Seabirds as agents of spatial heterogeneity on New Zealand’s offshore islands

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Online Resource 1

Seabird Burrow Density Calculations and Modeling

Counting all of the burrows in a reasonably sized area surrounding each sample point was impossible due to time constraints. High-density plots in particular would be subject to inaccuracies of counting, but a hidden or hard-to-find burrow would be even more important in low-density plots. Estimation of burrow density (BD), with acceptance of some random error, was the only realistic option. Our goal was to transform our field-measured index (distance-to-burrow, or DTBs, for the three closest burrows to the plot center) into a value representing burrows per area.

We used independently collected DTB data matched to burrow counts from multiple 100 m² plots established on a larger set of 21 islands (Mulder et al. 2009) to parameterize a model of burrow density. We assumed that BD was approximately homogeneous over the scale of 10 m x 10 m (100 m²). We first calculated BD using three DTBs measured from the plot center, divided by the search area needed to find three burrows (Fig. 1a-b). In our geospatial study, this methodology meant fixing the

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third DTB (the farthest distance measured) as the radius of a circle centered on the
sample point and encompassing the search area. If three burrows could not be found
within 5 m, then 5 m became the radius of the search area (Fig. 1c). This method results
in BDs calculated on a continuously varying scale from <1 m² to ~78 m², which are
sensitive to small changes in DTB when burrow densities are high (because DTBs
become short and search areas very small, e.g., Fig. 1a).

We regressed these DTB-calculated BDs (equivalent to BDs from the 3-burrow
search areas in Fig. 1) against the known densities counted in the plots from the larger
study (equivalent to BDs from the square plots in Fig. 1). The resulting model, below,
was log-transformed (ln[x+0.01]) to meet the assumptions of linear regression. On both
sides of the equation, BD is counted or calculated in burrows m⁻².

\[
\text{Counted BD} = -0.01 + (0.010 + \text{DTB} - \text{Calculated BD})^{0.923}
\]

The calculated value based on DTB could predict burrow counts well (F(1, 286) = 6421, p <
2.2x10⁻¹⁶, R² = 95.7%) so we used it to convert all of our distance-based index (DTB)
measurements into area-based seabird burrow densities (equivalent to BDs from the 5 m
radius circle in Fig. 1) for use in this geospatial study.
Fig 1 Examples of three burrow densities, each calculated three different ways: a square plot (10m x 10m), a circular plot (radius 5m, area (~78 m²)), and a circular plot with a radius equal to the distance to the third nearest burrow. X indicates the plot center; small circles represent burrow entrances. Shaded areas indicate the area searched to find three burrows (a & b) or the maximum circular search area (c) while dotted lines drawn from the plot centers indicate the radius used to calculate the search area.