# POPULATION STATUS OF THE ENDANGERED HAWAIIAN HAWK

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ABSTRACT.—We assessed the current abundance and distribution of Hawaiian Hawks ('io; *Buteo solitarius*) on the island of Hawaii to determine if this federally endangered bird should be downlisted to threatened status. We found a density of 0.004 hawks/ha on the island. Using an estimate of 400 000 ha of suitable 'io habitat on Hawaii, we estimated a total of 1600 hawks (1120 adults; 560 pairs) on Hawaii. Based on the wide distribution of 'io among vegetation types on the island and little apparent change in numbers during the past decade, we agreed with the recommendation for downlisting the hawk but suggested that researchers collect long-term demographic data to better understand the status of this species.

KEY WORDS: Buteo solitarius, *Hawaiian hawk, 'io, population status.*

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El estado de población del *Buteo solitaruis* en peligro de extinción.

RESUMEN.—Nosotros fijamos la cantidad corriente y distribución de *Buteo solitarius* en la isla de Hawaii para determinar si el pájaro en peligro de extinción por leyes federales debe ser reducido a estado amenazado. Nosotros los encontramos una densidad de 0.004 halcón/ha en la isla. Usando la estimación de 400 000 ha de hábitat conveniente en Hawaii, nosotros estimamos un total de 1600 halcones (1120 adultos; 560 parejas) en Hawaii. En base de la distribución amplia de *B. solitarius* entre clases de vegetación en la isla y poco cambio aparente en la cantidad durante la década pasada, nosotros estamos de acuerdo con la recomendación para reducir el halcón pero sugerimos que los investigadores junten datos demográficos de larga duración para poder entender el estado de este especie mejor.

[Traducción de Raúl De La Garza, Jr.]

The Hawaiian Hawk (*Buteo solitarius*), or 'io, was federally listed as an Endangered Species in 1967 (37 FR 4001, 11 March 1967) based on its restricted range on the island of Hawaii (hereafter Hawaii), its low numbers at the time of listing (Berger 1981), and the perceived threats to its preferred habitat from agricultural and commercial developments (U.S. Fish and Wildlife Service [USFWS] 1984). At the time of listing, no intensive study of the ecology of the 'io had ever been conducted, and anecdotal accounts gave differing reports on its abundance across the island (Munro 1944, USFWS 1984).

Uncertainty over 'io abundance continued through the next decade. An intensive survey initiated by the USFWS in 1976 on Hawaiian forest birds was unable to estimate the 'io population size (Scott et al. 1986). After a detailed study of 'io breeding biology in <1% of the island's area, Griffin (1985) found that the species might be relatively unaffected by habitat modifications compared to many other native bird species after finding that foraging and nesting occurred in agricultural areas and in stands of exotic vegetation (Baskett and Griffin 1985). Griffin (1985, 1989) estimated the population at 900 breeding pairs and a total of 2700 individuals in 1983. Because of this, the USFWS proposed downlisting the 'io from endangered to threatened status (58 FR 41684, 4 August 1993). Because of questions over the validity of basing such a reclassification on 10-year-old data, the USFWS requested that an island-wide survey be conducted of the 'io population to obtain a more current estimate of the population size.

Herein, we present our survey results and sampling design to provide a baseline for future surveys designed to monitor the size of the 'io population on Hawaii.

STUDY AREA AND METHODS

The most efficient way to sample dominant vegetation types across Hawaii for the occurrence of 'io was to conduct unlimited distance point counts (Blondel et al. 1981) along paved and dirt roads across the island. Point counts were selected to make our methods generally comparable to those of Scott et al. (1986), who conducted the most complete previous census of 'io on Hawaii as part of the USFWS's Hawaiian Forest Bird Survey (1976–79). We also needed a method that could sample the 'io's use of vegetation ranging from lowland agricultural areas to subalpine woodlands (Scott et al. 1986, Griffin 1989), and would be applicable to birds with home range sizes varying from 48 ha in agricultural areas to 490 ha in forests and mid-elevation pasturelands (Baskett and Griffin 1985). Use of roadways was the only feasible means of satisfying these objectives. Some studies have indicated that roadside counts can give biased estimates of bird densities and vegetation associations, but other studies have indicated that road counts can be useful and appropriate when large areas need to be sampled and monitored long term (Fuller and Mosher 1981).

When possible, we used roads that crisscrossed an area to more thoroughly sample for 'io. We conducted point counts 0.1–16 km off main roads to ensure that traffic noise did not interfere with the counts and that we more adequately sampled vegetation that could contain 'io. Count stations were located disproportionately among vegetation types (Table 1), based on information that 'io were unlikely (or very uncommon) in shrublands (vegetation type 10), upper-elevation mamane-naio (*Sophora chrysophylla-Myoporum sandwicense*) woodlands (vegetation type 12), and exotic pioneering lava vegetation (vegetation type 5) (J. Jeffrey and J. Giffin pers. comm.).

All count stations were 0.8–3.2 km apart, and counts were conducted by 1–2 observers between 0900–1700 H. Each point count lasted for exactly 10 min, which was the same count length used by Scott et al. (1986), and included 8 min of listening and watching for hawks, plus 2 min of playback of taped adult territorial and fledgling calls of 'io. After the first minute of the tape elapsed, we turned it off and observed the area for any hawks for 7 min. Anytime an 'io responded to the tape, either by calling or flying to the point, we immediately stopped the tape, but continued the count to determine if any additional hawks were observed. We then played the tape again for 1 min, and watched for the last minute of the count.

Although surveys have not previously used broadcast calls, Banko (1980) and Baskett and Griffin (1985) reported that 'io call and defend their territories in the winter. On 12–13 December 1993, we tested if broadcasted territorial calls elicited responses from 'io by going to areas known to have 'io present (J. Jeffrey pers. comm.). We watched 'io that were ≥200 m away while we played the taped calls. Eighty percent of the hawks responded by taking flight, calling or coming to the tape.

No counts were conducted when precipitation exceeded a light rain, or when wind exceeded 24 km/h. We recorded the distance from the point of initial detection of all observed hawks, the detection mode (visual, aural or both), the morph (light, dark, unknown), and the vegetation where the bird was observed (Table 1). Although

Table 1.  Vegetation descriptions and codes for survey transects used in analyses of Hawaiian Hawk numbers across Hawaii in December 1993.[a]

| CODE | FRE-QUENCY[b] | DESCRIPTION |
|---|---|---|
| 1 | 63 | Sugar cane fields with exotic and/or native trees or shrubs at edges, as windrows. |
| 2 | 41 | Short or tall exotic trees with exotic shrubs, and sometimes exotic grasses. |
| 3 | 22 | Macadamia nut or papaya orchard with native and/or exotic trees or shrubs at edges. |
| 4 | 38 | Grassland with scattered exotic and/or native trees (especially o'hia); scattered homes. |
| 5 | 5 | Pioneer exotic vegetation growing on lava. |
| 6 | 68 | Native trees and native shrubs occasionally with scattered orchard trees, or exotic understory and homes. |
| 7 | 99 | Mixed exotic and native trees, sometimes with mixed exotic and native shrubs or grass. |
| 8 | 24 | Residential area with scattered exotic and native vegetation. |
| 9 | 40 | Native tree and mixed exotic and native shrub vegetation on lava, sometimes with scattered homes; a pioneer community. |
| 10 | 2 | Mixed exotic and native shrubs with scattered native and exotic trees. |
| 11 | 16 | Native trees and grassland; non-pioneer community. |
| 12 | 4 | Mamane-naio vegetation, with grass and/or exotic shrub understory, or sometimes with scattered exotic trees. |

[a] Scientific names of plants listed: sugar cane (*Saccharum officinarum*), macadamia nut (*Macadamia ternifolia*), papaya (*Carica papaya*), o'hia (*Metrosideros polymorpha*), mamane (*Sophora chrysophylla*), and naio (*Myoporum sandwicense*).
[b] Frequency = total number of times the described vegetation was recorded along survey routes.

we tried to determine age and sex of hawks in the field, it was often difficult to make a positive identification, so in our analyses we combined all sightings.

We used program DISTANCE (Buckland et al. 1993, Laake et al. 1993) to estimate the densities of 'io in the 12 major vegetation types recorded during our surveys

Table 2.   Summary of 'io density estimates (all ages together) by vegetation type, calculated by program DISTANCE (Laake et al. 1993) from survey data across Hawaii, December 1993.[a]

| VEGETATION CODE[b] | TOTAL EFFORT[c] | NO. POINTS | NO. 'IO OBSVD. | ESTIMATOR MODEL NO.[d] | ESTIMATE | SE | %CV | 95%CI | df | DETECT. PROB. | ENC. RATE | DENSITY BOOTSTRAP[f] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | EST. | %CV | RUNS |
| All veg types | 399 | 399 | 98 | 5 | 0.004 | 0.0007 | 15.9 | 0.003–0.006 | 345 | 0.02 | 0.24 | 0.004 | 23.7 | 400 |
| Veg 1 | 63 | 63 | 26 | 1 | 0.002 | 0.0006 | 29.1 | 0.001–0.003 | 86 | 0.08 | 0.41 | 0.002 | 56.2 | 100 |
| Veg 2 | 41 | 41 | 5 | 1 | 0.0004 | 0.0003 | 77.1 | 0.0001–0.002 | 12 | 0.11 | 0.12 | —[g] | | |
| Veg 3 | 22 | 22 | 5 | 1 | 0.003 | 0.0016 | 58.8 | 0.0009–0.008 | 22 | 0.03 | 0.23 | — | | |
| Veg 4 | 38 | 38 | 16 | 1 | 0.004 | 0.0011 | 29.1 | 0.002–0.006 | 52 | 0.04 | 0.42 | — | | |
| Veg 5 | 5 | 5 | 0 | —[h] | | | | | | | | | | |
| Veg 6 | 68 | 68 | 10 | 1 | 0.003 | 0.0014 | 41.3 | 0.002–0.007 | 76 | 0.02 | 0.15 | — | | |
| Veg 7 | 99 | 99 | 22 | 1 | 0.005 | 0.0013 | 26.6 | 0.003–0.008 | 118 | 0.02 | 0.22 | 0.005 | 67.6 | 100 |
| Veg 8 | 24 | 24 | 7 | 1 | 0.009 | 0.0046 | 54.0 | 0.003–0.024 | 26 | 0.01 | 0.29 | — | | |
| Veg 9 | 40 | 40 | 1 | — | | | | | | | | | | |
| Veg 10 | 2 | 2 | 0 | — | | | | | | | | | | |
| Veg 11 | 16 | 16 | 7 | 1 | 0.005 | 0.0024 | 50.5 | 0.002–0.013 | 17 | 0.03 | 0.44 | — | | |
| Veg 12 | 4 | 4 | 0 | — | | | | | | | | | | |

[a] For explanation of DISTANCE program estimations, see text.
[b] For vegetation code explanation, see Table 1.
[c] Total effort = the sum of the number of times each point and its corresponding vegetation was sampled.
[d] Estimator Model No. = the mathematical estimator model selected by program DISTANCE to analyze the point data, where the chosen model was the one that had the smallest Akaike's Information Criterion value (AIC).
[e] Density estimations: Estimate = density in number of 'io/hectare; SE = standard error of the estimation; %CV = percent coefficient of variation of the estimate; 95% CI = 95% confidence interval for the estimate; df = degrees of freedom used in the analysis; Detect Prob. = the estimate of average probability of detecting an 'io; Enc. rate = the number of animals expected to be observed per point.
[f] Density Bootstrap values: Est. = bootstrapped density estimate; %CV = percent coefficient of variation of this estimate; Runs = total number of bootstrap runs conducted.
[g] "—" = too few degrees of freedom to conduct bootstrap analyses.
[h] "—" = no or too few 'io observed along this survey route, so no density analysis could be performed.

(Table 1). Observations of 'io were entered as the radial distance to the hawk from the point. We truncated the distances at 3000 m (the maximum distance at which most 'io were observed) to allow all hawk observations to be entered into the analyses. We instructed the program to select the most appropriate density estimation model for each analysis, based on maximum likelihood ratio tests of the models vs. each other. We also instructed the program to conduct 400 bootstrap samples for the island-wide data, to obtain reliable estimates of the variances around the density estimates, and 100 bootstrap samples for each of the analyses of density by vegetation type.

We estimated the current population size of the 'io on Hawaii based on the density of hawks per vegetation type, and the estimated percent cover by each vegetation type on the island of Hawaii (Jacobi and Scott 1985, Cuddihy and Stone 1990).

RESULTS AND DISCUSSION

We sampled 40 transects across Hawaii, with 399 points covering approximately 500 km of roads. Among these points, 98 different 'io were ob-served. Thirty-three hawks were identified as adults, 7 as immatures, and 58 as unknown-aged. Forty-five hawks were light morph birds and 14 were dark morphs.

Densities ranged from a low of 0 in vegetation types 5, 9, 10, and 12 to a high of 0.009 hawks/ha in vegetation type 8 (Table 2). Most densities were between 0.003 and 0.005 hawks/ha, with an overall mean of 0.004 hawks/ha. Vegetation types 5 and 9 had lava as a major ground component, and thus had poorly-developed tree cover. Type 10 vegetation was dominated by shrubs, and type 12 was in mamane-naio woodland. Type 2 vegetation was typified by exotic trees of various sizes and had very few hawks. Type 8 vegetation consisted of residential areas with both native and exotic tree components and showed the highest hawk densities. Grasslands with scattered exotic and native trees (vegetation type 4) also had moderately-high den-

sities of birds. Bootstrapped density estimates matched the model estimates in all cases where adequate degrees of freedom existed.

Surveys found 'io most commonly in areas with native and/or exotic tree cover, usually with understories of exotic grass, and sometimes with native and/or exotic shrub understories. Although 'io were not found frequently in small patches of mixed native and exotic forest surrounded by open fields or orchards, they were commonly observed over the open areas, or in open places, with scattered native and/or exotic trees. For example, in sugar cane fields with ribbons of native or exotic trees between fields, or with trees extending down from higher elevation forests; in open pasture land with scattered native trees; in orchards (especially macadamia nut) with taller native and/or exotic trees at the perimeters. This indicated that 'io are now using areas that are not pure native forest. Based on these data and anecdotal breeding records from these more open areas, it appears that they are also able to successfully breed there (J. Jeffrey and J. Giffin unpubl. data).

Griffin (1985, 1989) estimated that the population of 'io on Hawaii was about 2700 hawks in 1983. Of this, 1800 were adults. This estimate served as the basis for the Hawaiian Hawk Recovery Plan developed by the USFWS (1984). It used an abundance of 2,000 hawks (the midpoint between the 1500 and 2500 adult birds thought to be needed for a self-sustaining population) as the target to downlist the species to threatened status. The island-wide estimate of 'io density was based on a total forested area of 343 000 ha (J.M. Scott pers. comm., Griffin 1989). This value corresponded roughly to the potential 'io habitat contained within the Hawaiian Forest Bird Survey area (Jacobi and Scott 1985). Using this area, and the overall estimate of 'io density from our surveys (0.004 birds/ha, 95% Confidence Interval [C.I.] = 0.003–0.006), we obtained a total density of 1372 'io (range = 1029–2058) on Hawaii. Much of the lowland forested areas of Hawaii, including the sugar cane, macadamia nut and other disturbed areas occupied by 'io, were excluded from Griffin's area estimate. We therefore modified the Griffin estimate by adding 60 000 ha of mixed sugar cane-lowland forested area and various other minor vegetation types (Cuddihy and Stone 1990), bringing the total potential 'io habitat to 400 000 ha. This raised our estimate of 'io on the island to about 1600 birds (range = 1200–2400), with 1120 adults or 560 pairs.

Our estimated density of adults (1120) is about 25% below the lower end of the target range necessary for a stable 'io population, according to the Recovery Plan (target = 1500–2500 adult birds). Assuming that all birds alive during our surveys survived to breed, the total number of birds we estimated (1600) is just above the lower end of the target range, but is still below the mean target value of 2000. The target value of adults is not enclosed in the confidence interval around the 0.004/ha value (95% C.I. = 0.003–0.006), but is enclosed if we assume that all hawks alive breed (400 000 ha x 0.006 = 2400 hawks).

We found a relatively high number of birds that were widely distributed among vegetation types on Hawaii, including heavily-disturbed areas. In addition, our results were similar to those found 10 years earlier by Griffin (1985, 1989), indicating the likelihood of a relatively stable population during the past decade. Thus, we concluded that downlisting to threatened status was supported.

As other biologists have suggested for the 'io, long-term demographic studies are necessary to accurately assess the overall status of the population (USFWS 1984, Griffin 1989). Our fieldwork did not assess population trends, reproductive fecundity and success, dispersal or mortality, all of which have been shown to be problematic for other forest birds on Hawaii (Scott et al. 1986). Thus, we think that the USFWS should initiate a long-term demographic study so future density estimations can be evaluated in light of other population data. Such a study is necessary before delisting from threatened status is considered.

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