San Juan Island Western Bluebird Reintroduction Program Annual Report 2013

Evaluating restoration progress during the two-year
post-translocation period (2012-2013)

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INTRODUCTION

Evaluating success is a challenging, yet necessary, component of any reintroduction project. The primary goal of a reintroduction project is to establish a self-sustaining population. However, this goal requires the achievement of two independent events: population establishment (short-term) and population persistence (long-term), each of which are associated with different temporal scales and often influenced by different factors (Armstrong and Seddon 2008). For example, short term success may be influenced by the translocation techniques used in the reintroduction, while long-term success will require demographic rates that, on average, yield a non-declining population growth rate. Demographic monitoring of the target populations during the translocation and post-translocation period is required for evaluating success; monitoring can also reveal management actions that improve long-term success.

American Bird Conservancy, Ecostudies Institute, San Juan Preservation Trust, and many other partners conducted a 5-year translocation and monitoring study of Western Bluebirds (*Sialia mexicana*) on San Juan Island, WA from 2007 to 2011 (Slater and Altman 2012). Over the 5-year period, 125 individuals, 99 adults and 35 juveniles, were translocated and released. The reintroduced population of Western Bluebirds met simple criteria of success: annual increases in population size and successful reproduction by translocated individuals and their offspring. In general, the population also met more rigorous criteria: reproduction and survival estimates in the reintroduced population were similar to those found in high-quality reference populations elsewhere in the Pacific Northwest. These results suggested success towards the short-term goal of establishing a reintroduced population of Western Bluebirds on San Juan Island. However, the population remained small and at risk, and continued demographic monitoring was recommended to evaluate population persistence and to identify management issues that may require attention.

Here, we report on two-years (2012-2013) of post-translocation demographic monitoring in the reintroduced population on San Juan Island to further evaluate long-term reintroduction success. In 2013, we also initiated nestbox monitoring in the donor population at Joint Base Lewis-McChord military base (JBLM) in south Puget Sound. Monitoring at JBLM was initiated for three reasons. First, we wanted to compare reproduction parameters in this large, and presumably non-declining, population with estimates from San Juan Island. In previous reports, we have compared reproduction estimates in the reintroduced population with other Pacific Northwest populations. However, these comparisons were not made over the same temporal scale, and thus could be biased because they don't account for annual variation due to environmental factors, such as weather. Second, we wanted to obtain an index of the size of the bluebird population on JBLM as a baseline for future monitoring. Third, we wanted to better evaluate the effect of removing birds for translocation. The bluebird population at JBLM has been used as a donor population for 7 years, with 8-20 adults removed per year. Although there has been no apparent impact on the population due to these removals, monitoring provides a quantitative measure to base future decisions on the use of this population as a source for birds. This is important as removals are expected to occur for 3 to 4 more years as part of the reintroduction program on Vancouver Island, BC.

METHODS

Study Area

We collected data on population size and demography from the reintroduced Western Bluebird population on San Juan Island, Washington State (48° 32' N, 123° 05' W) and the primary donor population at JBLM in south Puget Sound (47° 01' N, 122° 37' W). On San Juan Island, over 400 nestboxes have been placed on residential and agricultural lands, primarily in open habitats that were presumably suitable for bluebirds. At JBLM, a bluebird nestbox program was started in the early 1980s to help recover the bluebird population, which had declined to only a handful of birds. Today, more than 300 boxes have been established for bluebirds.

Population size- San Juan Island

On San Juan Island, we determined population size by counting uniquely-identified territorial and non-territorial adults through a combination of systematic and targeted playback surveys: on territories previously occupied by bluebirds, in unoccupied but apparently suitable habitat, and where bluebird sightings were reported by private landowners. Most nestboxes were placed on private lands. In general, we tried to survey all apparently suitable habitat on the island that could be observed from roads or walked following permission of landowners, acknowledging that some private lands were not surveyed due to their inaccessibility. During the translocation period, we employed a full-time technician for monitoring; in 2012 and 2013, monitoring was conducted by part-time technicians. Because monitoring was reduced, the amount of time searching for individuals during the post-translocation period was likely lower than during the translocation period and nests may not have been monitored as frequently. Monitoring began in early-April and continued until mid-August. Some volunteers assisted in searching for territories, supplemental feeding, and monitoring nests.

We consider our measure of adult population size an index rather than a census. Using counts of individuals detected over the breeding season likely underestimated true population size because some unknown number of individuals went undetected either because we failed to detect them in areas we surveyed or they occurred in areas we were unable to survey. While we believe few individuals escaped detection, this index should be viewed as a minimum estimate of population size.

Population size- JBLM

Monitoring was conducted at 267 boxes on JBLM training areas, the main cantonment area, McChord Air Field, and Tenalquot Prairie (owned by Center for Natural Land Management; CNLM) by a technician, various volunteers, and JBLM staff over the course of the breeding season (April to August). We assumed that occupied boxes would consist of independent breeding pairs because bluebird pairs rarely move to a new nestbox for their second or third brood, even after nest failure (Gary Slater, Ecostudies, pers. obs.). We considered the number of boxes occupied as an index of the minimum estimate of population size for the survey area because: 1) we did not monitor all boxes, 2) some bluebirds used natural cavities that were not monitored, and 3) we had no way to estimate the floater (non-breeding) population.

Reproduction – San Juan Island

Upon the location of a breeding territory, we identified color-marked individuals, searched for evidence of breeding behavior (e.g., mate feeding, nest-building), and checked nest boxes. Territories were visited about once a week until egg-laying was initiated; thereafter, nest checks were more frequent, particularly near transition dates so nestling age could be better estimated. Nestlings were banded at 10 to 16 days old.

When possible, we provided supplemental food (mealworms) to birds on established breeding territories during periods of cool (< 16° C), windy, and rainy weather, conditions often associated with nest failure (Herlugson 1980). However, feeding was not always consistent among territories. Supplemental feeding was conducted to increase population growth rate via improved fecundity and survival rates.

We determined nest initiation date (i.e., first date of incubation) and clutch size when possible. 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 for clues to the cause of nest failure. To allow for comparisons with other studies in the Pacific Northwest, we measured productivity in three ways: 1) the number of young fledged per nest, 2) the number of young fledged per successful nest, and 3) the number of young fledged per breeding female per year. We determined the number of young fledged from each nest as the count of nestlings of sufficient age and size that departed the nestbox and were not subsequently found on the ground. We continued to monitor territories through July to determine whether renesting occurred.

Reproduction – JBLM

In general, the 267 boxes were checked every 1-2 weeks early in the breeding season until nestboxes showed signs of occupancy by bluebirds. Thereafter, they were checked every 3-7 days, unless access was limited due to training activities. Boxes not occupied by bluebirds continued to be checked every 1-2 weeks. Except for nests on McChord air field, no supplemental food was provided to breeding pairs. We classified all nest outcomes as having either high or low confidence. If nests were not checked at least seven days prior to the estimated fledging date and there was no obvious evidence about the fate of the nest, the fate was considered successful, but was classified as having low confidence. The same reproduction parameters were estimated for the bluebird population on JBLM as on San Juan Island.

Survival – San Juan Island

Since 2007, we have attached colored leg bands to translocated individuals, unmarked individuals found on San Juan Island, and nestlings to estimate annual survival measures. In some years, we did not band all nestlings because some territories were not found until after the nest had fledged. We captured unbanded adults in mist nets, either by luring them to the net with recorded vocalizations, by setting the net in front of their nest box or, if they were harassing birds in an aviary, setting the net adjacent to the aviary.

We calculated annual return rates for age and sex groups in the reintroduced Western Bluebird population by calculating the number of individuals alive in breeding season t +1 divided by the number of individuals alive in breeding season t. This simple estimate does not produce error estimates or consider recapture probability (p; i.e., the probability of resighting an individual assuming it is present). Therefore, we complemented these results by estimating apparent survival and recapture probability using program MARK (version 5.1; White and Burnham 1999). In this study, local survival rate (ϕ) is the probability of a bird alive during breeding season t to return to the local site and be available for resighting during the breeding season t + 1. Apparent survival rate improves upon annual return rates because it takes into consideration recapture probability; however, mortality and dispersal are still confounded.

For the survival analyses, we considered any individual captured or resighted during the breeding season (March to July) as alive in that year. Survey data consisted of live recaptures for the period 2007 to 2013, thus for each individual we had an encounter history of 6 occasions. The dataset included successfully fledged nestlings that were banded, adults banded on San Juan Island, and translocated individuals that established a territory. Translocated birds (adults and juveniles) that were never observed or did not establish a breeding territory were censored because of bias associated with including transient individuals. For the same reason, we also removed several translocated individuals that established a territory on San Juan Island following release, but in the following year were observed nesting near their original capture site at the donor site. Finally, we censored the first survival interval for translocated juveniles that returned to San Juan Island to breed. For example, we treated a translocated juvenile banded in 2009 and resighted in 2010 and 2011 as if it had been marked as an adult for the first time in 2010 (i.e., they were not used in estimating juvenile survival). We considered only evaluating San Juan Island banded individuals in the analyses, but rejected this constraint as overly restrictive, particularly given the sparse dataset. Our objective was to investigate whether variation in apparent survival existed due to age (juvenile vs. adult), sex (male vs. female), or year, recognizing that our data were sparse.

To investigate the effects of age, sex, and year, we constructed 11 models that we believed represented reasonable descriptions of Western Bluebird survival based on our knowledge of the species' ecology. Our global, or most parameterized, model included annual variation in survival, ϕ, between adult males and females and constant survival for juvenile males and juvenile females and variation in recapture probability, *p*, between adults and juveniles. We first conducted a Goodness-of-Fit (GOF) test of our global model using the parametric bootstrap test implemented by program MARK. We ran 100 simulations to generate a distribution of deviance values against which to compare the deviance of the fully-parameterized model of the true data. Results indicated good fit ($P = 0.39$) of the global model, therefore we subsequently attempted to improve model fit by running the additional 10 nested models with reduced numbers of parameters. We estimated values of c (the variance inflation factor or level of overdispersion) in two ways. First, we computed c as the deviance of the true data model by the mean deviance of the simulated models. Second, we computed c as the observed c (model deviance divided by deviance degrees of freedom) divided by the mean of c obtained via simulations. We evaluated the degree of support for each model using Akaike's Information Criterion (AIC), as corrected for small sample size (AICc; Burnham and Andersen 1998). AIC methods measures how well a model fits, but incorporates a penalty for the addition of parameters, thus providing a satisfactory trade-off between bias and variance (Burnham and Anderson 1998). We obtained estimates of ϕ and *p* from the best fitting models.

Evaluating restoration progress on San Juan Island and data analysis

Since the project started, one approach we have used to evaluate reintroduction success is to compare demographic rates in the reintroduced population with rates from other populations in the Pacific Northwest. Similar rates between populations are considered an indication of success because we assume these large "reference" populations have a non-declining rate of population growth, the primary goal of the reintroduction project. To date, we have used estimates in ponderosa pine (*Pinus ponderosa*) forests on the east slope of the Cascade Mountains, WA (Kozma and Kroll 2010) and residential and agricultural habitats in the Willamette Valley, OR (Keyser et al. 2004) for comparison. One weakness in this approach was non-overlapping temporal scales. The Kozma and Kroll (2010) study was conducted from 2005 to 2008 and the Keyser et al. (2004) study was conducted from 1995 to 2001. We suspect vital rates to be strongly influenced by variation in environmental conditions. We addressed this problem in 2013, by conducting monitoring at JBLM allowing comparisons of reproduction measures between populations during the same time period. We also examined more recent data on reproduction in the Willamette Valley, OR from the Prescott Bluebird Recovery Project. No new data on survival rates were available, so the only comparisons made were between rates estimated on San Juan Island and by Keyser et al. (2004)

Values are reported as means + SD. We compared vital rates between populations using means and 95% confidence intervals. Analyses were conducted using R (version 2.12.0; R Development Core Team 2010) and SPSS.

RESULTS

San Juan Island - Population size

We found 32 adult bluebirds (15 male, 17 females) in 2012, the first breeding season after translocations were completed, then in 2013 the population declined by 56% to 14 adults (8 males, 6 females; Fig. 1). Only one translocated individual remained in the population in 2013. The number of non-translocated individuals in the population had increased annually from 2007 to 2012, but declined sharply in 2013. The first known dispersal event by a bluebird to San Juan Island was recorded in 2013, when a female originally banded at JBLM established a breeding territory. We also recorded the first known dispersal event by a San Juan Island-fledged individual to another population, when a 2012 female juvenile was found in the reintroduced population on Vancouver Island.

We examined the age structure of the reintroduced bluebird population over time to evaluate whether the severe decline observed in 2013 was due to normal mortality in an aging population or an extreme event that affected all age classes. The former scenario could occur if several years of poor nesting success, such as observed in 2011 and 2012, led to low recruitment and an aging population structure. We found the age structure of the reintroduced bluebird population did not show an aging population (Fig. 2). Rather, the most noticeable pattern was that no adults in age classes older than SY (first-season breeders) in 2012 returned in 2013.

San Juan Island - Reproduction

Concomitant to population size, the number of breeding territories also declined precipitously in 2013, dropping from 14 to 6 (57%), after remaining stable at 12 to 14 territories from 2010 to 2012 (Fig. 3). We monitored 19 nests on 14 breeding territories in 2012 and 10 nests on 6 breeding territories in 2013. Reproductive estimates for the reintroduced population from 2007-2013 are provided in Table 1. In 2012, 5 of 14 (36%) pairs on territories renested following the success or failure of a nest; in 2013, 3 of 6 (50%) pairs did so. These proportions were much lower than observed in 2010 (75%; 9 of 12) and 2011 (71%; 10 of 14).

Nest initiation and clutch size. Mean incubation date for first attempts in 2012 was 15 May + 19 days (N = 11), later than estimates from any previous year (Table 1). In 2013, mean incubation date was 30 April + 4 days (N = 6), earlier than the average over all years. Mean clutch size for first attempts was 5.3 + 1.0 (N = 11) in 2012 and 5.0 + 1.0 (N = 3) in 2013, nearly identical to the average observed during the period from 2008 to 2013.

Nesting success and productivity. We banded 47 nestlings in 2012 and 24 in 2013, down from 77 and 84 in 2011 and 2010, respectively. Nesting success was 53% (10 of 19) in 2012 and 60% (6 of 10) in 2013, continuing a period of below average success since 2011 (Table 1).

In 2012, the most common cause of nest failure was predation (*N* = 4). At two depredated nests, we found evidence (adults feathers scattered on ground) that the breeding female was killed. Based on scratches found on the boxes, the predator was presumed to be mammalian, most likely a raccoon (K. Foley, San Juan Preservation Trust, pers. comm.). The second most common cause of nest failure was abandonment (*N* = 3), with adults abandoning eggs in one case and young in the other two. In two cases, the breeding female disappeared following abandonment. We suspect that the cause of one nest failure was disease, because the breeding female and four of six young were dead inside the box. During banding several days previously, it was noted that the nest was very messy (saturated with feces due to absence of fecal sacs), a condition observed in previous years during periods of rainy, cold weather.

In contrast to 2012 and previous years, we found no evidence of predation in 2013. All four nest failures were due to abandonment. In two cases, females laid a single egg and then disappeared and were presumed dead. Although we observed no predation, in one case a bluebird pair was unable to secure a nest box due to House Sparrow occupation. Upon placing another nestbox nearby the pair immediately began nesting.

For all three productivity measures, the estimates in 2012 and 2013 were the lowest for any year in which monitoring occurred (Table 1). The mean number of young fledged from all nests, including unsuccessful nests, on San Juan Island was 2.2 (± 2.4, *N* = 19) in 2012 and 2.4 (± 2.5, *N* = 10) in 2013. The mean number of young fledged from only successful nests was 4.1 (± 1.6, *N* = 10) and 4.0 (± 1.8, *N* = 6), in 2012 and 2013, respectively. The number of young per breeding female was 2.6 (± 2.8, *N* = 16) in 2012 and 4.1 (± 4.5, *N* = 6) in 2013.

San Juan Island - Survival

During the period from 2007 to 2013, we banded 458 bluebirds, 139 (103 adults, 36 nestlings) that were translocated and released to San Juan Island and 319 (11 adults, 308 nestlings) on San Juan Island. The 24 nestlings banded in 2013 were not included in the survival analyses because they were present in only one annual period. After censoring individuals, we included the capture histories of 327 individuals in the survival analysis (Table 2).

The GOF test indicated our most parameterized model fit sufficiently (*P* = 0.39), enabling us to evaluate additional nested models with reduced numbers of parameters. Both estimates of c were 1.1 (model deviance/mean deviance of simulation and observed c/mean of c derived from simulations), indicating little overdispersion, therefore we did not adjust parameter estimates.

The top two models indicated apparent survival varied between juveniles and adults and that adult survival was time-dependent (Table 3). However, there also was also support (ΔAIC < 2.0) for a model with variation in survival between juvenile males and juvenile females.

Adult survival rates for the top three models, which were all similar, showed a steady decline with an exceptionally steep decline in 2012-2013 (Table 4). Annual adult survival rates for the best model were 2008-09 = 0.59, 2009-10 = 0.53, 2010-11 = 0.39, 2011-12 = 0.37, 2012-13 = 0.18 (Fig. 3). Annual survival rate for juvenile for the top two models ranged from 0.14 to 0.15 (Table 5). For the model that showed variation in juvenile survival (#3), juvenile male survival was 0.19 compared to 0.15 for juvenile females (Fig. 4).

Return rates, which do not incorporate detectability, were similar to modeled survival estimates (Table 6). However, return rate estimates for juveniles show substantial annual variation that is absent in the MARK models, presumably due to sparse data. In 2013, the return rate for juvenile males (0.05) was substantially lower than in any of the previous years (range = 0.14 to 0.35).

JBLM – Population size and Reproduction

Of the 267 nest boxes, the majority were located on numbered training areas (169), with McChord Airfield (65), main cantonment area (17), and Tenalquot Prairie (16) holding the remaining boxes (Table 7). We do not know the total number of nest boxes available to bluebirds on JBLM, but based on our knowledge of box locations, we suspect > 50 nest boxes were not monitored. We found 81 (30%) nestboxes were occupied by Western Bluebirds. This yields a minimum population index for the survey area of 162 individuals. However, this estimate does not include pairs translocated before monitoring began, pairs using nest boxes that were not monitored, pairs using natural cavities, or individual floaters, making the true population index for JBLM larger, perhaps substantially so. This estimate also does not include other breeding territories in the South Puget Sound area.

We found 126 bluebird nests and monitored the fate of 117 nests. At 3 nests, the bluebird pair and dependent young were trapped and translocated to Vancouver Island and at 6 nests fate was unable to be determined. We found 66 of 117 (55%) nests were successful, producing 295 bluebird juveniles (Table 8). Based on monitoring frequency, we had low confidence in determining fate at 18 nests, but removing these nests had a negligible effect on reproductive estimates (Table 8,9). For nests with high confidence, mean clutch size was 5.4 (1.1), mean incubation date was 13 May (11), and mean young per nest was 2.3 (2.4).

We found that the rate of territory re-occupancy by bluebirds after translocation was high (Table 10). All four territories where bluebird pairs or pairs with dependent young were removed in 2012 were reoccupied. At the eight territories where bluebirds were removed in 2013, 4 (50%) were re-occupied during the breeding season, including a nestbox that was translocated as late as 29 May (Table 10).

Evaluating restoration progress on San Juan Island and data analysis

Although productivity measures from the San Juan population during the last two years were the lowest on records, the overall estimates (from 2007 to 2013) do not differ significantly from published studies on bluebird populations in the Willamette Valley, OR (Keyser et al. 2004, Prescott Bluebird Recovery Project) or the east slope of the Cascade mountains in central Washington (Kozma and Kroll 2010; Table 11).

Reproductive measures did not differ significantly between the bluebird population at JBLM and San Juan Island (Table 11). This is a little surprising since bluebird pairs at nests on San Juan Island are given supplemental food, whereas nests at JBLM, except for the 7 nests at McChord, do not. Nest initiation date was nearly 2 weeks later at JBLM (13 May; SD = 11) than San Juan Island (30 April, SD = 4), although that pattern has been observed in previous years (Gary Slater, pers. obs.).

We found adult survival rates on San Juan Island varied annually, but not by sex, and Keyser et al. (2004) found survival rates only varied by sex, making direct comparisons difficult. Adult survival rates in 2010-11 and 2011-2012 on San Juan Island were significantly lower than estimates for males in the Willamette Valley, but not females (Figure 6). However, adult survival rates in 2012-13 on San Juan Island were significantly lower than rates for males and females in the Willamette Valley (Figure 6).

Keyser et al. (2004) did not find variation in survival by sex in juveniles (0.26; 95% CI: 0.22, 0.30). Juvenile survival rates were lower on San Juan Island than in the Willamette Valley, although only female juvenile survival (0.14; 95% CI: 0.09. 0.22) was significantly lower (Figure 7).

DISCUSSION

In the two years following the cessation of translocations in 2011 the size of the reintroduced population of Western Bluebirds on San Juan Island has declined substantially, threatening the success of the reintroduction effort. The population size is currently the same as it was during the 2nd year of translocations. Population declines correspond with the lowest reproduction and survival rates observed since the project was initiated, and based on reproduction estimates in 2013 we expect the population size to shrink further in 2014. On the positive side, overall reproduction estimates appear to be consistent with other Pacific Northwest populations, including JBLM, and we observed the first known movements between the reintroduced population and other populations in the region, showing the connectivity of local populations in the region. Still, the population of bluebirds on San Juan Island may be at a tipping point. We believe that emergency management actions, including additional translocations, are warranted and necessary to ensure the success of this reintroduction effort.

Emergency management actions are warranted because evidence suggests that the population decline was likely due to random environmental factors, which influenced reproduction and survival rates and led to negative population growth, rather than remnant deterministic factors that previously caused the species to disappear from the region. One factor that appears to have had a negative influence on reproduction rates from 2011 to 2013 were generally cold and wet conditions during each breeding season. Cold and wet conditions are a leading cause of nest failure in Western Bluebirds (Herlugson 1980) because they depress invertebrate abundance, the bluebird's primary food source, and decrease foraging efficiency at a time when adults need food the most to feed young and maintain thermoregulation. In 2011 and 2012, weather conditions were driven by back-to-back La Nina weather events (NOAA 2013), which typically produce cold and rainy conditions in the Pacific Northwest. The 2011 year was one of the wettest and coldest on record, especially in April and May (4^{th} wettest and coldest on record since 1891). The 2012 year was the 8^{th} wettest on record with the bluebird's nesting season marked by below average temperatures and above average precipitation. Although conditions in 2013 were not influenced by the ENSO cycle, a 2-week rain event in late May caused large-scale failure at both bluebird and swallow nests on San Juan Island. This pattern was also observed in the reintroduced population on Vancouver Island and the donor population at JBLM.

Although reproduction rates during the period from 2011 to 2013 were the lowest of any year in which the reintroduced population was monitored, values appear to be consistent with values from other populations in the Pacific Northwest when viewed over the same time period. Low nesting success by bluebirds was reported in the Willamette Valley, OR in 2011 and 2012 due to cold and wet breeding season conditions (Prescott Bluebird Recovery Project, Fall newsletters 2011, 2012). In 2013, nesting success (53%) and mean young per nest (2.3) at JBLM were similar to values observed on San Juan Island (nesting success = 60%; mean young per nest = 2.4). Additional monitoring in both reintroduced and reference populations will be needed to determine whether low reproduction rates recently observed on San Juan Island are due to a declining trend or the result of stochastic environmental factors; doing so will be a critical element in evaluating long-term success.

Low survival rates in recent years have likely had the biggest impact on population size in the reintroduced population. Annual adult survival rates in the reintroduced population have declined since 2010, with a particularly severe decline observed in 2012-2013. Although this declining trend is cause for concern, evidence again points to stochastic factors affecting this demographic rate. Survival analyses conducted prior to 2013 found annual adult survival rates averaged 0.45, but the 2013 analyses revealed annual variation in adult survival, with lower survival in 2010-11 and 2011-12 (range = 0.36 - 0.39) and an exceptionally steep decline in 2012-2013 (0.18). Lower survival rates in the previous years (2010-11, and 2011-12) could be related to La Nina conditions present in the region during that time period. As for the severe decline in 2012-2013, our examination of the age structure of the bluebird population over time indicated the decline was likely due to an extreme event that affected survival of all adult age classes, rather than normal mortality associated with an aging population following low recruitment (as might be seen after several years of poor reproduction). Data on juvenile survival reinforces this hypothesis as the annual return rate from 2012-2013 was the lowest observed since monitoring started in 2008. Continued monitoring will be critical to further evaluate factors affecting variation in bluebird survival and reintroduction success.

Management recommendations

Translocations should be conducted beginning in 2014 to reverse population declines. The population is expected to decline further in 2014 due to poor reproduction in 2013 and without augmentation the population faces possible extirpation. Funding and the availability of birds from source populations will determine the number of translocations that can be conducted in 2014. Current funding levels should support 2 or 3 translocation events. The JBLM population, which served as the primary source population for initial translocations to San Juan Island, now serves as the source for ongoing reintroductions on Vancouver Island and therefore birds are unlikely to be available from that population, even though it appears robust to removals. The Willamette Valley offers the next best option as a source for birds. This area was used for several translocations in 2008-2013 because the bluebird population is large and relatively close to San Juan Island.

With limited funding, we should use the most efficient translocation technique. To date, the most efficient technique has involved moving breeding pairs with dependent young in late May and early June. This method has a high success rate, allows young to imprint on the breeding area, and is early enough in the breeding season for adults to renest. This method may have a bigger impact on the donor population than moving pairs early in the breeding season because territories are more likely to be reoccupied earlier in the breeding season. However, the removal of only 2 or 3 pairs should not have a measurable impact on the donor population. We should also consider translocating single individuals, if adults lacking mates are observed on breeding territories. These individuals could perhaps be taken from the JBLM population, given its apparent resiliency to removals. Translocations should be continued annually until the population size increases to a level near its previous high, acknowledging funding will need to be raised for such efforts.

In addition to translocations, long-term monitoring and management appears necessary for the reintroduction project to be successful. Monitoring remains a critical component for evaluating reintroduction success and will be necessary until demographic data indicate the population is secure with low extinction risk. Information gained from monitoring also helps to identify limiting factors in the bluebird population and understand the consequences of management actions (e.g., predator management, supplemental feeding). As we better understand limiting factors and the outcomes through our monitoring, additional management recommendations are likely to come to light.

Management actions to date have focused on the goal of increasing population size as quickly as possible because population size is positively-correlated with population viability. Most management efforts have been aimed at increasing productivity by pairs because options for increasing survival of adults and juveniles are limited. Supplemental food has been provided to breeding pairs during periods of cold and wet weather and the nesting period from hatching to 1-2 weeks post fledging. While supplemental food may increase adult and juvenile survival, its largest impact appears to be on productivity through increasing the probability of renesting by adult females. Providing supplemental food should be continued where feasible, continuing the practice of placing supplemental food far from nests (>50 m) and not along the same fence line. Although only correlative, no nests were depredated in 2013 following changes in placement of supplemental food.

Most management has revolved around nestboxes, including where they are placed and the human activities that take place around them for monitoring. Nestboxes are typically placed in habitats believed to be suitable for bluebirds, with safety a key consideration. Safety is critical because the largest cause of both nest failure and adult female mortality during the breeding season is nest predation. Most predations events have been attributed to either House Sparrows or mammalian predators (cats, raccoons). Following several years of high predation a renewed emphasis was placed on modifying human activities around nests in 2013 to increase safety, including not creating dead end paths to nestboxes, using behavioral observations when possible to determine nest status, and providing supplemental food far from nests and not along the same fence line. In 2013, there were no predation events and no females killed at the nest site. Although there were fewer nests and reduced predation is only correlative, we need to remain vigilant with management aimed at keeping nestboxes safe.

One ongoing threat that will likely always be a problem requiring management is direct and indirect effects of House Sparrows. House Sparrows are nest predators and will kill adult bluebirds to gain access to a nestbox, but they also impact bluebirds through exploitative competition by denying access to nestboxes. For example, even though only six bluebird breeding pairs were found in 2013, one pair was apparently unable to renest following its first attempt because nestboxes in its territory were occupied by sparrows. Once a new nestbox was placed in the territory, the pair renested. Observations over the summer showed that the occupancy rate of nestboxes by House Sparrows has increased dramatically from previous years and that in many territories previously occupied by bluebirds the majority of boxes were occupied by sparrows (Gary Slater, pers. obs.). For example, at the Portland Fair Well site, which was previously occupied by bluebirds, nestboxes in the middle of the field far from structures were occupied by sparrows.

House Sparrow control will need to be a focus of management for the bluebird population to grow; without active management, we can expect bluebird pairs to have difficulty locating vacant nestboxes in high-quality habitat and face increasing nest predation rates. Management should focus on removing sparrow nests from boxes in high-quality habitat. Nestboxes should be checked across the island on a 1 to 2 week interval to ensure sparrow nests are unsuccessful. Removing nests during the incubation stage should be targeted because doing so will have a significant impact on reproductive output by sparrows, while not presenting the moral challenge of removing nests with nestlings. In areas believed to have low-quality habitat for bluebird, nestboxes should also be checked every 2 weeks, but additional management should be considered, such as removing the nestbox or placing an excluder over the entrance to allow only swallows (oval opening 3/4" in height and 1 ¾" in width) or smaller cavity-nesters (1" diameter for chickadees). Management options to be considered in the non-breeding season include plugging entrance holes of boxes until migratory birds, including bluebirds, arrive from migration. This may reduce the competitive advantage House Sparrows have being a resident species. Trapping and removing House Sparrows at feeders during the winter where sparrows have especially high densities should also be explored.

Although the population remains small, the project would benefit by employing a full-time technician, again acknowledging the need for funding to do so. In addition to monitoring responsibilities, a full-time technician could focus on management and outreach activities aimed at improving long-term reintroduction success and developing a framework for long-term monitoring and management of the population. The time needed to recover the bluebird population on San Juan Island to the size equal to when translocation were stopped in 2011 may take 2-4 years, even if reintroductions are continued for multiple years.

TABLES

Table 1. Reproductive estimates (+ S.D.) for Western Bluebird Population on San Juan Island, WA.

	2007	2008	2009	2010	2011	2012	2013	Total
Breeding territories	1	6	8	12	14	14	6	60
Monitored nests	0	9	10	24	25	19	10	97
Clutch size [a]		6 (0.0)	5.3 (1.1)	5.3 (0.75)	5.4 (0.52)	5.3 (1.0)	5.0 (1.0)	5.3 (0.8)
Nest initiation date [b]	-	-	2 May (7)	20 April (9)	7 May (9)	15 May (19)	30 April (4)	6 May (15)
Young banded	0	32	44	84	77	47	24	308
Successful nests	-	7	8	17	14	10	6	62
Nest success (%)	-	78%	80%	71%	56%	53%	60%	64%
Nestlings fledged[c]	3	31	42	84	76	41	24	301
No. young/nest	-	3.6 (2.6)	4.2 (2.4)	3.5 (2.5)	2.9 (2.7)	2.2 (2.4)	2.4 (2.5)	3.1 (2.5)
No. young/successful nest	-	4.6 (1.8)	5.3 (1.0)	4.9 (1.1)	5.2 (0.8)	4.1 (1.6)	4.0 (1.8)	4.8 (1.3)
No. young/breeding female	3	5.3 (3.2)	5.3 (4.2)	7.0 (4.2)	5.4 (3.8)	2.6 (2.8)	4.1 (4.5)	4.8 (3.9)

[a] First attempts only.
[b] Only of returning pairs; does not include nests from pairs that include a translocated individual in that year.
[c] Number of nestlings known to have fledged including those in which nests were not found.

Table 2. Summary of capture history by age, sex, and year for Western bluebird individual included in the survival analysis performed in Program Mark.

	2007	2008	2009	2010	2011	2012	2013	**TOTAL**
Adult								
Female	1	5	4	9	4	3		**26**
Male	1	4	5	7	2	0		**19**
Juveniles								
Female		13	17	41	35	23	11	**140**
Male		13	19	42	37	18	13	**142**
Total	**2**	**35**	**45**	**99**	**78**	**44**	**24**	**327**

Table 3. Candidate models explaining variation in apparent juvenile and adult survival (Φ) of Western Bluebirds and recapture probability (*p*) in the reintroduced Western bluebirds population on San Juan Island, WA, from 2007 to 2013.

Model	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par	Deviance
1: $\Phi age_{(juvenile(.)/adult(./time))}$, $p_{(.)}$	406.33	0.00	0.32	1.00	8	53.18
2: $\Phi age_{(juvenile(.)/adult(./time))}$, $p_{(age)}$	407.15	0.82	0.21	0.67	9	51.90
3: $\Phi age_{(juvenile(sex)/adult(./time))}$, $p_{(.)}$	407.96	1.62	0.14	0.44	9	52.70
4: $\Phi age_{(juvenile(sex)/adult(./time))}$, $p_{(age)}$	408.52	2.18	0.11	0.34	10	51.15
5: $\Phi age_{(juvenile(.)/adult(./.))}$, $p_{(.)}$	409.23	2.89	0.08	0.24	3	66.40
6: $\Phi age_{(juvenile(.)/adult(./.))}$, $p_{(age)}$	409.97	3.64	0.05	0.16	4	65.10
7: $\Phi age_{(juvenile(.)/adult(sex/.))}$, $p_{(.)}$	410.95	4.62	0.03	0.10	4	66.07
8: $\Phi age_{(juvenile(.)/adult(sex/.))}$, $p_{(age)}$	411.69	5.35	0.02	0.07	5	64.76
9: $\Phi age_{(juvenile(sex)/adult(sex/.))}$, $p_{(.)}$	411.99	5.66	0.02	0.06	5	65.06
10: $\Phi age_{(juvenile(sex)/adult(sex/.))}$, $p_{(age)}$	412.75	6.42	0.01	0.04	6	63.76
11: $\Phi age_{(juvenile(sex)/adult(sex/time))}$, $p_{(age)}$ [a]	419.24	12.91	0.00	0.00	16	48.98

[a] The global model included variation in age: juvenile survival by sex, but not time, adult survival by sex and time; and variation in recapture probability by age with time held constant.

Table 4. Adult survival estimates (+ 95% CI) for models with Delta $AIC_c \leq 2.0$.

Model	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
1	**	**0.59** (0.31-0.83)	**0.53** (0.33 -0.72)	**0.39** (0.25 – 0.56)	**0.37** (0.22 – 0.55)	**0.18** (0.13 – 0.25)
2	**	0.58 (0.30-0.81)	0.52 (0.32 -0.71)	0.38 (0.24 – 0.55)	0.36 (0.21 – 0.53)	0.18 (0.13 – 0.26)
3	**	0.45 (0.18-0.76)	0.60 (0.35 -0.80)	0.41 (0.25 – 0.59)	0.45 (0.29 – 0.62)	0.16 (0.07 – 0.34)

Table 5. Juvenile survival estimates (+ 95% CI) for models with Delta $AIC_c \leq 2.0$.

Model	Female	Male
1	**0.14** (0.09 – 0.22)	
2	0.15 (0.09 – 0.22)	
3	0.14 (0.09 – 0.22)	0.19 (0.13 -0.27)

Table 6. Return rates in the reintroduced Western Bluebird population on San Juan Island, WA from 2007 to 2013.

	Number of individuals alive		
	Time = *t*	Time = *t* +1	
2007-2008			
Adults	2	0	0.00
2008-2009			
Total adults	12	4	0.33
Adult males	6	1	0.17
Adult females	6	3	0.50
Total juveniles	30	4	0.13
Juvenile males	14	3	0.21
Juvenile females	13	1	0.08
2009-2010			
Total adults	17	10	0.59
Adult males	9	6	0.67
Adult females	8	4	0.50
Total juveniles	48	8	0.17
Juvenile males	23	8	0.35
Juvenile females	17	0	0.00
2010-2011			
Total adults	32	13	0.41
Adult males	19	8	0.42
Adult females	13	5	0.38
Total juveniles	84	14	0.17
Juvenile males	43	8	0.19
Juvenile females	41	6	0.15

	Number of individuals alive		
	Time = *t*	Time = *t* +1	
2011-2012			
Total adults	33	13	0.39
Adult males	17	8	0.47
Adult females	16	5	0.31
Total juveniles	82	15	0.18
Juvenile males	42	6	0.14
Juvenile females	38	9	0.24
2012-2013			
Total adults	30	5	0.17
Adult males	14	3	0.21
Adult females	16	2	0.13
Total juveniles	40	4	0.10
Juvenile males	20	1	0.05
Juvenile females	20	3	0.15
TOTAL (2007-2013)			
Total adults	126	45	0.36
Adult males	65	26	0.40
Adult females	59	19	0.32
Total juveniles	284	45	0.16
Juvenile males	142	26	0.18
Juvenile females	129	19	0.15

Table 7. Western Bluebird nest monitoring results at JBLM during the 2013 breeding season.

Training Area	Number of boxes checked	Number occupied by WEBL	% boxes used by WEBL	Total Nests
4	6	4	67%	6
5	8	3	38%	3
6	17	9	53%	14
8	9	1	11%	2
9	5	0	0%	0
10	4	1	25%	1
11	3	0	0%	0
12	4	3	75%	4
13	14	3	21%	3
14	15	6	40%	10
15	12	4	33%	6
18	2	0	0%	0
21	22	8	36%	12
22	3	0	0%	0
23	9	2	22%	3
7S	7	0	0%	0
AIA	28	20	71%	36
CIA	1	1	100%	2
Main Cantonment	17	3	18%	6
McChord	65	7	11%	9
Tenalquot	16	6	38%	9
TOTAL	267	81	30%	126

Table 8. Western Bluebird nest monitoring results at JBLM during the 2013 breeding season.

	Nests Monitored	Successful [1] (%)	Failed	Young Fledged [2]	Unknown Fate	Trapped/ Relocate
All Nests	117	67 (55%)	50	295	6	3
Nests (high confidence)	99	52 (53%)	47	230		

[1] Successful nests fledge at least one young.
[2] Young fledged are those assumed fledged based on the count at the nest box check prior to fledging unless there was evidence of mortality at the last nest box check.
[3] If nests were not checked at least 7 days prior to the estimated fledging date and there was no obvious evidence about the fate of the nest (e.g., juveniles observed with adults, dead nestlings in nest) the fate was classified as having low confidence.

Table 9. Mean (S.D) productivity for Western Bluebird nests with known fates at JBLM during the 2013 breeding season.

	Nests	Clutch size	Incubation Date	Mean young per nest	Mean young per successful nest
All nests	117	5.3 (1.0)	13 May (11)	2.5 (2.4)	4.4 (1.2)
High confidence	99	5.4 (1.1)	13 May (11)	2.3 (2.4)	4.4 (1.3)

[1] If nests were not checked at least 7 days prior to the estimated fledging date and there was no obvious evidence about the fate of the nest (e.g., juveniles observed with adults, dead nestlings in nest) the fate was classified as having low confidence.

Table 10. Reoccupancy of territories at JBLM following removal for translocation.

Translocation Event	Date	TA	Box	Removed	Territory reoccupied in 2013	Comment
2012						
2012_01	4/23/12	5	358	Pair	Yes	
2012_02	4/27/12	7S	180	Floater male	Yes	Adjacent box occupied
2012_02	4/27/12	13	44	Single female	Yes	Adjacent box occupied
2012_03	6/4/12	7S	180	Pair with young	Yes	Adjacent box occupied
2012_04	6/4/12	14	337	Pair with young	Yes	
2013						
2013_01	3/18/13	18	50	Pair	No	
2013_02	3/24/13	7S	429	Pair	No	
2013_03	3/24/13	5	10	Pair	Yes	
2013_04	4/10/13	5	358	Pair	Yes	
2013_05	4/10/13	4	4	Pair	Yes	
2013_06	4/10/13	AIA	209	Pair	Not monitored	
2013_07	5/29/13	23	B5	Pair with young	Yes	
2013_08	5/31/13	15	23	Pair with young	No	
2013_09	6/5/13	23	94	Pair with young	No	

Table 11. Comparison of reproduction estimates (± S.D.) between San Juan Island, WA and other Pacific Northwest populations.

	San Juan Island, WA		JBLM, WA	WV, OR[a]	WV, OR[b]	East Cascade, WA[c]
	2013	2007-13	2013	2007-11	1995-2001	2005-08
Monitored nests	10	97	99	2534	153	80
Clutch size[d]	5.0 (1.0)	5.3 (0.8)	5.4 (1.1)	4.9 - 5.1	**	**
Nest initiation date[e]	30 April (4)	6 May (15)	13 May (11)	**	**	**
Nest success (%)	60%	70%	53%	65 - 80%	**	**
No. young/nest	2.4 (2.5)	3.1 (2.5)	2.3 (2.4)	2.6 - 3.5	3.3 (2.4)	**
No. young/successful nest	4.0 (1.8)	4.8 (1.3)	4.4 (1.3)	4.0 - 4.4	**	4.5 (1.7)
No. young/breeding female	4.1 (4.5)	4.8 (3.9)	**	**	4.8 (2.5)	**

[a] Data from Prescott Bluebird Recovery Project in Willamette Valley, Oregon. (http://www.prescottbluebird.com/stat_nesting.html; accessed 10December 2013).
[b] Data from Willamette Valley Oregon; Keyser et al. 2004.
[c] Data from east slope of Cascades in central Washington (ponderosa pine forests); Kozma and Kroll 2010.
[d] First attempts only.
[e] First attempts only; for San Juan Island estimate, nests by pairs that contained a translocated individual were not included.

FIGURES

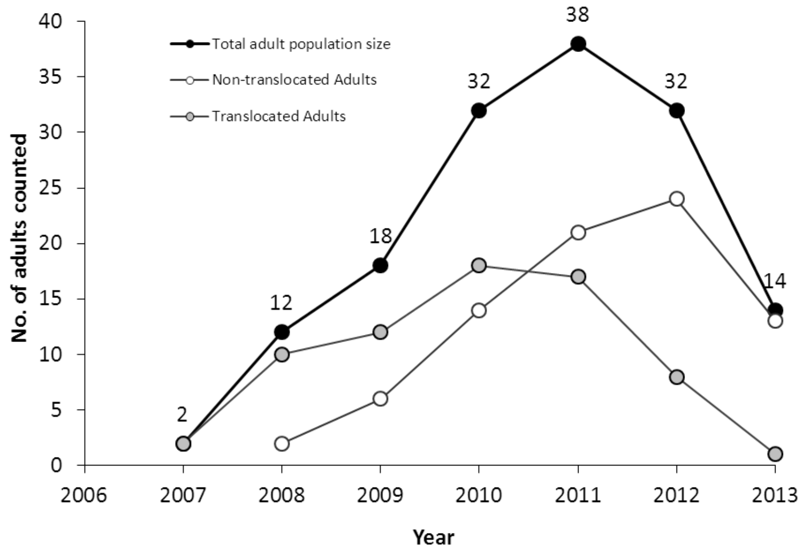

Figure 1. Number of Western bluebird adults counted on population surveys on San Juan Island, Washington, 2007-2013.

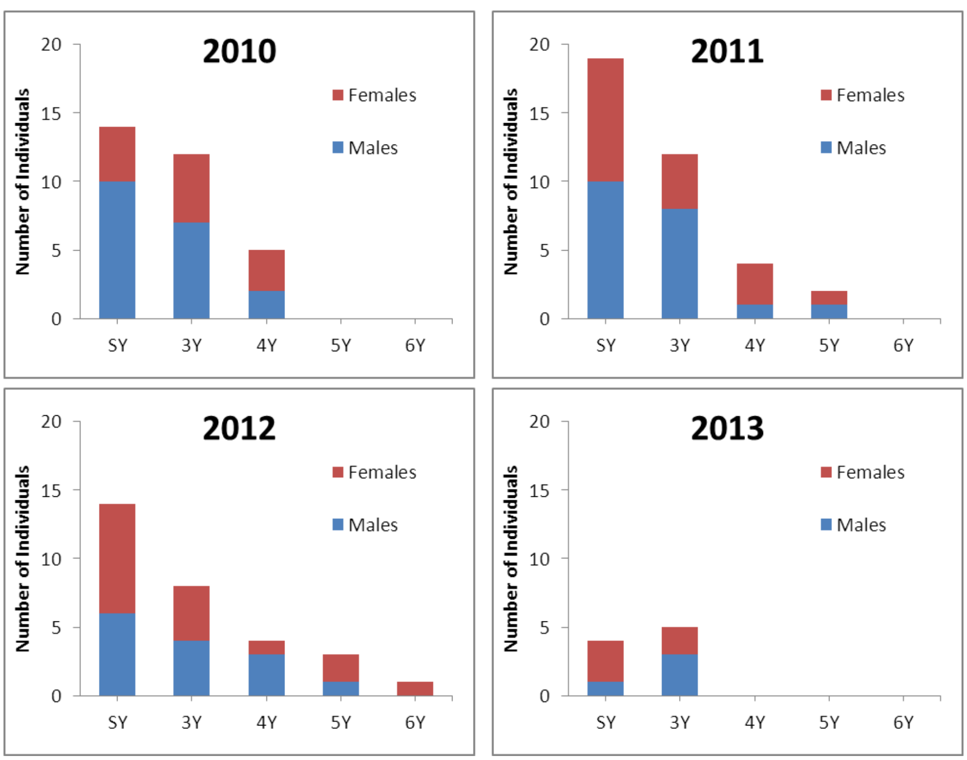

Figure 2. Age and sex composition of banded Western Bluebirds on San Juan Island from 2010 to 2013. Assumption: translocated birds captured in 2010 and 2011 as ASY individuals were assigned to the 3Y category, the youngest age they could be. Reference: Number of young banded: 2010 = 84, 2011 = 76, 2012 = 41.

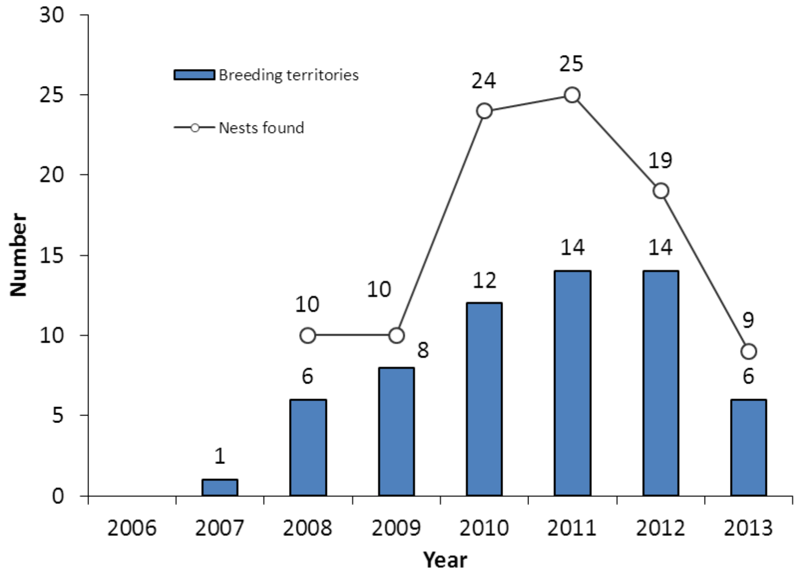

Figure 3. Number of Western Bluebird breeding territories (bars) and nests (circles) found on San Juan Island, Washington, 2007-2013.

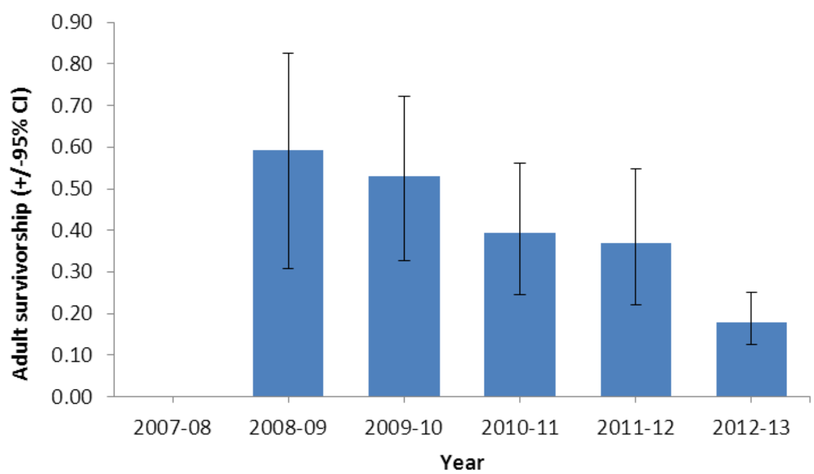

Figure 4. Apparent annual survival estimates (95% CI) for adult Western Bluebirds on San Juan Island, Washington, 2007-2013. Survival parameters for the period from 2007-08 could not be estimated.

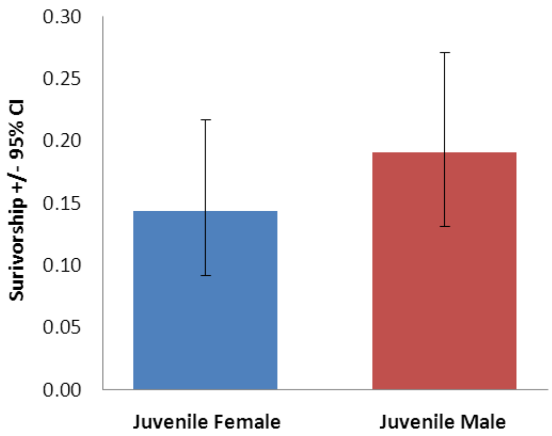

Figure 5. Apparent survival estimates (95% CI) for juvenile Western Bluebirds on San Juan Island, Washington, 2007-2013.

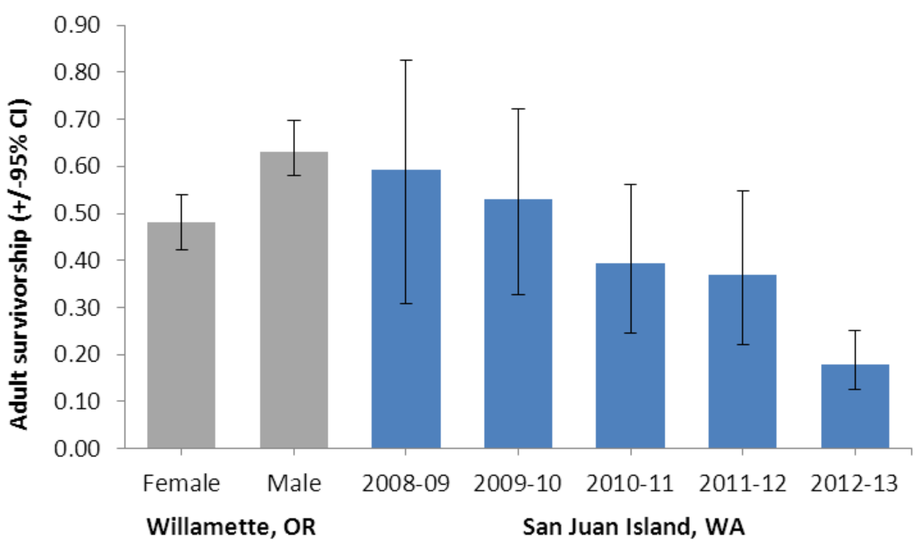

Figure 6. Apparent annual survival estimates (95% CI) for adult Western Bluebirds on San Juan Island, Washington, 2007-2013 in comparison to those from the Willamette Valley, Oregon for the period from 1999-2001 (Keyser et al. 2004). Survival parameters for the period from 2007-08 on San Juan Island could not be estimated.

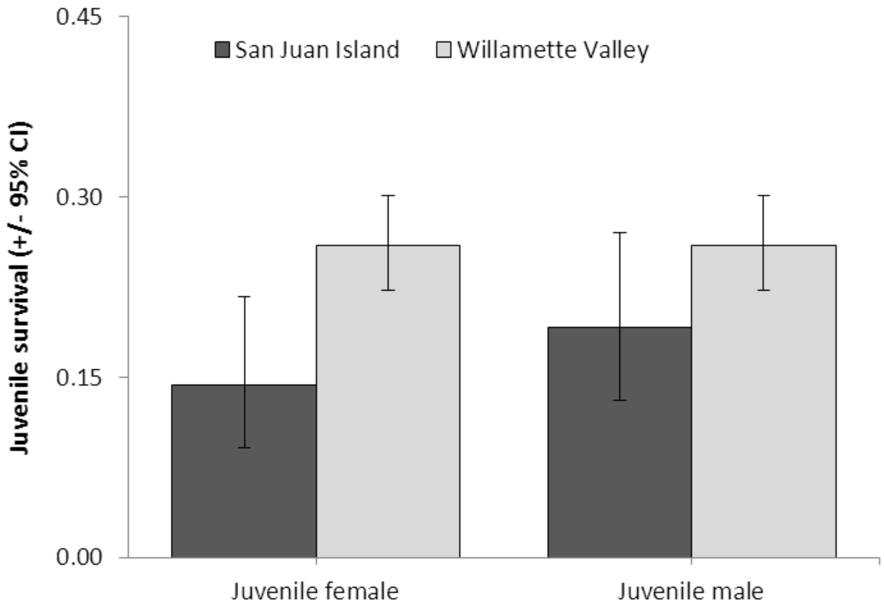

Figure 7. Apparent annual survival estimates (95% CI) for juvenile Western Bluebirds on San Juan Island, Washington, 2007-2013 in comparison to those from the Willamette Valley, Oregon for the period from 1999-2001 (Keyser et al. 2004). Survival parameters for the period from 2007-08 could not be estimated.

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