# Kiwikiu productivity: Nest survival and annual reproductive success in the Hanawi Natural Area Reserve, Maui, Hawaii

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## Introduction

Nest success is a commonly used metric for estimating productivity in birds (Hartman and Oring, 2009; Nappi and Drapeau, 2009), but information on nest success alone is rarely sufficient to understand population dynamics and does not always accurately reflect reproductive output (Murray, 2000; Jones et al., 2005). One alternative is to monitor breeding pairs to determine the presence of offspring, which can provide a better measure of annual reproductive success (ARS).

Population viability analysis (PVA) is a tool to examine extinction risk and can provide important information to managers (Akcakaya and Atwood, 1997). PVA rely on accurate demographic data, however because of their rarity, the quality of such data is often poorest for endangered species.

The federally endangered Kiwikiu (Maui Parrotbill; *Pseudonestor xanthophrys*) is restricted to a single small population on the northeastern slopes of Haleakalā, Maui, Hawaiʻi (U.S. Fish and Wildlife Service, 2006). There is little data on annual or lifetime reproductive success and the stability of the population is difficult to access from surveys (Camp et al., 2009).

Here we derive measures of nest survival and annual reproductive success for Kiwikiu to estimate productivity for this endangered species and to illustrate the confounding interpretations that can be drawn based on the different methods.

## Methods

*Study Area* -We studied MAPA in two study areas (FSB, HR3) in the Hanawi Natural Area Reserve (Figure 1).

*Individual and Breeding Pair Identification* – Between January and June of 2006-2011, we monitored 128 adult pairs. In 103 of these pairs, one or both birds were banded with unique color band combinations. In pairs where both adults were unbanded, individuals were only classified as discrete pairs when their home ranges bordered those of other marked individuals.

*Nest Success*- We located and monitored Kiwikiu nests until fledgling or failure was confirmed. Causes of failure could not be determined for the majority of nests because of their height (mean=10.9 m).

Nest survival was calculated from observed exposure days using a Mayfield estimate (Mayfield, 1961; Mayfield, 1975). Given the frequency with which our nests were monitored, Mayfield models provide adequate estimates (Etterson and Bennett, 2005).

*Productivity* - We noted the ID and location of all adults encountered and the presence of juveniles. Productivity was estimated as the percentage of pairs with an offspring divided by the total number of pairs observed.

## Results

*Nest Success* - During six breeding seasons, we located 30 Kiwikiu nests. Of these, eight did not progress past the nest building stage or insufficient data prevented their inclusion in our analyses.

We monitored 22 active nests during the 2006-2011 breeding seasons. Of these 15 failed. Total exposure days was 338.5. The daily survival probability was 0.956 (±0.022 SE), which resulted in a nest survival probability of 20.5%. One egg was presumed to be infertile after not hatching after 31 days of observation, seven of the 15 failures occurred during the first 10 days of the nestling period, and one chick was depredated by a Pueo (*Asio flammeus sandwichens)* (Table 1).

*Productivity* - At HR3, we monitored 65 pairings during the 2006-2011 breeding seasons. At FSB we monitored 63 pairings during the 2008-2011. Our productivity estimate for HR3 was 44.62% and 42.86% for FSB. These data resulted in an overall productivity estimate of 43.75% (Table 2). There was a slight difference in productivity across years between the two study sites (2008-2011) ($\chi^2$=6.53, $k$=3, P=0.10).

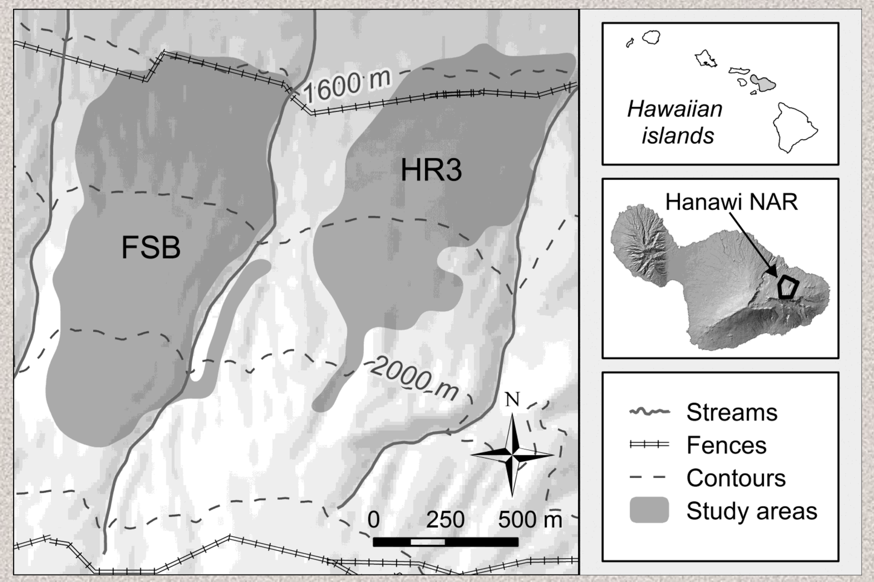


**Figure 1.** FSB (77 ha) and HR3 (56 ha) study area in the Hanawi Natural Area Reserve, Island of Maui, Hawaii.

**Table 1.** Kiwikiu nest survival 2006-2011 on active nests located within Hanawi NAR (Mayfield estimate of daily survival probability=0.956; nest survival probability=20.5).

| Site | Year | Exposure Days | Successful?/ Stage at termination |
|---|---|---|---|
| HR3 | 2006 | 13.5 | Y |
| HR3 | 2006 | 15.5 | N/Nestling |
| HR3 | 2007 | 7.5 | N/Incubation |
| HR3 | 2007 | 30.5 | Y |
| HR3 | 2007 | 13.5 | N/Incubation |
| HR3 | 2007 | 8.5 | N/Nestling |
| HR3 | 2007 | 5.5 | N/Nestling |
| FSB | 2007 | 7.5 | N/Incubation |
| HR3 | 2008 | 31.5 | N/Incubation |
| HR3 | 2008 | 2.5 | N/Incubation or early Nestling |
| HR3 | 2008 | 30 | Y |
| HR3 | 2008 | 16 | Y |
| HR3 | 2009 | 20.5 | N/Nestling |
| HR3 | 2009 | 10.5 | N/Nestling |
| HR3 | 2009 | 10.5 | N/Nestling |
| HR3 | 2009 | 17.5 | N/Nestling |
| HR3 | 2009 | 12 | Unknown/Obs. ended |
| FSB | 2010 | 20 | Unknown/Obs. ended |
| HR3 | 2010 | 15.5 | N/Incubation or early Nestling |
| FSB | 2011 | 9.5 | N/Nesting |
| FSB | 2011 | 6.5 | N/early Nesting |
| HR3 | 2011 | 34 | Y |

**Table 2.** Per pair productivity at both study sites (FSB and HR3) 2006-2011

| Site | Year | Pairs Observed | Pairs w/ HY | % Successful |
|---|---|---|---|---|
| **FSB** | 2008 | 11 | 3 | 27.27% |
| | 2009 | 15 | 8 | 53.33% |
| | 2010 | 18 | 6 | 33.33% |
| | 2011 | 19 | 10 | 52.63% |
| **HR3** | 2006 | 11 | 4 | 36.36% |
| | 2007 | 11 | 3 | 27.27% |
| | 2008 | 10 | 4 | 40.00% |
| | 2009 | 8 | 6 | 75.00% |
| | 2010 | 9 | 5 | 55.56% |
| | 2011 | 16 | 7 | 43.75% |
| **FSB Totals** | | 63 | 27 | 42.86% |
| **HR3 Totals** | | 65 | 29 | 44.62% |
| **Total** | | 128 | 56 | 43.75% |

## Discussion

Documenting the presence of breeding pairs with fledglings provided a more accurate picture of Kiwikiu productivity than did monitoring nests. Population viability analyses using our nest success estimate to represent productivity predicted sharp population declines (MFBRP unpub). Based on population monitoring with point transect distance-sampling throughout the Kiwikiu range, such a decline is unlikely (Camp et al., 2009).

Kiwikiu have a long breeding season for passerines (Simon et al., 2000) and re-nest up to three times after failures. Terrain and accessibility make locating all potential nests extremely challenging. Under such conditions when all nesting attempts cannot be found, nest survival can be particularly misleading (Thompson et al., 2001). While nest monitoring is useful for identifying factors limiting productivity (i.e. weather or predation), unless all nests are located this method may underestimate productivity (Jones et al., 2005).

Calculating nest survival and ARS across the same years allowed a comparison of the two methods of measuring productivity for this rare and cryptic species. Management decisions often rely on accurate demographic estimates, including productivity. While nest success may be an easier productivity metric to collect for some species, compared to documenting fledglings, this should not be misrepresented by calculating ARS through observed nest survival, as has been seen in previous literature (Thompson et al., 2001*)*. For species occurring at low densities in difficult to traverse terrain with multiple nest attempts, determining productivity by documenting fledglings is superior to locating and monitoring nests.

PVA models may assist in the management of endangered species but are sensitive to changes in model parameters, emphasizing the need for accurate demographic data.

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