat.

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Appendix A. Locations of georeferenced lark detections at Erion's Wetland in 2022. Red circles are males, blue circles are females, and yellow circles are of unknown gender. The latter includes both hatch-year birds and indeterminate gender birds.



Appendix B. Locations of georeferenced lark detections at Erion's Wetland in 2023. Red circles are males, blue circles are females, and yellow circles are of unknown gender. The latter includes both hatch-year birds and indeterminate gender birds.



Appendix C. Locations of georeferenced lark detections at Herbert Farm in 2022. Red circles are males, blue circles are females, and yellow circles are of unknown gender. The latter includes both hatch-year birds and indeterminate gender birds.



Appendix D. Locations of georeferenced lark detections at Herbert Farm in 2023. Red circles are males, blue circles are females, and yellow circles are of unknown gender. The latter includes both hatch-year birds and indeterminate gender birds.

