cies List from February 1st, 2000 indicates 640 endangered, threatened, candidate or species of concern snail taxa. Hobdy ('93) estimates that there were once roughly 780 species of snails endemic to the Hawaiian islands ("Lana`i - A Case Study: The Loss of Biodiversity on a Small Hawaiian Island"; *Pacific Science*; vo. 47, no. 3; pp 201-210, University of Hawai`i Press, © 1993). According to Severns (personal communication 1999), there were 763 species of taxonomically valid species of snails recognized as Hawaiian, of which all but 2 to 4 are endemic. Most were single-island endemics. An additional 16 species questionably belong to Hawaii, and a further 14 are possibly senior synonyms (prior descriptions under a different name).

Earlier articles have estimated that there were once 42 species of native land snails on Lana`i. However, more recent work estimates 71 species. (See table prepared by Mike Severns, based on Cowie, Catalog of Native Land & Fresh Water Molluscs of the Hawaiian Islands, Backhuys Publishers, Lieden, 1995 and others. These are listed in Table 5-9.

Although native snail fauna is among the more diverse groups of native species, some experts believe that most species of Hawaiian snails radiated from members of a single genus of progenitors, *Tornatellides*, which has been found on bird feathers throughout the Pacific islands. (Personal communications, Dr. Michael Hadfield, Mike Severns).

Snails were and integral and abundant part of the original, uniquely endemic ecosystems of Lana`i. Most native snails are single island endemics, existing no where else on Earth. Snails in Hawaii mainly eat fungus, lichens and algae off leaves of trees. It is not clear whether this could have any beneficial impact on the trees, or how important this role was. Snails, like other abundant life forms, were part of the nutrient cycle, contributing to the total biomass, soil nutrients, and so forth. They were a dietary component of certain native birds. The endangered Po`ouli (Melamprosops phaeosoma) eats snails (Gon), and it is believed that certain extinct species of large flightless birds ate snails (Severns), although apparently the larger snails were not eaten. (Severns, personal communication; Pilsbry, Manual of Conchology, Storrs & James, Ornithological Monographs 45 & 46, James Juvik, Atlas of Hawaii, 3rd Edition).

Severns has explained a phenomenon noticed during the time when sheep were on Lana`i, in which mollusc populations seem at first to increase with disturbance of native communities, though in the long run they may be adversely affected. He believes that invasive mammals, such as sheep ate lower stature plants / trees at the edge of the forest, exposing large, shallow-roooted `ohi`a trees to winds which they were not capable of withstanding.. When the trees fell, they extended the range of the fringe (semi-forest, semi-scrub) habitat, and certain populations adapted to inhabit fringe areas expanded.(Severns, personal communication, information from article in preparation for Pacific Science)

Snail species are described in Table 5-9.

TABLE 6-9 Native Snails of Lana`i

Family	Sub Family	Genus	Sub Genus	Species	Preferred Habitat, Food,Habits, Elevation Ranges and Other Notes	Max Size mm	Description
Helicinaidae		Pleuropoma	Pleuropoma				have opercula (trap door)
				kaaensis	Dry land, W. Lana`i	3.10	
				lacinosa		3.20	
				piliformis	Found on Lanaihale.	3.50	
Achatinellidae	Achatinellae	Partulina	Eburnella		Eburnellas live in Lanaihale and fringe forest. live in trees, feed on lichens & algae. nocturnal		
				variabilis	Scrub `ohi`a areas, likes habitat that gets some light, vegetation not too dense, not usually found in the tops of trees. may be adapting to live on guava	18.00	semi-gloss shell
				lactea	Variation of variabilis	22.00	
				semicarinata		18.00	
				hayseldeni	Variation of semicarinata	18.00	well defined, sharp ridge around body keel that runs around periphery of the last whorl.
			Partulina		Lanaihale & fringe forest, uluhe & scrub `ohi`a areas feeds on lichens and algae, nocturnal, lives in trees. lives at somewhat lower elevations than other Partulinas (2,000-4000' on W. Maui) , but found on Hale		dull, rough shell,
				crassa		22.00	
	Auriculellinae	Auriculella			Tree dweller, feeds on lichens and algae, nocturnal.		
				brunnea		8.00	
				lanaiensis		5.80	
	Pacificellinae	Lamellidea	Lamellidea				
				gracilis		3.75	
	Tornatellidinae	Tornatellaria					
				cincta		5.00	
				trochoidea		4.00	
		Tornatellides	Tornatel-lidides				
				acicula		3.00	
				macromphala		2.75	
				perkinsi		3.00	
				procerulus		3.50	
				terebra		3.00	
Amastridae	Amastrinae	Amastra	Amastra		Lana`i once had large Amastras. These tend to be more ground-dwelling. They live under rocks, under ferns and other ground vegetation, and in leaf litter. Can live in mesic and fringe, down to dry-forest. Somewhat lower elevation than Partulinas, but lived in Hale.		
				aurostoma		25.00	
				balteata		23.60	
				biplicata		23.00	
				durandi		20.00	
				grayana	Found in Lana`i Hale on ground	21.50	
				longa	Disappearance noted in 1912.	12.00	
				magna		36.00	largest known Amastra in Amastra genus. (Corelia is in a different genus)
				moesta		15.80	
				nucula		12.00	
				obscura		16.50	

				pusilla		8.50	smallest amastra on Lana`i
				rubristoma		19.30	
		Amastra	Heteramastra	fraterna		10.00	
		Laminella			Tree dwellers, feed on lichens and algae, nocturnal		
				concinna	Found on koele side of summit, about 3,000'	11.20	
				circumcinta	Color variation of concinna	12.00	striped. this is the only striped Laminella.
				gracilor		15.50	
				remyi	Very similar to tetrao. Found behind koele.	14.00	
				tetrao	Very similar to remyi. Found behind koele.	17.20	
		Tropidoptera					
				alata	Found behind koele	8.50	
				lita		10.00	
	Leptachatini-nae	Leptachatina	Leptachatina		Fringe to grassy areas	14.00	bullet shaped, shiny shells
				impressa	Found behind koele	7.00	
				lanaiensis		8.00	
				longiuscula		10.50	
				perkinsi	Found on ridges of gulches	10.50	
				semipicta	Found behind koele	8.00	
				smithi	Found in mountains behind koele	9.25	
				subovata	Was once abundant	7.30	
				supracostata		6.30	
Pupillidae	Nesopupinae	Lyropupa	Lyropupa				
				lanaiensis		2.50	
				rhabdota		2.50	
			Lyropupilla				
				sparna		2.20	
			Mirapupa				
				costata			
		Nesopupa					
			Limbatipupa				
				newcombi		1.65	
			Nesodagys				
				rhadina	Likes damp rocks, smooth, barked trees	1.95	
				thaanumi	Found in moss on tree trunks	2.75	
				wesleyana	Likes damp rocks, smooth, barked trees	2.00	
			Nesopupilla				
				baldwini	Found on top of Lana`i Hale	2.50	
				dispersa	Found freshly dead in mahana gulch	1.53	
		Pronesopupa					
			Pronesopupa				
				boettgeri			
				hystricella			
Endodontidae		Cookeconcha			Found on the ground, live in cracks between rocks, fallen logs, etc.		
				lanaiensis	Found in Koele and on Hale	4.77	flat rounded spire
				ringens	Likes wet forest. Found on Koele and on Lana'ihale	4.61	
		Endodonta		concentrata	Found on the ground, live in cracks between rocks, fallen logs, etc.	5.43	flat angular spire
Succineidae	Succineinae	Succinae	Succinae	caduca			
		Succinea	Truella	rubella	Fringe to drier areas		fingernail-thin
Helicarionidae	Euconulinae	Euconulus	Nesoconulus				
				kaunakakai	Under talus	2.33	
				subtilissimus	Ground dwelling	2.36	
	Mycrocystinae						

		Hiona	Hionella				
				perkinsi	Likes ground moisture, high elevations	6.50	
		Philonesia	Haleakala		Live in wet forest, like forest understory, very susceptible to dessication, typically likes higher elevations and wetter areas than Partulinas.		have thin, almost transparent shells, charcoal gray to black,
				diducta	Found under lichens on a`alii shrubs	4.81	
				interjecta		6.28	
				turgida	Found under lichens on trees	5.50	
			Philonesia	maunalei	Found in talus under kukui tree	6.33	
Zonitidae	Gastrodontinae	Striatura	Pseudohy-alina	discus		3.40	
	Zonitinae	Nesovitrea		pauxilla		5.00	

Table courtesy of Mike Severins

Sources: Cowie, Catalog of Native Land & Fresh Water Molluscs of the Hawaiian Islands, Backhuys Publishers, Leiden, 1995, and others

Threats/ Concerns to Native Snail Populations

Threats to snails in Lana`i include predation by rats, other snails, and possibly birds; altered and diminished habitat, introduced pathogens, and the risk of damage from human activities. These threats are delineated below. (*Source:Personal communications, Dr. Michael Hadfield and Mike Severns*)

- **Predation by other snails**

Oxachilus aliaris

Introduced predatory snail, eats natives.
Believed by Severns to have been introduced during WWII.
By the 1960s, most ground-dwelling snails were extinct.
Mucous coating smells of garlic.
Eats young snails when hatched.

Euglandina Rosea

Introduced predatory snail from the Florida swamps.
Not yet reported on Lana`i ,
Due to its agressive nature, forest managers should be on the alert for this predatory snail.
Introduced to the islands intentionally in 1958 to control another species of introduced snail.
A comparison of the life cycle of the predatory *Euglandina* to that of native snails such as *Achitinella* and *Partulina* highlights the vulnerability of the native snails. Whereas Achitinella and Partulina mature slowly (6-7 years), and live to a maximum of about 20 years, producing only 1 to 7 offspring per year, the introduced Euglandina takes less than a year to mature, produced more than 600 eggs per individual per year, and has a life span of up to 5 years. (Loope, 1998, in Mac, M.M.; P.A. Opler; C.E. Puckett, Haecker; and P.D. Doran *Status and Trends of the Nation's Biological Resources*, 2 volumes; U.S. Department of the Interior, U.S. Geological Survey; Reston, Va..; Chapter on Hawaii & the Pacific Islands by Lloyd Loope, quoting Mike Hadfield et al 1986) - (Hadfield, M.G.; *Extinction in Hawaiian achetelline snails*; Malacologia; 27:67-81; 1986)

- **Possible predation by other animals such as introduced birds**

- **Habitat of choice:**

Native snails remaining are found living in low vegetation. This makes them more vulnerable to predators loss of natural habitat and possible introduction of diseases by introduced snails or slugs.

- **Invasion of non-host plant species**

For example, Eucalyptus or other species that eliminate natural habitat species and which do not provide host for native snails.

- **Poorly planned management efforts**

Even well-intentioned attempts to help retain and enhance habitat could pose a threat. Proposed fence lines or other forest management facilities should be surveyed to insure that snail populations are not disturbed.

TABLE 6-10 Native Birds of Lana'i

Family	SubFamily	Genus	SubGenus	Species	Sub species	Common Name	Description
Fringillidae		Himatone		sanguina		apapane	Only remaining endemic forest bird in Lana`i. adult has crimson body with white belly and under-tail coverts, and black tail and wings. first plumage on the young is brown. strong flier, flies high in small groups from one part of the forest to another. keeps mainly to tree tops. wings vibrate loudly in flight. active in tree tops, hopping from one flower to another. food, nectar, insects and caterpillars.
Fringillidae		Paroreomyza	maculata	montana		Lana`i creeper, alauwahio	Wilson called this Paroreomyza maculata montana. Hawaiian names: Alauwahio, Alauwi, Lauwi. short flights, food in bark of tree trunks and branches. pretty, chirping call. yellowish green upper body with lemon-yellow under body. about 5" long. nest was compact ball of fine grass stems and skeleton leaves, 1.75" across the bowl, 0.75" deep, 0.5" thick. last seen in 1937 per Munro.
Antidae		Branta		sandwicensis		Nene	Listed as Nesochen sandwichensis by Munro, but not mentioned by him as being on Lana`i. Ornithological monographs list as Branta sandwicensis. Both refer to it as nene. black, brown and buff with greyish parts. hind neck, cheeks, chin and throat black, also black ring around lower throat. 23"-28". webs on feet smaller than other geese. feeds on berries. lived and fed mainly in dry upland country; wintered and raised young in lowland lava flows. noted as living from sea level to 2,200' by Munro. nest was a hollow in the ground, or eggs laid on surface and surrounded by pieces of brush. Munro reported laid 3 to 6 cream white eggs. eggs 3.36"x2.35", but usually only 2 chicks. Nene on Maui typically lay about 4 eggs. Hawaiians used to hunt nene for food, esp. during molting season.
Fringillidae		Dysmorodrepanis		munroi		hookbilled finch	Perkins called it Dysmorodrepanis munroi. Not clear if Munro thought it was finch or drepanid? Endemic to Lana`i. nearly extinct per Munro in 1944. bird found in 1913 by Munro had upper body light grey with tinge of green, white mark over the eye, but it was molting. found in Kaiholena Valley in 1913, and later in Waiakeakua. beak unusual in that mandibles curved toward each other so that only the tips touched. Retiring bird. Munro believed that this bird used to live in the akoko forest (Euphorbia lorifolia) that originally covered the Lana`i plains. Munro took one feeding on the fruit of an opuhe (Urera sandwichensis), which has fruit about the same size. lived in upper forest and plains of Lana`i. between the islands.
Fringillidae		Hemegnathus		obscurus	lanaiensis	Akialoa	Munro calls it Hemignathus obscurus lanaiensis (Rothschild). Rothschild described male as black olivaceous green, with dirty yellow breast and cream white under tail covers. However both Munro and Perkins thought that this must have been either a younger bird or if an adult, one not in its breeding stage, as they found it to be quite yellow. The female was a dull greayish olive, with yellowish abdomen. By 1944, Munro felt it was probably extinct, as it had not been seen in many years. It was seen hunting for insects on an o`hi`a. Munro believed it had also inhabited the akoko forest. it hunted for insects on the trunks and limbs of trees, and Perkins noted that the one he saw seemed rather tame, continuing to hunt for food at times not 5 yards distant.

Fringillidae		Hemignathus		virens		Amakihi, honey creeper	Bishop museum printout lists Hemignathus virens. Ornithological monographs list Loxops virens. Munro calls it Chorodrepanis virens chloroides. Known as the Lana`i amakihi. Type of honeycreeper. Looks not described specifically, but Munro mentions that the species vary little in size, with total length varying from 4.2 to 4.75 inches. He noted that Perkins felt that the species inhabiting Hawaii, Molokai, Maui and Lana`i were essentially the same. He describes the Kauai and Hawaii amakihis, and foregoes description of the appearance of the Molokai, Maui or Lana`i species. The Kauai species had bright green upper parts, with yellowish under parts. The Hawaii species was described as being much yellower than the Kauai species, with a smaller bill. Kihi means curved, and describes the shape of the bill. One assumes that the Lana`i species was also green on top and yellow underneath. The Lana`i amakihi was once very common in the forest, but numbers were reduced by introduction of bird diseases. Munro says that they were plentiful prior to 1923, when the town was built. By the writing of his 1944 book, he says that they were very much reduced in numbers as of a few years ago and their chance of survival slight. The forest was small and of no considerable elevation, and its proximity of the town lent little protection through isolation. Munro observed a nest and noted that it was 3.75" wide by 3.5" deep, with a 1.75" hollow at the top, with the characteristic odor of the Drepanine birds. The Lana`i amakihi had this odor so stronly that, "A bird flying past to windward left the odor plainly perceptible in the air." Munro saw a nest in a small tree 12' from the ground. The female approached and tried to lure him away by scolding and fluttering. The nest overhung the steep valley side, but was hidden by the trees above from owls. It was made of grass and fiber from the ieie vine, and lined with rootlets and some sheeps wool.
Fringillidae		Loxops		virens		Amakihi, honey creeper	
Fringillidae		Psittirostra		psittacea		O`u	Munro lists as Psittacirostra psittacea (Gmelin). Bishop lists as Psittirostra psittacea. Munro notes that Temminck, Rothschild and Henshaw all referred to it as Psittirostra. He seems to credit Temminch with the name, but states that Psittacirostra as used by Perkins is more grammatically correct. Munro states that the male was known as the O`u poolapalapa, or yellow-headed O`u; and the female as O`u laueo, or leaf green O`u. The bird has a bright green body, and the male of the species has a yellow head. The female and young did not have a yellow head, and the younger birds were not quite as bright. The bill was parrot-like and hooked, possibly facilitating scooping fleshy flower bracts and picking ripe fruit from the upright spadix of the ieie vine. The O`u had a beautiful voice, with clear whistling notes leading in to a plaintive call. Munro noted that the birds were common in 1923 and seemed to be doing well, but by 1944 he felt that they were near extinction. O`u naturally fed on the fruit and flowers of the ieie vine, and on the berries of arborescent lobelias, and other upland fruits but they were also seen feeding on guava and mulberries. Unfortunately, Munro believed this is part of the reason they became extinct. The O'u had a habit of coming to the low level areas for food, which exposed the species to introduced bird diseases which they could then carry back to their forest habitat. No nests were seen. Munro thought they were probably well hidden in staghorn ferms and ieie vines. O`u feathers were used in Hawaiian featherwork..

Fringillidae		Vestiaria		coccinea		I`iwi, honey creeper	Munro lists as Vestaria coccinea (Forster). Type of honey creeper. Bright scarlet wings and tail. Also black wings. Rose colored bill. 5.75" long. According to Munro, in 1891 the i`iwi and apapane were so numerous that they raised a continual buzz. Lived in `ohi`a and Pelea trees. Lived at all elevations from the seashore to the mountaintop, whereever flowering ohi`a forest reached. Munro noted, "It semed to me that the `ohi`a honey had a stimulating effect as these birds were full of life and gaiety when frequenting the profusely blooming ohi`a trees." I`iwi fed on nectar, caterpillars and insects. They flitted from flower to flower and hopped among twigs and leaves in search of caterpillars. The call apparently varied. When feeding it was a sharp chirp, at other times a longer call. Munro described it as "like the creaking of a wheelbarrow, but a little more musical". Apparently the call was more discordant in lower elevation trees, and more musical among the treetops. Munro also noted, "...in a great assembly of birds the medley of sounds produced by hundreds of apapane, i`iwi and other birds produced a pleasing chorus and cheerful effect." Although I`iwi liked `ohi`a nectar, the main food was thought to be caterpillars. Nests were built of dry stems, leaves and rootlets, and some skeletonized capsules of Poha. They were usually placed in tall ohi`a trees. The feathers were used in Hawaiian featherwork.
Muscicapidae		Myadestes		lanaiensis		Lana`i thrush, Amaui, (olomau - molokai species)	Munro lists as Phaeornis obscura lanaiensis. Bishop Museum and Ornithological Monographs list as Myadestes Lanaiensis (family Muscicapidae). Munro quotes Wilson as noting that the Lana`i Thrush "resembles P. obscura and P. myadestina, but is smaller than either while the bill is distinctly intermediate in size between those of the two species.". The outer pair of tail feathers have slight white markings at the tip, while the abdomen and undertail feathers are nearly pure white. Top was brown. Wing from carpal joint to tip was 3.65". Lana`i thrush differed from those of the other islands in its call. The other thrushes were great singers, but the Lana`i thrush had only 2 or 3 notes which it used constantly. It inhabited the forest and frequented the low trees and underbrush. It nested in the thickest underbrush amongst 'ie'ie vine and staghorn fern. It was a retiring species, more often heard than seen. It ate berries and insects. Munro also reported finding a small landshell in one. The thrush had the habit of trembling and quivering its wings when approached or excited. When disturbed, it flew upward into the trees. Munro believed the Hawaiian name for all of the thrushes was Amaui (from Manu a Maui?). The Hawaii thrush was called Omao or Amaui. The Molokai thrush was called Olomau or Amaui. Munro cites as his source "the very old Hawaiian whom Perkins consulted".
Procellariidae		Pterodroma		phaeopygia		U`au, dark-rumped petrol	Only remaining Munro lists as Pterodroma phaeopygia sandwichensis (Ridgway). Hawaiian name was Uau, Uaau, or Uwau. The back was a brownish slate, with darker wings and tail. The forehead, cheeks and underparts were white, and the head was black. Length was about 15.5". The call was a long drawn out u-a-u. The flight was a darting zig zag, interspersed with sailing. It nested in the mountains of all the main islands, in holes under the roots of trees and stones at elevations ranging from 1,500' to 5,000' (the latter obviously not on Lana`i.). It was killed off the mongoose in Hawaii, Maui and Molokai. Munro believed that cats and pigs killed it on Lana`i. The eggs were glossy white and laid in April - May. The young birds were considered a delicacy by Hawaiians, and were kapu to common people, reserved for chiefs. Older birds were eaten after they had been salted. By 1944 Munro commented that it was in danger of extinction, though it seemed from his text that it was already gone completely from Lana`i.

Recurviro-stridae		Himantopus		mexicanus		Hawaiian stilt	Listed by Munro as Himantopus himantopus knudseni. Listed by Bishop museumas Himantopus mexicanus. not listed in ornithological monograph. Hawaiian names `Ae`o, and also kukuluaeo (Kukuluaeo was the word for stilts, or for a person walking on stilts. it signifies one standing high or set up like an aeo). The back and upper body are blue-black, the underparts white, the tail smoky gray, with white markings over the forehead and around the eye and long thin pink legs. The young are brown/grey above and lighter below. The length is about 16.5". The flight is flapping with legs stretched out behind. Feeds on larvae of dragon flies, small fish, worms, seeds and roots of water plants. The cry is short and sharp. The nest is a hollow in dry mud bordering shore lagoons in summer. Eggs are laid in May with 8-12 in a clutch. Eggs brown with large black spots, 1.9"x1.36", thicker at the large end, pointed at the small end, and ovoid. Adult birds are very agressive at trying to lure intruders away from nest and young.
Strigidae		Asio		flammeus		Owl	Asio flammeus sandwichensis (Bloxam) per Munro. Hawaiian name Pueo, probably from one of its calls according to Munro. Tawny ocraceus to buffy white, plentifully striped with dark brown. Immature birds are much darker. The birds are about 15.25" long. The Hawaiian owl was spread through all the islands, and numerous in open grassy country. Though a day hunter, it is more active at dusk or in early morning. It was common in the late nine-teenth century on Lana`i, but by 1944 Munro commented that its territory had been so taken over by agriculture that numbers had decreased. Nests in grass tufts in a hollow in the earth. Eggs are white and almost round. The Hawaiian owl eats mostly mice, but it also eats smaller birds. On Lana`i some hunted over trees in the forests, searching for other bird nests. Most Lana`i species of birds hid their nests from owls. The owl has several cries. The cries of the yound sound something like hissing, and the cries of the old can sound like a muffled dog bark. The owl will spread its wings when approached in a threatening manner. It is fierce enough with its claws that it will fight off cats and dogs.
		Thambe-tochen					

Native Birds on Lana`ihale

FIGURE 6-7 Apapane

Sixteen species of native birds have been recorded in Lana`i, not including non-resident seabirds and seasonal migrants.

Of eight species of native forest birds once known to inhabit Lana`i, the only one known to remain is the apapane (*Himatone sanguinea*). The apapane eats both nectar and insects. Its primary food source is `ohi`a blossom. The amakihi is believed extinct, but a systematic survey should be undertaken to determine status.

Lana`i also has two native seabirds, the Newell's shearwater, and the endangered Dark-rumped petrol. Dr. Fern Duvall recently found a fresh-killed carcass (cat-kill) in Kaiolena gulch while looking for *Hedyotis schlechtendahliana var. remyi* with Bob Hobdy.

Many species casualties among native birds were associated with specific ecosystem niches. The o`u was closely tied with mesic `ie`ie (*Freycinetra arborea*) forest areas. (`ie`ie is a climbing pandanus found in mesic areas) The Lana`i hookbill and akialoa were once plentiful in lowland *akoko* forest (*Chamaesyce celastroides v. lorifolia*). The i`iwi, extinct from Lana`i, was associated with endangered lobeliads. These endangered, bird-pollinated lobeliads in turn were required food for the i`iwi.

The decline of visiting sea bird populations may also have adverse impacts to the Lana'ihale forest. With loss of native trees and habitat, visiting sea birds don't come to Lana`i as much. Bird guana from these birds was thought to once have been an important source of forest nutrients in the islands. Fewer visits by these birds in turn causes diminishing forest nutrients. With diminishing nutrients, forest maintenance and recovery become more difficult. (*Source: Personal communication, Dr. Fern Duvall, 2005.*)

Various species of birds known from fossil records or historical accounts are also gone from Lana`i. Lana`i once had a flightless Ibis species, believed to have lived in Lo`ulu palm habitat. It also had a Moa nalo, a large, flightless grazing bird with a turtle-like head. The extinct Lana`i Hookbill was so fantastic looking that when it was first discovered, its authenticity was questioned.

Apparently at some point in history the Hawaiians developed a pastime of sewing skins of different birds together to make fantastic creatures, and upon first discovery, the Lana`i Hookbill was believed to have been one such creation. There were also two species of flightless rail, a flightless owl, a nene and two relatives of the nene. (*Source: Personal communication, Dr. Fern Duvall*)

A list of the bird species once found in Lana`i is found in Table7-10 This table contains observations by the naturalists of the time on possible causes of extinction.

Importance of Birds In Lana`ihale

Birds serve(d) several important & specific functions in the watershed on Lana`i, including:

- direct pollination of native plant species
- seed dispersal (ex: amakihi ate fruit and insects, spread seeds in feces)
- source of nutrients (especially from sea-bird feces)

Nutrient cycles, especially as affected by seabirds, are now being understood to effect soil and plant health more than previously recognized . It is believed that a contributing cause of progressive degradation of the forest is the loss of sea birds returning nutrients to the soil via guano (Dr. Fern Duvall, referring to research by Storrs Olsen of the Smithsonian Institute).

Birds were an integral part of the pristine ecosystem, so there may have been additional functions which we would not be able to study in the absence of the system intact.

Bird Species Descriptions

A list of native birds once found in Lana`i is provided in Table 6-10. This list was compiled from the Bishop Museum Bird Checklist, Birds of Hawaii (George C. Munro, 1960, 1982), and communication with Dr. Fern Duvall of the State DLNR Division of Forestry & Wildlife.

Threats to Birds on Lana'ihale

One of the primary threats to remaining birds on Lana`i is the loss of habitat. Although threats to birds are listed below, it should be noted that the threats to plant communities listed above are also among the key threats to bird populations.

TABLE 6-11 Threats to Birds in Lanaihale

Loss of habitat	Examples, akoko, lobeliads, etc. Direct loss of food source Inadequate space to support and sustain healthy breeding populations If `ohi`a is lost, apapane would probably be lost also
Loss of native pollinators	Loss of pollinators of habitat, (birds, insects) causes threats to remaining habitat. Introduction of pest birds that eat native insects that pollinate native plants.
Introduction of pest birds	Competition with native birds for food, nesting sites. Destruction of native pollinators Introduction of bird diseases including: avian malaria (protozoan), avian pox (virus) Direct agression Examples: White eye - competes for food, nesting sites Japanese bush warbler - compete for food, nesting sites Cardinals - feed on sandalwood fruits Java sparrow
Rats, Cats	Predation. Rats & mice also eat seeds of native habitat trees & plants.
Introduction of insects	Carry avian diseases, for example, mosquitoes carry avian malaria and avian pox. Compete with native insect pollinators.
Diminished population	Remaining population sizes may not be adequate to insure sustainability. It is estimated that in order to sustain a population, there should be a minimum "effective population" size of no less than 500 pairs. By "effective population" it is meant excluding juveniles, aged, or unpaired birds. There also needs to be adequate habitat extent to support such population. In 1980 it was estimated that there were: 540 ± 213 apapane in a transect area of 20 sq. kilometers on Lana`i 15,825 ± 1,129 in a transect area of 44 sq. kilometers on West Maui 94,000 ± in a transect area of 404 sq. kilometers on East Maui

TABLE 6-12 Problem Birds on Lana'i

Common Name	Latin Name	Comments
Japanese White Eye	Zosterops japonicus	Competes for food and nesting sites. Present on all main islands. Common.
Japanese Bush Warbler	Cerria diphone	Competes for food and nesting sites. First recorded on Lana'i in 1980.
Northern Cardinal	Cardinalis cardinalis	Feeds on sandalwood fruits. Present on all main islands. Common.
Java Sparrow		
Erckel's Francolin	Frncolinus erkelii	Common.
Gray Francolin	Francolinus pondicerianus	Very Common.
Spotted Dove	Streptopelia chinensis	May feed in native forest. Common.
Warbiling Silverbill	Lonchurra malabarica	Common. First recorded on Lana'i in 1979.
Chukar	Alectoris chukar	Very common. Introduced in 1923.

Native Insects in Lana`ihale

The Bishop Museum arthropod list contains records of 472 endemic and indigenous arthropods from Lana`i. Even this number is thought not to be complete. Bishop Museum's checklist lists 11 extinct species, 2 Candidate 1 level species, and 25 Candidate 2 level species. No species are listed as endangered or threatened. Hobdy ('93) estimated that 30% of insect species on Lana`i were believed to be endemic, and that roughly 10% of the native insect species in Hawaii were on Lana`i. Even with so many species recorded, it is believed that records for insects are lacking. A partial list of arthropod species native to Lana`i follows in Table 6-13. Rather than attempt to provide descriptions for all of over 400 species, only those listed as candidate species or species of concern are covered.

Insect endemism is not as high as plant endemism, in part because insects can fly and are able to move between the Maui Nui islands. However, in terms of numbers of species, the majority of native species were insects. There are or were native species of spiders, wasps, flies, fungus gnats, beetles, leaf hoppers and true bugs, among others. Endemic Lana`i insects include species of beetles *(Coleoptera)*, flies (*Diptera)*, bugs *(Hemiptera)*, true bugs (*Homoptera)*, bees & wasps (*Hymenoptera)*, moths and butterflies (*Lepidoptera*), and others.

Most Lana`i insect species are very host-specific in feeding & breeding requirements, and are closely interrelated to vegetation communities (Hobdy, 1993). This means they were likely to have fulfilled many key roles in ecosystem integrity, including pollination, etc. Insects also contributed to nutrient cycle, biomass, organic material, and litter component. Native insects were often important as pollinators of specific plants, or because they provided food for birds that were pollinators of specific plants. Insects were also predators, detritivores, soil processors and wood borers, contributing to the food cycle, the breakdown of dead trees and leaves, to soil nutrients, etc.

Examples of some interesting native Lana`i insects include the Nesoprosopis bees and Pomace flies. Over 50 species of Nesoprosopis bees have been found in the islands. Dr. Sam Gon III, of The Nature Conservancy, estimates that there were about 17 on Lana`i, several of which were only found on Lana`i. Nesoprosopis bees, also known as yellow-face bees are smaller and thinner than honeybees, and more solitary. They feed on tiny flowers.

Pomace flies are one of the best examples of adaptive radiation. Over 800 species of native Hawaiian pomace flies have been described, and almost all are host-specific. Pomace flies are often called fruit flies, but they are actually part of a different family of insects.

Threats to Lanaihale Insects

Primary threats to remaining native insect populations in Lana`i include:

- Loss of habitat such as nesting sites or food sources necessary to maintain populations.
- Introduced insects may prey on or compete with other insects, damage plants, or carry disease A few of these problem insects are desribed in the Table 6-14.
- Many insects were brought in with cane or pineapple crops to manage insect pests, but instead turned out to be generalist and fed on native insects and plants.
- Loss of native insects in turn can equate to loss of critical habitat elements, such as pollinators or food source, for other species.
- Introduced Pathogens.

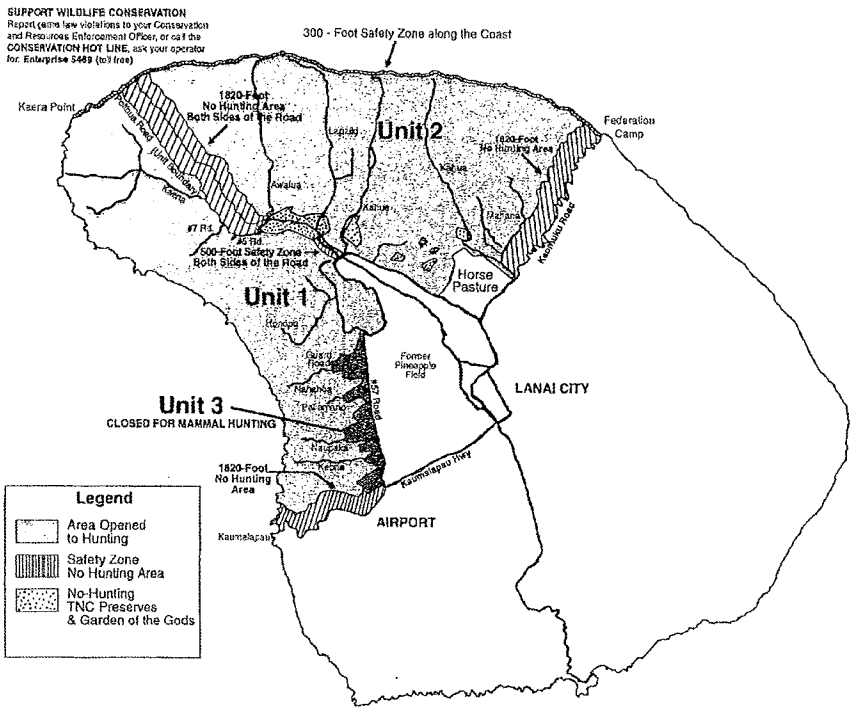
TABLE 6-13 Lana`i Arthropods - Endangered, Proposed, Threatened, Candidate and Species of Concern

US FWS Status	Bishop L Status	Order	Family	Genus	# Spp in Genus	# Spp on Lana`i	# Lana`i Spp Listed	Species	Description
E		Heteroptera	Scutelleridae	Manduca				blackburniae	Blackburn's sphinx moth
C2	C1	Odonata	Coenagrionidae	Megalagrion	22	8	3	pacificum	damselfly - Pacific megalagrion
C8	C1	Odonata	Coenagrionidae	Megalagrion				xanthomelas	damselfly - orange-black megalagrion
SOC	C2	Archaeognatha	Machilidae	Neomachilis				heteropus	Hawaiian long-palp bristletail
SOC		Coleoptera	\	Rhyncogonus				freycinetiae	Weevil, `Ie'ie rhyncogonus
SOC	C2	Coleoptera	Curculionidae	Rhyncogonus	34	3	2	lanaiensis	Lana`i rhyncogonus weevil
	C2	Coleoptera	Elateridae	Hyaleus				plebius	
SOC	C2	Coleoptera	Cerambycidae	Plagithmysus	139	4	2	lanaiensis	Long-horned beetle, Lana`i `Ohi`a beetle
SOC		Coleoptera		Plagithmysus				platydesmae	Long-horned beetle, Pilo Kea
SOC	C2	Coleoptera	Elateridae	Eopenthes	33	4	2	arduus	Click beetle , arduus eopenthes
SOC		Coleoptera		Eopenthes				plebius	Click beetle, common eopenthes
SOC		Coleoptera		Proterhinus	72				Hawaiian Proterhinid beetles
SOC	C2	Diptera	Drosophilidae	Drosophila				lanaiensis	Lana`i pomace fly
SOC	C2	Heteroptera	Scutelleridae	Coleotichus	1	1	1	blackburniae	Koa bug
	C2	Heteroptera	Miridae	Kalania	1	1	1	hawaiiensis	
	C2	Heteroptera	Pentatomidae	Oechalia	14	2	1	grisea	
SOC	C2	Heteroptera	Rhopalidae	Ithamar	2	2	1	hawaiiensis	Hawaiian rhopalid bug
SOC	C2	Homoptera	Psudococcidae	Phyllococcus	1	1	1	oahuensis	mealy bug - opuhe gall
SOC	C2	Hymenoptera	Colletidae	Hyaleus	60	15	11	anthracina	anthracinian yellow-faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				assimulans assimulans	assimulans yellow-faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				caeruleipennis	blue-wing yellow-faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				difficilus	difficult yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				facilis	easy yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				filicum	fern yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				laeta	laetan yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				longiceps	longhead yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				obscuratan	obscuratan yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				satelles	satellus yellow faced bee
SOC	C2	Hymenoptera	Colletidae	Hyaleus				volatilis	volatile yellow faced bee
SOC	C2	Hymenoptera	Vespidae	Odynerus	100	11	1	nigripennis	black-winged odynerus vespid wasp
SOC	C2	Lepidoptera	Crambidae	Omiodes	23	4	1	monogona	Hawaiian bean leaf roller
SOC		Lepidoptera		Helicoverpa				confusa	Moth, confused helicoverpan noctuid
SOC		Neuroptera	Distolean	Eidolean				perjurus	Molokai Antlion
SOC	C2	Odonata	Coenagrionidae	Megalagrion				nigrohamatum nigrohamatum	damselfly - nigrohamatum megalagrion

TABLE 6-14 Insect Pests in Lana`i

Genus	Species	Common Name	Description
Sophonia	rufofascia	Chinese leaf hopper, two-spotted leaf hopper	Destroys uluhe stands, `ohi`a lehua trees. Worse when plants are under stress from drought or etc. Suck the juices out of leaves, leaving yellow spots. Can stress trees to death. Typical scenario: deer move in, eat ferns and other understory, then plant is exposed and ground becomes dry. When drought hits, plants are more stressed and leaf hopper creates more damage.
Adoretus	sinicus	Chinese rose beetle	Feeds on leaves of native plants, incl. Abutilon menziesii. Affects mostly dryland and some mesic plants. Less of a problem than the leaf hopper.
		Hibiscus snow scale	Affects mostly dryland areas, and mostly Hibiscus, (including Abutilon and ilima).
		Mosquitoes	Introduce and carry avian malaria, avian pox and other diseases that destroy bird populations, some of which may have been pollinators.
		Ants	There are no native ants in Hawai`i. Ants prey on and compete with native insects for food, nest sites, etc. There have been many extinctions of native insect species due to ants.
		Yellow jackets, vespula wasps	Very predatory, and very disruptive to native ecosystems. Yellow jacket entry would be difficult to prevent, as a queen could make it from another island across to Lana`i, so measures need to include monitoring and removal.
		Small parasatoid wasps	Several types of small parasatoid wasps have been introduced. These lay their eggs in the eggs of spiders and other native insects, killing the young of native insects before they hatch.
		Black twig borer	Pest brought in with coffee. Attacks native plants. Affects dry areas and mesic areas surrounding Lana`ihale.

FIGURE 6-8 Game Management Units on Lana'i



Existing Conservation Efforts

Existing conservation efforts include game management and monitoring efforts run by both Castle and Cooke Resorts, LLC and the State, volunteer planting efforts run mostly by the company, Rare plant exclosures supported by the Company and the US Fish & Wildlife Service, and ex situ collections of various species.

Game Management & Monitoring

The State DLNR runs hunting primarily on the north and western sides of the island, while CCR manages the south and east portions. Different hunting periods and areas are allotted for use of rifle, muzzle loader, and archery hunts. Success rates vary with animal populations, weather, hunter skill and etc. Company-run hunts include paid hunts by hotel guests, as well as resident damage control hunts on Lana'ihale, night hunts, and license hunts on former agricultural lands. Damage control hunting is sometimes undertaken around the resorts, golf courses and other infrequently hunted areas when complaints are raised. However, animal management that close to hotel grounds is generally restricted to hotel employees.

At one time, the Nature Conservancy also managed animal populations in its Kanepuu preserve and