An Assessment of Population Status, Limiting Factors, and Conservation Actions for an Oregon Vesper Sparrow Metapopulation in the Willamette Valley, Oregon, 2016-2023

Photo: Lisa Millbank

FINAL REPORT

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Executive Summary

Oregon Vesper Sparrow is one of the most imperiled birds in North America. It has been designated as a bird of high conservation concern and vulnerability by all natural resource entities within its breeding and wintering range and is currently being reviewed by the U.S. Fish and Wildlife Service for listing under the Endangered Species Act. A range-wide inventory, anecdotal reports, and intensive demographic research in three ecoregions within its range suggest that the remaining population is approximately 3,000 birds. Breeding Bird Survey data indicates a statistically significant declining population trend of 3.2% per year.

This report summarizes data collected in 2016-2023 to assess population status and potential limiting factors and recommend conservation actions for an Oregon Vesper Sparrow metapopulation in the Willamette Valley, Oregon. Study design emphasized an examination of multiple metrics within three demographic vital rates (i.e., productivity, survival, dispersal), and among several habitat types and land uses. Additional components included habitat assessment to evaluate the role of vegetative composition and structure on nest-site selection and nest success, artificial conspecific attraction in 2020-2021 to solicit colonization of unoccupied sites, and archival GPS tags attached to birds in 2022 and retrieved in 2023 to assess migratory routes and wintering locations.

The study was conducted at 25 sites within a mostly 12-mile radius of Corvallis, Oregon. There were two primary sites (Bald Hill Farm and Soap Creek Ranch), 10 secondary sites, and 13 tertiary sites categorized by degree of effort, which included 1-3 individuals in the field every day for 4-6 months. Among primary and secondary sites, six had larger populations (10-30 pairs) and six had smaller populations (1-7 pairs). The 13 tertiary sites were visited 1-2 times/season to assess occupancy, but not every year. The three habitat types included two grasslands (pasture and prairie) and Christmas tree farms. There was an assessment of population size on all sites, nest monitoring for metrics of productivity at the primary sites, and color-banding and resighting for metrics of survival and dispersal at both primary and secondary sites.

Results are presented as descriptive summaries of the data (e.g., means, percents) with some inferential analyses to assess statistical significance and provide an initial assessment and insights into potential areas of concern for conservation actions. Future analyses will include more robust and integrated statistical analyses and modeling to examine relationships between and among demographic variables to understand the results more holistically and strategically.

Productivity

● Apparent nest success (i.e., without corrections for observation days) was 47.7%, and the Mayfield estimate of nest success (i.e., corrected for observation days) was 25.6% (n=113). True nest success (i.e., nests monitored from the laying of the first egg) was 33.3% (n=16). True nest success for the two primary sites was 29.0% (n=11), and the difference was not significant from the metapopulation.
● Nest success was higher at Soap Creek Ranch (apparent 47.7% and Mayfield 27.0%, n=42) than at Bald Hill Farm (apparent 45.6% and Mayfield 26.7%, n=46), but the differences were not significant.
● Apparent and Mayfield estimates of nest success in pastures were 49.1% and 28.2% (n=84), 54.8% and 22.4% in Christmas tree farms (n=31), and 31.3% and 12.7% in prairies (n=10). There were no significant differences, although there was a low sample size in prairies.
● There was a decline in apparent (36.7%) and Mayfield (11.7%) estimates of nest success in 2023 that were the lowest since initiation of nest monitoring in 2017.
● Apparent nest success for Savannah Sparrow at Bald Hill Farm and Soap Creek Ranch was 40.8% and the Mayfield estimate was 22.2% (n=20). These were lower than Oregon Vesper Sparrow at the same two sites, but the differences were not significant (apparent, p=0.63; Mayfield p=0.64).
● Daily survival rate was 0.9449 for the entire nesting period, 0.9392 for the egg laying/incubation period, and 0.9554 for the nestling period. There was no significant difference between the latter two.

● Nest failure occurred mostly at the egg stage (71.8%, n=89). Predation accounted for 71.0% (n=88) of all nest failures. It was higher at Soap Creek Ranch (71.7%, n=33) than Bald Hill Farm (71.4%, n=40), but the difference was not significant. It was highest in prairies in prairies (82.6%, n=19) and lowest in pastures (67.8%, n=59), but the difference was not significant.
● Cattle trampling occurred on 4.2% (n=8) of the nests in pastures (n=172) and accounted for 9.1% of nest failures in pastures (n=88). Cattle trampling occurred on 8.0% (n=4) of Savannah Sparrow nests in pastures (n=50) and accounted for 13.3% of nest failures in pastures (n=30). These were not significantly different from Oregon Vesper Sparrow.
● Clutch size ranged from 2-5 with a mean of 3.8 eggs/nest (n=133).
● Egg hatch rate was 86.1% (n=316). It was higher at Bald Hill Farm (90.6%, n=128) than Soap Creek Ranch (83.7%, n=141), and the difference was nearly significant. It was highest in prairie (89.7%, n=39) and lowest in pastures (85.1%, n=249), but the difference was not significant.
● Egg hatch rate for Savannah Sparrow was 98.9% (n=88) and there was a highly significant difference from Oregon Vesper Sparrow (86.1%, n=316).
● Fledge rate was 3.3 birds/successful nest and 1.6 birds/total nests (n=362).

Survival

● There were 791 birds (341 adults and 450 hatch-year) color-banded at 13 sites. Among adults, this included 270 males, 50 females, and 21 birds of unknown gender. Among hatch-year birds, this included 396 nestlings and 54 juveniles.
● There were 698 return events including 574 adults (included multiple events by some individuals) and 124 first-year birds. There were 25 resights (4.4% of resights) of gap-year birds (i.e., birds that go undetected one year but are resighted in a following year).
● Although return rates are considered apparent survival estimates, our return rates likely approach true survival since the analyses indicate limited emigration outside the study area and high detectability within the study area.
● Between-season survival was 62.2% for adults (n=575) and 33.7% for first-year birds (n=125). The difference between males (64.3%, n=480) and females (56.1%, n=87) was not significant. The difference between nestlings (32.7%, n=107) and juveniles (40.9%, n=18) also was not significant.
● Between-season survival of first-year birds was lower at Bald Hill Farm (30.5%, n=36) and higher at Soap Creek Ranch (39.5%, n=64) than the metapopulation (33.7%), but the difference was not significant.
● Annual adult male and first-year survival estimates have dropped each of the last three years, reaching their lowest levels in 2023 since initiation of the study.
● Bald Hill Farm and Soap Creek Ranch had between-season survival rates for females of 62.5% (n=25) and 67.7% (n=42), respectively. These were not significantly different from males.
● Both Bald Hill Farm and Soap Creek Ranch had higher female and lower male survival estimates than the metapopulation, although the differences were not significant.
● Among primary and secondary sites, between-season survival of adult males ranged from 54.4% (n=62) at Soap Creek Ranch to 71.3% (n=71) at Holiday Bellfountain Road, and the difference was significant.
● Between-season survival for birds fledged prior to June 15 (46.5%, n=60) was significantly higher than for those banded after that date (22.2%, n=22).
● Post-fledging survival at the two primary sites was 65.0% (n=173) through three weeks, 57.5% (n=153) through six weeks, and 50.0% through nine weeks (n=133). There was no significant difference between intervals or between sites for any interval.
● There was a live resight during the post-fledging period of at least one fledgling from 96.4% of the 84 nests that fledged color-banded nestlings.
● Post-fledging mortality was 35.0% during the first three weeks, 7.5% during weeks 3-6, and 7.5% during weeks 6-9.

Dispersal

● There were 57 documented dispersal events from 44 individuals.
● The annual between-season dispersal rate to new sites was 6.2% (n=43) of the population. This included 4.9% (n=28) of adults and 12.0% (n=15) of first-year birds.
● Among the two primary sites, rates of emigration and immigration were nearly identical at Soap Creek Ranch (11:12), but there was greater emigration at Bald Hill Farm (20:13).
● Dispersal events were dominated by males (66.7%, n=38). Proportionately to numbers banded, dispersal events were greater among females (24.5%, n=12) than males (14.9%, n=38), but the difference was not significant.
● There were examples of dispersal events greater than 10 miles in all between- and within-season categories of dispersal, except within-season post-fledging. The longest dispersal distance for males was approximately 23.3 miles, and for females approximately 8.8 miles.
● There were examples of dispersal events among all age classes, including 5-7 year-old birds.
● There were 17 dispersal events (29.8%) resulting in a change in habitat type.
● All but two dispersal events were to an occupied site. Both were first-year males to unoccupied sites that had been occupied in previous years. In both cases a mate was never detected, and the birds stayed approximately one and two weeks before returning to their natal site and nesting.
● Among 232 nestlings that were color-banded and fledged successfully, there were eight examples of within-season post-fledging dispersal events (3.5%). Among five of those documented to have survived the first year, four established breeding territories at their natal site and one at its dispersal site.
● There were two reports of color-banded birds outside the breeding season. One in November 2018, near Sacramento, California and the other in April 2023, near Medford, Oregon. The former was never seen again, and the latter was resighted three days later where it had been banded the previous year.

Site Fidelity

● Site fidelity was significantly higher for adults (93.9%, n=535) than for first-year birds (85.6%, n=107). Among adults it was 94.4% (n=453) for males and 90.8% (n=79) for females with no significant difference. Among first-year birds it was 85.1% (n=91) for nestlings and 88.9% (n=16) for juveniles with no significant difference.
● Among primary and secondary sites, between-season site-fidelity for adults and adult males was highest at Crestmont Ranch (97.1% [n=68] and 98.5% [n=65]), and lowest at Holiday Bellfountain Road (85.9% [n=79] and 87.8% [n=72]). The difference was significant for both adults and adult males.
● Site fidelity at Bald Hill Farm was 93.9% (n=62) for males and 88.0% (n=22) for females. At Soap Creek Ranch it was 98.4% (n=61) for males and 92.9% (n=39) for females. The differences were not significant.
● Among first-year birds, site fidelity was higher at Soap Creek Ranch (90.6%, n=59) than at Bald Hill Farm (83.3%, n=30). The difference was not significant.

Site Persistence

● Among juveniles during the post-fledging period, site persistence >50 days was 77.1% (n=135) and >60 days was 68.0% (n=119). At Bald Hill Farm it was 68.9% (n=62) and 54.4% (n=49). At Soap Creek Ranch it was 85.9% (n=73) and 82.4% (n=70). The differences between sites were significant.
● Among birds that fledged prior to June 15 and documented to survive through six weeks, site persistence to at least September 1 (approximately 2.5 months post-fledging) was 52.9% (n=63).
● The longest documented site persistence of a juvenile was 115 days and the latest resight of a juvenile was October 4.

Population Status

● Since inception of the study in 2016, two sites with small populations (1-2 pairs) have been extirpated. Two other sites with small populations (2-5 pairs) as recent as 8-10 years ago, were extirpated by the beginning of the study.

● Annual estimates of population size based on counts of males at each primary and secondary site was variable but similar in 2022 to population size in 2018 or 2019. However, in 2023 both primary sites and most secondary sites decreased in population size by 15-45% from the previous year.
● Population declines at both primary and most secondary sites in 2023 were approximately 50% less than their peak population during the study. Bald Hill Farm had a population decline of approximately 37% in 2017, stability through 2020, an increase by approximately 34% in 2021, and then a decline of approximately 45% in 2023.
● Population declines throughout the metapopulation in 2023 were likely due in part to adult male mortality from record cold and wet weather just prior to and during spring migration through northern California.
● Cumulative lambda for the metapopulation was 0.883 indicating a declining population, including declines in each of the last three years. The only parameter with a decline in each of the last three years was first-year survival. Female survived declined the last two years, and productivity declined in 2023.
● Cumulative lambda for Bald Hill Farm was 0.914 indicating a declining population, and 1.077 for Soap Creek Ranch indicating an increasing population. Cumulative lambda for the two primary sites combined was 1.006 indicating a stable population.
● Cumulative lambda at Bald Hill Farm declined for the first time in three years in 2023. Cumulative lambda at Soap Creek Ranch has declined each of the last three years.
● Cumulative lambda for the metapopulation using true nest success (i.e., 33.3%, n=48) was 0.947. Cumulative lambda for Bald Hill Farm and Soap Creek Ranch using true nest success was 1.026 (n=38). Both are higher than the corresponding lambda using the Mayfield estimate of nest success.
● Analysis of source/sink status indicated that the metapopulation and each primary site have been a source population since 2020, except Bald Hill Farm dropped into a sink population in 2023. Both the metapopulation and Soap Creek Ranch also have dropped towards sink status in the last two years.
● Analysis of source/sink status using true nest success through 2023 indicated that the metapopulation (0.169) and the two primary sites combined (0.115) were source habitats.
● Migration and wintering mortality of first-year birds was 16.3% resulting in a year-one mortality of 66.3%. Annual adult mortality rates increased each year starting with 35.2% mortality between ages 1-2.
● Breeding populations at the primary sites were structured by age class in descending order. One and two year old birds comprised approximately 70-75% of the population.

Habitat Assessment

● Habitat data were collected at 92 grassland nests (88 with outcome) and associated random 1-meter square plots, and at 39 of the 92 nests along 10-meter transects.
● Grasses accounted for slightly less than half of the cover at nest plots (47.9%) and forbs approximately one-third (34.4%). Bare ground was 5.5% and thatch/litter was 5.8%.
● The height class with the highest percentage herbaceous cover was height class 2 (8-16 in). Approximately one-half the cover occurred in height classes 1-2. There were no significant differences between nests and random plots or successful and failed nest plots in any height classes.
● Native species accounted for 16.1% of the cover at nest plots and 17.2% at successful nests. These were not significantly different from random plots (19.2%) or failed nests (16.4%).
● Introduced species accounted for 69.9% of the cover at nest plots and 66.1% at successful nests. These were not significantly different from random plots (68.2%) or failed nests (70.7%).
● The species with the greatest cover at nest plots was the introduced forb *Daucus carota* (8.5%), and at successful nest plots the introduced grass *Lolium perenne* (8.0%).
● The native forb *Madia gracilis* and the introduced grass *Agrostis tenuis* had significantly more cover in nest plots than successful nest plots. Conversely, the introduced grass *Lolium perenne* had significantly more cover in successful nest plots than nest plots.
● The two species with significantly more cover in both successful nest plots than failed nest plots and in nest plots than random plots were the introduced grasses *Bromus sterilis* and *Lolium perenne*.

● The only two plant species significantly associated (positively) with both nests and successful nests were two introduced grasses, *Bromus sterilis* and *Lolium perenne*.
● Mean distance from nests to shrubs was 14.2 meters, to trees 28.1 meters, and to edge 74.5 meters (n=193), with no significant difference between successful and unsuccessful nests in all three categories.

Artificial Conspecific Attraction

● The only detections of Oregon Vesper Sparrows at the five conspecific attraction sites were at Lumos Prairie in 2020 and 2021. There was a single male for two weeks in 2020 and three pairs in 2021. There was at least one successful nest in 2021 based on the detection of fledglings with adults.

GPS Tagging

● GPS tags were attached to 14 adult birds from five sites in 2022. All but one of the birds were males and the ages ranged from 1-3 years old. Two birds were recaptured in 2023 at two different sites. The battery died on one bird in February with data only on fall migration and the wintering period. The other bird had complete data through spring migration. Both wintered in south-central California.
● The recapture rate of GPS-tagged birds was less than expected likely due in part to increased mortality of adult males due to extreme weather in California just prior to and during spring migration, 2023.

Conservation Implications

This study is providing critical knowledge for initiating targeted conservation actions to recover the imperiled Oregon Vesper Sparrow. There is a clear direction and immediate need to implement some actions now (see Recommendations). Some metrics, especially at the scale of site or habitat type, will require more data and rigorous statistical analyses for formulating additional recommendations and implementing appropriate conservation strategies. Confidence in the results and conservation recommendations is bolstered by large sample sizes and the degree of spatial and temporal effort.

The study also provides an important example of how intensive long-term research with extensive spatial effort using mark-resight methodology can provide robust data on essential demographic metrics for determining population status including critical data on parameter estimates often considered difficult to obtain (e.g., post-fledging survival, dispersal). Further, it accomplishes this for a bird of high conservation concern and priority status through a relatively non-invasive methodology with less risk compared to the alternative (e.g., radio-tracking) which includes potential and documented negative impacts on the survival of adults and especially nestlings and fledglings.

<u>Population Status and Demographic Metrics</u>
Estimates of population size based on counts of males during demographic research, and calculation of lambda using Mayfield estimates or true nest success, both indicate a declining metapopulation. The highest population estimates were in 2020-2021 for both primary sites and most secondary sites. This was followed by consistent declines in 2022 and 2023, especially the latter year when most sites dropped in population by 15-45% from the previous year and were the lowest since initiation of the study. Specifically, population size at the two primary sites and one secondary site were approximately 10 pairs each in 2023 which is 50% of their peak population size, and now at a level of great concern for potential extirpation.

Population size declines in 2023 were likely due in part to suspected high levels of mortality for adult males from record cold and wet weather prior to and during spring migration in the latter part of March and first two weeks of April in northern California. The adult male survival rate in 2023 (41%) was well below the mean survival rate (65%) and the lowest documented since the study was initiated. Adult males typically arrive the last 4-5 days of March and the first 10 days of April, but in 2023 the first sighting was April 9, approximately 12-13 days late. The weather likely increased adult male mortality either directly from the weather itself or indirectly from the inability to fuel up sufficiently to make the trip. This hypothesis is

further supported by the fact that older females returned at the same rate as the mean (56%). Since they arrive in mid-April they missed the worst weather conditions and hence had better and more typical survival.

Lambda results from demographic data follow the same temporal pattern and declining trends for the metapopulation as the population counts. However, for the two primary sites the lambda trend is in the opposite direction from each other, except for both declining in 2023. This appeared to be driven by decreased first-year survival and nest success, both of which were the lowest since the beginning of the study.

Two factors suggest that lambda for the metapopulation may be higher. First, there is an inherent underestimation of female survival due to their secrecy during nesting and only incidental nest monitoring at secondary sites. Secondly, the metapopulation is disproportionately dominated by older birds at secondary sites due to the absence of color-banding of nestlings and subsequent resighting of surviving first-year birds into the population. The older birds have an increased likelihood of mortality and bias the analyses towards lower survival estimates.

An alternative assessment of lambda using only data from the two primary sites where there was intensive data collection on all parameters of lambda (i.e., without the biases of effort at the secondary sites especially for nest success/productivity and female survival), indicates a stable population using the Mayfield estimate of nest success (1.006) or a stable to slightly increasing population using true nest success (1.026). However, even at the two primary sites, lambda declined in 2023.

Empirical data from this metapopulation for each vital rate and associated metrics provide opportunities for exploratory manipulations of the population growth model as described below to evaluate which parameters have the greatest potential to increase lambda. It would require unrealistic increases for some metrics (e.g., nest success, egg hatch rate) to result in a stable or increasing lambda. However, reasonable increases in some metrics (e.g., adult female survival, first-year survival) and continued consistency in other metrics can result in the lambda of a stable or increasing metapopulation.

The current nest success of 0.256 would need to increase to 0.410 to achieve a stable population. This seems unlikely since it is higher than true nest success (0.333) and higher than any Mayfield estimate of nest success ever reported for any other subspecies of Vesper Sparrow.

The current female fledgling rate of 1.63 would need to increase to 1.88 to achieve a stable population. Even if egg hatch rate was 100% and there was no loss of nestlings, this would only reach a female fledgling rate of 1.82. This is already being achieved in Christmas tree farms (1.9), although with a small sample size. However, this degree of increase in egg hatch rate seems unlikely.

The current first-year survival estimate of 0.337 would need to increase to 0.460 to achieve a stable population. Using true nest success, the estimate would need to increase to 0.385. The former seems unlikely since our first-year survival estimate is already among the highest ever reported for a migrant passerine species. However, the increase needed using true nest success seems reasonable since previous estimates for this metapopulation were 0.396 through 2019 and 0.414 through 2020.

The current adult female survival estimate of 0.561 would need to increase to 0.620 with true nest success or 0.680 with the Mayfield estimate of nest success to achieve a stable population. The former is already being achieved at both primary sites (Bald Hill Farm 0.625 and Soap Creek Ranch 0.677), and the latter at Soap Creek Ranch.

Alternatively, lesser degrees of increase across multiple metrics also could increase lambda. However, the scenarios depicted above for increases in specific metrics to achieve a stable population depend at the same

time on no decreases in the other metrics. High annual variability has been evident for several metrics, thus improvements in a singular metric as described above may still be insufficient with the annual variability of potential decreases in other metrics.

There is no productivity metric with consistent high rates to potentially compensate for metrics with variable or lower rates. Thus, there is little margin for error to maintain productivity, which can be quickly compromised with one or more poor years in any metric. Additionally, productivity metrics tend to be site-specific which limits the effectiveness or appropriateness of broad-scale conservation recommendations. Further, some productivity metrics require more insight into causality such as low egg hatch rates or nest success or have yet to be revealed with existing descriptive analyses.

The analysis of source/sink status also supports the population declines in 2022 and 2023. The metapopulation and both primary sites were source populations through 2022. However, in 2022 and 2023 the metapopulation and Soap Creek Ranch declined in degree of source status and Bald Hill Farm dropped into sink status in 2023.

Survival estimates for adult, first-year, and post-fledging birds were mostly consistent across seasons and sites through 2021. Although all have declined precipitously in the last two years, they are still relatively high among grassland birds, and female survival estimates may be underestimated as described above. Further, survival metrics are mostly driven by spatial and temporal factors independent of local breeding site conservation actions. Site fidelity is relatively high and mostly consistent across sites and years for both adult and first-year birds. Site persistence of juveniles also is high with most surviving birds spending 2-3 months on the natal site before migrating.

Dispersal analyses indicated that this is a metapopulation of geographically distinct sub-populations linked by the interchange of some individuals. Dispersal events were annual although with low frequency (i.e., 6.2% of the population). They included occurrences of all types of dispersal events (i.e., adult and natal between-season, adult within- and post-breeding season, and natal post-fledging), and several with distances in the 10-20 miles range. They also occurred between and within habitat types (i.e., grasslands and Christmas tree farms), and were representative and variable among gender and age.

Analyses of habitat data provided limited insight into habitat relationships for guiding habitat restoration and management activities. There were few significant associations of plant species with nest placement or outcomes, and an absence of significant associations of preferences between native and introduced species and nest placement or outcomes within the landscape (e.g., distances to shrubs, trees, and edge). The results were used to update a prescription for land managers that included suitable habitat type (i.e., grassland or savannah), coarse-scale habitat conditions (i.e., structurally diverse with short and moderate statured herbaceous vegetation and scattered shrubs or trees), and finer-scaled height and cover amounts for growth form, species, and non-species ground cover.

Conservation Challenges, Opportunities, and Priorities

A primary conservation challenge lies in the realistic ability to positively affect metrics of concern. On the breeding grounds, there are greater opportunities for conservation actions to improve productivity metrics than survival or dispersal metrics. Efforts could be initiated to minimize negative impacts on nest success through spatial and temporal planning and implementation of habitat restoration or management and livestock operations (see Recommendations). This could include reduction or avoidance of land use or land management disturbances (e.g., grazing management or habitat restoration) during the early nesting season to enhance nest success and increase opportunities for survival of first-year birds which have significantly higher survival estimates than those fledging later in the nesting season (see Recommendations). Nest success could also be enhanced through habitat management that removes corridors of woody vegetation that fragment the habitat to reduce predator abundance and access (see Recommendations). It will also be

important to evaluate the reason for low egg-hatch rates (see Recommendations), especially the potential for genetic issues since Savannah Sparrows in the same fields have a high egg hatch rate. These actions will require extensive coordination with land managers and livestock operators along with population and nest monitoring to maximize effectiveness and minimize impacts on land use operations.

Another conservation challenge is that restoration of the prairie-savannah habitat type is usually deficient in providing suitable habitat for Oregon Vesper Sparrow in the Willamette Valley due to the fertility of the soils and the regular invasion and dominance of aggressive non-native vegetation. Without a mechanism(s) to reduce vegetation growth, the site becomes too tall and dense with little to no sparsely vegetated areas despite the appropriate habitat type. The potential mechanisms to achieve and maintain habitat suitability in the herbaceous layer are late winter/early spring grazing and dispersed spot-spraying or mechanical efforts to create sparsely vegetated patches.

The rate of nest failures in pastures due to cattle trampling of nests was relatively low and acceptable based on overall nest success and the essential need for grazing to maintain habitat suitability in pastures. Additionally, there are opportunities to manage grazing to potentially maximize suitable habitat and further reduce nest losses due to cattle trampling (see Recommendations). This includes a schedule of grazing upland areas into suitability just prior to nesting (i.e., before May) and then moving the cattle into wetter fields or parts of fields where there is limited nesting in the early nesting season. This also supports the desire to maximize the number of fledglings produced in the early nesting season since there was significantly higher between-season survival of first-year birds fledged in the early nesting season compared to birds fledged later.

The determination that this is a connected metapopulation indicates that conservation actions taken at a subset of sites also will benefit the metapopulation. Although the sites are patchily distributed and mostly on private working lands, there can be confidence that efforts on sites with supportive ownership will promote the sustainability and recovery of the metapopulation. Further, the documentation of highly variable dispersal events supports the potential value of habitat restoration and management to provide suitable habitat on conservation lands for all individuals, independent of age, gender, or life history.

Conversely, the conservation implications of high site fidelity between years exacerbates the difficulty of establishing new populations or reestablishing extirpated populations when there is habitat degradation or loss at a site and the distance between fragmented patches of suitable habitat is large. Thus, habitat enhancement to encourage recruitment of birds to occupied or unoccupied sites should occur near existing populations, especially large populations, to maximize the likelihood of response from the limited pool of dispersing birds (see Recommendations).

The combination of high site fidelity and the dominance of this metapopulation on private, working lands exacerbates concerns about its population status, but also provides both a conservation challenge and opportunity. It emphasizes the importance of working with private landowners to maintain suitable habitat, but also the uncertainty to ensure continued land use and management to sustain populations in changing economic markets (see Recommendations).

Although outreach to these private land managers for conservation support is desirable (see Recommendations), it is a higher priority to emphasis sites with more potential for direct management and conservation of populations. This includes both existing populations on conservation lands, and the establishment of new populations on appropriate unoccupied conservation lands (see Recommendations). The goal should be to move towards a higher percentage of the metapopulation on conservation lands with management opportunities, and with less reliance on private working lands where those opportunities are limited or non-existent.

Given the urgent need to secure populations on dedicated conservation lands and the short-term positive results from artificial conspecific attraction at one site, artificial conspecific attraction may be a valid technique for settlement and establishment of new populations (see Recommendations). However, it may take multiple years to result in establishment of a population.

The recent extirpations of several small populations suggest the need to prioritize conservation actions on larger populations where there is more potential resiliency to recover from natural or anthropogenic population fluctuations (see Recommendations). Further, large populations also provide the potential for more surplus birds for dispersal and population establishment or enhancement elsewhere following years of high productivity. This is critical for this metapopulation since there was high site fidelity and limited dispersal unless forced by exceeding the carrying capacity of a site. Enhancement of large populations will likely require both expansion of suitable habitat areas and improvement of habitat suitability in the herbaceous layer (see Recommendations).

Recommendations

The results as presented and interpreted throughout this document suggest the following recommendations for advancing conservation and recovery of the Oregon Vesper Sparrow metapopulation near Corvallis, Oregon.

Recovery

1. Prioritize conservation of large populations (over small populations) where there is greater potential of resiliency to recover from natural or anthropogenic population fluctuations and less likelihood of extirpation.
2. Prioritize establishment of new populations on dedicated conservation lands (over private working lands) where management can be targeted for desired habitat conditions independent of production or economic considerations.
3. Prioritize habitat management or restoration at occupied sites that emphasizes increased area of suitable habitat and especially suitable habitat conditions in the herbaceous layer.
4. Prioritize habitat management or restoration at occupied or potential sites near existing populations to enhance the likelihood of recruitment of new birds.
5. Avoid habitat management or restoration on occupied sites during the early nesting season (i.e., May 1-June 15) to maximize the likelihood of productivity during that critical period.
6. Conduct essential habitat management or restoration on occupied sites after June 15 to reduce impacts on nesting birds potentially including nest buffers, duration and intensity of activities, and equipment travel (e.g., field edges and consistent routes).
7. Conduct habitat management or restoration on occupied sites outside the nesting season in staggered phases that retains at least half the existing occupied suitable habitat annually.
8. Conduct shrub and small tree removal within occupied suitable habitat where these features provide a contiguous linear travel corridor for nest predators (e.g., small and medium-sized mammals) and also fragments the amount and area of suitable habitat.
9. Enhance habitat suitability of interior patches of herbaceous-exclusive upland grasslands through the planting of widely scattered native trees and/or shrubs (less than 10% cover).
10. Manage grazing rotations on pasturelands to maximize suitable habitat conditions and reduce cattle trampling of nests by grazing upland habitats or areas of high bird densities in March and April before nesting, and wet habitats or areas of low bird densities in May and early June.
11. Implement artificial conspecific attraction to encourage colonization at appropriate unoccupied sites (i.e., near an existing large population and a site managed for conservation).
12. Conduct outreach and seek cooperation with land protection agencies and organizations to identify, prioritize, and secure conservation status for existing and potential sites with populations or suitable habitat.
13. Conduct outreach and seek agreements with livestock and Christmas tree farm managers and their associations to work cooperatively for conservation.

Research

1. Conduct analyses of unhatched eggs to assess potential reasons for low hatch rates.
2. Document the effect of grazing intensity on habitat use and productivity metrics under existing practices and seek opportunities to manage gazing for viable and sustainable populations.
3. Expand nest monitoring efforts to Christmas tree farms and prairies to understand the status of productivity in these land uses.
4. Expand efforts to capture and color-band females to increase sample sizes and enhance the rigor of statistical analyses through increased effort in the last two weeks of April when they are arriving, and through playbacks of nestling vocalizations immediately post-fledging.
5. Expand efforts to assess post-fledging survival in conjunction with nest monitoring at additional sites, especially Christmas tree farms.
6. Expand the spatial extent of the study area to enhance documentation and understanding of dispersal.
7. Expand efforts with GPS tagging to increase sample sizes and enhance knowledge of migratory routes and wintering locations.

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