MODELING HAWAIIAN FOREST BIRD DISTRIBUTIONS AND POPULATION TRENDS.

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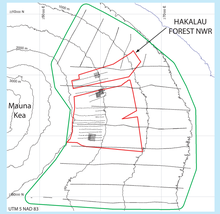
INTRODUCTION

- The Hawai'i Forest Bird Interagency Database Project (HFBIDP) is an ecological study of the Hawaiian avifauna developed by the USGS Pacific Island Ecosystems Research Center. The HFBIDP has produced a database containing more than ¾ million records from over 400 forest bird surveys since the mid-1970s on the major Hawaiian Islands.
- We used GIS to integrate information on species densities at surveyed locations with habitat data derived from remote sensing and field sampling. We then developed predictive models at the landscape level of the distribution and population sizes of the Hawaiian avifauna.
- Results are presented for 8 native and 4 alien bird species from 66 surveys within a 64,843-hectare study area on northeastern Hawai'i Island that encompasses the Hakalau Forest National Wildlife Refuge (HFNWR).

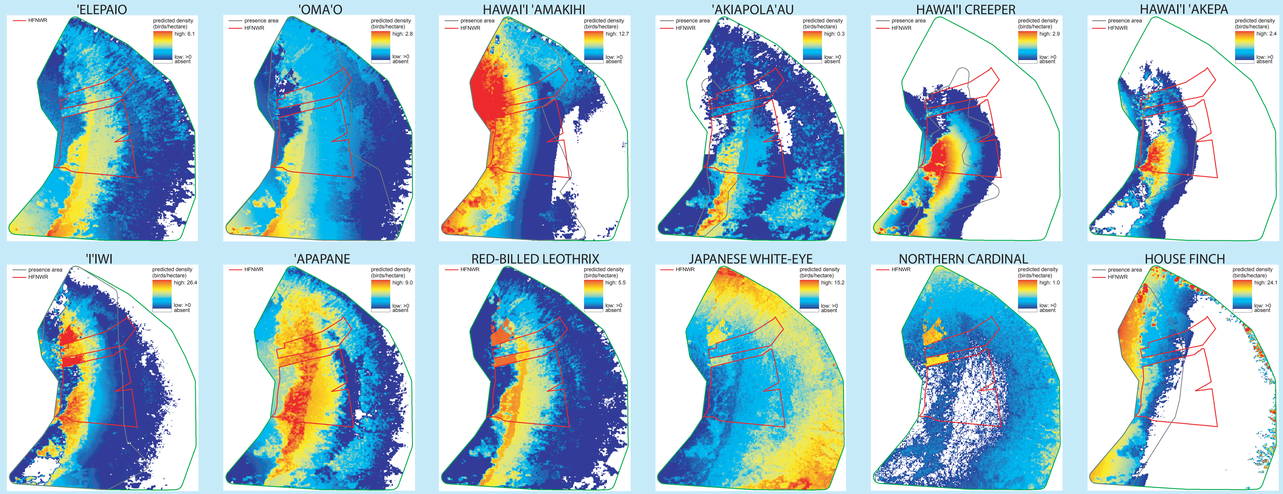
STUDY AREA

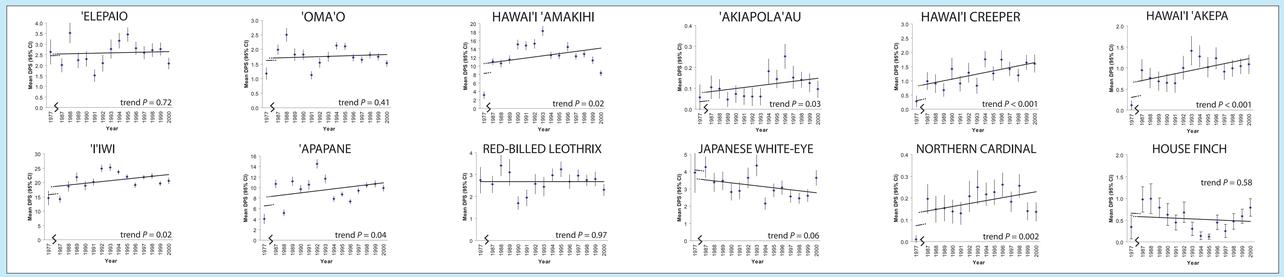
SURVEY TRANSECTS



METHODS

- Survey sites were mapped and linked to habitat information derived from digital elevation models, rainfall and temperature isopleth interpolation, and land-cover classification of Landsat 7 imagery. Classified imagery provided data on dominant vegetation composition and structure, including canopy closure, canopy height, and the richness of land-cover types. Aerial photo interpretation was used to determine the presence of understory components including native tree ferns and matted ferns and invasive species such as banana poka (*Passiflora mollissima*) and guava (*Psidium* spp.).
- Bird densities were calculated with the program DISTANCE from counts (i.e., abundance) sampled with variable circular plot (VCP) methodology (Buckland et al. 2001). VCP uses radial distances from observer to birds to calculate detection probabilities. Detection probabilities, in turn, determine the effective area sampled from which bird densities are derived (i.e., density = count / area).
- Regression was used to model observed density and habitat associations, and to predict density for unsurveyed habitat. The models used an autoregressive method that incorporated a spatially-dependent covariance structure, thereby accounting for fine-scale autocorrelation in density and habitat variables (Lichstein *et al*. 2002). Coarse-scale autocorrelation was controlled with trend surface terms (i.e., standardized geographic coordinates).
- Estimates of densities and standard errors were generated with autoregressive models for all 1-hectare cells within the study area, and summed to estimate population size. The population estimate is limited to a species' "presence area" if the current regional distribution is smaller than the study area.
- Trends were obtained by the regression of log-transformed mean annual density on year for surveys conducted in 1977 and from1987 to 2000 within the HFNWR.
- Power to detect declines in the density of native species was examined for a prospective 10-year monitoring period with the program TRENDS (Gerrodette 1993). Power was calculated for an alpha of 0.20 and four annual rates of decline (1%, 3%, 5%, 10%) given the inter- and intra-annual variance observed from past surveys. Variance was measured as the coefficient of variation (CV), and derived by the regression of annual means on year.





Population and standard error estimates derived from predicted densities.

Species	Origin/Status	Population Size	Standard Error	Extent (km^2) [a]
'ELEPAIO (*Chasiempis sandwichensis*)	**native**	**138,930**	**605**	**648**
'OMA'O (*Myadestes obscurus*)	**native**	**57,533**	**191**	**473**
HAWAI'I 'AMAKIHI (*Hemignathus virens*)	**native**	**200,760**	**990**	**416**
'AKIAPOLA'AU (*Hemignathus munroi*)	**native/endangered**	**1,585**	**44**	**108**
HAWAI'I CREEPER (*Oreomystis mana*)	**native/endangered**	**17,842**	**221**	**167**
HAWAI'I 'AKEPA (*Loxops coccineus*)	**native/endangered**	**8,311**	**144**	**108**
'I'IWI (*Vestiaria coccinea*)	**native**	**285,422**	**1,267**	**384**
'APAPANE (*Himatione sanguinea*)	**native**	**255,898**	**1,037**	**648**
RED-BILLED LEIOTHRIX (*Leiothrix lutea*)	**exotic**	**82,006**	**480**	**648**
JAPANESE WHITE-EYE (*Zosterops japonicus*)	**exotic**	**460,373**	**1,417**	**648**
NORTHERN CARDINAL (*Cardinalis cardinalis*)	**exotic**	**8,677**	**93**	**648**
HOUSE FINCH (*Carpodacus mexicanus*)	**exotic**	**64,799**	**568**	**201**

[a] Area encompassed by either the 648 km^2 study area or species' presence area (i.e., area of occurrence).

Power (%) to detect a decline in density of native species.
Red text indicates power is adequate (i.e., >=80%).

Species	CV	Annual rate of decline 1%	3%	5%	10%
'ELEPAIO	**0.654**	**24**	**34**	**47**	**84**
'OMA'O	**0.549**	**25**	**39**	**57**	**96**
HAWAI'I 'AMAKIHI	**0.465**	**26**	**41**	**60**	**96**
'AKIAPOLA'AU	**1.346**	**22**	**27**	**32**	**52**
HAWAI'I CREEPER	**0.730**	**24**	**33**	**44**	**79**
HAWAI'I 'AKEPA	**0.718**	**24**	**33**	**44**	**80**
'I'IWI	**0.345**	**28**	**52**	**79**	**100**
'APAPANE	**0.694**	**24**	**33**	**45**	**81**

RESULTS

Distribution and Population Size

- 'Amakihi and 'Apapane are widespread and populations are sizable.
- 'I'iwi population is large but mostly restricted to upper elevation forest.
- 'Elepaio and 'Oma'o have moderately sized populations and are widespread but most common in upper elevation forest.
- Populations of Hawaii Creeper and 'Akepa, two endangered species, are fairly small and locally distributed.
- Population of the endangered 'Akiapola'au is very small and restricted to a narrow belt of habitat.
- Red-billed Leothrix population is moderately sized and widespread, particularly at mid- and high elevations.
- Japanese White-eye population is large and widespread, particularly at lower elevations.
- Northern Cardinal population is small and mostly restricted to margins of forest habitat.
- House Finch has a small population in the study area, but is ubiquitous in open habitats at margins of the study area.
- HFNWR includes portions of the regional populations of three endangered species: 'Akiapola'au (50%), Hawaii Creeper (49%) and Hawaii 'Akepa (72%).

Trends and Power

- Densities of Hawaii Creeper and 'Akepa have increased significantly (P <= 0.01) over the past 24 years.
- Densities of 'I'iwi, 'Amakihi, 'Apapane and Northern Cardinal show marginally significant (0.01 < P <= 0.05) increases over the same period.
- Current survey effort in HFNWR has the ability to detect >=10% annual rate of decline in mean density over 10 years for 6 of the 8 native species examined. Trends of rare species with highly variable densities, such as 'Akiapola'au and Hawaii Creeper, cannot be detected with adequate power.
- Low to moderate rates of decline (i.e., 1%-5% per year) cannot be detected within 10 years with sufficient power for any of the native species.

DISCUSSION

- Analyses are updates of the initial study carried out a quarter century ago by Scott *et al*. (1986).
- Density predictions generated for 1-hectare cells permitted the characterization of local habitat conditions. This approach is an improvement over previous methods of extrapolating densities from survey stations to strata that are presumed to possess homogeneous habitat conditions.
- Autoregressive modeling effectively addresses fine-scale spatial autocorrelation in bird density and habitat variables. It avoids overstatement of explanatory variable significance in models that assume independent errors and provides adjusted regression coefficients.
- Parts of the regional populations of species of concern (i.e., 'Akiapola'au, Creeper and 'Akepa) lie outside of the protection afforded by the Hakalau Forest NWR. Populations in these areas are vulnerable to habitat degradation.
- Native habitats harbor widespread and large populations of alien bird species. The competitive effects of these species upon native birds are poorly understood.
- A more intensive and different sampling design is necessary for determining the status of rare and highly variable species. Long-term programs specifically designed to monitor demography (i.e., nesting success, productivity, juvenile and adult survival, natal dispersal) should be considered for such species.

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