Avian Restoration in the Prairie-Oak Ecosystem: A Reintroduction Case Study of Western Bluebirds to San Juan Island, Washington

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Abstract

Avian reintroductions are an important conservation tool, but landbird reintroductions are substantially underrepresented compared to other avian taxa, which hinders progress in improving the value and efficacy of landbird reintroductions. We document an ongoing reintroduction of Western bluebirds (*Sialis mexicana*) to their historic range in the prairie-oak ecosystem on San Juan Island, Washington. Further, we assess the success of preliminary reintroductions and discuss the feasibility of further landbird reintroductions in this threatened ecosystem in the Pacific Northwest. We released 80 adults and 26 juveniles from 2007 to 2010 using a variety of soft-release techniques, and we collected demographic data on the reintroduced population. The program achieved preliminary criteria of success: individuals were safely translocated to the release site, and released individuals established breeding territories; both translocated individuals and their offspring reproduced successfully; and the reintroduced population grew each year. Results reinforced the use of large aviaries and two to three week holding periods for reintroductions of the genus *Sialia*, and also showed, for the first time, that the reintroduction of a migratory landbird can be effective. Besides contributing to bird conservation, the reintroduction generated tangible accomplishments towards conservation of prairie-oak habitats through education and habitat protection. Reintroductions of Western bluebirds to former parts of their range and of slender-billed white-breasted nuthatch to south Puget Sound should be considered practical options for future avian conservation efforts in the prairie-oak ecosystem.

Introduction

Reintroductions are an important conservation tool for restoring extirpated bird species to former areas of their historic range (Scott and Carpenter 1987, Griffith et al. 1989). Most reintroductions seek to enhance the long-term survival of a species, restore native biodiversity, increase conservation awareness, or some combination of these goals, through the establishment of a viable, self-sustaining population (IUCN 1995). Conservation practitioners turn to reintroductions when the factors that led to the species' extirpation have been eliminated or reduced, yet natural recolonization fails, presumably because of a species' poor dispersal ability or the presence of a physical barrier (e.g., urban development). The number of documented reintroductions has increased substantially since the 1990s, resulting in a better understanding of the factors associated with successful reintroductions (Seddon et al. 2007). However, landbird reintroductions have been substantially underrepresented, with raptor and game bird reintroductions proportionally more common (Seddon et al. 2005). The lack of case studies hinders progress in improving the value and efficacy of landbird reintroduction as a conservation tool at local and landscape scales. For example, we are unaware of any case studies that detail the translocation of a migratory landbird species, and therefore conservation practitioners or funding agencies may be reluctant to initiate such a project without examples that such a strategy would be effective.

In this paper, we address the lack of case studies on landbird reintroductions by reporting on an ongoing effort to reintroduce Western bluebirds (*Sialis mexicana*) in the prairie-oak ecosystem of the Pacific Northwest. Many landbird species, including the Western bluebird, have been negatively affected by the loss, fragmentation, and degradation of prairie-oak habitats following Euro-American settlement (Chappell et al. 2001, Altman 2011). In addition to the bluebird, the slender-billed white-breasted nuthatch (*Sitta carolinensis aculeata*), Lewis's woodpecker (*Melanerpes lewis*), and streaked horned lark (*Eremophila alpestris strigata*) have exhibited range contractions and local extirpations (Altman 2011). Over the last decade, habitat management and restoration projects and increased statutory and regulatory protection (WDFW 2005) have increased the extent and quality of prairie-oak habitats in many places, but none of the above listed species have returned to portions of their former range.

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The renewed interest and success of ongoing habitat restoration and conservation efforts led us to consider the timeliness of reintroducing Western bluebirds to San Juan Island, a site where they were formerly considered common but have been extirpated since 1964 (Lewis and Sharpe 1987). Without assistance the likelihood of bluebirds reestablishing a population on San Juan Island appeared low. The long distance (165 km) and large area of unsuitable habitat (i.e., urban Seattle and Puget Sound) between San Juan Island and the closest source population in south Puget Sound apparently hindered dispersal, as there was no evidence of successful colonization in the three decades since the species was extirpated. However, a pre-project assessment indicated that sufficient habitat was available in north Puget Sound, centered on San Juan Island, to support a bluebird population. In addition, local conservation organizations (e.g., San Juan Preservation Trust, San Juan County Audubon Society) promoted the protection and restoration of the prairie-oak ecosystem, ensuring that habitat would be available in the future, and encouraged the placement of nest boxes in appropriate habitat. Nest boxes played a critical role in the recovery of Western bluebird populations in the Willamette Valley in Oregon (e.g., Keyser et al. 2004) and in south Puget Sound (Jim Lynch, Department of Defense, personal communication). The recent successful establishment of a non-migratory population of Eastern bluebirds in Florida through reintroduction offered transferable methodologies suitable for a reintroduction of Western bluebirds (Slater 2001, Lloyd et al. 2009). Thus, given a reasonably high likelihood of success and given the difficulty that bluebirds had in reestablishing a population, we initiated reintroductions of Western bluebirds to San Juan Island in 2007. We had two main goals: first, to establish a viable, self-sustaining population of Western bluebirds, and second, to use the reintroduction as a public-outreach effort aimed at advancing the conservation of prairie-oak habitats.

The specific objectives of this paper are to: 1) document reintroduction methods; 2) assess preliminary reintroduction success; and 3) discuss the viability of reintroductions to restore other extirpated species in prairie-oak habitats of the Pacific Northwest. To our knowledge, this is the first reintroduction of Western bluebirds and the first reintroduction of a migratory landbird species in North America. Results from this assessment will provide another case study of the reintroduction of a landbird species and will contribute to our general knowledge of the factors associated with reintroduction success, and therefore may help guide future reintroductions.

Study Area

San Juan Island is the second-largest of the San Juan Islands with a land area of 142.6 km^2 and is located 30 km off the northwest Washington coast in Puget Sound (48° 32′ N, 123° 05′ W; Figure 1). The San Juan Islands receive less rainfall than elsewhere in western Washington due to their position in the rain shadow of mountains on the Olympic peninsula and Vancouver Island; mean annual precipitation is 51 cm (Western Regional Climate Center 2010). The terrain varies from rocky, undulating hills reaching 329 m in elevation to narrow lowland valleys to rocky shorelines and beaches. Vegetation communities are diverse, varying with slope, aspect, and elevation. Most upland forests are dominated by a single coniferous species, Douglas-fir (*Pseudotsuga menziesii*), with scattered Western hemlock (*Tsuga heterophylla*) and Western redcedar (*Thuja plicata*), but oak (*Quercus garryana*) and grassland communities occur on most southwest-facing slopes (e.g., American Camp, Mt. Young). Agriculture and residential developments dominate most of the lowland valleys. Historically, these areas were characterized by open oak and prairie habitats intermixed with wetlands; scattered oaks still remain, especially on rocky outcrops and valley ridges. San Juan Valley was the largest lowland area (~ 500 ha), and prior to settlement was called "Oak Prairie" due to the groves of oaks that covered it (Custer 1859). We focused pre-release management efforts (nest boxes, landowner contacts) in lowland areas with remnant patches of oaks because historic records indicate that is where bluebirds occurred (Miller et al. 1935, Bakus 1965, Lewis and Sharpe 1987). During the study, we placed > 400 nestboxes in appropriate habitat on San Juan Island.

Methods

Study Species

A non-excavating cavity nester, the bluebird breeds in a variety of open habitats where nest cavities, low perches, and an open understory are present (Szaro 1976, Germaine and Germaine 2002). In the Pacific Northwest, the bluebird is considered a short-distance migrant (Guinan et al. 2008). The Western bluebird was extirpated from the San Juan Islands archipelago, Whidbey Island, and adjacent mainland sites (e.g., Olympic peninsula, Whatcom county) during the mid-1900s (Lewis and Sharpe 1987, Buchanan 2005) and was last observed on Vancouver Island, British Columbia in 1995 (Campbell et al. 1997). Because the species

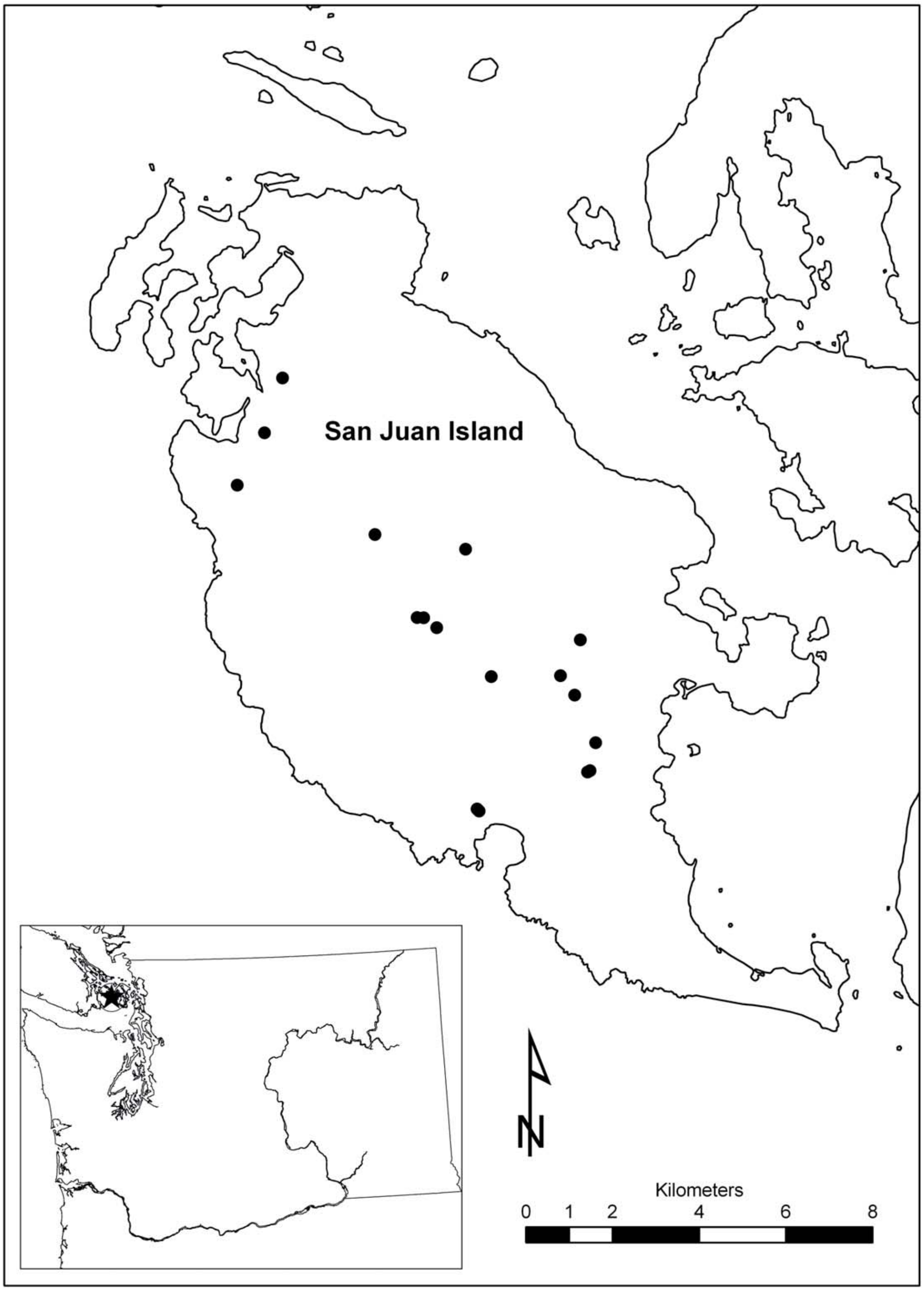

Figure 1. Map of San Juan Island, Washington showing locations of Western bluebird releases conducted from 2007 to 2010.

occupies a broad array of open habitats, the primary cause of their decline was apparently the loss of a critical habitat element, nesting cavities. Nest cavities were eliminated by the felling of large oak trees, in which cavities were most abundant (Gumtow-Farrior 1991), and management practices that removed snags. The arrival of the European starling (*Sturnus vulgaris*) to Washington in the mid-1950s likely exacerbated the decreasing availability of nest cavities (Herlugson 1978, Buchanan 2005). Currently, its northernmost population occurs in south Puget Sound, centered on Joint Base Lewis-McChord military base, where the most extensive area of prairie-oak habitat remains in the Puget lowlands (Chappell et al. 2001).

Translocations

We translocated bluebirds to release sites on San Juan Island in each breeding season (March – June) from 2007 to 2010 (Figure 1). We used three translocation strategies. First, most birds were captured as they established breeding territories and were moved as pairs. Second, we moved a few bluebird pairs with their nestlings towards the end of the breeding season. Third, in 2010 we translocated a few single females, captured either as floaters or removed from an established territory, because we observed a higher ratio of males to females in the reintroduced population. Bluebirds were captured using playbacks and mist-nets positioned next to nest boxes where individuals had exhibited breeding behavior. Most individuals were captured from the population on Joint Base Lewis-McChord military base (47° 01′ N, 122° 37′ W), 165 km from the release site, because of its proximity and large size. In 2010, we captured two pairs from a population near Corvallis, Oregon (44° 39′ N, 123° 14′ W), 450 km from the release site, to increase genetic diversity of the founder population. All translocated individuals were banded with a unique combination of a single aluminum U.S. Fish and Wildlife Service band and color-bands. Birds were transported to San Juan Island in a small (0.5 m x 0.5 m x 0.5 m) bird cage, supplied with perches and food (mealworms), via vehicle or plane. During transport, the cage was covered with a lightweight cloth to minimize stress by reducing the amount of light into the cage, yet allowing air circulation (Bocetti 1994). Translocated nestlings were not placed in cages so they could be fed every 30 min.

Initial releases were conducted in the San Juan Valley, primarily on private land. Release sites were selected based on the presence of suitable habitat (e.g., proximity to oaks, appropriate foraging habitat), the willingness of landowners to host an aviary and place nest boxes on their property, and, upon establishment, the proximity of bluebird territories. As territories became established, we also released individuals outside of the San Juan Valley in open habitats where an oak component was present (e.g., Cady Mountain, Beaverton Valley). Release sites for single females were selected based on the presence of a single territorial male.

Bluebirds were placed in outdoor aviaries at the release site. Aviaries were constructed with plywood and hardware cloth, which allowed for open views of the surrounding area, yet provided protection from the sun, rain, and wind. A one-meter skirt of hardware cloth was placed on the ground along the outside of the aviary to deter entry by predators. In each aviary, various-sized branches were positioned to provide multiple perch choices and a nest box was provided for roosting. If nestlings were translocated, they were placed in an artificial nest in the nest box with the top removed so adults would quickly observe begging, stimulating them to feed. Food (mealworms and crickets) and water were provided ad libitum.

In 2007, bluebird pairs were placed in 1 x 1 x 2 m (small) aviaries and held for three days prior to release. Thereafter we placed pairs in 2 x 2 x 2 m (large) aviaries and held birds until we observed evidence of nest-building or other breeding behavior, unless no activity was seen after three weeks, in which case they were released at the end of the three week period. We placed all pairs with nestlings in large aviaries and released the family group after the young had fledged and were capable of sustained flight (≥ seven days). We used small aviaries and a three day holding period for single females in 2010. Upon release, we monitored individuals if they remained near the release site, but did not chase individuals if they flew out of sight. We then searched the release site and adjacent areas of suitable habitat daily for at least one week or until the birds were located and established a territory. If individuals were not found after this time, we searched for birds as part of our regular systematic searches. We also established a bluebird hotline, providing a means for private landowners to report bluebird sightings.

Monitoring

We collected data on the number of released individuals that established a territory, reproduction, and population size of Western bluebirds on San Juan Island in each of four breeding seasons (March-July) from 2007 to 2010. We searched for translocated birds and breeding territories by conducting systematic playback surveys at release sites in appropriate habitat and in areas where bluebird sightings were reported by landowners. In 2007, we conducted three systematic island-wide surveys using volunteers; volunteers also conducted weekly roadside surveys in areas assigned as high quality habitat. In subsequent years, we initiated surveys in mid-March, when individuals began establishing territories, and continued surveys throughout the breeding season. Upon the location of a territory, we identified individuals, checked nest boxes, and searched for evidence of breeding behavior (e.g., mate feeding, nest-building). Unmarked individuals were captured and banded with USFWS and color bands. We visited territories every three to five days until evidence of nesting was detected, and thereafter monitored nest status every one to three days until nestlings fledged or the nest failed. Nestlings were banded when 10 to 16 days old.

In the latter half of the 2008 breeding season, we began providing supplemental food (mealworms) to birds on established breeding territories. By feeding birds on established territories we hoped to accelerate population growth via improved fecundity and survival, thereby improving the likelihood of population establishment and persistence. In 2008, supplemental food was provided only during periods of cool (< 16 °C), windy, and rainy weather, conditions often associated with nest failure (Herlugson 1980). In subsequent years, we expanded supplemental feeding to also include the period from hatching until one to three weeks after fledging, regardless of weather conditions. Supplemental food was typically provided in the morning (0600 to 1100), but was given in the evening during inclement weather, and it amounted to about 20 mealworms per individual in the territory.

We considered a nest successful if it fledged ≥ one nestling. If eggs or young disappeared before the anticipated time of fledging (< 18 days old), we assumed the nest failed and we searched the immediate vicinity to determine cause of nest failure. Regardless of whether a nest failed or fledged young, we followed the pair in subsequent weeks to see if they renested.

We indexed the size of the adult population in each year of the study by counting the number of territorial and non-territorial adults found during our systematic monitoring surveys over the course of the breeding season. While we believe few individuals escaped detection, this index should be viewed as a minimum estimate of population size, as some unknown number of individuals was likely missed.

We evaluated preliminary reintroduction success by considering three criteria. First, released individuals were translocated safely and established territories; second, released individuals and their offspring bred successfully; and third, population size increased annually.

Results

Translocation Success

We translocated 81 adults (66 as pairs, 12 as pairs with nestlings, 3 single females) and 27 nestlings and placed them in aviaries during the 2007-2010 breeding seasons. One hundred six birds were safely translocated and released as healthy individuals. The only exceptions included one adult female and one juvenile that died in their aviary of unknown causes, following the escape of the adult male.

TABLE 1. Number of Western bluebirds released on San Juan Island, Washington from 2007 to 2010 and their fate.

	2007	2008	2009	2010
Adults released as pair	16	16	18	16
Established territory	2	10	6	8
Returned to capture site	6	3	5	*[a]
Disappeared	8	3	7	8
Single females				3
Established territory				2
Disappeared				1
Adults released with nestlings		3	4	4
Established territory		0	2	*
Disappeared		3	2	*
Nestlings released		8	10	8
Established territory		1	2	*
Disappeared		7	8	*

[a] Fate of individuals will not be determined until after 2010.

For adults released as pairs, 26 (40%) established territories, 14 (20%) returned to the donor site, and 26 (40%) were not observed again (Table 1). In 2007, when paired adults were placed in small aviaries and held for three days, only 13% were subsequently found on a breeding territory. In comparison, when paired adults were placed in large aviaries and held for ≥ one week, 49%, on average, were found on a breeding territory in 2008 to 2010. Adults translocated as pairs maintained their pair bonds, except for three pairs in 2010; in all three cases the female paired with a resident male, while none of the three males were ever observed on a territory. Two of seven (29%) adults translocated with nestlings in 2008 and 2009 established a territory. Adults released with juveniles in 2010 remained on the island, but did not establish a territory; success of these translocations will not be determined until future breeding seasons. Three of 18 (17%) translocated nestlings have returned to San Juan Island to breed. Two of three (66%) translocated single females paired with resident males and established a territory.

Reproduction

We found evidence of successful breeding in each year of the project and both translocated individuals and their locally-produced offspring reproduced successfully. In 2007, we did not find a nest, but found one breeding pair with three juveniles. Overall, we monitored the fate of 43 nests on 6 breeding territories in 2008, 8 breeding territories in 2009, and 12 breeding territories in 2010. From 2008 to 2010, we banded 32, 44, and 84 nestlings, respectively, and nesting success, on average, was 73%. Of the 12 nest failures, at least five were attributed to predation. One nest failed when a house cat killed the breeding female. We believe house sparrows (*Passer domesticus*) were a significant predator based on evidence of broken eggs and the remains of adult females (three cases), both characteristics of house sparrow predation, and observations of sparrows near failed nests. Remaining failures were due to nest abandonment, a nest box falling, or unknown causes. Although the cause of failure at several nests was categorized as unknown, the disappearance of the breeding female coincident to nest failure, leads us to suspect that those females also may have been killed.

Overall, we found a total of 19 unique nest sites, all in nest boxes. Twelve of the nest boxes that bluebirds selected were located either in a grove of oaks or within 100 meters of oak trees, while the remaining seven were located on agricultural land or in a residential development. Twelve of the nest sites were in nestboxes located in the San Juan Valley.

Population Size

Annual counts of adults indicated that the population grew in each year of the project and that growth from 2008 to 2010 was, on average, 59% (Figure 2). Our population index reached 35 individuals in 2010. We found evidence of an increasing male bias in the population's sex ratio, locating two unpaired males in 2009 and seven unpaired males in 2010. Both the number of translocated adults and non-translocated adults increased in each year, with non-translocated adults comprising 37% of the population in 2010. In 2008, we found two second-year birds that were unbanded. We suspect at least one of these birds was an offspring from the single breeding pair in 2007. In 2010, we found 4 unbanded birds, 3 females and 1 male. These individuals represent either immigrants from other populations or offspring from territories on San Juan Island that were not found.

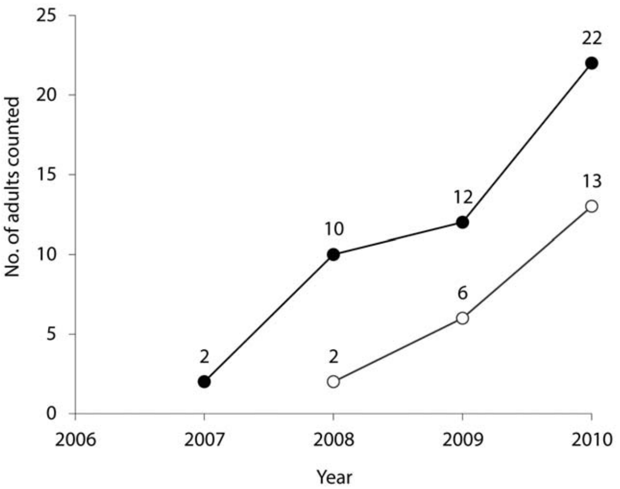

Figure 2. Number of translocated (dark circles) and non-translocated (clear circles) adult Western bluebirds documented on San Juan Island, Washington from 2007 to 2010.

Discussion

Results from this study indicate progress towards establishment of a reintroduced population of Western bluebirds on San Juan Island and represent an example of how landbird reintroductions can contribute to avian conservation. After four years of releases, the reintroduction program met our three criteria of preliminary reintroduction success. Individuals were safely translocated to the release site, and translocated individuals established breeding territories; both translocated individuals and their offspring reproduced successfully; and the reintroduced population exhibited annual population growth in each year of the project. Thus far, we have completed four years of translocations and released 80 adults. The goal of the project is to release > 90 adult bluebirds, a level found to be correlated with reintroduction success (Griffith et al. 1989). We expect to reach that number in one more year.

After adjusting our translocation methods in 2008 due to poor success in 2007, the proportion of adult bluebirds that established a territory following release (49%) fell within the range of other landbird reintroductions. For example, in Florida, 57% (n = 47) of released Eastern bluebirds established breeding territories (Slater 2001), and in Hawaii, 43% (n = 14) of puaiohi (*Myadestes palmeri*) established breeding territories (Tweed et al. 2003). We also documented 14 (25%) individuals returning 165 km to their capture site. Several authors have reported landbirds returning approximately 20 km to release sites (Clarke and Schedvin 1997, Fancy et al. 1997), but we found no studies reporting the number of returning individuals when the distance between capture and release sites was large (> 20 km; e.g., Armstrong 1995, Armstrong and Craig 1995). In Florida, only two (4%) Eastern bluebirds returned 35 km to the donor site (Slater 2001). The Western bluebird's status as a migratory species may explain their capacity to successfully return such a long distance, in comparison to a resident species such as the Eastern bluebird, which may not be as well-adapted to long-distance movements. If this pattern generally holds true in reintroductions of other migratory landbird species, the number of individuals necessary to establish a founder population may be larger than for non-migratory species because migrants could choose to return to their capture site.

Successful reproduction and a growing population are two demographic indicators that serve as key criteria of preliminary reintroduction success because they are associated with a self-sustaining population and indicate that habitat in the reintroduction site is suitable. The observed growth in population size of the reintroduced bluebird population on San Juan Island was due to an increasing number of both translocated birds and non-translocated birds. Growth in this latter category is especially important, as it indicates the return of island-born or immigrating individuals following migration. Overall, we found reproductive measures and return rates on San Juan Island (Slater and Altman, unpublished data) similar to values found in other Pacific Northwest populations of Western bluebirds (Keyser et al. 2004, Kozma and Kroll 2010). Mean bluebird productivity in northwestern Oregon was 3.3 ($\pm$ 1.9 SD) young nest^{-1} (Keyser et al. 2004) and in central Washington was 4.5 ($\pm$ 0.2 SE) young successful nest^{-1} (Kozma and Kroll 2010). Annual estimates of bluebird survival range from 23 to 27% for juveniles and average 48% and 63% for adult females and males, respectively (Keyser et al. 2004). Ultimately, long-term success of this reintroduction (i.e., following the cessation of translocations) will be evaluated with respect to population persistence, as measured by the population's ability to maintain a population growth rate $\geq$1.0 once carrying capacity has been reached (Armstrong and Seddon 2008).

Post-release monitoring is an important component of reintroductions because it allows practitioners to revise methodologies and reveals potential future challenges (Ostermann et al. 2001). During this project, we modified translocation methods on two occasions based on results from post-release monitoring. In 2007, we investigated a simpler and more cost-effective release strategy (small aviary, short holding time), rather than the more labor- and cost-intensive methods used in a reintroduction of Eastern bluebirds (Slater 2001). In 2007, our success rate was poor, and hence we reverted to using larger aviaries and a longer holding period, which improved our success rate. In 2010, we conducted releases of single females in response to an increasing number of unpaired males in the reintroduced population. This technique was effective, and we expect to continue the practice as needed.

Post-release monitoring has also revealed potential challenges to the long-term establishment and persistence of the reintroduced population of bluebirds, most notably an increasing male bias in the sex ratio of the population. This situation appears to be a product of two factors: low site fidelity by juvenile females and high mortality of adult females during the nesting period (Slater and Altman, unpublished data). We expect that in the long-term, low site fidelity by juvenile females should be offset by immigration of females from other populations, but with the absence of nearby populations to serve as a source, the likelihood of robust immigration is uncertain. Long-term monitoring will be needed to evaluate immigration patterns and population structure. On the other hand, we may be able to influence the rate of female mortality at nest sites due to predation through management, specifically placing nest boxes in safer locations. For example, nest boxes should not be placed in locations that might be attractive to house sparrows, an aggressive nest competitor, such as near houses or other structures. Educating private landowners on proper nest box placement will be an important management activity, especially following the cessation of translocations.

The success of the Western bluebird project has not been limited to bird conservation objectives. With the bluebird highlighted as a flagship emblem of prairie-oak conservation, we made significant achievements towards our second project goal: advancing the conservation of prairie-oak habitats by using the reintroduction as a public-outreach tool. Via tours, school programs, and traditional and social media outlets, we educated the public in bluebird ecology and prairie-oak conservation. These efforts have generated a community of bluebird enthusiasts and a changed culture of conservation on the San Juan Islands. As an example, the reintroduction project has stimulated the building and establishment of > 400 nest boxes and the protection, through acquisition and conservation easements, of several hundred hectares of habitat (Kathleen Foley, San Juan Preservation Trust, personal communication).

Even though long-term success of the Western bluebird reintroduction may not be determined for several years and threats to prairie-oak habitats persist, the achievements to date encourage a discussion of the use of reintroduction as a conservation strategy for other extirpated prairie-oak bird species. Such a discussion deserves attention because the large number of organizations and agencies (e.g., Cascadia Prairie-Oak Partnership, Garry Oak Recovery Team) dedicated to the conservation of prairie-oak habitats should ensure continued restoration and management into the future. In addition, climate change models predict the amount of prairie-oak habitats in the Pacific Northwest to increase (Schafer et al. 2001). With our knowledge of landbird reintroductions and the ecology of extirpated species, we can make some initial assessments on the feasibility of additional landbird reintroductions in the prairie-oak ecosystem. For example, translocation of bluebirds to other former parts of their range (Vancouver Island and Gulf Islands, British Columbia) appear defensible and should be considered a high priority, based on the success of the bluebird reintroduction on San Juan Island.

Like the bluebird, the slender-billed white-breasted nuthatch and Lewis's woodpecker are cavity nesters, and the availability and management of cavities will play a key role in their ability to be reintroduced to their former range (Altman 2006). While restoration in oaks can develop the physical structure that these species require, cavities are typically the last element to develop because oak growth is slow and cavities are most prevalent in older oaks. To address this problem, nest boxes can be used as an interim tool, if species accept them as surrogates for tree cavities. Both the slender-billed white-breasted nuthatch and Lewis's woodpecker are known to use nest boxes (Grubb and Pravosudov 2008; Diane Kook, East Cascade Audubon Society, personal communication). The experiences and partnerships gained through the bluebird reintroduction should enhance potential future reintroductions of nuthatches and Lewis's woodpecker, especially as all three species have similar habitat requirements and a common limiting factor, nesting cavities.

However, several other factors favor immediate consideration of the nuthatch as a suitable target of reintroduction, while further investigation into the feasibility of reintroducing Lewis's woodpecker is warranted. First, the degree of range contraction is substantially less for the nuthatch (i.e., south Puget Sound only) than for Lewis's woodpecker, implying that the woodpecker was more vulnerable than the nuthatch to the threats that likely caused their disappearance (e.g., habitat loss and fragmentation, cavity competition). One possible explanation for why the nuthatch was able to persist in areas where the woodpecker disappeared is that their small size enabled them to access a wider range of cavity sizes, which also allowed them to better avoid competition with other cavity-nesters, particularly exotic species (e.g., starling). Second, life history characteristics of the nuthatch should lead to higher pairing success in a reintroduction than those of the woodpecker. The nuthatch is considered a sedentary resident, a relatively poor flyer, and near-obligate to oak habitats in the region (Hagar and Stern 2001, Chappell 2005), compared to the woodpecker, which is migratory and occupies a wide range of habitat conditions, including riparian woodlands (Tobalske 1997). Third, the successful reintroduction of the brown-headed nuthatch (*Sitta pusilla*), a congener of the slender-billed, provides a basis of transferable methods for a reintroduction (Slater 2001, Lloyd et al. 2009). Finally, a feasibility assessment for the nuthatch has been completed and a large population in the Willamette Valley could serve as a source population (Slater and Altman 2006).

The streaked horned lark, on the other hand, does not nest in cavities and occupies a very different suite of habitats - sparsely vegetated sites such as spits, beaches, and prairies. In the Pacific Northwest, this subspecies is genetically unique, has suffered a fairly severe range contraction, and its range-wide population is made up of multiple, small, disjunct populations (Pearson and Altman 2005). The use of reintroduction as a conservation strategy has been proposed in some regions of their former range (north Puget Trough, south Puget Sound), but not all, due to the variety of threats that face this species (Pearson and Altman 2005). Although the partnerships generated in the Western bluebird project will prove beneficial to a streaked horned lark reintroduction, the very different life history of the species will likely require a different approach from the bluebird reintroduction, both in terms of methodology and conservation strategies aimed at protecting suitable habitat.

Conclusion

This paper provides another case study of a landbird reintroduction and improves our knowledge of the value and efficacy of the use of reintroduction as a conservation tool for landbirds. The Western bluebird reintroduction serves as the second replicate of translocations used for the genus *Sialia*, and results strengthen support for the effective use of soft-release techniques (e.g., 2-3 weeks in large aviaries). We also show for the first time that the reintroduction of a migratory landbird can be successful. In addition to advancing bird conservation, the bluebird reintroduction has also generated substantial achievements towards the conservation of the prairie-oak ecosystem, a common goal of reintroduction efforts (IUCN 1995). Finally, the results of this study provide optimism that additional reintroductions in the prairie-oak ecosystem could serve as an effective conservation strategy. Reintroduction efforts would appear to be most feasible for the Western bluebird in other parts of their former range and for the slender-billed white-breasted nuthatch in south Puget Sound.

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Literature Cited

Altman, B. 2006. Restoring populations of cavity-nesting oak-associated bird species. *In* D. Apostal and M. Sinclair (editors), Restoring the Pacific Northwest: the Art and Science of Ecological Restoration in Cascadia. Island Press, Washington, D.C. Pp. 358-359.

Altman, B. 2011. Historical and current distribution and populations of bird species in prairie-oak habitats of the Pacific Northwest. Northwest Science 85:194-222.

Armstrong, D. P. 1995. Effects of familiarity on the outcome of translocations, II. A test using New Zealand robins. Biological Conservation 71:281-288.

Armstrong, D. P., and J. L. Craig. 1995. Effects of familiarity on the outcome of translocations, I. A test using saddlebacks *Philesturnus carunculatus rufusater*. Biological Conservation 71:133-141.

Armstrong, D. P., and P. J. Seddon. 2008. Directions in reintroduction biology. Trends in Ecology and Evolution 23:20-25.

Bakus, G. J. 1965. Avifauna of the San Juan Island and Archipelago, Washington. Allan Hancock Foundation, University of Southern California, Los Angeles.

Bocetti, C. I. 1994. Techniques for prolonged confinement and transport of small insectivorous passerines. Journal of Field Ornithology 65:232-236.

Buchanan, J. B. 2005. Western bluebird (*Sialia mexicana*). *In* T. R. Wahl, W. Tweit, and S. G. Mlodinaw (editors), Birds of Washington: Status and Distribution. Oregon State University Press, Corvallis. Pp. 290-291.

Campbell, R. W., N. K. Dawe, I. McTaggert-Cowan, J. M. Cooper, G. W. Kaiser, M. C. McNall, and G. E. J. Smith. 1997. Birds of British Columbia, Volume 3. University of British Columbia Press, Vancouver.

Chappell, C. B. 2005. White-breasted nuthatch (*Sitta carolinensis*). *In* T. R. Wahl, W. Tweit, and S. G. Mlodinaw (editors), Birds of Washington: Status and Distribution. Oregon State University Press, Corvallis. Pp. 280-281.

Chappell, C. B., M. S. M. Gee, B. Stephens, R. Crawford, and S. Farone. 2001. Distribution and decline of native grasslands and oak woodlands in the Puget Lowland and Willamette Valley ecoregions, Washington. *In* S. H. Reichard, P. W. Dunwiddie, J. G. Gamon, A. R. Kruckeberg, and D. L. Salstrom (editors), Conservation of Washington's Native Plants and Ecosystems. Washington Native Plant Society, Seattle, WA. Pp. 124-139

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 80:161-167.

Custer, H. 1859. Report to the U.S. Boundary Commission of Henry Custer, Assistant, of a reconnaissance of San Juan Island, and the Saturna Group. Unpublished report on file at San Juan National Historic Park, American Camp Visitor's Center, Friday Harbor.

Fancy, S. G., T. J. Snetsinger, and J. D. Jacobi. 1997. Translocation of the palila, an endangered Hawaiian honeycreeper. Pacific Conservation Biology 3:39-46.

Germaine, H. L., and S. S. Germaine. 2002. Forest restoration treatment effects on the nesting success of Western bluebirds (*Sialia mexicana*). Restoration Ecology 10:362-367.

Griffith, B., J. M. Scott, J. W. Carpenter, and C. Reed. 1989. Translocation as a species conservation tool: status and strategy. Science 245:411-480.

Grubb, Jr., T.C., and V. V. Pravosudov. 2008. White-breasted nuthatch (*Sitta carolinensis*). *In* A. Poole (editor), The Birds of North America. Cornell Lab of Ornithology, Ithaca, NY.

Guinan, J. A., P. A. Gowaty, and E. K. Eltzroth. 2008. Western bluebird (*Sialia mexicana*). *In* A. Poole (editor), The Birds of North America. Cornell Lab of Ornithology, Ithaca, NY.

Gumtow-Farrior, D. L. 1991. Cavity resources in Oregon white oak and Douglas-fir stands in the mid-Willamette Valley, Oregon. M.S. Thesis. Oregon State University, Corvallis.

Hagar, J. C., and M. A. Stern. 2001. Avifauna in oak woodlands of the Willamette Valley, Oregon. Northwestern Naturalist 82:12-25.

Herlugson, C. J. 1978. Comments on the status and distribution of Western and mountain bluebirds in Washington. Western Birds 9:21-32.

Herlugson, C. J. 1980. Biology of sympatric populations of Western and Eastern bluebirds. Ph.D. Dissertation, Washington State University, Pullman.

International Union for Conservation of Nature (IUCN). 1995. Guidelines for reintroductions. Reintroduction Specialist Group, IUCN/Species Survival Commission, Gland, Switzerland.

Keyser, A. J., M. T. Keyser, and D. E. L. Promislow. 2004. Life-history variation and demography in Western bluebirds (*Sialia mexicana*) in Oregon. The Auk 121:118-133.

Kozma, J. M., and A. J. Kroll. 2010. Nest survival of Western bluebirds using tree cavities in managed ponderosa pine forests of central Washington. Condor 112:87-95.

Lewis, M. G., and F. S. Sharpe. 1987. Birding in the San Juan Islands. The Mountaineers Books, Seattle, WA.

Lloyd, J. D., G. L. Slater, and S. Snow. 2009. Demography of reintroduced Eastern bluebirds and brown-headed nuthatches. Journal of Wildlife Management 73:955-964.

Miller, R. C., E. D. Lumley, and F. S. Hall. 1935. Birds of the San Juan Islands, Washington. The Murrelet 16:51-65.

Ostermann, S. D., J. R. Deforge, and W. D. Edge. 2001. Captive breeding and reintroduction evaluation criteria: a case study of peninsular bighorn sheep. Conservation Biology 15:749-760.
Pearson, S. F., and B. Altman. 2005. Range-wide streaked horned lark (*Eremophila alpestris strigata*) assessment and preliminary conservation strategy. Washington Department of Fish and Wildlife, Olympia.
Schafer, S. L., P. J. Bartlein, and R. S. Thompson. 2001. Potential changes in the distributions of Western North America tree and shrub taxa under future climate scenarios. Ecosystems 4:200-215.
Scott, J. M., and J. W. Carpenter. 1987. Release of captive-reared or translocated endangered birds: what do we need to know? The Auk 104:544-545.
Seddon, P. J., D. P. Armstrong, and R. F. Maloney. 2007. Developing the science of reintroduction biology. Conservation Biology 21:303-312.
Seddon, P. J., P. S. Soorae, and F. Launay. 2005. Taxonomic bias in reintroduction projects. Animal Conservation 8:51-58.
Slater, G. L. 2001. Avian restoration in Everglades National Park (1997-2001): translocation methodology, population demography, and evaluating success, Final Report to Everglades National Park. Unpublished report on file at Ecostudies Institute, Mount Vernon, WA.
Slater, G. L., and B. Altman. 2006. Feasibility assessment for reintroducing the slender-billed white-breasted nuthatch to south Puget Sound, Washington. Unpublished report on file at Ecostudies Institute, Mount Vernon, WA.
Szaro, R. 1976. Population densities, habitat selection, and foliar use by birds of selected ponderosa pine forest areas in the Beaver Creek watershed. Ph.D. Dissertation, Northern Arizona University, Flagstaff.
Tobalske, B. W. 1997. Lewis's woodpecker (*Melanerpes lewis*). *In* A. Poole (editor), The Birds of North America. Cornell Lab of Ornithology, Ithaca, NY.
Tweed, E. J., J. T. Foster, B. L. Woodworth, P. Oesterle, C. Kuehler, A. A. Lieberman, A. T. Powers, K. Whitaker, W. B. Monahan, J. Kellerman, and T. Telfer. 2003. Survival, dispersal, and home-range establishment of reintroduced captive-bred puaiohi, *Myadestes palmeri*. Biological Conservation 111:1-9.
Washington Department of Fish and Wildlife (WDFW). 2005. Washington's comprehensive wildlife conservation strategy. Washington Department of Fish and Wildlife, Olympia.
Western Regional Climate Center. 2010. Climate summary for Friday Harbor (1998-2008). Western Regional Climate Center, Reno, NV. Available online at http://www.wrcc.dri.edu/summary/fhr.wa.html (accessed 1 September 2010).

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