Spatial and Temporal Heterogeneity in Reproductive Success of Tidal Marsh Song Sparrows (Melospiza melodia): the Importance of “Edge Effects” and Habitat Configuration

Yvonne Chan, Nadav Nur, Diana Steelberg, Hildie Spautz, and Julian Wood.

Point Reyes Bird Observatory, 4900 Shoreline Highway, Stinson Beach, CA 94970.

Introduction

Historic filling, flooding, and conversion to salt evaporation ponds has eliminated 80% of the original tidal marsh in San Francisco Bay and fragmented remaining wetlands (Goals Project 1996). This loss and fragmentation of habitat in the San Francisco Bay region has contributed to the decline of tidal marsh Song Sparrows (Melospiza melodia) populations in San Francisco Bay and has led to the designation of M. m. editha, M. m. seraphini, and M. m. pulchella as California species of special concern. Due to their historic declines and limited geographic ranges (Marshall & Dedrick 1994), it is important to identify and understand the factors that influence the population viability of these endemic subspecies. This information may help managers prioritize acquisition and develop effective management strategies.

Reproductive success is an important component of overall population viability. In this study we examined spatial and temporal differences in reproductive success over an 8-year period in an effort to quantify inter- and intra- marsh differences. Here we evaluate the hypothesis that Song Sparrow reproductive success is adversely affected by habitat fragmentation, as measured by edge proximity and habitat configuration, primarily through increased predator access to nests.

Objectives

1. Nest survivorship: Calculate estimates of nest survivorship and test for differences between sites and years.
2. Causes of nest failure: Quantify causes of failure, including flooding and predation.
3. Habitat edge effects: Examine reproductive success in relation to edge proximity (upland and water).
4. Marsh configuration: Examine reproductive success in relation to landscape level characteristics such as marsh size and shape.

Methods

Song Sparrow nests were located and monitored at study sites including San Pablo Bay and two Suisun Bay marshes (Figure 1). Table 1 (between 1996 and 2000). Nest finding and monitoring, following guidelines outlined in Martin and Gersloff (1991), began in early March and lasted until breeding activity sharply declined in mid-July. Nests were checked every four days until outcome (success vs. failure) could be determined, usually based on conditions at the nest or by observing parental behavior near the nest. Precautions were taken to keep disturbance at the nest site to a minimum.

For each site and each year, we calculated Mayfield estimates of daily survival rate (Maysfield 1978) combining laying, incubation and nesting periods of development, and compared to the 8-year nesting period. This method takes into account the period of time the nest was under observation. We also checked the fate of each nest according to four distinct movements of nest survivorship (Table 2).

To further investigate the causes of nest failure, we used aerial photos and GIS (ArcGIS 9.2; ESRI 2000) to characterize the location of each nest (digitized from field maps) with respect to the nearest upland and water body interface. We used logistic regression to model the effects of size, year and edge proximity (upland and water), and water on nest success using measures of nest success. We also calculated several marsh configuration metrics (Table 2) and used logistic regression to model the effects on nest success.

Table 1. Summary of nest survivorship data, probability of nest failure, and habitat configuration variables

<table>
<thead>
<tr>
<th>Metric</th>
<th>Total</th>
<th>Mayfield Estimates</th>
<th>Probability of Nest Failure</th>
<th>Probability of Nest Failure Adjusted for Size</th>
<th>Habitat Configuration Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland Distance (m)</td>
<td>100-200</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>Predation</td>
</tr>
<tr>
<td>Water Distance (m)</td>
<td>500-600</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>Distance to Upland Edge</td>
</tr>
<tr>
<td>Distance to Upland Edge (m)</td>
<td>&gt;1000</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td>Distance to Water</td>
</tr>
</tbody>
</table>

Results

1. Nest Survivorship: L.4.33 Song Sparrow nests were monitored between 1996 and 2000. Mayfield estimates of nest survivorship ranged from 5.3% to 32.2% (mean = 15.4%) per year (Figure 2). Nest survivorship differed significantly among years (Figure 2), with higher rates of nest success in 1998 and 1999 compared to 1997 and 2000.

2. Causes of nest failure: Overall, 85% of all nests monitored failed due to predation; 6.5% failed due to other causes. The habitat of 22.5% of nests, successfully fledged young. Causes of failure were similar across marshes, although rates of predation were significantly higher in Suisun Bay sites than in San Pablo Bay marshes (Figure 3).

3. Edge effects: We used logistic regression analysis to examine four categories of nest success with respect to edge effects (Table 2). Across sites, controlling for annual variation, we found that the lowest nest success occurred to nesting period (Figure 3). The distance to the nearest upland edge had lower rates of predation and higher success to hatching, while nests farther from the upland edge had higher nest overall nest success, lower rates of predation, and higher success to hatching (Table 3, Figures 5 and 6). Controlling for differences within sites, only success to hatching was positively affected by upland distance (Table 3).

The edges of water proximity were significant when controlling for inter-site variation, supporting that upland edge effects were due to differences among study sites and did not explain differences in nest success within single marsh (Table 3).

4. Habitat Configuration: Logistic regression results indicated that the performance rate of a marsh increases, the smaller proportion of nest failure and the proportion of nests surviving to hatching, while failure due to predation increases (Table 4). Controlling for marsh size, the effect of perimeters remaining in marsh significantly affects habitat configuration and shape, as such, we may affect nest success (Table 4). Marsh isolation (distance to nearest 100ha marsh) was negatively associated with overall nest success and to hatching. Among site differences were significant when controlling for size, post hoc analysis indicated that the additional size to nest survivorship and nest success remained unexplained by habitat configuration.

Table 2. Effects of edge proximity on nest success. Logistic regression results.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>z-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upland Distance</td>
<td>-0.13</td>
<td>0.06</td>
<td>-2.13</td>
<td>0.03</td>
</tr>
<tr>
<td>Water Distance</td>
<td>-0.12</td>
<td>0.06</td>
<td>-2.00</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Conclusions

Although we consider these results preliminary, analysis thus far suggest that Song Sparrow nest success is negatively affected by fragmentation of marsh habitat. Comparing across sites, we found that nests closer to upland edges fledged young success more often, suggesting that landscape-level differences in marsh configuration are important to reproductive success. This was also supported by the higher proportion of nest success found in large marshes with proportionately less edge.

Because we did not attempt to account for the proportion of nests surviving to hatching, but a significant association with nesting survival; we infer that increased edge predation is responsible for the survival edge effect. This suggests that edge predation, but not nest predation, is more successful in marshes that are closer to upland habitats. The lack of significant upland edge effects within individual marsh study sites may mean that nest predation are edge-dependent at the scale, or it may be that upland edge proximity is not sufficiently affecting rates within a study site. The lower rates of nest success the closer to the upland edge, we predict edge predation significantly, suggests that open water may serve as a barrier to predators. Alternatively, there may be variation in nesting success that results in edge to water that effect predators sites.

Further research may be needed to understand the predictability of tidal marsh acquisition and development of management strategies. To further explore this, we suggest that managers with less upland edge and more water edge have higher rates of Song Sparrow reproductive success, ultimately contributing to rates to the population viability of this species within San Francisco Bay.

Acknowledgments

We would like to thank Don McNaull, Roadie Green, and Christoph Zeidler for their support. We also thank the Point Reyes Bird Observatory for their generous support. This research was funded by the Bernard Osher Foundation, the Richard Grand Foundation, the Gabilan Foundation, the Mary A. Crocker Trust, ESRI, Hewlett-Packard and the U.S. Environmental Protection Agency.

Literature Cited


Figure 1. Mayfield estimates of nest survivorship by year and site.