RESULTS AND DISCUSSION

Three native bird species and 12 non-native bird species were detected during the surveys (Table 2). The native species present were the Apapane, Maui Amakihi, and Iiwi. All of these species have previously been observed in the park. The non-native species present were Barn Owl (*Tyto alba*), Black Francolin (*Francolinus francolinus*), Common Myna (*Acridotheres tristis*), House Finch (*Carpodacus mexicanus*), Japanese Bush-warbler (*Cettia diphone*), Japanese White-eye (*Zosterops japonicus*), Northern Cardinal (*Cardinalis cardinalis*), Nutmeg Mannikin (*Lonchura punctulata*), Red-billed Leiothrix (*Leiothrix lutea*), Skylark (*Alauda arvensis*), Spotted Dove (*Streptopelia chinensis*), and White-rumped Shama (*Copsychus malabaricus*). Iiwi was the only rare native species observed. Japanese White-eye was the most abundant species, and Iiwi, Barn Owl, and Skylark were the rarest species (Table 3).

Table 2. *Summary of forest bird detections for individual transects at Kalaupapa National Historical Park for surveys conducted March–April 2004 and March–May 2005.*

	Species		Kukaiwaa	Kauhako Crater	Lower Waikolu	Lower Waihanau	Kalaupapa Cliff Trail	Upper Waihanau	Puu Alii NAR	Upper Waikolu
	Common Name	**Scientific Name**								
Native	Apapane	*Himatione sanguinea*			✓	✓	✓	✓	✓	✓
	Iiwi	*Vestiaria coccinea*								✓
	Maui Amakihi	*Hemignathus virens wilsoni*			✓				✓	
Non-native	Barn Owl	*Tyto alba*			✓					
	Black Francolin	*Francolinus francolinus*		✓			✓			✓
	Common Myna	*Acridotheres tristis*	✓	✓	✓		✓			
	House Finch	*Carpodocus mexicanus*	✓	✓			✓	✓	✓	✓
	Iiwi	*Vestiaria coccinea*								✓
	Japanese Bush-warbler	*Cettia diphone*	✓	✓	✓	✓	✓	✓	✓	✓
	Japanese White-eye	*Zosterops japonicus*	✓	✓	✓	✓	✓	✓	✓	✓
	Northern Cardinal	*Cardinalis cardinalis*	✓	✓	✓	✓	✓	✓	✓	✓
	Nutmeg Mannikin	*Lonchura punctulata*	✓						✓	
	Red-billed Leiothrix	*Leiothrix lutea*							✓	✓
	Skylark	*Alauda arvensis*					✓			
	Spotted Dove	*Streptophelia chinensis*		✓	✓	✓	✓	✓	✓	✓
	White-rumped Shama	*Copsychus malabaricus*	✓	✓	✓	✓	✓			

Table 3. *Forest bird detection data for Kalaupapa National Historical Park for surveys conducted March–April 2004 and March–May 2005.*

	Species	Number of Transects Occupied	Number of Detections	Percent of Occurrence	Birds per Station
Native	Apapane	67	223	66	2.2
	Iiwi	1	1	1	0.0
	Maui Amakihi	12	20	12	0.2
Non-native	Barn Owl	1	1	1	0.0
	Black Francolin	11	21	11	0.2
	Common Myna	10	23	10	0.2
	House Finch	19	53	19	0.5
	Japanese Bush-warbler	84	310	82	3.0
	Japanese White-eye	96	452	94	4.4
	Northern Cardinal	46	128	45	1.3
	Nutmeg Mannikin	2	5	2	0.1
	Red-billed Leiothrix	35	85	34	0.8
	Skylark	1	1	1	0.0
	Spotted Dove	26	47	25	0.5
	White-rumped Shama	29	64	26	0.6

Table 4 summarizes the inventory data by elevation strata. All three native bird species were found at the high elevation sites, all of which contain native vegetation. Ohia-dominated forest remains in high elevation Puu Alii NAR and Waikolu Valley, and the adjacent Upper Waihanau area has a mixed native/non-native forest. The one Iiwi detection was at the high elevation Waikolu site, which is consistent with where Iiwi are most often detected: in closed canopy, high stature ohia forest above 1500 m (Gorresen et al. in press). Three Iiwi were detected during the 1979 HFBS as well, on the Puu Alii NAR transect (Scott et al. 1986).

Apapane were detected most frequently at high elevation sites (92% occurrence and 3.2 BPS) forests. Percent occurrence and BPS for Apapane for just the two upper elevation HFBS transects that were also surveyed in 1979 were 94% and 3.14. The percent occurrence for the 1979 HFBS was similar at 100%, but the BPS was twice as high at 6.4. At mid and low elevations Apapane were detected much less frequently (35 detections). At low elevations they were found in lower Waikolu Valley (22 detections) and at three stations in the back of Waihanau Valley (eight detections). Apapane are believed to forage up and down the valley wall, thus are detectable at the upper and lower Waihanau Valley transects.

At lower elevations Maui Amakihi were detected exclusively on the Waikolu Valley transect, which is dominated by non-native vegetation (17 detections). Percent occurrence and BPS for Maui Amakihi were 23% and 0.4 for the lower elevation transects. Curiously, only three (five percent occurrence, 0.1 BPS) Maui Amakihi were detected at the high elevation site of Puu Alii, which is dominated by native vegetation. The percent occurrence and BPS were 6% and 0.03 for the two HFBS transects (Puu Alii NAR and Upper Waikolu). In comparison, the percent

occurrence and BPS for the 1979 HFBS were similar to the 2005 results of the low elevation transects. It should also be noted that a female Maui Amakihi was seen nest-building in Waikolu Valley at an elevation of 100 m.

Avian malaria (*Plasmodium*), of which the non-native mosquito *Culex quinquefasciatus* is a vector, is one of the factors responsible for the reduction in native bird populations in Hawaii (Warner 1968). However, recent studies in the Puna district of Hawaii Island have shown that Amakihi populations have increased (Woodworth et al. 2005). Atkinson and LaPointe (in review) report that detections of Amakihi at low elevations may indicate the development of resistance to avian malaria that can be passed to their offspring, thereby facilitating the repopulation of low elevation areas. Molokai's highest point reaches 1,515 m; therefore, the entire island lies within the elevation range of mosquitoes. As a result, all native avifauna are exposed to mosquitoes and, consequently, to avian malaria and pox. The presence of Maui Amakihi and Apapane at the low elevation sites in Kalaupapa may be evidence of resistance to disease.

Non-native birds were present throughout the inventory transects. Of the non-native bird species, only Barn Owl, White-rumped Shama, Skylark, and Common Myna were absent from high elevation stations. Red-billed Leiothrix were absent from low and mid elevation (200-500 m) stations.

The Japanese White-eye and Japanese Bush-warbler were the most common non-native bird species detected during the survey and were found at all elevations. Introduced to the Hawaiian Islands in the early 1900s, Japanese White-eye occurred on all transects sampled in our inventory. The percent occurrence of Japanese White-eye estimated for the two HFBS transects for this inventory (88%) remain close to that of the 1979 Molokai HFBS (100%), but the BPS in 2004 (2.36) was lower than in 1979 (7.34; Scott et al. 1986). Japanese White-eyes are omnivores and forage mostly on fruit, nectar, and insects from the understory (Scott et al. 1986). This forage behavior may impact native birds, such as the Maui Amakihi, that use similar food resources (Mountainspring and Scott 1985).

Japanese Bush-warblers were first detected on Molokai in the late 1970s (Pyle 1979; Conant 1980). During the 1979 HFBS, Japanese Bush-warblers were not detected on the two high elevation HFBS transects that were surveyed in 2004 (Scott et al. 1986). This survey reports percent of occurrence and BPS of 100% and 4.32 at these same transects. Given that this species was only present on Molokai for a couple of years prior to the 1979 surveys, their rapid growth between surveys is not surprising. Berger (1981) typifies the Japanese Bush-warbler as preferring habitat with an abundant understory; they primarily forage for insects, but also eat fruit and nectar.

Red-billed Leothrix was introduced to the Hawaiian Islands in the early 1900s, and by the 1970s was well established on Molokai (Scott et al. 1986). This species forages mostly in the understory on insects and fleshy fruits (Mountainspring and Scott 1985). Red-billed Leothrix was only found at the high elevation HFBS transects, with percent occurrence and BPS of 70% and 1.7 for those two transects. These findings agree with the 1979 HFBS where these birds occurred mainly above 1,100 m elevation, with a percent occurrence of 70% and a BPS of 2.96 (Scott et al. 1986).

Table 4. *Summary of forest bird detections by elevation range in Kalaupapa National Historical Park for surveys conducted March–April 2004 and March–May 2005.*

	Species	Low Elevation (<200m)*			Mid Elevation (200-500 m)*			High Elevation (>500 m)*		
		# Detections	% Occurrence	BPS	# Detections	% Occurrence	BPS	# Detections	% Occurrence	BPS
Native	Apapane	30	26	0.8	5	60	1	188	92	3.2
	Iiwi	0	0	0.0	0	0	0	1	2	0.0
	Maui Amakihi	17	23	0.4	0	0	0	3	5	0.1
Non-native	Barn Owl	1	3	0.0	0	0	0	0	0	0.0
	Black Francolin	5	10	0.1	3	40	0.6	13	8	0.2
	Common Myna	21	23	0.5	2	20	0.4	0	0	0.0
	House Finch	46	33	1.2	3	40	0.6	4	7	0.1
	Japanese Bush-warbler	49	56	1.3	7	60	1.4	254	98	4.3
	Japanese White-eye	222	95	5.7	39	100	7.8	191	88	3.2
	Northern Cardinal	96	87	2.5	10	80	2	22	14	0.4
	Nutmeg Mannikin	4	3	0.1	0	0	0	1	2	0.0
	Red-billed Leiothrix	0	0	0.0	0	0	0	85	59	1.4
	Skylark	0	0	0.0	1	20	0.2	0	0	0.0
	Spotted Dove	35	48.7	0.9	1	20	0.1	11	10	0.2
	White-rumped Shama	57	87	1.5	10	60	1.4	0	0	0.0

* Low elevation: includes all stations on the Kukaiwaa, Kauhako Crater, Lower Waikolu, Lower Waihanau transects and stations 6&7 on the Kalaupapa Cliff Trail transect.
Mid elevation: includes stations 1-5 on the Kalaupapa Cliff Trail transect
High elevation: includes all stations on the Upper Waihanau, Upper Waikolu and Puu Alii transects

Introduced to the Hawaiian Islands in 1929, Northern Cardinals are well established in native and non-native habitats throughout the islands (Scott et al. 1986). Northern Cardinals prefer hedges, thickets, and open woodlands and eat a variety of foods, such as seeds, fruits, and insects (Scott et al. 1986). This species was found at all transects except for the two high elevation HFBS transects. This agrees with the results of the 1979 HFBS which also showed no detections of Northern Cardinals on these transects (Scott et al. 1986).

White-rumped Shamas were first released on Oahu in 1940, and by 1960 were established on Kauai (Scott et al. 1986). This species was frequently detected in 2005 with a percent occurrence of 24% and BPS 0.57, but only at the low elevation sites. According to Scott et al. (1986), there were no known records on Molokai for this species when the HFBS were conducted in 1979. This species mainly eats insects (Berger 1981).

Spotted Doves were introduced in the late 1800s, and are widely dispersed among the Hawaiian Islands (Scott et al. 1986). This species was more common at lower elevations, with a percent occurrence of 48.7% and a BPS of 0.9 for low elevation sites. Percent occurrence and BPS for the two HFBS transects in 2004 was very low at 4% and 0.04. The low elevation densities are more similar to Scott et al. (1996) findings from the 1979 HFBS, which showed percent occurrence and BPS to be 34% and 0.88. Spotted Doves mainly forage for insects and seeds on the ground.

House Finches arrived in the Hawaiian Islands before 1870, and became well established by the 1940s (Scott et al. 1986). This species occurs over a broad range of habitats and is most common over a range of elevations in dry woodlands and savannas (Scott et al. 1986). During the 2004 survey, the percent occurrence was 6% and BPS was 0.06 at the two HFBS transects, which is similar to the 1979 survey findings of percent occurrence and BPS of 4% and 0.04.

Introduced from India in 1959, Black Francolins occur on Molokai, as well as Hawaii, Maui, Molokai, and Kauai. This species was not found at either of the two HFBS transects, but was found at the other high elevation transect. With a percent occurrence of 11% and a BPS of 0.2, it was not detected often during the survey. This is not unexpected since highest densities of this species occur in dry shrubland and savanna, with some individuals entering closed canopy forests along roads, clearings, and grassy areas. The 1979 HFBS results did detect Black Francolins at the higher elevation, with a percent occurrence of 20% and a BPS of 0.42. This species consumes plants, insects, and seeds (Scott et al. 1986).

Common Mynas were introduced from India in 1865, are common to abundant in low elevation areas excluding forest interiors, and are predominately terrestrial omnivores (Scott et al 1986). All detections of Common Mynas occurred at low elevation stations in the 2004/05 survey, which is consistent with the 1979 HFBS results, which also showed no detections of Common Mynas.

Nutmeg Mannikins were introduced in the mid 1800s and spread rapidly thereafter (Scott et al. 1986). Only five individuals were detected during this survey, and only one was detected at a high elevation HFBS transect. The HFBS did find that the highest densities of this species in the state were found on Molokai at low to mid elevations (Scott et al. 1986).

Of the last two species detected, the Barn Owl and the Skylark, only one individual of each was detected, neither of them at high elevations. Barn Owls are nocturnal and are not commonly

found in the forest (Scott et al. 1986), which may account for their low detection rate. The Barn Owl was sighted at about 200 m elevation among the non-native trees of the Lower Waikolu transect. No Barn Owls were detected during the 1979 survey at the two high elevation HFBS transects. The single Skylark was detected among the non-native scrub along the Kalaupapa Cliff trail. Skylarks are most common in dry scrub, savanna, and woodland, and also were not detected on Molokai during the 1979 HFBS (Scott et al. 1986).

We make three recommendations to improve future surveys. First, as birds are more vocal during breeding seasons than other times of the year, we recommend that surveys should be conducted during periods of peak vocalization to ensure high detectability. Second, increasing the amount of area covered in future surveys (i.e., surveying additional valleys) is also suggested; this will increase the spatial coverage and increase the sample size. Lastly, Molokai Thrush and Molokai Creeper are thought to possibly be extinct. If they are extant, we would not expect to detect them during VCP counts as this technique is not appropriate for extremely rare species. For surveying these species we suggest following the Rare Bird Search protocol established by Reynolds and Snetsinger (2001; see also Turner et al. 2006) in the intact high elevation forests to confirm whether they are truly absent.

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