Florida Grasshopper Sparrow 5-Year Strategic Vision

– a recovery implementation strategy

Third Draft

Last updated 9 April 2019

EXECUTIVE SUMMARY

Florida grasshopper sparrow (FGSP; *Ammodramus savannarum floridanus*) populations have been in sharp decline despite intensive management and research efforts. Habitat loss, alteration of hydrology and fire regimes, and possibly disease, have played a role in the decline. As breeding pairs reached critically low numbers in 2015, the U.S. Fish and Wildlife Service (Service) began a captive-breeding program to augment the wild population via captive-reared birds. The Service and Florida Fish and Wildlife Conservation Commission (FWC), with input and feedback of the FGSP Working Group, present this FGSP 5-year Strategic Vision to guide management actions for the species. The goal of the vision is to stabilize and grow the wild population over the next five years through habitat management, wild population management, and captive rearing and release, while identifying management actions that can reverse the population decline and reduce and eventually eliminate the need for future captive rearing.

The FGSP 5-year Strategic Vision outlines necessary objectives and actions to achieve the goal stated above. The vision is a recovery implementation strategy for components of the species-specific recovery actions S2, S4, and S5 and habitat-level recovery actions H1 and H3 (Service 1999). The appendices delve into specific details of the captive-rearing program, release strategies, and health screening protocol. This is a living document and will be revisited and revised by the Service and FWC as our body of knowledge about the FGSP grows and new information becomes available to help guide our decision-making.

The **Introduction** reviews the history of FGSP conservation and the necessity of a time bound vision moving forward. The **Conservation goal** clearly states the desired outcome of the vision, to stabilize and grow the wild population over the next five years.

Six measurable **Objectives,** to be implemented at all sites with extant FGSP populations, outline how the conservation goal will be achieved:

- Habitat Management (Objective 1)
- Nest Protection (Objective 2)
- Monitoring and Database Management (Objective 3)
- Captive Management and Release (Objective 4)
- Research (Objective 5)
- Outreach (Objective 6)

The **Methods** list clear, attainable actions for each objective.

Stakeholder Engagement and Decision-Making Framework summarizes the development of the vision and the process of future decision making. As the trust managers, Service and FWC will make final decisions if group consensus within the FGSP Working Group cannot be reached.

Check points and criteria for success are quantifiable criteria to guide decisions and evaluate the program. The checkpoints at years two and five serve as an assessment of success for the captive-rearing program and a decision point to continue agency support.

The annual **Budget** outlines estimated costs, sources for funding, and anticipated shortfalls and how they will be addressed. The timeline details funding for each action that will facilitate long-range planning.

Appendix A describes the rationale for the details in the captive management and release strategies. Decisions on the size of the release cohort, captive-rearing methods, location of the captive program, magnitude of the captive effort, age at release, disease risks, risk management, pre-release health screening, acclimation, and release location are presented with rationales based on scientific literature and the best available data on FGSP biology.

Appendix B provides an adaptive management framework for testing aspects of the release plan. Appendix B specifies the composition of captive release cohorts as well as methods related to pre-release health screening and acclimation, post-release monitoring via radio transmitters, and systematic point-counts. Criteria for success and evaluation of release methods provide check-ins and procedures if release methods require modification.

Appendix C specifies pre-transfer screening protocol to ensure continuity of treatment and health information gathered from captive FGSPs.

Appendix D defines protocols of captive-rearing facilities, both for present and possible future partners. These best practices have consistently shown high survivorship and productivity, and their application at current and future partner facilities will optimize the success of the captive-breeding program.

Appendix E contains literature cited for the document, including appendices.

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INTRODUCTION

Despite ongoing management efforts, sharp declines in Florida grasshopper sparrow (FGSP; *Ammodramus savannarum floridanus*) populations have been observed in recent years, and the subspecies is now nearing extinction. As of the 2018 breeding season, there were an estimated 23 breeding pairs left in the wild. Habitat loss, altered fire regimes and hydrology, and land-use change likely have been responsible for population declines, and disease has been hypothesized as a potential contributor. Recent research confirms that adult survival and productivity rates are too low to support a stable population. Data indicate that survival rates of unprotected nests in most years is so low that adult survival rates would have to be greater than almost any value reported for another temperate passerine species to overcome the observed poor productivity (FWC unpub. data, Pizarro Muñoz et al. 2018).

To date, conservation partners have employed a multi-pronged approach to address the declines. Partners have conducted land management to restore and maintain suitable habitat. Research projects have provided guidance on habitat management and have identified limiting life history stages. Based on the results of this research, partners have instituted emergency actions (e.g., predator fencing, nest lifting, red-imported fire ant [*Solenopsis invicta*] treatments) that have substantially improved nest success, though they do not provide long-term solutions. In 2015, the U.S. Fish and Wildlife Service (Service) initiated a captive-breeding program to augment the wild population via release of captive-reared birds. FGSP breeding pairs are currently held at Rare Species Conservatory Foundation (RSCF) in Loxahatchee and White Oak Conservation Holdings (WOCH) in Yulee, with additional unpaired adult males held at Santa Fe College Teaching Zoo (SF) in Gainesville. This effort is likely to produce substantial conservation benefits through release of captive-reared birds beginning as early as 2019. Looking into the future, reversing FGSP declines will require continued investment in land management and nest protection, captive rearing to augment the wild population, and research to identify solutions in the wild that eliminate the need for continued captive rearing.

The Service and the Florida Fish and Wildlife Conservation Commission (FWC), with input from the FGSP Working Group, present this 5-year Strategic Vision for the management of the FGSP. The vision is a recovery implementation strategy for components of the species-specific recovery actions S2, S4, and S5 and habitat-level recovery actions H1 and H3 (Service 1999)[1]. The vision provides a clear goal, objectives, and success criteria, along with an integrated set of

[1] From 1999 Recovery Plan: S2. Protect and enhance existing populations of Florida grasshopper sparrows; S4. Continue efforts to monitor the status and trends of Florida grasshopper sparrow populations; S5. Increase public awareness of the biology, ecology, status and trends of the Florida grasshopper sparrow; H1. Protect and enhance currently occupied habitat; and H3. Continue research on grasshopper sparrow/habitat interactions. https://www.fws.gov/verobeach/MSRPPDFs/FloridaGrasshopperSparrow.pdf

actions designed to achieve them. Estimates of the resources required for full implementation are included. The strategic vision is time-bound, and success criteria are intended to provide agencies and partners the information they need to assess the degree to which continued investment is warranted in each facet of current FGSP conservation efforts.

CONSERVATION GOAL

Stabilize and grow the wild population over the next five years through habitat management, wild population management, and captive rearing and release, while identifying management actions that can reverse the population decline and reduce and eventually eliminate the need for future captive rearing.

OBJECTIVES

(To be implemented at all sites with extant FGSP populations)

1. Restore and maintain optimal conditions in occupied and potential FGSP habitat through continued use of land management practices, such as prescribed fire, mechanical treatments, and, where appropriate on private lands, prescribed grazing.
2. Improve reproductive success by locating and protecting FGSP nests with fences, by lifting nests at risk of flooding, and by conducting treatments to control fire ants when appropriate.
3. Conduct demographic monitoring of wild FGSP on public and private lands (with landowner permission) wherever FGSP occur.
4. Augment the wild FGSP population in a manner that stabilizes and grows the wild population (current stabilizing target is 23 breeding pairs, based on the estimated size of the 2018 wild population) through captive rearing, genetic management of captive and wild populations, and the release of captive-reared individuals in an adaptive management context.
5. Conduct research that will assess the likelihood of meeting overall population goals and will identify management actions that can stop the decline, grow the population, and eliminate the continued need of a captive support population.
6. Increase public knowledge of the status and trends of the FGSP, its recovery needs, and opportunities for the public to participate in the FGSP's recovery.

STAKEHOLDER ENGAGEMENT AND DECISION-MAKING FRAMEWORK

This vision was developed with input from the FGSP Working Group (working group), a public-private partnership that has worked collaboratively on FGSP conservation since 2002. The Service and the FWC distributed a draft of the document to the working group on September 11, 2018 and conducted a facilitated working group meeting on September 17, 2018, in an effort to reach consensus among working group members for the elements of this plan. Consensus is defined to mean that all members actively support the plan or at least can accept it. When the working group was unable to reach consensus on an issue, the Service and FWC, who serve as trust managers for the people of the United States and Florida, respectively, made the final decision. The Service and FWC considered written and verbal comments provided by working group members when developing the second draft of this plan. The Service and FWC released the second draft prior to a November 28-29, 2018, Disease Risk Analysis (DRA), facilitated by the Conservation Planning Specialist Group of the International Union for the Conservation of Nature. This third draft incorporates information from the DRA.

METHODS

HABITAT MANAGEMENT (Objective 1)

Continued habitat management is fundamental to the persistence of wild FGSP. FGSP require open, frequently-burned dry prairie habitat. FGSP habitat will be maintained in an early successional stage through frequent prescribed fire (every 1 to 2 years, recommended in Feb-Mar [prairie occupied by FGSP] or Apr-May [prairie not occupied by FGSP]). Prescribed grazing may be an option for maintaining habitat in some cases, with the prescription decided on a case-by-case basis in coordination with Service and FWC staff. Roller-chopping and tree removal help to expand and improve FGSP habitat. Priority will be given to the maintenance of dry prairie habitat in locations known to currently support FGSP populations followed by the restoration and maintenance of potential habitat in unoccupied areas.

> **Action 1:** Conduct prescribed fire, tree removal, roller-chopping, and exotic grass control at all field sites (Three Lakes Wildlife Management Area [TLWMA], Avon Park Air Force Range [APAFR], Kissimmee Prairie Preserve State Park [KPPSP], and a private ranch [Ranch]) to maintain dry prairie habitat in suitable condition for FGSP.
>
> **Action 2**: Create an appendix that contains guidance on habitat management (e.g., prescribed fire, mechanical treatments, prescribed grazing) for FGSP.

NEST PROTECTION (Objective 2)

Poor nest success has been identified as one of the major proximate causes of population decline for FGSP. Working group partners have demonstrated dramatic improvements in nest success by installing predator deflection fences around known nests, lifting nests that are at risk of flooding, and treating red imported fire ants near known FGSP nests. A nest fenced at the start of incubation has a 53% chance of fledging young, compared to 4% for an unfenced nest (2017 TLWMA estimates; FWC unpub. data). Continuing these management actions is critical until larger-scale management solutions can be identified and implemented.

Action 3: Continue to locate wild FGSP nests and install predator deflection fences at those nests at all field sites.

Action 4: Continue to lift FGSP nests at risk of flooding at all field sites using established working group protocols.

Action 5: Treat red imported fire ant mounds found near FGSP nests using established hot water techniques (King and Tschinkel 2006; G. Thompson, pers. comm.) or via manual removal (with shovel).

MONITORING AND DATABASE MANAGEMENT (Objective 3)

Understanding the current wild population size, population trends, and reproductive effort is necessary for making informed conservation decisions. Demographic monitoring has been critical to identifying limiting life history stages and crafting management strategies and research to address threats.

Action 6: Continue to survey all known wild populations and recently unoccupied habitat annually using standardized point count and band-resighting methods.

Action 7: Continue coordinating with private landowners to identify and monitor other FGSP populations on private lands should they exist**.**

Action 8: Continue demographic monitoring of wild FGSPs and monitor captive-reared FGSP released into the wild. This includes capturing and affixing color bands on all newly discovered adults and nestlings and locating and monitoring nests to obtain estimates of reproductive success.

Action 9: Standardize demographic, point count, and habitat data collection across sites and merge into a master archival database. Demographic data will then be summarized annually to generate vital rate estimates and pedigree analysis tables for each subpopulation.

CAPTIVE MANAGEMENT AND RELEASE (Objective 4)

The objective of the FGSP captive program (2019-2024) is to produce and release enough FGSPs to maintain a stable or increasing wild population. This means that, at a minimum, enough birds would be released to maintain at least 23 wild breeding pairs, based on the size of the 2018 wild population. Ideally, enough releases would occur to grow the wild population to a size that is more resilient to demographic and environmental stochasticity. However, we recognize that captive-rearing efforts are expensive and logistically challenging, and, ultimately, management actions will need to produce a substantial improvement in wild vital rates to grow the population in a manner that is fiscally feasible and sustainable. Without these improvements to wild population vital rates, the scale of the captive effort would need to grow annually for an undetermined amount of time in order to result in a growing wild population. Although we hope to exceed the minimum presented here, the captive program must at least produce enough recruits into the wild population to keep the population stable while ways to improve wild vital rates are sought (Objective 5)·

Captive management and release portions of the vision will be executed within an adaptive framework. The captive program will be a cooperative effort, as reflected by rapid data sharing among partners and joint authorship of peer-reviewed scientific products that arise from program activities. The strategy below, for which a thorough rationale is provided in Appendix A, is based on information presented at the DRA, literature review, and expert opinion.

1. *Determination of minimum annual cohort size.* We estimate that at least 8 captive-reared females need to be recruited into the breeding population each year to stabilize the wild population at 23 breeding pairs. Assuming a minimum post-release survival and recruitment threshold of 15%, we estimate that at least 53 captive-reared females need to be released annually to meet our target of 8 recruited females (Appendix A). Our target is specific to females because they are the limiting sex, but any males not needed to support the captive population will also be released. Assuming a balanced sex-ratio of captive-reared birds, the number of released males will approximate that for females. The 15% target was chosen as a realistic minimum starting point to establish initial

estimates for the minimum cohort size. We will refine the recruitment rate (and hence the minimum cohort size) once we have data from releases.

2. *Captive-rearing methods.* The 53 females (and similar number of males) will be reared by adult FGSP pairs in captivity following a captive breeding for immediate release program (as described by Lieberman and Kuehler 2009). In addition, head-starting of salvaged eggs and nestlings may be used to supplement captive breeding and to help us meet or exceed our annual production goals.

3. *Location of captive-rearing facilities*. The captive-rearing facilities will remain distant to the wild site (*ex situ*) rather than constructing a new facility at a wild population site (*in situ*), unless the results from release trials or the mid-point program evaluation suggest an *in situ* option should be considered.

4. *Magnitude of captive effort*. At least 14 FGSP breeding pairs will be necessary to meet our annual release target of 53 captive-reared females (see Appendix A). Captive FGSP will be housed and cared for in outdoor aviaries, and facilities will follow the protocols proven to successfully produce parent-reared fledglings (Appendix D). We currently have enough FGSP in captivity to meet this target, but additional funding is needed to expand breeding facility space and support operations.

5. *Age at release*. Captive-reared birds will be released as both independent juveniles and as second-year adults within an adaptive framework to test the survival and recruitment probabilities of these two developmental stages (Appendix B).

6. *Pre-release health screening.* FGSPs targeted for release will undergo a pre-release health screening (Appendix C) *ex situ* prior to being cleared for transfer and release.

7. *Acclimation with pre-release observation*. Parent-reared FGSP will spend 2 nights in a field aviary prior to release to allow for adjustment to radio transmitter harnesses, recovery from human handling, and recovery from transport (Appendix B). Shorter acclimation periods within this time frame or direct release of parent-reared birds may occur, if warranted, to mitigate risks to the birds (e.g., to eliminate intraspecific aggression from males). If an injured or ill bird needs to be captured from the aviary, the rest of the release cohort will be held for one additional night to allow for recovery from disturbance. Hand-reared birds, which are expected take longer to acclimate to the prairie, will be held for 4-7 nights, at the discretion of husbandry staff. Adjustments to

the length of field acclimation will be made based on observations of birds pre- and post-release.

8. *Location of release*. The 2019 experimental release trials (Appendix B) of captive-reared FGSP will take place at TLWMA, with the intent to release birds at other sites as soon as feasible (see Appendix A: Release Location). We will evaluate release sites for 2020 and beyond each fall (Appendix B: Evaluation of Release Methods) using triggers based on outcomes from prior releases as well as the preparation and suitability of alternate release sites to receive birds (Appendix A: Release Location).

The following are potential contingency plans in case unforeseen circumstances (e.g., emerging disease concerns) delay or preclude releases:

- *If a facility must temporarily cease releases (e.g., if additional information about disease is required before releases can continue)*. Birds will be prevented from breeding, either by separation or egg collection, and will be held in a safe and humane manner until the necessary information is obtained. Limited breeding may occur if sufficient funding is identified to expand one or both facilities.
- *If captive birds cannot be released from some but not all facilities due to unforeseen circumstances.* An evaluation will be made as to whether genetic material can be shared between facilities via egg transfer. If possible, genetically valuable pairs will continue to breed at the site at which birds cannot be released and eggs will be transferred to the alternate captive-breeding facility. This would continue until sufficient genetic material was transferred to the active captive-breeding facility. Birds at the non-releasing facility will be retained in a safe and humane manner until they join another collection for display or education or they die naturally. The breeding facility with releasable birds will implement the preferred captive management and release strategy. If the number of release birds per cohort is less than what is identified in the preferred strategy, partners may consider expanding capacity at the releasing facility or exploring the feasibility of alternative options for captive rearing (e.g., *in situ* captive breeding, head-starting, or establishment of a captive flock at another facility).
- *If captive birds can no longer be released from any facility*. Birds will be retained by each facility in a safe and humane manner until they join another collection for display or education or they die naturally. Partners will explore the feasibility of alternative options for captive rearing, such as *in situ* head-starting or *in situ* captive breeding and release.

Action 10: Rear enough captive FGSP to add at least 8 competent breeding females to the wild population on an annual basis during 2019-2024, in accordance with Appendices A and

D. We estimate that this will take release of at least 53 females (plus males) per year (Appendix A).

Action 11: Conduct limited collections of individuals from the wild and transfer individuals between facilities as necessary to maintain genetic diversity of the captive population. Continue genetic management of the captive and wild FGSP populations using PMx kinship analysis software (Lacy et al. 2011; Appendix B).

Action 12: Augment the wild population through release of captive FGSP, in accordance with Appendices A, B, C, and D.

Action 13: Monitor released birds to evaluate success of releases, and test hypotheses regarding release methods that maximize survival and recruitment (Appendix B).

RESEARCH (Objective 5)

Continued research is necessary to identify strategies to stop the decline, grow the population, and reduce and eventually eliminate the continued need of a captive support population. Addressing the following research topics will provide information necessary to guide future actions and to frame the likelihood of meeting population recovery goals.

Action 14: Determine the influence of roller-chopping on nest survival.

Nest survival for sparrows is too low to support a stable or growing population. One hypothesis suggests that nest predators such as snakes may prefer the cover provided by palmettos, so palmetto reduction may improve nest survival by reducing predator densities. Densities and nest survival of FGSPs and Bachman's sparrows (*Peucaea aestivalis*) within existing roller-chopped areas or experimental plots can be compared with untreated control plots.

Action 15: Continue ongoing research into diseases of wild and captive FGSP.

Although recent demographic data point to low nest success as a proximate cause of population declines, one hypothesis is that disease may have played a role in previous observed declines (e.g., at APAFR in the early 2000s) and in the low adult survival observed in some recent years. In addition, disease has been a common cause of mortality of captive FGSP. More information on pathogens in the wild and captive populations is needed to understand the risk associated with release of captive birds and whether any wild pathogens exist that could be responsible for historic or ongoing declines.

Two active studies focus on describing diseases found in wild and captive FGSP populations. First, FWC and University of Florida (UF) are collaborating to screen blood and fecal samples from birds from all wild sites and WOCH for a suite of vector-transmitted (e.g., filarial nematodes), direct-transmitted (e.g., extra-intestinal coccidia), and virome-based pathogens. Second, University of Georgia (UGA) is conducting necropsies on carcasses from captive and wild populations to identify the specific causes of mortality. UGA has sequenced the entire genome of the coccidia organisms discovered in captive FGSP to assist with wild sample screening.

Action 16: Investigate how fire history, habitat features, and post-fledging conditions influence survival rates of juvenile birds.

Like most passerines, juvenile survival for FGSPs is lower (ca. 21%) than annual adult survival (ca. 48%; FWC unpub. data). Improving juvenile survival could help compensate, in part, for low nest success and low adult survival observed in FGSP. Research on other passerine birds suggests that habitat features often influence survival during the first few weeks after fledging when most mortality for juveniles occurs, so opportunities may exist to alter management strategies to improve juvenile survival. FGSP juveniles have been observed utilizing habitat with more shrub vegetation than territorial adults and it is possible that juveniles may rely on areas of dense vegetation for predator avoidance during key developmental periods. Fire history and other habitat data (e.g., distance to forest edge, roller chopping history) from natal sites can be used to understand how these factors may influence first year survival. Understanding how other factors such as individual condition (mass at banding), time of year, and severe weather events influence juvenile survival in the wild also will be relevant when planning and evaluating the release of captive-reared birds. Monitoring released captive birds (or possibly wild fledglings) with radio-transmitters will complement this research action by providing information on general habitat use and causes of mortality (Appendix B).

Action 17: Understand the effects of land use changes, alternative management strategies, and climate factors on the decline of FGSP to inform future management actions.

Understanding the factors driving past FGSP declines will provide a retrospective review of contemporary management efforts and shed light on the degree to which large-scale processes have affected the sparrow. This comprehensive analysis will help frame the likelihood of meeting population recovery goals with or without captive supplementation. Twenty years of point count survey trend data (1998-2018) can be used to evaluate competing hypotheses explaining historical declines of FGSP, such as changes in land use (habitat fragmentation,

waterflow restoration), management strategies (changes in fire seasonality and frequency, palmetto density), and climate factors (Southern Oscillation Index, rainfall patterns, severe weather events). Data availability, especially with respect to post-fire habitat metrics, may limit the scope of this study.

> **Action 18:** Improve our understanding of FGSP genetic diversity at the subpopulation and subspecies level and develop program goals for genetic management.

Intentional genetic management of captive and wild FGSP subpopulations will be necessary to maximize the health and viability of the subspecies into the future. The FGSP presents a challenge because the pedigree is relatively shallow (2013-2018 data only) and incomplete (i.e., many birds have unknown parentage). However, the available pedigree data can be updated annually and analyzed with population management software to select optimal captive pairings, select individuals for collection or release, and inform optimal release locations. Additionally, existing DNA samples can be used for genomic sequencing of FGSPs. This sequencing data can be used to 1) set goals for genetic integrity of the captive-breeding flocks, 2) refine the captive pedigree analysis, and 3) evaluate the relatedness of the *floridanus* and *pratensis* subspecies using modern genomic techniques.

The actions listed above represent the highest priority research questions over the next five years. Given sufficient time, partners, and resources, other avenues for future research might include the effect of fire intensity and scale on nest predation risk, the predator-prey dynamics that drive abundance of known nest predators (i.e., spotted skunks and snakes), identifying limited resources for FGSP in winter, and exploring factors that drive FGSP territory movement and dispersal. Some of these questions are expected to be logistically difficult to answer but may be worth exploring if time and resources allow.

OUTREACH (Objective 6)

Continued outreach efforts are important to increase public knowledge about the plight of the species, to engender support for conservation efforts, and to inform the public about how they can assist these efforts. The Fish and Wildlife Foundation of Florida's Florida Grasshopper Sparrow Fund provides an opportunity for the public to support conservation actions in the vision.

> **Action 19**: Ensure partners and agency staff coordinate with each other and with FWC and Service community relations staff to deliver responsible, consistent messages that support the vision goal.

Action 20: Produce and distribute outreach products (e.g., news releases, popular articles, social media posts) designed to increase awareness and provide avenues for the public to support conservation actions identified in the vision.

CHECK POINTS AND CRITERIA FOR SUCCESS

The working group and its Implementation and Coordination Team will meet as necessary to make minor adjustments to project methods (e.g., habitat management techniques, nest protection methods, husbandry techniques). There also will be check-ins each fall, and in mid-June of 2020 and 2021, to adjust release methods (e.g., the optimal age class for releases), as outlined in Appendix B. We expect that check-ins will also provide Service and FWC an opportunity to review the general progress and success of the program, and, if appropriate, adaptive management may extend beyond minor adjustments. A briefing of Service and FWC leadership on the status of the program will occur annually at the end of each year.

Additionally, it is imperative to have measurable criteria to gauge the success of the program and trigger discussion and decisions. Formal checkpoints will occur in years 3 and 5 to evaluate progress according to the criteria below and to make decisions regarding the future of the program. The criteria below will guide and focus actions and will be revisited as appropriate based on new information and needs of the program.

January 2022 — A thorough program evaluation will occur after three years to assess whether captive rearing of FGSP is contributing enough to the conservation effort to merit continued agency support. Success of the captive-rearing program at this point will be defined as:

1. Released birds exhibit reproductive behaviors (e.g., song patterns, territory establishment, pair formation) comparable to wild birds.
2. Demonstration that at least one of the released age classes in at least one year can achieve a recruitment rate of ≥15% for females.

If measures of success are achieved, the captive-rearing effort will continue through the next evaluation period and recommended improvements to methodology will be implemented. If measures of success are not achieved, the approach to captive breeding outlined in the vision will be revised based on the best available data and agency leadership will determine whether continued support is warranted.

January 2024 Another program evaluation will occur after five years to assess the impact of all management and research actions to improve wild FGSP population growth. At this check-point, the measures of programmatic success will be defined as:

1. Released birds exhibit reproductive behaviors (e.g., song patterns, territory establishment, pair formation) comparable to wild birds.
2. Demonstration that at least one of the released age classes can achieve a mean recruitment rate of ≥15% for females during 2022–2023.
3. All properties with known wild FGSP populations have met their habitat management goals.
4. FWC staff and partners have continued monitoring and nest protection activities.
5. The wild FGSP population is extant and has remained stable or increased following the release of captive-reared birds.
6. Priority research projects have been completed, and research results indicate promising avenues for arresting and reversing the decline of wild populations without the need for continued captive breeding.

If measures of success are achieved at the end of the five-year period, then another vision document will be drafted to inform agency leadership of future goals for the FGSP program. If measures of success are not achieved, the captive-breeding program will be re-evaluated with Service and FWC leadership and the agencies will decide whether continued support is warranted. If program cessation is warranted, the specific timeline and details will be determined at that time in consultation with captive facilities. Options include release of birds into the wild or retention of birds in captivity in a safe and humane manner until they join another collection for display or education or they die naturally.

BUDGET

We estimate the average annual expenditures required to fulfill the actions of the vision to be $1,212,500, which includes ongoing land management activities provided by FWC, Florida Department of Environmental Protection, and Department of Defense (DOD) that specifically benefit FGSPs. Table 1 summarizes the annual budget and anticipated shortfalls by activity. We intend to address the budget shortfall in three primary ways:

- Service and DOD have made variable but substantial annual contributions to FGSP conservation efforts in recent years. Service staff will allocate $150,000 toward FGSP needs and will continue to pursue Service funding throughout the duration of the strategic vision.
- We expect that continued fund-raising by RSCF, WOCH, the Fish and Wildlife Foundation of Florida, Audubon Florida, and other NGOs will contribute to captive-breeding costs.
- FWC's internal discretionary funding and FWC's Section 6 grants can help fund outstanding information needs.

TABLES

Table 1: Strategic vision budget

Action	Average annual program costs	Anticipated annual shortfall 2019	Anticipated annual shortfall 2020-2023
FGSP specific land management[1,2]	$ 457,000	$ 0	$ 0
Field monitoring and nest protection[2]	$ 454,000	$ 0	$ 37,000
Captive rearing & studbook management	$ 230,000	$ 100,000	$ 230,000
Release and post-release monitoring[3]	$ 40,000	$ 0	$ 45,000
Research[3]	$ 47,500	$ 50,000	$ 35,250
Total	**$ 1,228,500**	**$ 202,000**	**$ 399,250**

[1]Estimate of FGSP-specific management costs.

[2]Shortfall is specific to monitoring and protection at a private ranch.

[3]Does not include the cost of enclosure built on the prairie, $46,000 per release site.

Table 2: Timeline

Action	2019	2020	2021	2022	2023
Land management					
TLWMA					
KPPSP					
APAFR					
Ranch					
Other private lands?					
Field monitoring + nest protection					
TLWMA					
KPPSP					
APAFR					
Ranch					
Other private lands?					
Captive rearing					
RSCF					
WOCH					
SF (holding only)					
Studbook management					
Release and post-release monitoring					
TLWMA					
Other sites					
Research					
Roller-chopping and nest survival					
Juvenile survival					
UF disease project					
UGA disease project					
Historic trends					
Genetic diversity					

Probable funding and resources available
Funding source or resources uncertain
Pending results from January 2022 check-in

APPENDIX A. Rationale for Captive Management and Release Strategy

INTRODUCTION

The purpose of this Appendix is to provide the rationale and decision-making process behind the captive management and release presented in the FGSP 5-Year Strategic Vision (vision). When developing the vision, we sought to revisit and redirect the objectives of the FGSP captive-breeding program to maximize the probability of meeting the vision's conservation goal. As described in the vision, the FGSP captive program is expected to produce birds that will serve as reinforcements (*sensu* Seddon et al. 2014) for wild FGSP populations. The overall goal of the captive-breeding program is to reduce the probability of extinction while we identify management actions that can stop the decline, grow the population, and reduce and eventually eliminate continued need for a captive support population. The success of a captive-breeding and release program can be influenced by many factors, including the species' life history characteristics; the age, sex, and number of individuals released; the timing and number of release events; and the release protocols that are used (Wallace 1994, Batson et al. 2015). We summarized available demographic data, reviewed the captive-breeding literature, and sought expert opinion to address the following primary questions:

1) How many captive-reared birds need to be produced and released each year to maintain at least a stable wild population, while solutions to wild population declines are discovered?
2) How should these "reinforcement" birds be produced (reared from eggs laid by captive pairs [captive breeding], or collected as wild eggs or nestlings and reared in captivity [head-starting])?
3) What is the appropriate location for the captive facility relative to the wild sites (*in situ* or *ex situ*)?
4) What is the required magnitude of the captive-rearing effort?
5) At what age should captive birds be released?
6) What are the disease risks associated with releasing captive-reared birds?
7) What risk management protocols should we follow?
8) How should we acclimate birds to their wild habitat prior to release?
9) Where should birds be released?

The captive management and release portions of the vision will be executed within an adaptive framework, and all initial decisions described below are subject to evaluation and revision as new information becomes available. Recommendations from the Disease Risk Analysis (DRA) in November 2018 informed release decisions.

1. DETERMINATION OF MINIMUM ANNUAL COHORT SIZE

The first step in determining the appropriate design for a captive FGSP program was to determine how many captive-reared birds would need to be released each year to meet our goal of stabilizing and growing the wild population, with "stabilizing" meaning maintaining a similar number of breeding females as the 2018 season (estimated at ca. 23 pairs). We estimate that 9 of the 23 wild females from 2018 will survive to 2019 based on recent annual survival rates that average 40%. Wild recruitment rates vary annually, but, based on recent data, we estimate that the 2018 females will recruit 6 new females into the 2019 population. We therefore estimate that a minimum of 8 captive-reared females would need to be recruited into the breeding population each year to stabilize the wild population at a modest 23 breeding females. As noted in the Captive Management and Release section, we hope to exceed the minimum presented here, but the captive program must at least produce enough recruits into the wild population to keep the population stable while ways to improve wild vital rates are sought.

Predicting the number of released birds necessary to achieve annual recruitment of at least 8 captive-reared females is challenging, given the highly variable outcomes of prior release programs. Decades of translocation research with wild birds in New Zealand indicate that the cost of release (i.e., mortality attributable to stress from translocation and initial release) ranges from 0-80% and averages about 30% (D. Armstrong, pers. comm.). Although data are lacking from captive-reared birds, the cost of release also appears to be high. Mean survival during the first month following release was 36–80% for three captive-reared passerine species (Table A1). Survival for captive-reared individuals over the first-year post-release is unknown for many projects, although some data suggest it can be comparable to survival of wild individuals (e.g., Loggerhead Shrikes [*Lanius ludovicianus*]; Lagios et al. 2014). Mean survival of independent juveniles to the following breeding season ranged from 26–52% for three species (Table A1). Recruitment values in the literature for captive-reared passerines ranged from 3-48% but tended to be below 10% (Table A1). The Mauritius Fody, which was released on a predator-free island, had the highest recruitment rate (Table A1). Low recruitment rates appear to have been in part a function of circumstance. For example, Mangrove Finches were released during a drought, when survivorship and breeding rates for many Galapagos finch species are low (Boag and Grant 1981, Grant and Grant 2006). In contrast, the low recruitment rates for captive-bred Loggerhead Shrikes exceeded that of wild juveniles (Nichols et al. 2010), highlighting the importance of referencing wild vital rates when evaluating the relative success of release programs.

Decision

Considering the high cost of release and low recruitment rate of past release programs, we chose a minimum recruitment rate of 15% of released birds, which is roughly 1/3rd the recruitment rate of wild juvenile birds (43%), when setting a target for the annual cohort size. Our intention is to achieve a recruitment rate greater than 15%, but we needed to choose a realistic minimum starting point to establish initial estimates for minimum cohort size. We will refine the recruitment rate (and hence the minimum cohort size) once we have data from releases. At this rate, at least 53 captive-reared females (as well as any males not needed for captive breeding) would need to be released per year to maintain a stable wild population. Fifteen percent recruitment is somewhat higher than most previous passerine programs (Table A1), but we think it may be realistic biologically given the adaptive design of our release effort and the high site fidelity of wild juveniles. Furthermore, it is important to note that even incremental reductions in recruitment rates below 15% would require substantially greater captive-breeding capacity than currently exists (e.g., 80 and 160 females would need to be released if the recruitment rates were 10% and 5%, respectively). As such, a 15% minimum target represents an objective that is both biologically and logistically feasible in the near future.

2. CAPTIVE REARING METHODS

To reach our target for annual production of released individuals, we considered two captive-rearing alternatives: captive breeding and head-starting. Captive-breeding programs use breeding pairs held in captivity to produce and rear chicks (Lieberman and Kuehler 2009). In contrast, head-starting programs involve intentionally collecting eggs or nestlings from the wild to rear in captivity (typically by hand; Lieberman and Kuehler 2009, Jeffs et al. 2016). Head-starting has been selected in cases where adults cannot be successfully housed or bred in captivity, or the probability of nest or fledgling survival in the wild is exceptionally low. For example, Mangrove Finch eggs were collected as part of a head-start program and raised in captivity until they reached nutritional independence to avoid a lethal parasite affecting wild nestlings (Cunninghame et al. 2015).

We considered several relevant factors when assessing which approach (or combination of approaches) is most appropriate for the FGSP program. The following bullets compare the advantages of captive breeding versus head starting as the *primary* means of producing birds for release.

Advantages of captive breeding for FGSPs:

- *The infrastructure and expertise are in place*. We are currently housing 10 FGSP breeding pairs in outdoor captive-breeding facilities, and substantial investments have resulted in major improvements in husbandry techniques resulting in high productivity (e.g., 9.3 fledglings/breeding pair at WOCH in 2017).
- *Few or no wild collections need to occur each year.* As noted above, the *ex situ* FGSP flock is already established. In the future, only minimal collection efforts of partial clutches will be required to maintain the genetic integrity of a captive-breeding population. In contrast, head-starting programs require removing eggs and nestlings from the wild each year. We estimate that, on average, 21% of wild dependent fledglings (and 19% of wild 4-day-old nestlings) would survive and breed if not collected (FWC, unpub. data). It is important to account for the number of nestlings collected from the wild when calculating the total recruitment (captive plus wild) that can be achieved through head-starting. Nestlings that are high risk of death from flooding or other events (salvaged nestlings) are an exception because none would have survived in the wild to be recruited into the population. Box A1 demonstrates how the three strategies (captive breeding using an existing captive flock, head-starting nestlings with average recruitment probabilities, and head-starting salvaged nestlings) contribute to overall recruitment and what the post-release recruitment rates would need to be under each scenario to accomplish the same goal. As demonstrated in Box A1, captive breeding is more efficient than head-starting as the primary means to produce birds for release, because few or no wild collections need to occur.
- *Retention of wild breeding pairs may be higher.* Another less quantifiable cost to head-starting nestlings with average risk relates to the propensity of nesting passerines to disperse from a breeding site within (Powell and Frasch 2000) or between (Hoover 2003) breeding seasons following repeated nest failure. Disruption from nest collection might cause dispersal, reducing the probability of renesting, or making the renest attempts difficult to find and protect.
- *Productivity is not reliant on availability of wild nests*. Captive FGSP have already demonstrated high reproductive potential. WOCH produced 9.3 fledglings per breeding female (28 fledglings by 3 females) in 2017 and 6 fledglings per breeding female (24 fledglings by 4 females) in 2018 when reproduction was halted mid-season because of capacity constraints. In contrast, head-starting is limited by the number of wild nests that are discovered and survive to collection age. We estimate that at least 42 wild nests would need to be collected each year to produce the 8 “reinforcement” female target if head-starting were the only method used to supplement wild populations. For reference, only 46 wild FGSP nests were discovered by field crews across all sites in 2018.

- *Nestlings are housed with and raised by adult birds.* Young birds may benefit by regular interactions with adults (Nichols et al. 2010). For example, young birds in outdoor enclosures responded to alarm calls from adult birds when a raptor flew overhead (A. Schumann, pers. obs.), which is an important natural behavior. Furthermore, parent-reared birds may be more proficient breeders (Myers et al. 1988), though further study is required to understand whether this is the case with FGSPs.

Advantages of head-starting for FGSPs:

- *It may be less expensive*. Captive-breeding programs require year-round facilities and staff, whereas head-starting programs may only need to operate for 4-6 months if birds are released as independent juveniles.
- *Potential for pathogen avoidance*. Hand-rearing wild nestlings has the theoretical potential to reduce exposure to high coccidia loads during the dependent period, because the young birds are kept indoors in cages that are easier to clean. However, in 2018, neither outdoor parent-reared nor indoor hand-reared FGSP juveniles suffered from coccidia-related mortality in captivity, suggesting that alternative husbandry methods have provided some relief to this serious challenge to the health of captive birds.
- *It can take advantage of salvaged eggs and nestlings*. Adult mortality, high water events, and other unexpected circumstances can lead to nest failure in the wild. Head-starting programs are well positioned to accept and rear salvaged eggs or nestlings that would otherwise be lost in the wild.

<u>Decision</u>

The advantages listed above indicate that a program focused primarily on captive-breeding techniques will be more likely to meet our objectives in the next 5 years than use of head-starting as the primary means of producing captive reared individuals. However, head-starting of salvaged eggs and nestlings is planned to supplement captive breeding to help us meet or exceed our annual production goals. As noted in Appendix B, limited head-starting also could help achieve sufficient sample sizes to compare survival and recruitment of parent-reared and hand-reared birds. Our selected strategy is represented in Box A2 using the values presented in Determination of Minimum Annual Cohort Size of this appendix.

3. LOCATION OF THE CAPTIVE PROGRAM

Captive-rearing programs can occur within or very near the wild site (*in situ)* or distant to the wild site (*ex situ)*. Initial FGSP captive-rearing efforts were established *ex situ* to leverage the facilities and expertise of RSCF and WOCH. Subsequent concern about disease at rearing

facilities has led to a reexamination of the most appropriate location of continued captive-rearing efforts.

Advantages of an *in situ* captive program for FGSPs:

- *Exposure to natural conditions.* This would allow captive-reared birds to learn and acclimate to wild climates and prey items prior to release.
- *Reduced exposure to novel pathogens.* By maintaining FGSP at or near the collection and release site, the introduction of novel pathogens would be limited to those transferred accidentally on husbandry equipment, supplemental food, or staff. This is contrary to animals produced at *ex situ* breeding facilities which present the highest risk of novel pathogen exposure and post-release transfer (Kock et al. 2010).
- *Proximity to release site.* Lengthy transport times can result in weight loss, increased stress, and even death of birds prior to release (Kuehler et al. 2000, Jakob-Hoff et al. 2014). Rearing birds on site reduces these risks.

Advantages of an *ex situ* captive program for FGSPs

- *Established infrastructure and staff. Ex situ* programs benefit primarily from established infrastructure and expertise and as such can be less expensive and achieve program goals more rapidly than a new *in situ* facility. *Ex situ* infrastructure and captive populations already have been established.
- *Reserve against disaster.* While an *ex situ* facility is in operation, it serves as a reserve population if a natural disaster or other catastrophe eliminates the remaining wild population(s).

<u>Decision</u>

The preferred alternative includes *ex situ* rather than *in situ* captive rearing. Off-site captive rearing has already produced a substantial population of captive FGSPs that demonstrate extremely high survivorship and productivity. Assuming continued success of *ex situ* captive rearing and the likelihood that the risk of release is acceptable (see Pre-release health screening section below), we will proceed with an *ex situ* program rather than invest substantially in an *in situ* program at this time. We will periodically re-evaluate the need for captive rearing *in situ* at check points outlined in the vision.

4. THE MAGNITUDE OF THE CAPTIVE EFFORT

The captive-breeding effort must produce enough young to meet our target of releasing at least 53 captive-reared females as well as replace breeding adults that die in captivity. Our target is specific to females because they are the limiting sex, but any males not needed to support the captive population will also be released. We used the following assumptions to generate the target number of breeding pairs for the FGSP captive-breeding program:

- The sex ratio of dependent fledglings in the captive flock averages 50:50.
- Captive annual fecundity will match 2017 estimates from WOCH (4.67 female fledglings/breeding female/year).
- First-year survival in captivity will remain high (90%) because of improved husbandry.
- Using these parameters, 14 captive-breeding pairs could produce 59 females of breeding age each year.
- Approximately 3% (n=2) of captive-reared females will be retained each cohort-year to replace breeders (based on 85% captive adult survival).
- This leaves 57 females available for release each year (4 more than our target).

<u>Decision</u>

Our annual release target of 53 captive-reared females should be met if we have at least 14 FGSP breeding pairs in captivity, provided they are housed and cared for in outdoor aviaries matching the conditions proven to successfully produce parent-reared fledglings (Appendix D). Currently 4 and 6 breeding pairs reside in outdoor pens at WOCH and RSCF, respectively. Another 2 and 7 unpaired adult males reside at WOCH and SF, respectively. There are currently 23 and 22 juveniles (sexes pooled) at WOCH and RSCF, respectively. Therefore, at a minimum, only 4 captive-reared second-year females would need to be retained in 2019 to create the target 14 captive-breeding pairs. However, optimal pairings will be determined by pedigree analysis (see Appendix B), and the housing location of the breeding pairs will be determined based on the criteria established in Appendix D and in coordination with captive facilities.

5. AGE AT RELEASE

Success of release programs is in part a function of the age of released birds. Younger animals are often more capable of adapting to a new environment than older ones (e.g., VanderWerf et al. 2014) perhaps because their brains are still developing (Krochmal et al. 2018). But there are also costs associated with releasing younger birds, the most substantial being reduced overwinter survivorship for wild versus captive animals. Current FGSP data demonstrates that

annual survival for independent juveniles is 79% in captivity but only 43% in the wild. However, many captive programs report behavioral deficiencies in captive-reared birds post-release and these deficiencies may be exaggerated for captive-raised animals prevented from associating with conspecifics in wild environments during critical learning periods (Snyder et al. 1996).

Programs typically release birds as independent juveniles or as adults. The relative advantages of each age class are summarized here:

Advantages of releasing independent fledglings:

- *May increase learning of wild behaviors*. Learning and matching the songs of future neighbors may be important for territory establishment (Beecher et al. 1994). In the late summer, juvenile FGSP have been observed practicing song while in juvenile flocks as well as visiting the territories of unrelated adult males still singing in late summer (FWC unpub. data). It is unknown how valuable these visits are to their social and song learning experience, but FGSP males with atypical songs may fail to attract mates (Hewett Ragheb et al. 2015). Exploratory movements by newly independent wild FGSP juveniles also may be important for surveying suitable habitat at a regional scale or the development of habitat-specific preferences.
- *May provide birds better conditions in which to acclimate*. Releasing birds in the summer of their hatch year also allows them to acclimate to the wild during warmer temperatures when insect prey may be more abundant. Post-release survival for hand-reared juvenile Cirl Buntings was higher for birds that were released in June or July compared to August (Fountain et al. 2017). Preliminary analysis on FGSP indicate that nestling mass and first-year survival is highest for wild birds that fledge in mid-summer (30 June) suggesting improved resource availability or favorable weather conditions during that period (FWC unpub. data). Releasing FGSPs in the summer would allow acclimation several months prior to the fall arrival of migratory Northern Harriers (*Circus hudsonius*; the most reported predator of overwintering FGSPs; Dean 2001). Additionally, releasing birds soon after they reach nutritional independence reduces the amount of time individuals are exposed to potentially novel pathogens *ex situ* (S. Citino, pers. comm.).
- *Birds released as independent young require fewer resources from captive-breeding facility staff*. If all captive-reared young were released as independent fledglings, the size of the captive flock would decrease during winter months, reducing annual operational expenses.

Advantages of releasing second-year adults

- *Greater proportion of captive flock would survive to breeding age*. As noted above, survivorship of birds in captivity is substantially greater than that in the wild.
- *Releases would not co-occur with molt*. FGSP pre-basic molt lasts approximately 38 days (starting in early July for first clutches; P. Reillo, unpub. data), is energetically demanding, and reduces flight capabilities in passerines (Swaddle and Witter 1997), and as such can restrict movement (Vega Rivera et al. 1999).
- *May increase site fidelity.* Male FGSPs appear to leave their breeding territories in the fall and wander to points unknown (Dean 2001). Release of captive birds just prior to the start of the breeding season would coincide with environmental, social, and hormonal cues that encourage pairing and breeding (i.e., residency) and thus potentially reduce the opportunity for dispersal. Conversely, it also is possible that releases just prior to the breeding season may reduce site fidelity because of intraspecific aggression from territorial birds (R. Bowman, pers. obs.).
- *Monitoring in spring is more effective.* The fate of released birds can be more effectively determined during spring and summer when sparrows are more conspicuous and full-time field crews are in place.

<u>Decision</u>

Given the uncertainty surrounding the appropriate age to release birds, we will conduct releases within an adaptive framework (Kemp et al. 2015). Appendix B outlines releases of both independent juveniles and second-year adults, with release of second year birds beginning in February 2019. We set a minimum goal of 15% recruitment (see Determination of Minimum Annual Cohort Size) for both release age classes because we do not yet know which age class will have a higher *combined* rate of 1) survival to breeding age, and 2) recruitment. Our hypothesis is that independent fledglings will have lower survival to breeding age, but higher recruitment rates compared to released second-year birds.

6. DISEASE RISKS

Disease is a common problem in many captive bird populations due to higher densities and stress of birds in captivity (Parker and Duszynski 1986, Swayne et al. 1991, Greiner 2008, McGill et al. 2010, Sainsbury and Vaughan-Higgins 2012). Management, nutrition, and disease-related issues led to a higher-than-acceptable rate of morbidity and mortality among captive FGSP, particularly young birds, during the 2016 and 2017 breeding seasons. Changes in husbandry practices led to a significant reduction in disease in the captive Florida grasshopper sparrow flocks, and no disease-related deaths were reported in 2018.

In November 2018 the Service, FWC, and partners conducted a DRA to evaluate the risks associated with release of captive-reared FGSP and to explore methods to address identified risks. DRAs are a common decision-making tool for captive release programs that provide a structured, evidence-based process for making responsible decisions in the face of disease risks (Leighton 2002, Jakob-Hoff et al. 2014, Jeffs et al. 2016). The DRA was facilitated by experts from the Conservation Planning Specialist Group of the International Union for Conservation of Nature.

The DRA considered the following fundamental question: What is the likelihood that an individual Florida Grasshopper Sparrow, held or reared in *ex situ* conditions, is infected with a particular high-risk pathogen that is missed during *ex situ* health screening and is then released as an infected individual into an existing *in situ* population? DRA participants chose to focus on two types of pathogens (filarial nematodes and coccidia) that have caused mortality in the captive populations. The DRA used a Rapid Assessment Protocol to evaluate whether participants viewed filarid nematodes and coccidia as high-risk pathogens for the release of FGSP. Please refer to the DRA report for additional details.

After the DRA, the agencies considered information presented at the DRA, independent peer reviews of the DRA report, scientific literature, and expert opinion to evaluate the risks of the pathogens for the release of captive-reared FGSP. When making a decision regarding the risk of these pathogens, the Service and the FWC considered three questions:

1) What are the primary pathogens of concern, and are they present in wild and captive populations?
2) Is the risk of known pathogens to the wild FGSP population and other bird species acceptably low?
3) Is the risk of delaying release to the wild FGSP population unacceptably high?

<u>What are the primary pathogens of concern, and are they present in wild and captive populations?</u>

DRA participants focused on two pathogens that have caused morbidity and mortality in the captive FGSP population: filarial nematodes (*Aproctella* sp.) and coccidia (*Isospora* sp.).

- *Nematodes*
    - Filarial nematodes are parasites found in the tissues of birds and other taxa. They are transmitted between birds via mosquitoes and other arthropod vectors. Most are nonpathogenic, but some have been associated with morbidity and mortality in captive and wild birds (Bartlett 2008).
    - Short gene region sequences from filarids found in wild and captive FGSP were an exact match, which strongly suggests that the disease is present in both

populations. Comparisons were made between filarids in the wild and captivity using 18S rDNA and/or CO1 mtDNA, which are commonly used to differentiate nematodes (Hamer et al. 2013, Prosser et al. 2013, Kalyanasundaram et al. 2018).

- *Coccidia*:
    - Coccidia are ubiquitous in wild bird populations, and migratory and non-migratory birds are routinely exposed to numerous strains of coccidia (Dolnik 2002, Berto et al. 2011, Knight et al. 2018). Ooysts are shed from infected birds and transmitted to other birds through food, water, or direct contact (Dolnik et al 2010, Knight et al. 2018). Management of coccidia is a common issue for captive-rearing and release programs (McGill et al. 2010, Ewen et al. 2012, Jakob-Hoff et al. 2014, Serna et al. 2018).
    - Multiple strains of coccidia have been identified in wild and captive FGSP populations and not all strains in the captive flock have been detected in the wild.
    - Nevertheless, biosecurity protocols suggest there is limited opportunity for the introduction of novel coccidia strains into the captive FGSP population. For example, White Oak Conservation uses foot baths and different sets of tools for Florida grasshopper sparrows, and the sparrow enclosures are separate and remote from other species at the facility. White Oak also does not maintain captive populations of other passerines, which further reduces– but does not completely eliminate -- the possibility of the Florida grasshopper sparrows obtaining a novel *Isospora* sp. while in captivity.
    - Another pathway for pathogen introduction includes wild birds perching on enclosures. The captive facilities are exposed to the same migratory and wintering species of birds as the prairie. The prairie is used by thousands of migratory and wintering birds each year, so it has never been isolated from disease outside its immediate geography. Given existing biosecurity protocols in captivity, it is unclear how birds at the two facilities would be exposed to pathogens not already carried by migrants to the prairie.

<u>Is the risk of known pathogens to the wild FGSP population and other bird species acceptably low?</u>

DRA participants defined pathogen-associated risk (high/medium/low) based on severity (i.e., mortality, morbidity), transmissibility, uncertainty (in consequences, diagnostics, or treatment), and prevalence/absence in the wild populations.

- *Nematodes*
    - 18 of 20 (90%) DRA participants categorized the risks associated with releasing a captive bird infected with nematodes as low/medium. Two (10%) of the attendees categorized the risk as high.
    - Factors that suggest that the risk of releasing captive-reared FGSP into the wild is acceptably low:

        - The exact match of short region DNA sequences from nematodes in wild and captive birds suggests that the pathogen is not novel. Comparisons were made between filarids in the wild and captivity using 18S rDNA and/or CO1 mtDNA, which are commonly used to differentiate nematodes (Hamer et al. 2013, Prosser et al. 2013, Kalyanasundaram et al. 2018).
        - The rate and severity of filarid infection in the captive flock was likely the result of unusually high mosquito (i.e., vector) densities. Mosquitos were congregating in enclosures, possibly due to the additional shade provided by the enclosures, and the rate of infection declined once this was resolved via netting. Heavy rains from a tropical weather system may have contributed by facilitating higher mosquito densities at White Oak that year.
    - Factors that led participants to categorize the risk from nematodes as high:
        - The pathogenicity of the identified strain in the wild population is unknown.
- *Coccidia*
    - 18 of 20 DRA participants categorized the risks associated with releasing a captive bird infected with coccidia to the wild FGSP population as low. Two attendees categorized the risk to the wild population as high.
    - Factors that suggest that the risk of releasing captive-reared FGSP into the wild is acceptably low:
        - As noted above, biosecurity protocols at both captive facilities suggest there is limited opportunity for the introduction of novel strains of coccidia, and the sparrows at captive facilities are exposed to the same migratory birds as the sparrows on the prairie. Therefore, it is likely that pathogens observed in captivity are already present on the prairie.
        - Literature indicates that coccidia are ubiquitous in birds and that migratory and non-migratory birds are routinely exposed to numerous strains of coccidia (Dolnik 2002, Berto et al. 2011, Knight et al. 2018). Infection with coccidia is not thought to result in high levels of mortality in wild populations (Parker and Duszynski 1986, Cushing et al. 2011, Pap et al. 2011, Mohr et al. 2017), though the intensity of infection can increase under stress (Gill and Paperna 2008, Pap et al. 2011). By contrast, the severity of coccidiosis tends to be greater in captivity (Parker and Duszynski 1986, Swayne et al. 1991, Greiner 2008, McGill et al. 2010, Sainsbury and Vaughan-Higgins 2012) because:
            1. increased stress leads to increased shedding of oocysts,
            2. unnaturally high bird densities in captivity allow build-up of oocysts,
            3. and the higher amounts of oocysts and higher bird densities lead to more exposure and higher dosing.
        - Many factors contribute to whether coccidia are pathogenic (Knight et al. 2018). The expression of coccidiosis is context dependent, caused by a

complex interplay of the pathogen(s), a bird's immune system and the environment. At White Oak Conservation, each bird that died had multiple issues, including a nutritional deficiency that has since been resolved.

    - Some exposure to native parasites may improve post-release survival for captive-bred animals (Faria et al. 2010). For example, the Cirl bunting, Eurasian crane and corn crake programs aimed to control, but not eliminate, coccidia parasites during pre-release care (McGill et al 2010, Sainsbury and Vaughan-Higgins 2012, Sainsbury 2015).
    - We know that Florida grasshopper sparrows at White Oak are removed from coccidiostats after the breeding season and survive without medication. White Oak ceased administering coccidiostats in late October, 2018, and the birds are still alive and healthy as of mid-March, 2019.
    - Coccidia-related mortality in captivity tends to occur in young and stressed adults (Middleton and Julian 1983, Giacomo et al. 1997, Adkesson et al. 2005, Mohr et al. 2017). As noted above, it is likely that the strains of coccidia in captivity are present in the wild population, but demographic data from the wild population do not indicate atypically high mortality rates during the first year of life for FGSPs (FWC, unpublished data).
  - Factors that led two participants to categorize the risk from coccidia as high:
    - Strains in the captive flock that have been associated with severe morbidity/mortality have not yet been detected in the wild.
    - The pathogenicity of the strains found in the captive flock is unknown in the wild population.

<u>Is the risk of delaying release to the wild FGSP population unacceptably high?</u>

- The wild FGSP population is declining, and the Service and the FWC estimates that fewer than 80 birds remain in the wild.
- Most DRA participants agreed that the wild population is at high risk of extinction and delays in releasing birds will delay the effectiveness of the captive program and its ability to contribute to wild population recovery.
- It is important for the captive-rearing effort to demonstrate the ability to successfully release and recruit birds into the wild population to justify continued investments of funding.

<u>Conclusion</u>

The Service and the FWC recognize that pathogens present in the captive population can result in disease and that release of captive FGSP carries some risk. We also acknowledge that, while the DRA achieved convergence, the DRA did not achieve consensus on all issues related to disease risk. However:

1) The Service and the FWC believe that the available evidence suggests that pathogens in the captive population are likely already present in the wild population.
2) Based on the DRA results, literature review, and discussions with experts, the Service and the FWC consider the known pathogens in the captive population to pose an acceptably low risk to the wild population.
3) The Service and the FWC feel that the consequences to the wild FGSP population of taking no action are high, given the precarious state of the wild population.

Therefore, the Service and the FWC have determined that the risk of releasing captive-reared FGSP to the wild population is acceptably low based on the recommendations from the DRA and consultation with experts. FGSP disease research continues, and we will modify our proposed path forward when new information suggests it is warranted.

7. RISK MANAGEMENT

Risk management protocols often include a period of separation from other individuals and a series of relevant pre-release health screenings. Pre-release health screening protocols are implemented to ensure that birds are in good health before they are released. However, the need for screening samples and health evaluations must be balanced with the detrimental effects of handling and confinement stress for the birds (Kock et al. 2010, Sangster and Vogelnest 2016).

Risk management protocols for passerine captive rear-and-release programs vary substantially. Quarantine for Cirl Buntings and Mangrove Finches required indoor facilities dedicated for hand-rearing nestlings that were insect-proof and separate from other species (Cunninghame et al. 2015, Jeffs et al. 2016). Once independent, juveniles were directly transferred to *in situ* field aviaries for acclimation, but no pre-release screening was performed once outdoors (Cunninghame et al. 2015, Jeffs et al. 2016). Captive hand- and parent-reared `Alala and Puaiohi underwent an initial health screening prior to transfer to an *in situ* acclimation aviary and a second health screening prior to release (Kuehler et al. 1995, Kuehler et al. 2000, Switzer et al. 2013). The DRA for Regent Honeyeaters found that there was no need for a quarantine at the breeding facilities to manage disease risk, but an extensive pre-release screening was performed at a central facility (Jakob-Hoff et al. 2014).

DRAs are often implemented to inform pre-release health screening protocols (and release programs more generally) because they provide a structured approach to describing the risk to wild populations associated with releasing captive-born or translocated animals (Leighton 2002,

Jakob-Hoff et al. 2014, Jeffs et al. 2016). At the FGSP DRA in November 2018, participants generally agreed that the FGSP release program requires a pre-release health screening protocol but not a strict quarantine.

The protocols for pre-release health screening depend on the pathogens of concern. In the case of FGSP, pathogens of most concern include microfilaria and extra-intestinal coccidia. Pre-release health screening decisions depend in part on whether the pathogens of concern can (or should) be cleared from birds scheduled for release. Coccidia can be reduced but not eliminated, and filarial worms often cannot be eliminated without endangering the bird. Some exposure to native parasites may improve post-release survival for captive-bred animals (Faria et al. 2010). The Cirl Bunting program aimed to control, but not eliminate coccidia parasites during pre-release quarantine (McGill et al 2010).

Decision

Service and FWC propose the following logic and methods for risk management based on the DRA, a review of the literature, and consultation with wildlife veterinarians.

- Service and FWC agree that a holding period for a pre-release health screening protocol is necessary, but that a strict quarantine is not required. Confining these birds to small indoor spaces for a strict quarantine may increase stress leading to immunosuppression or increased susceptibility to infection (Kock et al. 2010). In addition, confining birds in small indoor spaces will likely be detrimental to our goal of promoting wild-like behaviors.
- The purpose of the pre-release health screening period for FGSP will be to ensure that symptomatic, unhealthy birds are not released.
- The holding period for pre-release health screening will be conducted in outdoor aviaries at *ex situ* facilities as described in Appendix C.
    - Because outdoor aviaries cannot entirely prevent the flow of pathogens to or from the aviary, pre-release health screening pens should be located at the *ex situ* facilities.
    - Furthermore, *ex situ* pre-release health screening will facilitate timelier visual and clinical health monitoring by wildlife veterinarians (Kock et al. 2010) compared to remote *in situ* locations.
- The holding period will involve spatial separation of a small group from other captive species and conspecifics. Strict adherence to biosecurity protocols for human and equipment movement between aviaries will be followed. However, it is still possible that birds may be exposed to vector-borne pathogens or the feces of other birds flying over or perching on the aviaries.

- Coccidiostats (ESB, Toltrazuril) will continue to be administered during pre-release holding.
- The pre-release health screening protocol (Appendix C) includes a full physical examination, examination of blood smear for hemoparasite (e.g., microfilaria) presence and quantitation, and fecal examination to identify and semi-quantitate numbers of parasite oocysts/ova.
- After examination, the release group of birds should be housed in a separate enclosure from other birds with necessary biosecurity principles in place (mosquito proof screening, foot baths, separate tools, etc.) until shipment to the release site.
- The examining veterinarian and husbandry team, based on the pre-release physical examination and diagnostics, will make a judgement on the overall health of each bird and its suitability for release and this decision will be communicated to Service and FWC. If there are concerns about the health of a bird, these concerns will be communicated to Service and FWC and a plan will be developed for that bird (treatment, holding, later release, etc.). The trust management agencies ultimately are responsible for decisions regarding which individuals are released.

8. ACCLIMATION WITH PRE-RELEASE OBSERVATION

The decision to include an acclimation period before release is an important consideration of release programs. Expert reviews (Jones and Merton 2012, Batson et al. 2015) recommend direct releases for wild birds and delayed releases for birds raised in captivity. Delayed release may help ease the transition of naïve birds raised in captivity to the wild (Batson et al. 2015). For example, captive-bred gamebird species benefit (e.g., greater survival, greater site fidelity) from an acclimation period before being released into the wild (Combreau and Smith 1998, Lockwood et al. 2005). *In situ* acclimation periods are commonly seen in captive-rearing programs where birds are hand-reared in indoor "clean" spaces and no long-term *ex situ* holding space for independent juveniles is available or desired (`Oma`o [6-9 days] and Puaiohi [8-14 days], Kuehler et al. 2000; Cirl Buntings [5-9 days], Fountain et al. 2017; Mangrove Finches [4-6 weeks], Cunninghame et al. 2015). Other programs retain birds in *in situ* field aviaries to allow them to acclimate to novel temperatures (Regent Honeyeater [1-3 days], Jakob-Hoff et al. 2014), to learn to forage on native food items (`Alala [3-5 months], Kuehler et al. 1995), to regain weight lost during lengthy transport (Jakob-Hoff et al. 2014), or to provide structures that also serve as supplemental feeding stations post-release (Kuehler et al. 1995, Kuehler et al. 2000). However, some animals with critical developmental periods may not learn about their new environment effectively even with *in situ* acclimation periods if the acclimation occurs too late in life (Krochmal et al. 2018). Long durations may not always be warranted. For example, Menkhorst and colleagues (2010) did not find a survival advantage sufficient to justify the costs

of extended *in situ* acclimation for captive-reared helmeted honeyeaters. The rearing method (parent- vs. hand-reared), age of release, similarities in climate between source and release sites, and the duration of *ex situ* acclimation should be considered when deciding if captive-reared birds will benefit from an extended on-site acclimation period.

To test these ideas, the Service started a collaboration with WOCH and Tall Timbers Research Station to breed wild Eastern Grasshopper Sparrows (GRSP; *A. s. pratensis*; the migratory, non-listed subspecies) in captivity. During the summers of 2016-2018, 38 captive-raised GRSPs (36 independent fledglings and two second-year males) were transported from WOCH and released with radio transmitters to the wild Bainbridge population (J. Cox, unpublished data). Twenty were held in small field aviaries for 2-5 days prior to release, whereas 18 were released directly (16 by hand and two by passive release from transport box). Supplemental food was provided near the field aviaries for ca. 3 days, but none of the released birds were observed returning to the aviaries to feed. Of the 20 birds released after a short acclimation, six (30%) were confirmed settled on the landscape, nine died prior to leaving the aviary (five cage-related mortalities [flooding and ants] and four were too young), three went missing after release, and two dropped their transmitters and escaped from the aviary (J. Cox., unpub. data). Of the 18 birds that were released directly, 12 (67%) settled on the landscape and six went missing after release (J. Cox. unpub. data). Survivorship beyond the first month was unknown because very limited systematic searching was conducted after the radio-telemetry period ended and migratory passerines often disperse to new locations in their first year of life.

Several unanticipated cage related mortalities occurred in the group that had 2-5 days of acclimation resulting in higher post-release settlement for the direct-release group. However, some birds released directly by hand made long initial flights after release (potentially leaving the study area). This was not the case for the two birds that were allowed to exit the transport box on their own timing (passive direct release) suggesting that maintaining a calm environment during release may improve direct release settlement rates. The fact that so many birds survived the 3-4 weeks post-release suggests they were able to successfully forage on wild prey items and avoid predation. However, additional research is needed to determine optimal release protocols for FGSPs (Appendix B).

At the FGSP DRA in November 2018, the majority of workshop participants viewed one week or less as a reasonable holding period for birds occupying *in situ* aviaries, while some participants believed this duration should be at least two to four weeks and perhaps as long as about 60 days. The DRA report further describes the rationales behind participants' choices. Some of the advantages of short and longer acclimation periods are summarized below.

Advantages of direct release or short *in situ* acclimation periods (2 nights)

- The following cage-related risk factors must be addressed when birds are kept in *in situ* enclosures. Despite measures taken to address these sources of stress and mortality,

the probability of these risks occurring increases the longer birds are held in enclosures, therefore, short acclimation periods should have reduced risk associated with:

  - Predation from predators that gain access to aviaries
  - Conspecific aggression due to unnatural stocking densities or holding birds during periods when they would normally exhibit territorial aggression (this aggression has resulted in injury and death of FGSP in captivity).
  - Disease-related risks associated with stocking densities higher than wild sparrows (e.g. coccidiosis often occurs in captive situations when the birds are at higher than natural densities or are stressed; risk of coccidia exposure would be especially high around communal food bowls and would have to be managed; mosquitos may congregate inside aviaries increasing risk of vector-borne diseases)
  - Harassment from predators perching on or near aviaries
  - Unanticipated injury from cage structure
  - Malicious human disturbance (if the release site is on public property)
  - Insufficient nutritional supplementation (especially if birds in large aviaries will not drink from water bowls)
  - Keeper error
- Would not require subsequent capture events to apply radio transmitters
- Reduced in situ husbandry staffing requirements and therefore annual programmatic costs
- Reduced aviary size requirements because captive-reared birds can be released in stages over a period of several weeks and rotated through the same facility space
- More flexibility to schedule acclimation during periods of optimal weather conditions

Advantages of longer acclimation periods (4-7nights)

- Additional time to recover from handling or transport stress
- Additional insight on disease-related mortality events that occur because of the stress of transport, stress of new environment, or illness related to exposure to wild pathogens they may not have been exposed to in captivity
- Additional time to get familiar with native prairie habitat and climate
- Potential for increased site fidelity once released
- Sick birds could be captured and treated or removed from aviary
- Increased potential to find carcasses of birds to identify disease-related mortality

<u>Decision</u>

The optimal *in situ* acclimation length for captive-reared FGSP remains unknown but, some *in situ* acclimation period for FGSP is likely warranted based on the benefits noted for most captive-born animals (Batson et al. 2015). However, many of the reasons provided for holding

birds in acclimation cages in other captive-rearing programs do not apply in our system. We intend to initially evaluate two acclimation scenarios. First, parent-reared birds will be held in field aviaries for a brief acclimation period (2 nights). The objectives of the acclimation period for parent-reared FGSP are to allow for adjustment to radio transmitter harnesses, recovery from human handling, and recovery from transport (e.g. hydration). A shorter acclimation period within the two-night time frame or direct releases for some parent-reared birds may occur, if warranted, to mitigate risks to the birds (e.g., to eliminate intraspecific aggression from males). If an injured or ill bird needs to be captured from the aviary, the rest of the release cohort will be held for one additional night to allow for recovery from disturbance. In addition to the advantages outlined above, a short holding time seems appropriate for parent-reared FGSP because 1) the climates between the source and release sites are similar, 2) captive-reared FGSPs will be acclimated to outdoor conditions and natural prey items *ex situ* prior to release, 3) most DRA participants did not recommend lengthy acclimation periods for disease risk mitigation purposes, and 4) preliminary trials with parent-reared GRSP showed wild behaviors and relatively high immediate post-release survival for birds held in field aviaries for only 2-5 days (J. Cox, unpub. data). Second, hand-reared birds will be held in the field aviary for 4-7 nights. Hand-reared birds will be acclimated to climactic and outdoor conditions, but they may require additional time to develop natural behaviors relative to parent-reared birds. Acclimation approaches may be adjusted using an adaptive framework after observation of FGSP pre- and post-release.

8. RELEASE LOCATION

The goal of many captive-rearing programs is to establish new populations at sites not currently occupied by the target species (e.g., Kuehler et al. 2000, Jeffs et al. 2016), whereas others aim to support existing populations (e.g., Cunninghame et al. 2015). The “best” release location for captive birds may not necessarily be the location where birds were most recently located or are currently located (A. Lieberman, pers. comm.). Release sites may be selected based on predator control programs (Cristinacce et al. 2008), flood risks, availability of nest sites, native food abundance (Kuehler et al. 2000), avoidance of pathogens (Tweed et al. 2003), or amount of contiguous habitat or management support by local landowners (Jeffs et al. 2016). Other considerations include accessibility and the ability to construct acclimation pens in difficult terrain (Kuehler et al. 2000).

Translocation projects often suffer from dispersal away from the release site (Tweed et al. 2003; Clarke and Schedvin 1997), and a lack of conspecifics at new release sites has been proposed as a factor leading to increased dispersal behavior (Mihoub et al. 2011). Observations of FGSP territory placement and site fidelity in the wild suggest they may also prefer to be near conspecifics (FWC unpub. data). Releasing captive-reared birds into larger extant populations

may result in higher initial fidelity to the release site and facilitate pairing with wild FGSP. Alternatively, although site fidelity could be lower, releasing birds into small populations could bolster the populations most at risk of extirpation.

Decision

Initially, captive-reared FGSP will be released into extant subpopulations rather than attempting to establish new subpopulations. TLWMA was selected for the first year of release trials (2019; Appendix B) because it 1) has the largest extant FGSP population, suggesting conditions may be more suitable for survival or reproduction, 2) nest predation by red imported fire ants is rare, 3) we anticipate the larger resident population will promote post-release retention via conspecific attraction or pairing with wild birds, 4) it has an existing grid of fire lines which is amenable to systematic radio-telemetry tracking using an all-terrain vehicle, 5) year-round staff, funding, and equipment are available for post-release monitoring, 6) no additional authorizations are necessary, and 7) there are no military activities, private permissions, or seasonal high-water levels that would make certain areas inaccessible during key monitoring periods. Releasing captive-reared birds at one site first will allow for an initial evaluation of transport, acclimation, release, and post-monitoring techniques without adding a site effect.

Nevertheless, we recognize the urgency of bolstering smaller populations with captive-reared recruits in the near future to prevent extirpation. To balance the need to develop successful release methods with the urgency of supporting small populations, triggers will be developed (with consultation by the FGSP working group) and evaluated in fall 2019 to establish if, when, where, and how many birds should be released at alternate sites the following spring. Annual check-in meetings will be held each fall to revisit release site goals in relation to the most current data (see Appendix B: Evaluation of Release Methods). Example triggers may include:

1. Recruitment rates of captive-reared birds observed to date.
    - Example: If recruitment is <10%, this suggests that more work is needed to test and improve release techniques, and answering remaining methods questions may take priority over releasing birds at multiple sites. Also, if recruitment rates are very low, expanding the program to a second site may not be justified relative to the level of conservation benefit.
    - Example: If recruitment is >15%, this suggests that release methods are performing better than the minimum acceptable rate. Improvement may still be desired but supplementing vulnerable small populations may take priority over improving release methods, and/or the addition of a site covariate would have less impact on the evaluation of release techniques.
2. Preparation and suitability of alternate release sites to receive captive-reared birds.

    - Example: Depending on the recommended release strategy, field aviaries may need to be constructed, telemetry equipment purchased, and additional staff hired and trained. Organization and agency approvals for the required activities would need to be in place prior to the release of birds. An evaluation of known threats (e.g. nest predators) and availability of management solutions at that site may also be considered.
3. Availability of birds not necessary or otherwise suitable for testing pilot release techniques.
    - Example: If the genetic management of the captive flocks determines that several three-year old adult males are genetically redundant and not high priority for breeding, these males may be selected for release at an alternate site to make space for breeders with higher genetic value. Because these males fall outside of the target age classes for the initial release trials, releasing them at an alternate site would not detract from our ability to evaluate release methods, but may provide great value to the small population through increased conspecific attraction and genetic diversity at the site.
    - Example: More captive birds are produced than required for initial release trials and these birds are scheduled for release at an alternate site.

Table A1: Summary of demographic rates of released captive-bred passerines from published literature and expert opinion.

Metric	Common name	Scientific name	Mean	Citation
1st month survival	Cirl bunting	*Emberiza cirius*	59%	Jeffs et al. 2016
	Puaiohi	*Myadestes palmeri*	36%	Switzer et al. 2013
	'Oma 'o	*Myadestes obscurus*	80%	Kuehler et al. 2000
Survival to 1st breeding season	Cirl bunting	*Emberiza cirius*	28%	Jeffs et al. 2016
	Mangrove finch	*Camarhynchus helibates*	26%[1]	Charles Darwin Foundation 2018
	Mauritius fody	*Fouda rubra*	52%[2]	Cristinacce et al. 2009; A. Cristinacce, pers. comm.
Recruitment rate (proportion of released birds that bred)	Mangrove finch	*Camarhynchus helibates*	5%	Charles Darwin Foundation 2018
	Canadian loggerhead shrike	*Lanius lodovicianus*	3%	Nichols et al. 2010
	Helmeted honeyeater	*Lichenostomus melanops cassidix*	23%	Menkhorst et al. 2010
	Puaiohi	*Myadestes palmeri*	9%	Switzer et al. 2013
	Mauritius fody	*Fouda rubra*	43%[2]	Cristinacce et al. 2009; A. Cristinacce, pers. comm.

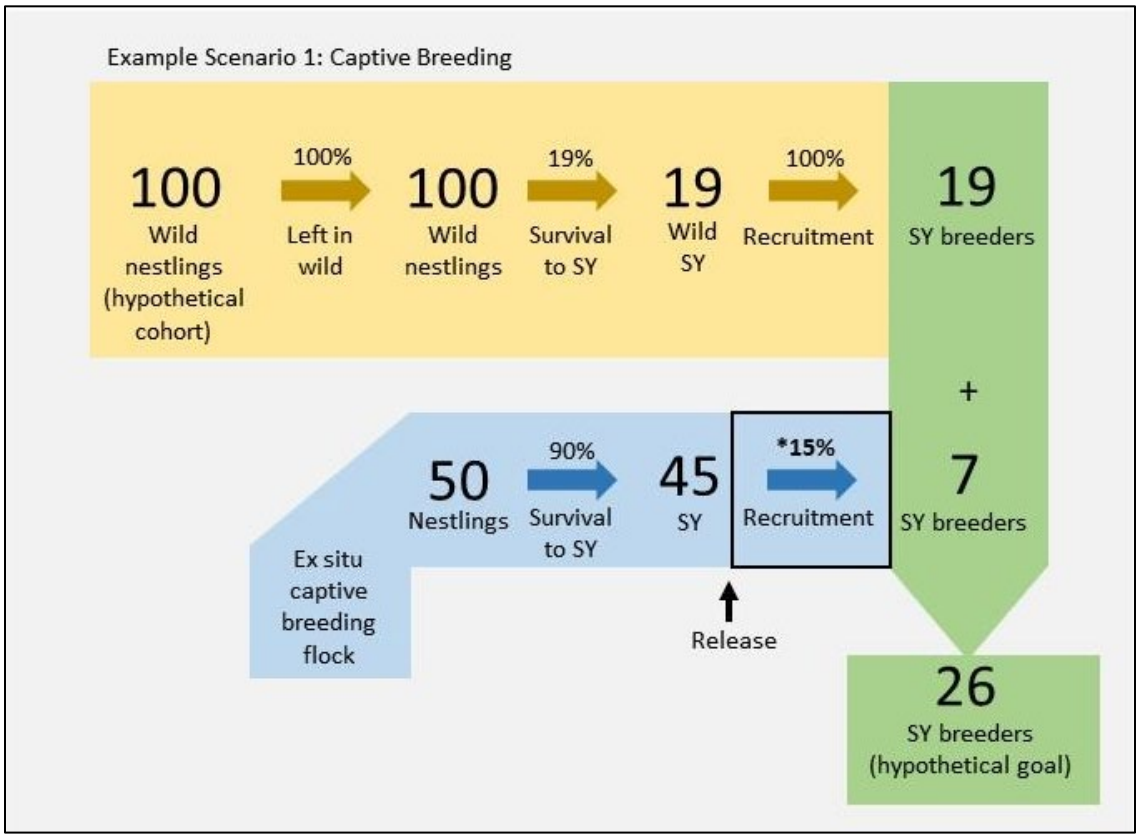
[1]Reported as "long-term post release" rather than survival to breeding.

[2]Releases occurred on a predator-free island

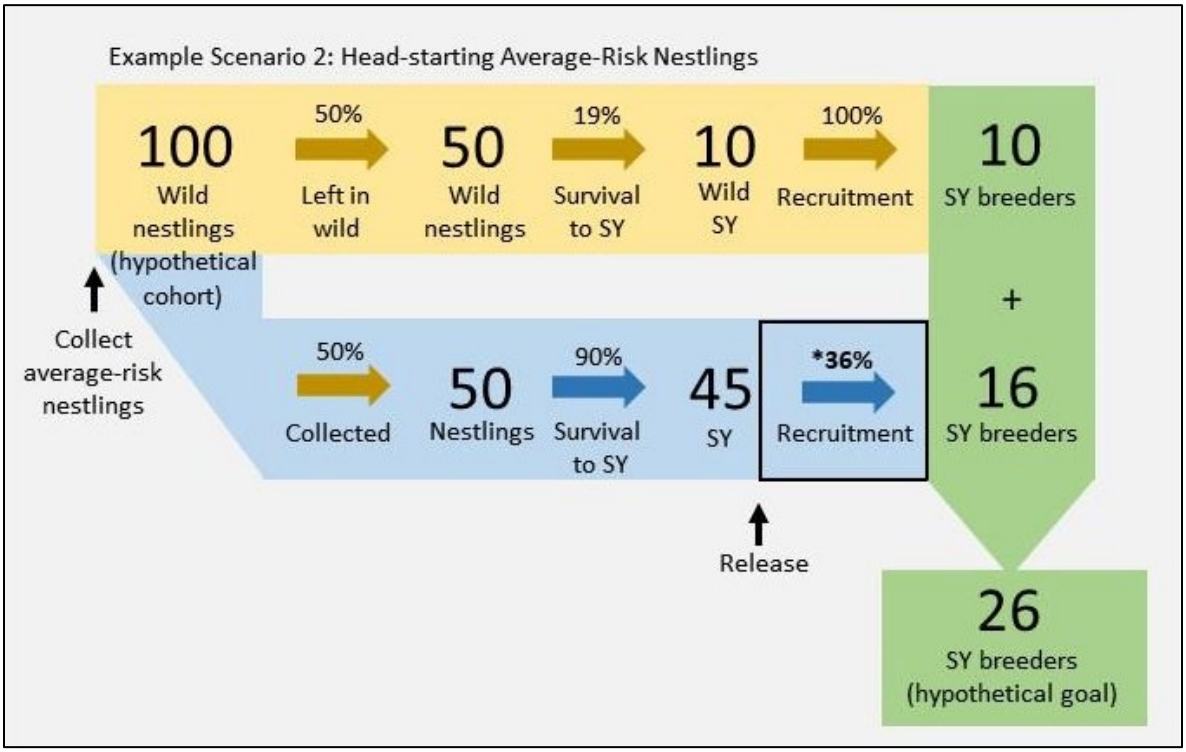
Box A1: Comparing the efficiency of alternative captive management options for FGSP.

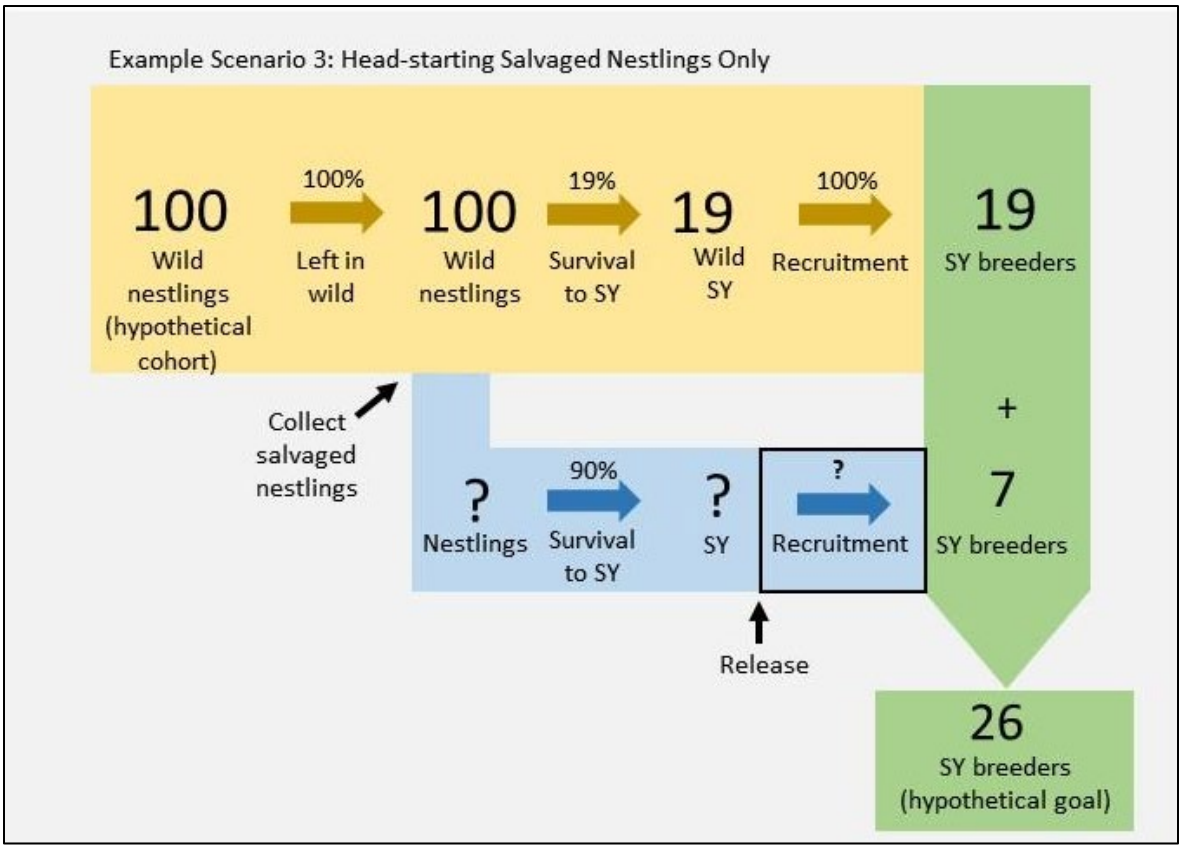
Introduction: The flowcharts in this section represent three alternative captive management scenarios for FGSP: 1) traditional captive breeding, 2) head-starting average-risk nestlings, and 3) head-starting salvaged nestlings only. The hypothetical goal for all scenarios is to produce a wild population with 26 second-year (SY) breeding females starting with a hypothetical cohort of 100, 4-day old nestlings. The post-release recruitment rates of captive-reared birds required to accomplish the goal are highlighted in the black boxes.

Methods: All scenarios use 4-day old nestlings as the starting point because this is the youngest age nestlings are eligible for collection and head-starting (P. Reillo, pers. comm.). We assumed a 19% probability of surviving the period between 4-days old to SY based on an 89% probability of surviving the period between 4 and 8 days of age in a fenced nest at TLWMA (0.97 daily survival rate; 2015-2017) and a 21% probability of surviving the period between fledging and the following year (first-year survival; FWC unpub. data). We assumed that 100% of uncollected females that survive to SY age are viable breeders because unpaired SY females are not detected. For collected or captive-bred nestlings, we assumed that all 4-day old nestlings in captivity will fledge and 90% will survive to breeding age. For Scenario 3, we assumed that collecting an unknown number of salvaged nestlings (certain to die if left in the wild) would not decrease the number of wild SY breeders produced. We back-calculated the post-release recruitment rate (black boxes) required to meet the hypothetical goal by calculating the number of SY breeders from captive-reared sources needed to reach 26, then dividing this number by the number of captive-reared birds surviving to SY age (45 in Scenarios 1 and 2).



Box A1: continued

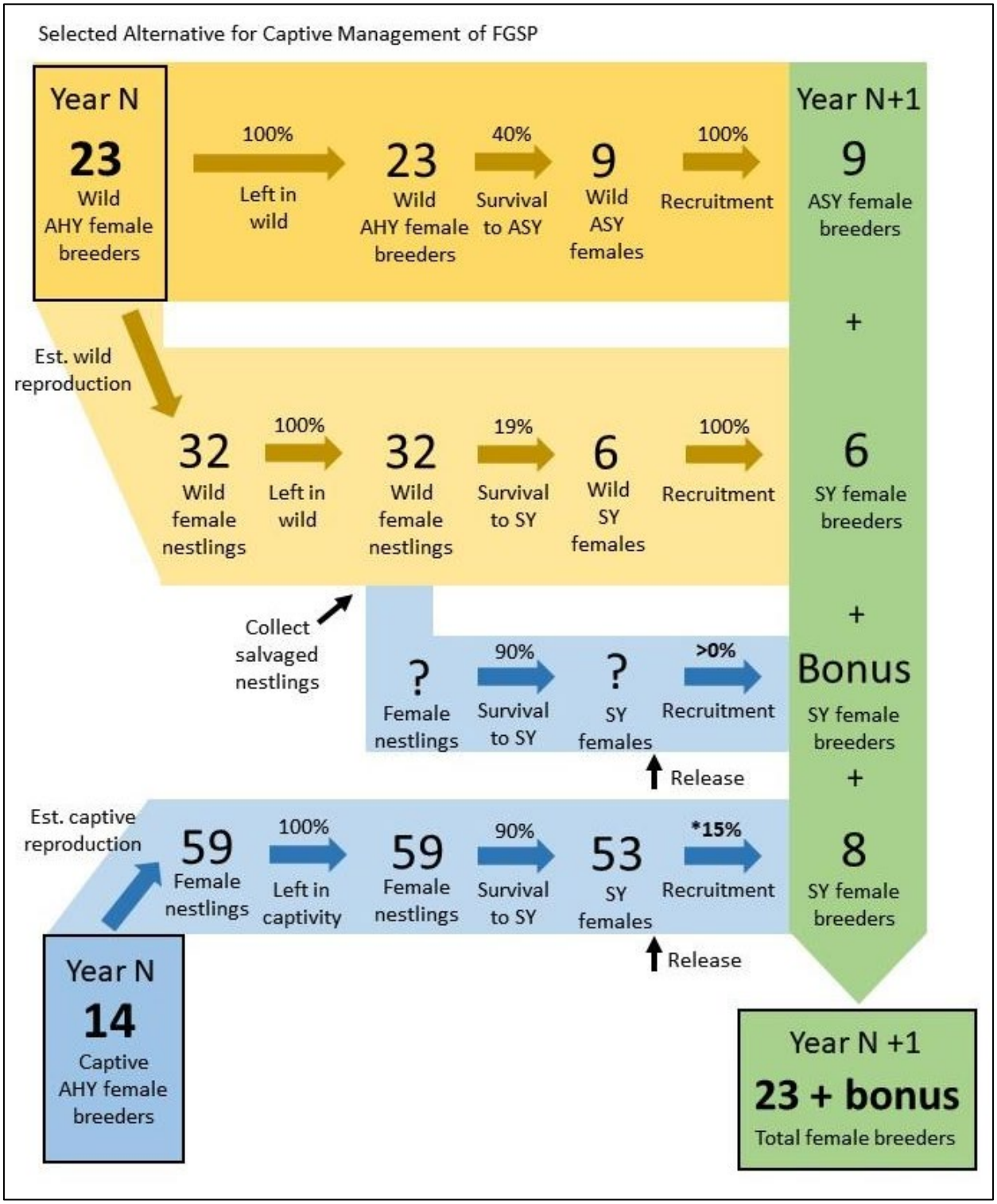




Box A1: continued

Conclusion: Traditional captive breeding (Scenario 1) is more efficient than head-starting average risk nestlings (Scenario 2) because it requires a lower post-release survival and recruitment rate. The post-release survival and recruitment rate required to meet the goal using only head-started salvaged nestlings (Scenario 3) is unknown, because the number of salvaged nestlings available each year is unknown. Therefore, using a traditional captive breeding strategy as the primary means to accomplish wild population goals may be the most effective, but collecting salvaged nestlings for head-starting has minimal impact to the wild population and may be used as a source of "bonus" SY recruits.

Box A2: Flowchart depicting the preferred alternative for captive management of FGSP as described in the 5-year vision document.



Box A2: continued

Methods: The starting number of after-hatch-year (AHY) adult females in Year N (23) is based on the estimated number of females in the wild in 2018. The minimum goal set by the vision for the captive program is to supplement the wild population with enough second-year (SY) female breeders to maintain at least 23 total female breeders in the wild. We estimate that 9 of 23 AHY females will survive to the following year (after-second-year; ASY) based on a mean annual survival rate of 40% (Three Lakes Wildlife Management Area population [TLWMA]; 2013-2017; FWC unpub. data). We assume that 100% of uncollected females that survive to breeding age are viable breeders because unpaired females are rarely detected. We estimate that the 23 females in Year N will produce 32, 4-day old female nestlings based on a fecundity rate of 1.39, 4-day old female nestlings per breeding female (TLWMA; 2013-2017; FWC unpub. data). We estimated a 19% probability of surviving the period between 4-days old to SY based on an 89% probability of surviving the period between 4 and 8 days of age in a fenced nest at TLWMA (0.97 Mayfield daily nest survival rate; TLWMA; 2015-2017) and a 21% probability of surviving the period between fledging and the following year (first-year survival; TLWMA; 2015-2017; FWC unpub. data). The number of salvaged nestlings collected for head-starting varies each year and is unknown but because there is little impact to the wild population, any salvaged female nestlings that survive to breeding age are considered bonus females. We estimate that 14 adult female breeders in a traditional captive breeding program in Year N will produce 59, 4-day old female nestlings based on an observed fecundity rate of 4.67, 4-day old female nestlings per breeding female (White Oak Conservation Holdings population; 2017). We assume all 59 will survive to fledge, and 90% will survive to the following year (Year N+1) while still in captivity. Using the minimum threshold for post-release survival and recruitment (15%) outlined by the vision, these captive-reared females will contribute 8, SY female breeders to the wild population resulting in a total of 23 female breeders in Year N+1 plus any recruits produced by head-starting. The numbers and rates presented in this figure represent the best available data and understanding of FGSP biology. However, the small FGSP populations are vulnerable to annual stochasticity and mean demographic rates are refined each year as additional data are collected.

APPENDIX B. 2019-2020 Adaptive Release Plan

OBJECTIVES

Rigorous experiments are warranted to evaluate the effectiveness of animal reintroductions. However, the ability of researchers to carry out true experiments in reintroductions is usually limited by low numbers of source individuals and the difficulty of conducting synchronous releases at multiple experimental sites (Armstrong et al. 2007). Consequently, an adaptive management framework has been recommended (Kemp et al. 2015). We propose to assess the feasibility of releasing FGSPs when the birds are at different stages of development (independent juvenile vs. pre-breeder). If sample sizes allow, we also will assess the relative effect of two rearing types (hand-reared vs. parent-reared) and different acclimation periods during the first year of release. Proposed objectives include:

1. Releasing enough captive-reared FGSP to meet the FGSP vision's objective of stabilizing or growing the wild population (i.e., maintaining at least 23 wild breeding females) each year.
2. Tracking released birds using radio telemetry to assess basic habitat use, movement patterns, and causes of death when possible.
3. Estimating the survival of released birds according to age at release and sex.
4. Resighting released birds and monitoring their nests during the breeding season to estimate pairing and nest success rates.

METHODS

Composition of Captive Releases

<u>Release candidates</u>

FGSP reared or housed at any *ex situ* facility will be identified for potential release in coordination with captive facilities, based on genetic value to captive or wild populations, sex, and age. FGSP pedigree data will be updated each fall with all captive and wild progeny surviving to banding age. Pedigree data will be evaluated with PMx demographic and genetic analysis software (Lacy et al. 2011) to evaluate the male-female pairings that would result in the highest genetic diversity in the captive flock. PMx will provide kinship parameters to assess relative genetic uniqueness and birds with fewer relatives in captivity or the wild will be prioritized for retention as breeders in the captive flock. The sex ratio of the birds targeted for release will depend on the sexes of the surviving captive birds and capacity constraints.

Birds will be released as part of a formal release experiment when they are either independent fledglings or pre-breeding second-year birds (see *Release Methods* below). Captive birds older than one year of age will be either retained in the captive flock as breeders as necessary, transferred to holding facilities, or released.

Ex Situ Pre-release Health Screening and Pre-transfer Screening

All captive-reared birds will be banded as nestlings when 5 days old. During this handling period they will be weighed, color-banded, vaccinated for West Nile/WEE/EEE virus, and a buccal swab will be collected for genetic sexing. Once juveniles reach nutritional independence (30-40 days post-hatch) they will be separated from their parents and undergo their first health screening examination (Appendix C). After the examination, juveniles will be placed in a separate, naturally vegetated, outdoor *ex situ* aviary with other birds from their eventual release cohort. Juvenile release cohorts often will be sibling groups to reduce the number of times birds will need to be handled. However, groups to be released as adult pre-breeders may contain unrelated birds depending on optimal pairings in captivity or in the wild. While in the aviary, juveniles will remain separate from other captive birds at the facility but may be exposed to wild birds that fly over or perch on the pen. Human movement to and from each *ex situ* aviary will follow strict biosecurity procedures (Appendix C). Preventative health measures such as frequent observation, routine blood draws, and vaccination will be conducted year-round so that sick animals can be identified and treated quickly.

Birds selected for release as independent juveniles will remain in their pens until all results from their health exam have been reviewed and they are at least 40 days post-hatch (younger birds may fail to thrive as observed during GRSP release trials; J. Cox, unpub. data). Birds selected for release as second-year pre-breeders will remain in their *ex situ* pens until the following January-February. Prior to their scheduled release, they will be screened again following the same examination protocol (Appendix C).

Translocation and Release

Release location

Release trials in 2019 will take place at the Route 60 dry prairie unit of the TLWMA in Osceola County (see Appendix A for rationale). The locations of releases in subsequent years will be evaluated each fall (see Appendix A and Evaluation of Release Methods).

Age of release

Sparrows will be released at two different seasons when the birds are at different developmental ages (Fig. B1). First, juveniles will be released soon after they reach nutritional independence (≥40 days post-hatching) and have passed their pre-release health screening exams. Although the exact month of releases is uncertain, we anticipate that fledglings may be available for release from late June to September, which matches the peak abundance of wild fledglings on the landscape. The second release group will be second-year pre-breeders released from January through March. Male releases are anticipated to occur by mid-February, just prior to the development of aggressive territorial behavior (A. Schumann, personal observation) and pre-dawn singing in the wild (FWC unpub. data). Female releases and remaining males, if any, should occur by the end of March. Changes to the plan may occur (Fig. B1), including releases after April 1st, if logistical constraints delay releases.

Hand-reared and parent-reared

If sample sizes allow, we also will assess the relative effect of two rearing types (hand-reared vs. parent-reared) during the first year of release. Releasing approximately 15 hand-reared birds (from a combination of captive-bred and head-started individuals) would likely be sufficient to evaluate whether hand-reared birds are effective breeders in the wild. Information from this assessment will help guide future planning.

Transport

On the morning of transport, captive birds will be captured within 2 hrs of sunrise using mist nets or hand nets and placed in separate transport boxes in climate-controlled vehicles. Transport time to TLWMA is ca. 3 hrs 30 min from WOCH and 1 hr 45 min from RSCF. Whenever possible, birds will be transported to the field site in batches (tentatively 4-8 birds per group). Birds will be provided with fresh insects and seed during transport. For comparison, the total transport time (including a stop for radio harness attachment) was 6 hrs for the GRSP release trials during transfer (J. Cox, pers. comm.).

Color-band verification

All birds scheduled for release will be banded with a USGS numbered aluminum band prior to entering the field aviary. Band combinations will be confirmed in advance with the captive

facilities and changed if needed to ensure that no captive-reared birds are accidentally released with band combinations that match wild birds.

In situ acclimation

In 2019, we plan to pursue and compare two acclimation strategies that require the use of a field aviary (see Appendix A for rationale): First, birds that have been parent-reared in captivity will be health screened and then placed in field aviaries for 1-3 nights (with a target of 2 nights). Second, birds that were hand-reared in captivity will be placed in field aviaries for 4-7 nights (with a target of 4 nights). Additionally, we may test the efficacy of direct releases (i.e., no acclimation period) for both parent- and hand-reared birds. Birds will be transported in group sizes consistent with release occurring over 8 weeks (February through March). Our goal is to release all males prior to late February to avoid aggressive behavior in the field aviaries and allow released males to establish territories at the same time as wild males. Females may also be released prior to late-February or up to 4 weeks later. We will avoid releases after April 1st to increase chances of reproduction of birds in the wild, but if logistical constraints delay releases, we may favor a release after April 1st over continuing to keep a bird in captivity. Acclimation periods of different lengths (including possible direct release) will be considered for both males and females based on the results of early releases to maximize the safety of the birds and the effectiveness of the program.

A field aviary has been constructed in dry prairie habitat not scheduled for prescribed fire during the holding period or prone to severe seasonal flooding. The field aviary was constructed to provide sufficient space (ca. 60 sq ft per bird).

While in the field aviary, FGSP will be provided with ample seed (including seeds native to the prairie), insects (crickets and waxworms), water, and shelter from severe rain. They will be monitored by local staff twice a day during daylight hours. Field cameras may be placed at the feeding stations inside the cages to monitor behavior, census the flock, and possibly detect any injury or illness. Field staff attended 2 weeks of training at the captive facilities prior to the transport of birds to the field aviaries. A detailed *in situ* husbandry protocol document was drafted prior to the arrival of birds. Veterinarians were contacted to serve as on-call resources in the event of injury or other health concerns.

Release

We will monitor the weather forecast with the intent to release birds when at least two consecutive days have <30% chance of rain with less than 0.65 cm (¼ inch) total accumulation. We will also delay the scheduled release of birds if high winds or cold temperatures (<40° F) are predicted. On the day of release, the food dish will be moved outside the cage and the release panel of the field aviary will be removed to allow the birds to leave on their own. Releases will be conducted ≥2 hrs after dawn to provide birds an opportunity to visit the food and water

bowls prior to release. The panel will be replaced once all birds have left. If any birds remain inside the aviary ≥1-2 hrs after the removal of the release panel, they will be assessed for health or behavioral issues. If problems are detected, these birds may need to be kept for a longer acclimation period, or returned to the captive facility. If no problems are detected, birds will be encouraged to leave the pen by gentle flushing. Supplemental food (seed) will be provided outside the field aviary for up to one-week post-release unless camera evidence suggests the food is not being used for >24 hrs.

Post-release Monitoring

Radio-tracking

We will fit birds with a radio transmitter while still at the captive facility on the day of transport. This will allow for one additional examination period prior to placement in field aviary to ensure harness fit. Transmitters will weigh ca. 0.6g or less (ca. 4% of a 15.0 g sparrow; Ag379 Lotek Brand transmitters) attached with a hip-harness using stretchable sewing thread that degrades relatively quickly so tags will eventually be dropped (Streby et al. 2015).

Approximately 25 radio transmitters will be deployed for each age class (50 per year). In 2019, radios will be divided among both sexes and acclimation length treatment groups. Because females are rarely observed in the wild, transmitters will be the only way to monitor their survival and movement during the 3-4 week period post-release. However, it may be conservative to leave some females without transmitters until we can verify the safety and effectiveness of the devices. Tracking males, which are more conspicuous, may allow us to monitor the effectiveness of the transmitters and we may be able to observe and respond to transmitter related injuries should they occur.

On the day of release, we will monitor released birds as frequently as possible during the first 48 hrs following release, with a goal of acquiring 2-5 locations per bird per day. On the first two days of tracking, released birds will be given sufficient physical space to avoid flushing or forcing movement by the observer, particularly if movements are identified between different detections. Observers will get close enough to retain a strong signal when volume dialed down to 3-4, but not much closer (J. Cox, pers. comm.). By tracking birds intensively during the first- and second-day post-release, we hope to better distinguish mortality from dispersal. For birds that do perish shortly after release, intensive tracking may allow us to locate the carcass to assign probable cause of death through visual evidence (predation) or necropsy. Any carcasses without obvious cause of death will be kept cold and immediately shipped to a diagnostic laboratory for necropsy, following the carcass handling protocol.

We will attempt to obtain at least one morning and one evening location on days 3-7 following release, especially for birds that present unusually high movements between detections

compared to other birds in their release cohort. We will then track the individuals once daily until transmitter signal is lost or the bird perishes. We expect transmitter batteries to reliably last up to 28 days (J. Cox, pers. comm.). For every detection event, we will collect a GPS location, time of detection, as well as data on flush distances and general behavior (wariness) upon discovery. If we cannot obtain a location for the individual, we will conduct a standardized search by driving ATVs (or a field truck with a mounted antenna) and stopping periodically across a standardized grid of firebreaks transecting the entire study area. Occasional airplane flights may be available to assist with detection of missing birds that may have left the study area. The mean daily distance traveled for wild independent GRSP juveniles was 146 m (range = 5-966 m; Small et al. 2015). The number of detections per day may vary depending on the number of staff available in relation to the total number of birds released. Movement patterns and distances traveled will be summarized for each released bird using GIS spatial analysis. We will summarize the fates, daily distances, and total number of tracking days for each released individual.

Post-release monitoring

After the radio transmitter battery dies, we will systematically search for males released as second-year pre-breeders during routine spring point count surveys at TLWMA (3 replicates; mid-Mar through early June). We will use a spotting scope to record the band combination and collect one or more GPS locations for each FGSP detected during point count surveys or opportunistically. Females released as second-year pre-breeders will not be easily detectable during standard point count surveys. Instead, we will use male behavioral information to assist with pairing status assignment and nest searching. We will then resight females in the field, on nest camera, or by capture to confirm identification of each female associated with active nests each year (Apr-Aug). We will add nest cameras to nests of captive-reared females to observe breeding behaviors. If abnormal behaviors are observed (e.g. infanticide, low provisioning rates) the field crews will consult the agencies to discuss emergency actions (collection of female or young).

For birds released as independent juveniles (both sexes), late-summer point count surveys are unlikely to result in detections. Once transmitter batteries die, juveniles will be resighted opportunistically during routine visits to occupied territories or areas where fledglings have been observed congregating. It is possible that juveniles with radio-tags will inform the field team of new fledgling congregation areas increasing the probability that banded juveniles will be incidentally resighted. Juveniles that survive their first winter will be included in routine spring monitoring (described above) to assess survival and reproductive status.

We will use mark-recapture modeling (R-mark; Laake 2013) to estimate interval survival and detection probabilities for birds released as second-year pre-breeders (Mar-Sep) and independents (Jun-Sep). Apparent annual survival of birds released in 2019 and 2020 will be

assessed by their detection on point count surveys or opportunistic sightings in 2020 and 2021 respectively. Partners at sites where birds will not initially be released (KPPSP, APAFR, and a private ranch) will report any dispersal movements of released birds detected during routine point count and band resighting surveys (Apr-Aug).

CRITERIA FOR SUCCESS

1. Released birds exhibit reproductive behaviors (song patterns, territory establishment, pair formation) comparable to wild birds.
2. Demonstration that at least one of the released age classes can achieve a recruitment rate of ≥15% for females.

EVALUATION OF RELEASE METHODS

We will evaluate release locations, the success of the two release age classes, and modify future release methods at specific time points.

Fall 2019: Evaluate transport, acclimation, release, and post-release monitoring methods and make recommendations for improvement. Also evaluate the survival and recruitment of second-year adults released in Feb 2019 and the survival of juveniles released in summer 2019. This preliminary information will be used to develop triggers for the potential release of captive birds at KPPSP, APAFR, or other sites. If triggers are met, then actions will be taken to expand the release program to multiple sites.

Mid-June 2020: Evaluate age of release. All juveniles produced in captivity in 2020 will be retained overwinter and released as pre-breeders in 2021 if the survival and reproductive rates of the 2018 and 2019 pre-breeders exceed those of the 2019 juveniles. If the two groups are not statistically different, then half of the 2020 cohort will be released as juveniles and half retained in captivity for release in 2021.

Fall 2020: Review results to date. Repeat evaluation of release location triggers and make recommendations to modify release methods (if needed). These fall evaluation meetings will be repeated each year.

Mid-June 2021 Evaluate age of release. All juveniles produced in captivity in 2021 will be retained overwinter and released as pre-breeders in 2021 if the survival

	and reproductive rates of the 2018-2020 pre-breeders exceed those of the 2019-2020 juveniles. If the two groups are not statistically different by this time, then we would release all birds as independent juveniles to allow for increased captive production and reduced *ex situ* operational costs.
January 2022:	Review results to date. Repeat evaluation of release location triggers and make recommendations to modify release methods (if needed). This evaluation will be combined with the 3-year program checkpoint (see Vision 'Checkpoints and Criteria for Success')
Fall 2022:	Review results to date. Repeat evaluation of release location triggers and make recommendations to modify release methods (if needed).
January 2024:	Review results to date. Repeat evaluation of release location triggers and make recommendations to modify release methods (if needed). This evaluation will be combined with the 5-year program checkpoint (see Vision 'Checkpoints and Criteria for Success')

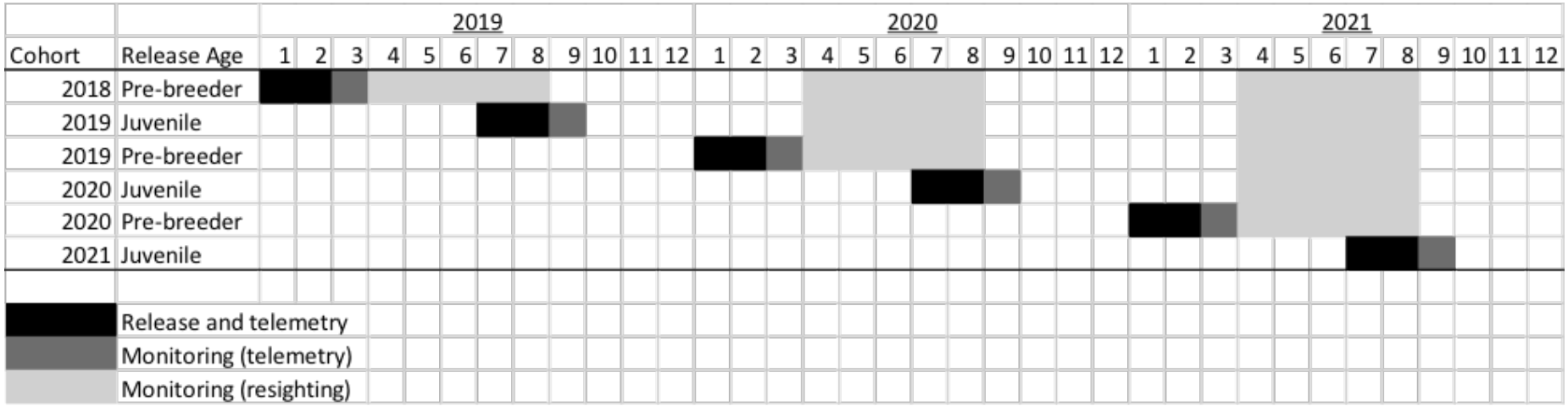


Figure B1: Proposed schedule of release and monitoring for captive-reared juvenile and pre-breeding second-year FGSP at TLWMA (2019-2021).

APPENDIX C. Pre-Transfer Health Screening Protocol

*The same screening will be repeated for birds held overwinter prior to their scheduled release date. However, the imperative for sample collection and examination must be balanced with the potential detrimental effect on acclimatization, health, and welfare of the birds (Sangster and Vogelnest 2016).
** This is a living document that will change as new information becomes available.

Pre-shipment/Pre-release Examination for Birds at Parental Separation Age (Days 21-29d post-hatch) AND After Hatch Year Birds
(*Parental separation exam may function as pre-shipment/pre-release exam if <30d apart*)

- Full Physical examination (Record on Examination Form):
    - Number bags used for holding birds and/or collecting feces, document which bag was used for each bird
    - Evaluate overall activity and strength of bird during catching and handling
        - Bird should be flying normally, have normal avoidance behaviors, and feel strong in the hand
    - Evaluate feather condition, quality, and color
        - Check primary and secondary remiges and rectrices for condition, strength, stress bars, and other abnormalities
        - Body feathers should appear normal and well groomed
        - Evaluate general numbers of feather lice and/or mites on bird
        - Evaluate cleanliness of vent feathers
    - Evaluate other integument and external structures
        - Skin is normal without significant trauma or other lesions
        - Beak is normally sized and shaped with normal occlusion
        - Nostrils are clear without drainage or blockage
        - Ears are open without drainage or blockage
        - Uropygial gland has normal appearance and size
        - Legs and feet have normal appearance and mobility without fractures or other lesions
            - Measure Tibiotarsal Length
        - Wings have normal appearance and mobility without fractures or other lesions
    - Evaluate Eyes and Surrounding Structures
        - Eyes and Pupil size symmetric, no opacities
        - Lids and conjunctiva normal – no discharge, inflammation, or other lesions
        - Periorbital sinuses show no swelling or abscessation
    - Evaluate Pectoral Muscling
        - Muscle should be well rounded and not concave with sharp keel

- Evaluate Subcutaneous Fat Stores
    - Some SQ fat should be present– check neck, thoracic inlet, axillary, inguinal, and abdominal areas.
    - Use The Subcutaneous Fat Scoring System on page 5 to determine score. This system was taken from the 2018 Monitoring Avian Productivity and Survivorship Manual.
- Evaluate Liver Size through abdominal wall
    - Should only see tip of liver below keel
- Evaluate body condition index
    - Record Tibiotarsal Length (mm) and body Weight (gm)

- Venipuncture WHEN FEASIBLE (if unsuccessful after 1-2 attempts, disregard blood collection)
    - Put small amount of Vaseline over ulnar vein, prick vein with a 30-gauge hypodermic needle, collect blood as it wells up in a heparinized capillary tube – collect 50 to 100 µl of blood, which is far below 1% of the total body weight for sparrows at this age.
        - You may use jugular vein, if experience with that location, to directly draw blood into syringe
        - Document approximate amount of blood collected
        - If homeostasis occurs, use cotton tip applicator OR sexing card to clot blood
    - Make one or two blood smears immediately, fix smears with methanol
        - Label slides with date of collection and bird accession number
        - Slide One:
            - Preferably use FedEx or UPS for direct delivery:
              Dr. Nicole Stacy
              Department of Large Animal Clinical Sciences,
              College of Veterinary Medicine, UF
              2015 SW 16th Ave.
              Gainesville, Florida 32608;
              (352)-294-4093 (o), (352)-870-5108 (c); StacyN@ufl.edu.
            - Dr. Stacy will archive blood smears at her facility.
            - Allow 2-3 days for evaluation to be completed
        - Blood Smear Evaluation: Estimated WBC count, WBC differential and morphology, RBC morphology, hemoparasite presence and quantitation (bacterium, apicomplexan, hemoflagellate or microfilaria)
        - The second slide, if available, will be archived at each captive-rearing facility.
    - Freeze remainder of whole blood for future needs (PCR, etc.)
        - Blow out the remaining blood with a syringe or pipette (do NOT use mouth) into a small Microcentrifuge tube (Pefector Scientific, Catalog#3200, volume 0.60 ml, polypropylene, autoclavable, RNase and DNase free) for storage.

        - The vial label should include at least the bird accession number, type of blood, and date.
        - Freeze (-70 degrees if possible) and keep at captive facility
    - Any remaining blood on wing of bird can be blotted with DNA sexing card
        - For sex determination, send to:
          Avian Biotech International
          1336 Timberlane Road
          Tallahassee, FL 32312-1766, 850-386-1145).
        - Alternatively, a feather tip may be collected and sent to Avian Biotech International for sexing. The DNA sexing card or feather sample will serve as a backup, in case the oral swab is insufficient, and only need to be collected if samples were not taken when birds were banded.
- +/- Oral swab with Whitman paper pledget (if this was not already done at day 5 OR when the bird was banded), for genetics and sexing
    - Swab cheek for at least 20 seconds
    - Store refrigerated in Chelex 100, PCR premix and
    - Send to
      Jim Austin,
      Molecular Eco Lab
      1501 Date Palm Dr., Bldg. 63
      Gainesville, FL 32611
      Phone: 352-846-0646 (office) or 352-443-9113 (cell)

- Fecal Examination – when possible, perform at least one fecal examination (direct and standard flotation) for each bird within 30 days prior to shipment to release site. If unable to collect individual samples, collect a pooled sample from feeding station and perform the direct and flotation examination on that sample.
    - The solution used and duration of float should be documented on the data sheet.
    - Identify and semi-quantitate numbers of parasite oocysts/ova
        - When feasible, use the MacMaster test to quantify oocysts present
            - Quantification may be used in conjunction with other screening tools assess health of bird
    - If fecal is positive (presence of any parasite), freeze remaining feces, or swab meniscus of float solution or direct fecal slide and freeze swab for future PCR
- +/- Vaccination (Innovator WNV + EW) – 0.2ml SQ in inguinal fold
- Coccidiostat (depending on facility):
    - +/- ESB, 1.5-2mg per bird/day
    - +/- PO Toltrazuril (0.01ml, 0.25mg) (Pantacox, Pantex Holland, 25 mg/ml solution)
- +/- Sevin dust application depending on presence of external parasites
- +/- SQ fluid administration depending on hydration and stress level

After examination, the release group of birds should be housed in a separate enclosure from other birds with necessary biosecurity principles in place (mosquito proof screening, foot baths, separate tools, etc.) until shipment to the release site. Coccidiostats (ESB, Toltrazuril) will continue to be administered during pre-release holding.

Each captive rearing facility will make a judgement on the overall health of each bird, based on the pre-release physical examination and supportive diagnostics recorded on the FGSP Examination Form. The Facility will communicate the suitability for release, and provide any supporting documentation (or pertinent information), to Service and FWC for final review and release determination. If there are concerns about the health of a bird, these concerns will be communicated to Service and FWC and a plan will be developed for that bird (treatment, holding, later release, etc.)

APPENDIX D. Captive Breeding Protocols

The Service and FWC, with guidance from the working group, have supported adaptive management at the captive-breeding facilities to allow for discovery of the captive-rearing protocols (e.g., aviary size and configuration, husbandry and health screening, etc.) that result in the greatest successes in productivity and survival. The cooperative nature of the captive breeding effort to date has resulted in substantial improvements in husbandry techniques and disease management at both captive facilities. The captive breeding effort will continue to be a cooperative effort, as evidenced by continued rapid data sharing among partners and a commitment to joint authorship of peer-reviewed scientific products that arise from program activities. Moving forward, the FGSP recovery program will adopt the following practices, which are those associated with consistently positive outcomes, to optimize the success of the captive-breeding program. These best practices will be adopted by all *ex situ* facilities housing adult breeding pairs and juveniles (2019-2024). Novel husbandry issues and new information may require adaptive modifications to the listed protocols pending consultation with Service and FWC.

Breeding Aviaries

- No more than two adults occupy a breeding aviary (birds are considered adults by March 1 of the year following their hatch year), unless otherwise authorized by Service and FWC (one male and two females may be considered on a case-by-case basis).
- Breeding aviaries at least 8’ x 24’ x 7’ in size have proven sufficient to support successful breeding and rearing of young FGSP. Canadian Loggerhead Shrike and Mauritius Fody programs both experienced improved behaviors and reproductive success following increase in aviary size (Cristinacce et al. 2008, Steiner et al. 2013). To maximize captive reproductive success, all breeding aviaries will be ≥ 192 square feet.
- All existing outdoor breeding pairs remain in outdoor aviaries unless they need to be moved indoors temporarily for health or other emergency reasons.
- Any indoor adult birds are transitioned to outdoor aviaries when and if safe to do so.

Juvenile Aviaries

- Independent fledglings occupy an outdoor aviary that provides a minimum of 30 square feet per individual bird.
- Hand-reared juvenile birds are transitioned to outdoor aviaries upon reaching nutritional independence (21-23 days; post-hatch).
- Parent-reared juvenile birds are separated from their parents and transferred to juvenile aviaries when they reach nutritional independence (21-23 days; post-hatch).
- Any wild-caught independent juvenile or adult FGSP collected for captive breeding is directly placed into an outdoor aviary.

Pairing and Genetic Management

- Captive facilities submit studbook and nest data each fall.
- The sex of all juvenile FGSP hatched or reared in captivity is assigned using genetic techniques.
- FGSP pairs are established based on efforts to maximize and preserve genetic diversity of the captive flocks (see details in Appendix B).
- Breeding pairs are established prior to March 1 of each year.
- FGSP pairs may be split and repaired in cases of behavioral or reproductive incompatibility.
- Breeding males are monitored for signs of aggression towards young and separated from family group after fertilization of eggs if necessary.

Rearing

- Breeding pairs in outdoor aviaries parent-rear their young unless the nestlings need to be removed from their parents and hand-reared because of health or safety reasons.

Conditioning

- All outdoor birds are provided with live (preferably wild) insects several times weekly to encourage or maintain natural foraging behaviors.
- All outdoor pens have natural substrate designed to prepare birds for wild conditions.
- Husbandry staff reduce interaction time with birds to prevent habituation.

Predation and Flood Management

- All field aviaries are constructed or reinforced with metal hardware cloth to prevent damage by rodents or other predators.
- The screen size for aviaries does not exceed 0.25 x 0.25 inches.
- Field aviaries have doors that fit tightly, with no gaps to allow entrance by snakes or other predators.
- Field aviaries are inspected regularly for damage.
- All newly constructed aviaries are thoroughly searched for snakes or other predators prior to adding FGSP.
- If present, red imported fire ant mounds in or near the aviaries are treated.
- All field aviaries have sufficient elevation to prevent nest flooding. Nests are lifted using established protocols (FWC, unpub. data) if at risk of flooding.
- Rain shelters are provided in each field aviary.
- All captive facilities have a hurricane-preparedness plan approved by Service and FWC.

General Husbandry

- All FGSP are housed separately from other species including during incubation and hand-rearing, and FGSP eggs and nestlings have dedicated incubators, hatchers, and brooders.
- All FGSP food, food preparation spaces, and equipment are housed separately from that of other species.

Health Screening

- All captive facilities conduct routine and opportunistic health screening of FGSP in their care as outlined in Appendix C (pending Disease Risk Analysis [DRA] in November 2018).
- All independent juvenile FGSP undergo health screening shortly after they are removed from their parents (Appendix C).
- All adult FGSP held for captive breeding undergo at least one annual exam. This can be done opportunistically or when birds are being handled for other reasons.
- Opportunistic health screening occurs whenever birds are captured for moving or other non-health or non-emergency-related reasons unless the bird is exhibiting signs of stress (e.g., labored breathing, lethargy, squinty eyes).
- Opportunistic fecal sample collection occurs to monitor for coccidia.
- Whenever enough blood, tissue, or other material exists, captive facilities share it with designated labs at the request of the FGSP Health Team coordinator.
- Captive-breeding facilities notify the Service about mortalities resulting from suspected disease, trauma, predation, or other unusual circumstance via email within 48 hours of the event.
- Copies of necropsy and pathology reports with notable findings are forwarded to the Service so that they can be shared with the FGSP Health Team.

Transfers

- Pending the results of the DRA, birds may need to be moved between captive and holding facilities to alleviate capacity issues, or to meet genetic pairing and release goals.
- All captive facilities participate in pre-transfer screening exams (Appendix C) and engage in giving and receiving egg, nestling, juvenile, or adult FGSP that qualify for transfer during the health screening exam.

Procedure

- No FGSP or their resulting progeny in the care of the captive facilities are transferred or disposed of without prior written approval from the Service.

- The captive facilities do not deviate significantly from the FGSP 5-Year Strategic Vision or any of its appendices (A - E) without first consulting the trust agencies (Service and FWC).

APPENDIX E. Literature Cited

Adkesson, M. J., J. M. Zdziarski, and S. E. Little. 2005. Atoxoplasmosis in tangers. Journal of Zoo and Wildlife Medicine 36(2): 265-273.

Armstrong, D. P., I. Castro, and R. Griffiths. 2007. Using adaptive management to determine requirements of re-introduced populations: the case of the New Zealand hihi. Journal of Applied Ecology 44:953-962.

Bartlett, Cheryl M. 2008. Filarioid nematodes. Pages 439-462 in Atkinson, C.T., N.J. Thomas, and D.B. Hunter, editors. Parasitic diseases of wild birds. Wiley-Blackford, Oxford.

Batson, W., R. Abbott, and K. M. Richardson. 2015. Release strategies for fauna reintroductions: theory and tests. Pages 7-16 in Armstrong, S.P., M.W. Hayward, D. Moro, and P.J. Seddon, editors. Advances in reintroduction biology of Australian and New Zealand fauna. CSIRO Publishing, Clayton South, Victoria, Australia.

Beecher, M. D., S. E. Campbell and P. K. Stoddard. 1994. Correlation of song learning and territory establishment strategies in the song sparrow. Proceedings of the National Academy of Sciences 91(4): 1450-1454.

Berto, B. P., W. Flausino, D. McIntosh, W. L. Teixeira-Filho, and C. W. Lopes. 2011. Coccidia of new world passerine birds (Aves: Passeriformes): a review of Eimeria Schneider, 1875 and Isospora Schneider, 1881 (Apicomplexa: Eimeriidae). Systematic Parasitology 80(3): 159.

Boag, P. T., and P. R. Grant. 1981. Intense natural selection in a population of Darwin's finches (Geospizinae) in the Galápagos. Science 214:82–85.

Charles Darwin Foundation. 2018. Conservation of the critically endangered mangrove finch (*Camarhynchus helibates*) in the Galapagos Islands: Field Season Report from the Charles Darwin Foundation to San Diego Zoo Global—Results to help evaluate management.

Clarke M. F. and N. Schedvin. 1997. An experimental study of the translocation of noisy miners *Manorina melanocephala* and difficulties associated with dispersal. Biological conservation 80(2):161-167.

Combreau, O. and T. R. Smith. 1998. Release techniques and predation in the introduction of houbara bustards in Saudi Arabia. Biological Conservation 84:147–155.

Cristinacce, A., A. Ladkoo, R. Switzer, L. Jordan, V. Vencatasamy, F. de Ravel Koenig, C. Jones, and D. Bell. 2008. Captive breeding and rearing of critically endangered Mauritus fodies *Foudia rubra* for reintroduction. Zoo Biology: Published in affiliation with the American Zoo and Aquarium Association 27(4): 255-268.

Cushing, T. L., K. A. Schat, S. L. States, J. L. Grodio, P. H. O'Connell, and E. L. Buckles. 2011. Characterization of the host response in systemic isosporosis (atoxoplasmosis) in a colony of captive American goldfinches (Spinus tristis) and house sparrows (Passer domesticus). Veterinary Pathology 48(5): 985-992.

Cunninghame, F., R. Switzer, B. Parks, G. Young, A. Carrion, P. Medranda, and C. Sevilla. 2015. Conserving the critically endangered mangrove finch: head-starting to increase population size. Pages 151-157 in Galapagos Report 2013-2014. GNPD, GCREG, CDF, and GC. Puerto Ayora, Galapagos, Ecuador.

Dean, T. F. 2001. Non-breeding season ecology of Florida grasshopper sparrows and Bachman's sparrows in central Florida dry prairies. Thesis, University of Massachusetts Amherst, USA.

Dolnik, O. 2002. Some aspects of the biology and host–parasite interactions of Isospora spp. (Protozoa: Coccidiida) of passerine birds. PhD dissertation, Carl von Ossietzky University, Oldenburg.

Dolnik, O. V., V. R. Dolnik, and F. Bairlein. 2010. The effect of host foraging ecology on the prevalence and intensity of coccidian infection in wild passerine birds. Ardea 98(1): 97-104.

Ewen, J. G., D. P. Armstrong, R. Empson, S. Jack, T. Makan, K. McInnes, and M. Alley. 2012. Parasite management in translocations: lessons from a threatened New Zealand bird. Oryx 46(3): 446-456.

Faria, P. J., C. van Oosterhout, J. Cable. 2010. Optimal release strategies for captive-bred animals in reintroduction programs: experimental infections using guppy and a model organism. Biological Conservation 143: 35-41.

Fountain, K., C. Jeffs, S. Croft, J. Gregson, J. Lister, A. Evans, I. Carter, Y. M. Chang, and A. W. Sainsbury. 2017. The influence of risk factors associated with captive rearing on post-release survival in translocated cirl buntings Emberiza cirlus in the UK. Oryx 51(2): 332-338.

Giacomo, R., P. Stefania, T. Ennio, V. C. Giorgina, B. Giovanni, and R. Giacomo. 1997. Mortality in black siskins (Carduelis atrata) with systemic coccidiosis. Journal of Wildlife Diseases 33(1): 152-157.

Gill, H. and I. Paperna. 2008. Proliferative visceral Isospora (atoxoplasmosis) with morbid impact
on the Israeli sparrow Passer domesticus biblicus Hartert, 1904. Parasitology Research 103: 493-499.

Grant, P. R., and B. R. Grant. 2006. Evolution of character displacement in Darwin's finches. Science 313:224–226.

Greiner, E. C. 2008. Isospora, atoxoplasma, and sarcocystis. Pages 108-119 in Atkinson, C.T., N.J. Thomas, and D.B. Hunter, editors. Parasitic diseases of wild birds. Wiley-Blackford, Oxford.

Hamer, G. L., T .K. Anderson, G. E. Berry, A. P. Makohon-Moore, J. C. Crafton, J. D. Brawn, A. C. Dolinski, B. L. Krebs, M. O. Ruiz, P. M. Muzzall, and T. L. Goldberg. 2013. Prevalence of filarioid nematodes and trypanosomes in American robins and house sparrows, Chicago USA. International Journal for Parasitology: Parasites and Wildlife 2:42-49.

Hewett Ragheb, E. L., C. Mezebish, and B. Lohr. 2015. Probable interspecific song learning in a Florida grasshopper sparrow (*Ammodramus savannarum floridanus*). The Wilson Journal of Ornithology 127(2): 277-280.

Hoover, J. P., 2003. Decision rules for site fidelity in a migratory bird, the prothonotary warbler. Ecology 84(2): 416-430.

Jakob-Hoff, R. 2001. Disease risk assessment for translocation of kaki (black stilt), *Himantopus novaezelandiae*, from captivity to the wild. Doc Science Internal Series #16. New Zealand Department of Conservation.

Jakob-Hoff, R., C. Carraro, A. W. Sainsbury, J. Ewen, and S. Canessa. Editors. 2014. Regent honeyeater disease risk analysis. IUCN SSC Conservation Breeding Specialist Group: Apply Valley, MN.

Jeffs, C., M. Davies, I. Carter, J. Gregson, A. Sainsbury, and J. Lister. 2016. Reintroducing the cirl bunting to cornwall. British Birds 109: 374–388.

Jones, C. G., and D. V. Merton. 2012. A tale of two islands: the rescue and recovery of endemic birds in New Zealand and Mauritius. Pages 33-72 in Ewen, J.G., D.P. Armstrong, K.A. Parker, and P.J. Seddon, editors. Reintroduction biology: integrating science and management. Wiley-Blackford, Oxford.

Kalyanasundaram, A., K. R. Blanchard, C. Henry, M. Z. Brym, and R. J. Kendall. 2018. Phylogenetic analysis of eyeworm (Oxyspirura petrowi) in northern bobwhite (Colinus virginianus) based on the nuclear 18S rDNA and mitochondrial cytochrome oxidase 1 gene (COX1). Parasitology Open 4.

King, J.R. and Tschinkel, W.R., 2006. Experimental evidence that the introduced fire ant, Solenopsis invicta, does not competitively suppress co-occurring ants in a disturbed habitat. Journal of Animal Ecology, 75(6): 1370-1378.

Kemp, L., G. Norbury, R. Groenewegen, and S. Comer. 2015. The roles of trials and experiments in fauna reintroduction programs. Pages 73-89 in Armstrong, S. P., M. W. Hayward, D. Moro, and P. J. Seddon, editors. Advances in reintroduction biology of Australian and New Zealand fauna. CSIRO Publishing, Clayton South, Victoria, Australia.

Knight, A., J. G. Ewen, P. Brekke, and A. W. Santure. 2018. The Evolutionary Biology, Ecology and Epidemiology of Coccidia of Passerine Birds. Advances in parasitology 99:35–60.

Kock, R. A., M. H. Woodford, and P. B. Rossiter. 2010. Disease risks associated with the translocation of wildlife. Revue scientifique et technique-Office international des épizooties 29(2): 329-350.

Krochmal, A. R., T. C. Roth, and H. O'Malley. 2018. An empirical test of the role of learning in translocation. Animal Conservation 21(1): 36-44.

Kuehler, C., P. Harrity, A. Leiberman, and M. Kuhn. 1995. Reintroduction of hand-reared alala *Corvus hawaiiensis* in Hawaii. Oryx 29(4): 261-266.

Kuehler, C., A. Lieberman, P. Oesterle, T. Powers, M. Kuhn, J. Kuhn, J. Nelson, Snetsinger, T., Herrmann, C., P. Harrity, and E. Tweed. 2000. Development of restoration techniques for Hawaiian thrushes: collection of wild eggs, artificial incubation, hand-rearing, captive-breeding, and re-introduction to the wild. Zoo Biology 19(4): 263-277.

Laake, J. L. 2013. RMark: An R interface for analysis of capture-recapture data with MARK. AFSC Processed Rep 2013-01, 25p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., Seattle.

Lagios, E. L., K. F. Robbins, J. M. Lapierre, J. C. Steiner, and T. L. Imlay. 2014. Recruitment of juvenile, captive-reared eastern loggerhead shrikes *Lanius ludovicianus migrans* into the wild population in Canada. Oryx 49:321-328.

Lacy, R. C., J. D. Ballou, and L. P. Pollock. 2011. PMx: software package for demographic and genetic analysis and management of pedigreed populations. Methods in Ecology and Evolution 3(2): 433-437.

Leighton, F. A. 2002. Health risk assessment of the translocation of wild animals. Revue scientifique et technique-Office international des épizooties 21(1): 187-216.

Lieberman, A. A., and C. M. Kuehler. 2009. Captive propagation. Pages 448-469 in Pratt, T. K., C.T. Atkinson, P. C. Banko, J. D. Jacobi, and B. L. Woodworth, editors. Conservation biology of Hawaiian forest birds: implications for island avifauna. Yale University Press, New Haven, Connecticut, USA.

Lockwood, M. A., C. P. Griffin, M. E. Morrow, C. J. Randel, and N. J. Silvy. 2005. Survival, movements, and reproduction of released captive-reared Attwater's prairie-chicken. Journal of Wildlife Management 69:1251–1258.

McGill, I., Feltrer, Y., & Jeffs, C. 2010. Isosporoid coccidiosis in translocated cirl. Veterinary Record, 167, 656-660.

Menkhorst, P., B. Quin, K. Cartright, and I. Smales 2010. Using captive bred helmeted honeyeaters to establish a new population and supplement an existing population, Victoria, Australia. Pages 165-170 in P. S. Soorae, editor. Global Reintroduction Perspectives: 2010. Additional Case Studies From Around the Globe. Gland, Switzerland: IUCN/SSC.

Middleton, A. L. A. and R. J. Julian. 1983. Lymphoproliferative disease in the American goldfinch, Carduelis tristis. Journal of Wildlife Diseases 19(3): 280-285.

Mihoub, J. B., A. Robert, P. Le Gouar, and F. Sarrazin. 2011. Post-release dispersal in animal translocations: social attraction and the “vacuum effect”. PLoS One, 6(12), e27453

Mohr, F., M. Betson, and B. Quintard. 2017. Investigation of the presence of Atoxoplasma spp. in blue-crowned laughingthrush (Dryonastes courtoisi) adults and neonates. Journal of Zoo and Wildlife Medicine 48(1): 1-6.

Myers, S. A., J. R. Millam, T. E. Roudybush, and C. R. Grau. 1988. Reproductive success of hand-reared vs. parent-reared cockatiels (*Nymphicus hollandicus*). The Auk 105:536–542.

Nichols, R. K., J. Steiner, L. G. Woolaver, E. Williams, A. A. Chabot, and K. Tuininga. 2010. Conservation initiatives for an endangered migratory passerine: field propagation and release. Oryx 44(2): 171-177.

Pap, P. L., C.I. Vágási, G.Á. Czirják, A. Titilincu, A. Pintea, G. Osváth, A. Fülöp, A. and Z. Barta. 2011. The effect of coccidians on the condition and immune profile of molting house sparrows (Passer domesticus). The Auk 128(2): 330-339.

Parker, B. B. and D.W. Duszynski. 1986. Coccidiosis of sandhill cranes (*Grus canadensis*) wintering in New Mexico. Journal of Wildlife Diseases 22:25-35.

Pizarro Muñoz, A., M. Kéry, P.V. Martins, and G. Ferraz. 2018. Age effects of Amazon forest birds and the latitudinal gradient in bird survival. The Auk 135:299-313.

Powell, L. A. and L. L. Frasch. 2000. Can nest predation and predator type explain variation in dispersal of adult birds during the breeding season? Behavioral Ecology 11(4): 437-443.

Prosser, S.W., M.G. Velarde-Aguilar, V. Leon-Regagnon, and P.D. Hebert. 2013. Advancing nematode barcoding: a primer cocktail for the cytochrome c oxidase subunit I gene from vertebrate parasitic nematodes. Molecular Ecology Resources 13(6):1108–1115.

Sainsbury, A. W. 2015. Mitigating the risk from disease while conserving parasites in future ecosystems: case studies from cirl buntings and corncrakes. Page 11 in Proceedings of Health and Disease in Translocated Wild Animals: Abstracts & Posters. Zoological Society of London Symposium, 14-15 May.

Sainsbury, A. W., and R. J. Vaughan-Higgins. 2012. Analyzing disease risks associated with translocations. Conservation biology: the Journal of the Society for Conservation Biology 26:442–452.

Sangster C., and Vogelnest. 2016. Plains-wanderer (Pedionomus torquatus) conservation breeding programme disease risk assessment. Internal Report.

Seddon, P. J., C. J. Griffiths, P. S. Soorae, and D.P. Armstrong. 2014. Reversing defaunation: restoring species in a changing world. Science 345:406-412.

Serna, H., A. Pocknell, A. W. Sainsbury, G. Peniche, D. P. Blake, and K. M. Beckmann. 2018. Eimeria spp. in captive-reared corncrakes (Crex crex): results of a GeneScan assay consistent with high prevalence of infection and extra-intestinal life stages. Avian Pathology 47:375–383.

Small, D. M., P. J. Blank, and B. Lohr. 2015. Habitat use and movement patterns by dependent and independent juvenile grasshopper sparrows during the post-fledging period. Journal of Field Ornithology 86:17-26.

Snyder, N. F., S. R. Derrickson, S. R. Beissinger, J. W. Wiley, T. B. Smith, W. D. Toone, and B. Miller. 1996. Limitations of captive breeding in endangered species recovery. Conservation Biology 10(2): 338-348.

Steiner, J., A. A. Chabot, T. Imlay, J. L. Savard, and B. J. M. Stutchbury. 2013. Field propagation and release of migratory Eastern loggerhead shrike to supplement wild populations in Ontario, Canada. Pages 80-84 in P. S. Soorae, editor. *Global Re-introduction Perspectives: 2013. Further case studies from around the globe*. Gland, Switzerland: IUCN/SSC Re-introduction Specialist Group and Abu Dhabi, UAE: Environment Agency-Abu Dhabi.

Streby, H.M., T.L. McAllister, S.M. Peterson, G.R. Kramer, J.A. Lehman, and D.E. Anderson. 2015. Minimizing marker mass and handling time when attaching radio transmitters and geolocators to small songbirds. Condor 177:249–255.

Swaddle, J. P., and M. S. Witter. 1997. The effects of molt on the flight performance, body mass, and behavior of European starlings (*Sturnus vulgaris*): an experimental approach. Canadian Journal of Zoology 75(7): 1135-1146.

Swayne, D. E., D. Getzy, R. D. Slemons, C. Bocetti, and L. Kramer. 1991. Coccidiosis as a cause of transmural lymphocytic enteritis and mortality in captive Nashville warblers (Vermivora ruficapilla). Journal of Wildlife Diseases 27:615–620.

Switzer, R., A. Lieberman, J. Nelson, and L. Crampton. 2013. Augmentation of the Puaiohi population through captive propagation and release on the Alakai Plateau, Kauai, Hawaii, USA. Pages 74-79 in P. S. Soorae, editor. Global re-introduction perspectives: 2013. Further case-studies from around the globe. IUCN/SSC Re-introduction Specialist Group, Gland, Switzerland.

Tavares da Silva, L.B., J.L. Crainey, T.R. Ribeiro da Silva, U.F. Suwa, A.C. Vicente, J. Fernandes de Medeiros, F.A. Pessoa, and S.L. Luz. 2017. Molecular verification of the New World Mansonella perstans parasitemias. Emerging Infectious Diseases 23:545–547.

Tweed, E. J., J. F. Foster, B. L. Woodworth, P. Oesterle, C. Kuehler, A. A. Lieberman, A. T. Powers, K. Whitaker, W. B. Monahan, J. Kellerman, T. Telfer. 2003. Survival, dispersal, and home-range establishment of reintroduced captive-bred puaiohi, *Myadestes palmeri*. Biological Conservation 11: 1-9.

U.S. Fish and Wildlife Service (Service). 1999. South Florida multi-species recovery plan. U.S. Fish and Wildlife Service, Atlanta, Georgia.

VanderWerf, E. A., L. H. Crampton, J. S. Diegmann, C. T. Atkinson, and D. L. Leonard. 2014. Survival estimates of wild and captive-bred released Puaiohi, an endangered Hawaiian thrush. The Condor 116(4): 609-618.

Vega Rivera, J. H., W. J. McShea, J. H. Rappole, and C. A. Haas. 1999. Postbreeding movements and habitat use of adult wood thrushes in Northern Virginia. The Auk 116(2): 458-466.

Wallace, M.P., 1994. Control of behavioral development in the context of reintroduction programs for birds. Zoo Biology 13(5): 491-499.