T. S. Dye & Colleagues, Archaeologists, Inc.
735 Bishop St., Suite 315, Honolulu, Hawai'i 96813

Archaeological Data Recovery Plan for Sites 50-40-98-1980 and 50-40-98-1981 Within the Miki Basin 200 Acre Industrial Development*

Lands of Kalulu and Kaunolū, Lahaina District, Lāna'i Island, TMK: (2) 4-9-002:061

Thomas S. Dye, PhD

May 9, 2018

Management Summary

At the request of Pulama Lāna'i, and pursuant to Hawaii Administrative Rules §13-278-3, T. S. Dye & Colleagues, Archaeologists has prepared an archaeological data recovery plan for Sites 50-40-98-1980 and 50-40-98-1981, located at Kalulu and Kaunolū, Lahaina District, Lāna'i Island. The data recovery plan follows the recommendations set out in the inventory survey report and proposes to carry out technological analyses of lithic materials collected from Site 50-40-98-1980, and charcoal identification and dating of the *fire-pits* at Sites 50-40-98-1980 and 50-40-98-1981.

Contents

*Prepared for Pulama Lāna'i, 1311 Fraser Avenue, P.O. Box 630310, Lāna'i City, HI 96763

Figures

1 Introduction

At the request of Pulama Lāna'i, T. S. Dye & Colleagues, Archaeologists has prepared an archaeological data recovery plan for Sites 50-40-98-1980 and 50-40-98-1981 located in the lands of Kalulu and Kaunolū, Lahaina District, Lāna'i Island (fig. 1). Sites 50-40-98-1980 and 50-40-98-1981 are located in the land parcel identified on tax maps as TMK: (2) 4-9-002:061.

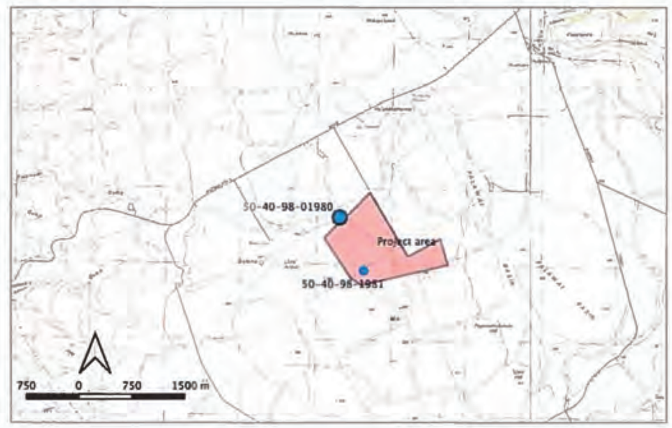

Figure 1: Location of Sites 50-40-98-1980 and 50-40-98-1981 and the Miki Basin 200 Acre Industrial Development on a USGS quadrangle map.

2 Sites 50-40-98-1980 and 50-40-98-1981

Site 50-40-98-1980 is located in the northernmost portion of the *project* area in a highly eroded area along the fence line boundary with the Lāna'i Airport (fig. 1). The site comprises two components, a lithic scatter and an eroded and exposed fire-pit.

The lithic scatter is located on the crest of a slope and extends south along a drainage cut. The scatter covered an area of approximately 30 × 120 m (meter) and, at the time of survey, contained 30 or more pieces of flaked basalt. All of the artifacts that were observed and collected from the scatter came from within or adjacent to the existing drainage in areas that lacked vegetation. A cowry shell fragment and several pieces of branch coral were observed within the scatter. Three adze rejects, a hammerstone, a waterworn pebble *manuport*, and a piece of branch coral were collected from the scatter (fig. 2). No artifacts were observed or collected in the vegetated areas around the drainage. This suggests that the artifacts have either moved downslope from a higher location as a result of water erosion or that the site has eroded and deflated over time. In either case, the artifacts would have been secondarily deposited from their original position.

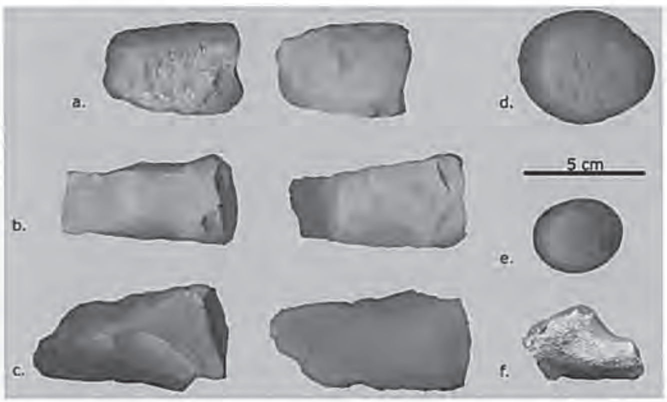

Figure 2: Artifacts collected from the Context 18 lithic scatter, part of Site 50-40-98-1980: *a*, dorsal and ventral views of an adze reject, distal portion; *b*, dorsal and ventral views of an adze reject, proximal portion; *c*, dorsal and ventral views of an adze reject, distal portion; *d*, waterworn cobble hammerstone; *e*, waterworn pebble manuport; *f*, branch coral. The three adze rejects are depicted with the dorsal side to the left and the ventral side to the right.

The second component of Site 50-40-98-1980 was an exposed fire-pit remnant located within the lithic scatter on the crest of the slope in a heavily eroded area. The fire-pit remnant was observed over an approximately 75 cm (centimeter) diameter area and had exposed charcoal and a few small cobble-size fire-affected rocks on the surface and eroding downslope. No black plastic or tubing was observed in or around the fire-pit because the plow zone in this location had completely eroded away. It is likely that the fire-pit had originally been truncated by plows when the pineapple field was cultivated. Following documentation of the fire-pit remnant, the fire-pit was bisected twice to determine its size and stratigraphic position (fig. 3).

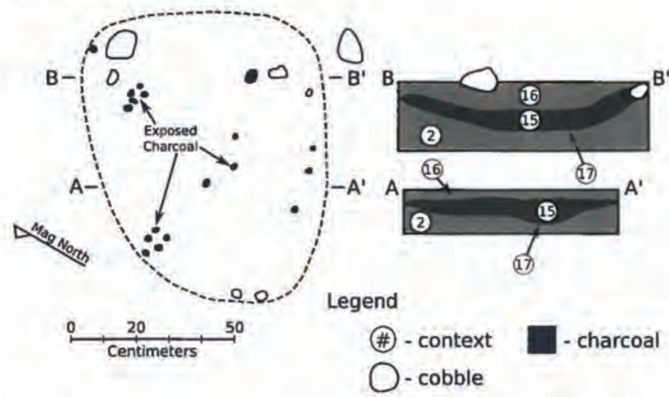

Figure 3: Sketch map and cross section drawing of a subsurface fire-pit recorded at Site 50-40-98-1980.

The first bisection point, A to A', cut the fire-pit in half to expose the stratigraphic section. Following bisection, a 15 cm deep profile was exposed. Context 16, a loose red silty *clay* loam sediment, was present from the current ground surface to a depth of 3 cm. It appears that the sediment has been deposited over the fire-pit due to water erosion along the drainage. The fire-pit, Context 15, is a band of charcoal that extends from 3 cm below surface to a depth of 12 cm. The fire-pit at this location is approximately 60 cm wide and is basin shaped. The interface between the Context 15 fire-pit and the material it had been dug into, the Context 2 dark reddish brown silty clay loam hard pan soil, was recorded as Context 17. The Context 2 soil was present to the base of excavation at 15 cm below surface.

The second bisection point, B to B', was cut just in front of the two rocks that were exposed on the surface. Following bisection, a 20 cm deep profile was exposed. Context 16, a loose red silty clay loam sediment, was present from the current ground surface to a depth of 6 cm. The sediment has been deposited over the fire-pit due to water erosion along the drainage. The fire-pit, Context 15, is a curved band of charcoal that extends from 6 cm below surface to a maximum depth of 15 cm. The fire-pit at this location is approximately 75 cm wide and is basin shaped. The interface between the Context 15 fire-pit and the material it had been dug into, the Context 2 dark reddish brown silty clay loam hard pan soil, was recorded as Context 17. The Context 2 soil was present to the base of excavation at 20 cm below surface. A charcoal sample was collected from each profile after bisection for wood taxa identification and ^{14}C analysis.

A subsurface cultural deposit recorded as Site 50-40-98-1981 was identified in a backhoe trench (see fig. 1, p. 2). The deposit was a truncated fire-pit remnant exposed in the southern profile of the backhoe trench (fig. 4). The fire-pit was truncated by the plow zone layer, Context 1, present to a depth of 35 cm below surface. The upper portion of the fire-pit appears to have been destroyed by a plow moving east to west; charcoal from the fire-pit is scattered an additional 65 cm to the west within the plow zone. The fire-pit remnant is approximately 65 cm in width, approximately 10 cm thick, basin shaped, and is present between 35 and 45 cm below surface. A single rounded volcanic cobble was observed within the feature. The fire-pit had been excavated into Context 2, a dark reddish brown silty clay hardpan soil present to a depth of 100 cm below surface. The interface between the fire-pit and the Context 2 soil it had been excavated into was recorded as Context 13. Context 2 overlay Context 9, a dark brown silty clay loam present to the base of excavation at 150 cm below surface. A charcoal sample was collected from the Context 12 fire-pit for wood taxa and ^{14}C analysis.

Sites 50-40-98-1980 and 50-40-98-1981 were evaluated as significant for the important information on Hawaiian history and prehistory that they have yielded.

3 Research Objectives

The inventory survey report recommended that a data recovery plan be developed and implemented prior to construction activities at the Miki Basin 200 Acre Industrial Development. It was further recommended that the data recovery plan develop research questions that can be addressed with data yielded by the following laboratory tasks:

Site 50-40-98-1980 Analysis of the wood charcoal collected from the Context 15 fire-pit for taxa identification and ^{14}C dating. Analysis of artifacts collected from the Context 18 lithic scatter to further investigate the tool-making reduction sequence utilized on the island [12].

Site 50-40-98-1981 Analysis of the wood charcoal collected from the Context 12 fire-pit for taxa identification and ^{14}C dating.

The research objectives of the proposed data recovery investigations include gathering data on the history of vegetation change on Lāna'i in an effort to date two periods of change, one during the traditional Hawaiian period and the other in the mid nineteenth

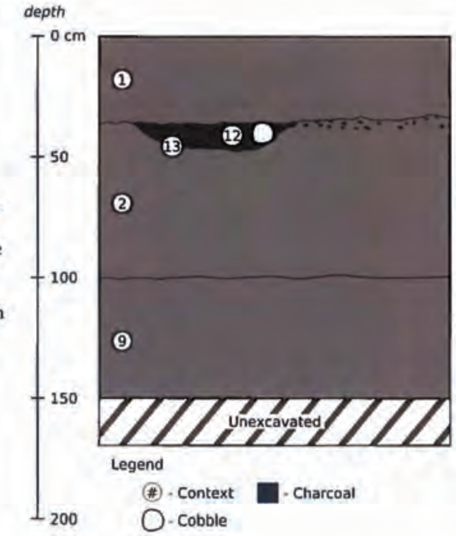

Figure 4: Stratigraphic profile of the south face of the backhoe trench showing the fire-pit, Site 50-40-98-1981, as contexts 12 and 13. Note that the fire-pit has been truncated by the plow zone, Context 1.

century when sheep and goats were raised on the island [7], and to complete paired technological and geochemical sourcing analyses of the lithic artifacts to determine the reduction sequences for the flaked stone implements, and to determine likely source locations for the fine-grained, tool-grade basalt items in the collection.

The first period of vegetation change that will be investigated involves a process identified as landscape transport [2; 8], whereby the Polynesian settlers of Hawai'i established about 28 species of plants brought to the islands from a homeland in the southern hemisphere [13:321 ff.]. This process has been dated to the mid-fifteenth century on O'ahu Island [6], but thus far has proved elusive on Lāna'i, where native plants dominate firewood throughout the traditional Hawaiian sequence. For example, wood charcoal from five taxa introduced by Polynesians, including cf. *kou*, *ipu*, *kukui*, *'ulu*, and *'ōhi'a 'ai* was recovered in small amounts (generally less than 1% by weight) in all of the charcoal collections from two sites at the coastal settlement in Kaunolū [1]. Based on the available dating evidence, the charcoal collections at Kaunolū date to late in the traditional Hawaiian sequence and to the early historic period. The lowland native forest at Kaunolū appears to have persisted into the early historic period. Similarly, several collections of firewood charcoal from Hulopo'e insecurely dated to the period AD 1300–1850 were composed primarily of native woods, with trace occurrences of *'ulu* and *kō* [10]. Two fire-pits dated to around the early historic period on the coast at Mānele [5] were fueled almost entirely with native species, and a somewhat earlier fire-pit located inland near Lāna'i City [4] also yielded predominantly native firewood.

The second period of vegetation change in the mid-nineteenth century involves the nearly complete collapse of the native lowland dry forest with the introduction of grazing herbivores [7]. To date, fire-pits from this recent period have not been identified and investigated on Lāna'i.

The research objective for the stone artifacts is to characterize the chaîne opératoire for the tools fashioned from fine-grained basalt. An attempt will be made to identify the source of the rock with non-destructive geochemical analysis, describe the reduction sequence along the lines set out by Weisler [12], and classify tools according to function [11], as far as possible given the fragmentary materials.

4 Data Needs, Methods, and Curation

The data needed to address the research objectives were collected during the inventory survey and comprise the contents of the two fire-pits and the secondarily deposited stone artifacts collected at Site 50-40-98-1980.

Field methods are not required to acquire and analyze the data because exhaustive field collections were made during the archaeological inventory survey.

The laboratory work needed to carry out the data recovery investigation includes charcoal identification at the Wood Identification Laboratory of International Archaeological Research Institute, accelerator mass spectrometry (AMS) dating of one specimen of short-lived wood charcoal from each of the fire-pits, and calibration of the laboratory results with the BCal software package [3]. Non-destructive geochemical characterization with EDXRF will be carried out at the University of Hawai'i at Hilo [9].

The procedure for depositing collections after the conclusion of the proposed data recovery project involves returning them to Lāna'i Island, where they will be redeposited at the Lāna'i Culture and Heritage Center, where they are currently stored.

The plan does not call for additional fieldwork. Thus, we do not anticipate that human burials will be disinterred.

Sites 50-40-98-1980 and 50-40-98-1981 were not determined significant under criterion "e," which pertains to sites that have "an important value to the native Hawaiian people or to another ethnic group of the state due to associations with cultural practices once carried out, or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts–these associations being important to the group's history and cultural identity" (§13-275-6(b)(5)). Thus, there is no requirement that consultation with members of the relevant ethnic group be undertaken during preparation of this plan.

Glossary

clay Fine earth particles less than 0.002 mm.

cobble Rock fragment ranging from 76 mm to less than 250 mm.

fire-pit A pit of varying depth, often bowl shaped at the base, usually identified by a concentration of charcoal and/or burned material in the fill, especially at the feature interface.

manuport A natural object found in an unnatural position, having been carried there by man.

project The archaeological investigation, including laboratory analyses and report preparation.

Hawaiian Terms

ipu The gourd, *Lagenaria siceraria*.

kō Sugarcane, *Saccharum officinarum*, was introduced to Hawai'i by Polynesian settlers, who cultivated it widely. The stalk was chewed between meals for its sweetness, brought on long journeys to ease hunger, and eaten in times of famine; juice from the stalk was fed to nursing babies, and used as a sweetening agent in medicinal herbal concoctions; the leaves were used as thatching for houses; the leaf midrib was used for plaiting braids that were made into hats; the stem of the flower was used to make darts for a child's game.

kou A native tree, *Cordia subcordata*, with a wood prized for its grain and ease of carving. It was used for carving a wide variety of objects from platters to images of gods; the leaves were made into dye and the flowers were also used in *lei* making.

kukui The candlenut tree, *Aleurites moluccana*, introduced to Hawai'i by Polynesian settlers. The outer husk of the fruit or nut was used to make a black dye for tapa and tattooing; sap from the fruit was used as medicine to treat thrush, and used as a purgative; the hard shell of the nut was used in *lei* making; the kernel of the nut was the source of an oil that was burned for illumination and also used as a wood varnish for surfboards and canoes; the kernel was also chewed and spit on rough seas to calm the ocean and baked kernels were mixed with salt and chili pepper to make a relish (*'inamona*); the trunk was used to make canoes and floats for fishing nets; a reddish dye was made from the bark and/or root; a gum exuded from wounded bark was used to treat tapa; the flower was mixed with sweet potato to treat thrush; the leaves were used in a poultice for swelling and infection.

'ōhi'a 'ai The mountain apple, *Syzygium malaccensis*, a forest tree growing up to 50 ft. high. Traditionally the trunk of the tree was used for house posts and rafters, enclosures for temples, and to carve idols. The fruit was eaten raw or dried. The bark was made into an infusion to remedy sore throats and a dye was also made from the bark.

'ulu 1. Discoidal, smooth stone as used in *'ulu maika* game; 2. Breadfruit, *Artocarpus altilis*.

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T. S. Dye & Colleagues, Archaeologists, Inc.
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Archaeological Data Recovery Report for Sites 50–40–98–1980 and 50–40–98–1981 Within the Miki Basin 200 Acre Industrial Development*

Lands of Kalulu and Kaunolū, Lahaina District, Lānaʻi Island, TMK: (2) 4–9–002:061

Thomas S. Dye, PhD

February 28, 2019

Management Summary

At the request of Pulama Lānaʻi, and pursuant to Hawaii Administrative Rules §13–278–4, T. S. Dye & Colleagues, Archaeologists has prepared an archaeological data recovery report for Sites 50–40–98–1980 and 50–40–98–1981, located at Kalulu and Kaunolū, Lahaina District, Lānaʻi Island. It reports on technological analyses set out in a data recovery plan, including EDXRF analysis of lithic materials collected from Site 50–40–98–1980, and charcoal identification and dating of the *fire-pits* at Sites 50–40–98–1980 and 50–40–98–1981. The lithic analysis indicates the secondarily deposited adze rejects collected from the surface of the Miki Basin 200 Acre Industrial Development project were flake blanks likely derived from outcrops on Lānaʻi Island and that rock from sources on Maui and Hawaiʻi Islands is absent from the collection. The wood charcoal and dating analyses from the two fire-pits at Sites 50–40–98–1980 and 50–40–98–1981 further strengthen the conclusion based on earlier analyses that native forests on Lānaʻi persisted into the nineteenth century, with little evidence for cultivation of canoe plants brought to the islands by Polynesian settlers. The persistence of native forest plants on Lānaʻi contrasts with the Waimānalo Plain on Oʻahu Island, where by the mid-fifteenth century AD canoe plants were typical sources of firewood.

*Prepared for Pulama Lānaʻi, 1311 Fraser Avenue, P. O. Box 630310, Lānaʻi City, HI 96763.

Contents

Figures

1 Introduction

At the request of Pulama Lāna'i, T. S. Dye & Colleagues, Archaeologists has prepared an archaeological data recovery report for Sites 50–40–98–1980 and 50–40–98–1981 located in the lands of Kalulu and Kaunolū, Lahaina District, Lāna'i Island (fig. 1). Sites 50–40–98–1980 and 50–40–98–1981 were identified and inventoried by DiVito et al. [10]. A data recovery plan was drawn up a few years later [12] that followed recommendations set out in the inventory survey report [10]. The data recovery plan proposed to carry out technological analyses of lithic materials collected from Site 50–40–98–1980, and charcoal identification and dating of the fire-pits at Sites 50–40–98–1980 and 50–40–98–1981. This document presents the results of these technological analyses and interprets them in the context of research questions having to do with the tempo of vegetation change on Lāna'i following discovery and settlement by Polynesians, and characteristics of lithic technology to determine reduction sequences for certain tools and likely source locations for the fine-grained, tool-grade basalt used to fashion the tools.

2 Data Recovery Plan

The data recovery plan for the project is summarized in the following sections.

2.1 Sites 50–40–98–1980 and 50–40–98–1981

Sites 50–40–98–1980 and 50–40–98–1981 are located in the land parcel identified on tax maps as TMK: (2) 4–9–002:061.

Site 50–40–98–1980 is located in the northernmost portion of the *project* area in a highly eroded area along the fence line boundary with the Lāna'i Airport (fig. 1). The site comprises two components, a lithic scatter and an eroded and exposed fire-pit.

The lithic scatter is located on the crest of a slope and extends south along a drainage cut. The scatter covered an area of approximately 30 × 120 m (meter) and, at the time of survey, contained 30 or more pieces of flaked basalt. All of the artifacts that were observed and collected from the scatter came from within or adjacent to the existing drainage in areas that lacked vegetation. A cowry shell fragment and several pieces of branch coral were observed within the scatter. Three adze rejects, a hammerstone, a waterworn pebble *manuport*, and a piece of branch coral were collected from the scatter (fig. 2). No artifacts were observed or collected in the vegetated areas around the drainage. This suggests that the artifacts have either moved downslope from a higher location as a result of water erosion or that the site has eroded and deflated over time. In either case, the artifacts would have been secondarily deposited from their original position.

The second component of Site 50–40–98–1980 was an exposed fire-pit remnant located within the lithic scatter on the crest of the slope in a heavily eroded area. The fire-pit remnant was observed over an approximately 75 cm (centimeter) diameter area and had exposed charcoal and a few small cobble-size fire-affected rocks on the surface and eroding downslope (fig. 3). No black plastic or tubing was observed in or around the fire-pit because the plow zone in this location had completely eroded away. It is likely

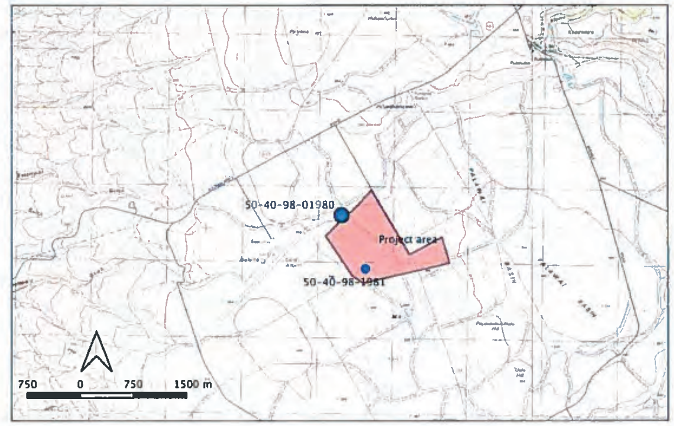

Figure 1: Location of Sites 50–40–98–1980 and 50–40–98–1981 and the Miki Basin 200 Acre Industrial Development on a USGS quadrangle map.

that the fire-pit had originally been truncated by plows when the pineapple field was cultivated. Following documentation of the fire-pit remnant, the fire-pit was bisected twice to determine its size and stratigraphic position (fig. 4).

The first bisection point, A to A', cut the fire-pit in half to expose the stratigraphic section. Following bisection, a 15 cm deep profile was exposed. Context 16, a loose red silty *clay* loam sediment, was present from the current ground surface to a depth of 3 cm. It appears that the sediment has been deposited over the fire-pit due to water erosion along the drainage. The fire-pit, Context 15, is a band of charcoal that extends from 3 cm below surface to a depth of 12 cm. The fire-pit at this location is approximately 60 cm wide and is basin shaped. The interface between the Context 15 fire-pit and the material it had been dug into, the Context 2 dark reddish brown silty clay loam hard pan soil, was recorded as Context 17. The Context 2 soil was present to the base of excavation at 15 cm below surface.

The second bisection point, B to B', was cut just in front of the two rocks that were exposed on the surface. Following bisection, a 20 cm deep profile was exposed. Context 16, a loose red silty clay loam sediment, was present from the current ground surface to a depth of 6 cm. The sediment has been deposited over the fire-pit due to water erosion along the drainage. The fire-pit, Context 15, is a curved band of charcoal that extends from 6 cm below surface to a maximum depth of 15 cm. The fire-pit at this location is

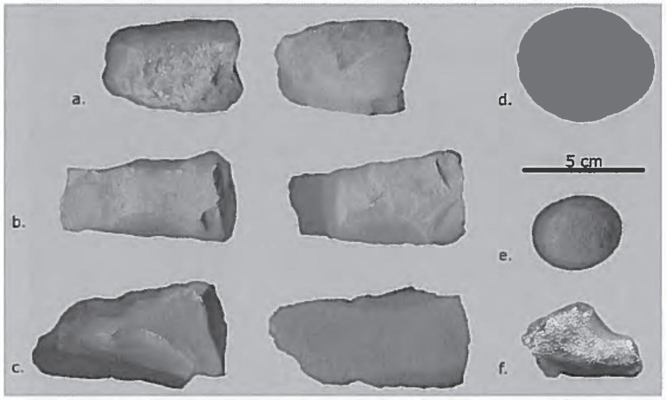

Figure 2: Artifacts collected from the Context 18 lithic scatter, part of Site 50–40–98–1980: *a*, dorsal and ventral views of an adze reject, distal portion; *b*, dorsal and ventral views of an adze reject, proximal portion; *c*, dorsal and ventral views of an adze reject, distal portion; *d*, waterworn cobble hammerstone; *e*, waterworn pebble manuport; *f*, branch coral. The three adze rejects are depicted with the dorsal side to the left and the ventral side to the right.

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A subsurface cultural deposit recorded as Site 50–40–98–1981 was identified in a backhoe trench (see fig. 1, p. 4). The deposit was a truncated fire-pit remnant exposed in the southern profile of the backhoe trench (fig. 6). The fire-pit was truncated by the plow zone layer, Context 1, present to a depth of 35 cm below surface. The upper portion of the fire-pit appears to have been destroyed by a plow moving east to west; charcoal from the fire-pit is scattered an additional 65 cm to the west within the plow zone. The fire-pit remnant is approximately 65 cm in width, approximately 10 cm thick, basin shaped, and is present between 35 and 45 cm below surface. A single rounded volcanic cobble was observed within the feature. The fire-pit had been excavated into Context 2, a dark reddish brown silty clay hardpan soil present to a depth of 100 cm below surface. The interface between the fire-pit and the Context 2 soil it had been excavated into was

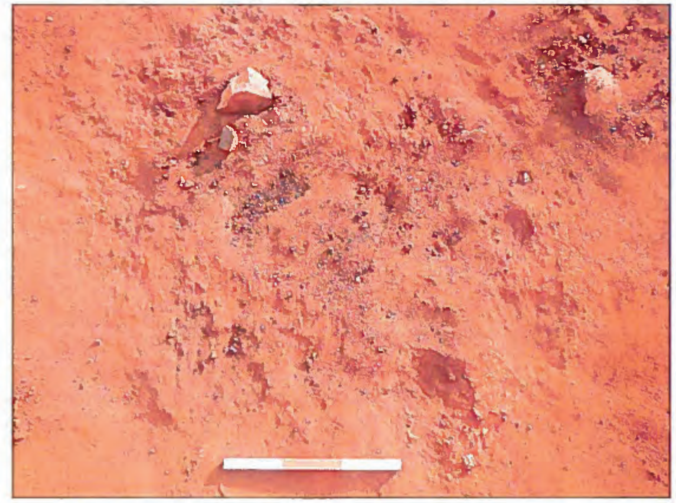

Figure 3: Exposed charcoal and fire-affected cobbles indicating the location of the fire-pit at Site 50–40–98–1980. The scale is marked in 10 cm increments.

recorded as Context 13. Context 2 overlay Context 9, a dark brown silty clay loam present to the base of excavation at 150 cm below surface. A charcoal sample was collected from the Context 12 fire-pit for wood taxa and ^{14}C analysis.

Sites 50–40–98–1980 and 50–40–98–1981 were evaluated as significant for the important information on Hawaiian history and prehistory that they have yielded [10:96].

2.2 Research Objectives

The inventory survey report recommended that a data recovery plan be developed and implemented prior to construction activities at the Miki Basin 200 Acre Industrial Development. It was further recommended that the data recovery plan develop research questions that can be addressed with data yielded by the following laboratory tasks:

Site 50–40–98–1980 Analysis of the wood charcoal collected from the Context 15 fire-pit for taxa identification and ^{14}C dating. Analysis of artifacts collected from the Context 18 lithic scatter to further investigate the tool-making reduction sequence utilized on the island [28].

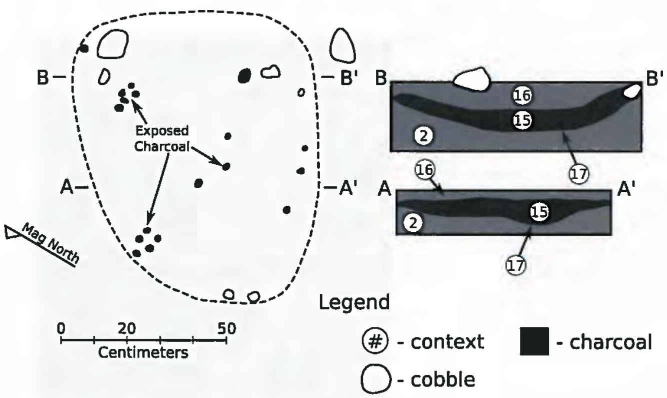

Figure 4: Sketch map and cross section drawing of a subsurface fire-pit recorded at Site 50–40–98–1980.

Figure 5: Stratigraphic profile of the bisected fire-pit at Site 50–40–98–1980. The scale is marked in 10 cm increments.

Site 50–40–98–1981 Analysis of the wood charcoal collected from the Context 12 fire-pit for taxa identification and ^{14}C dating.

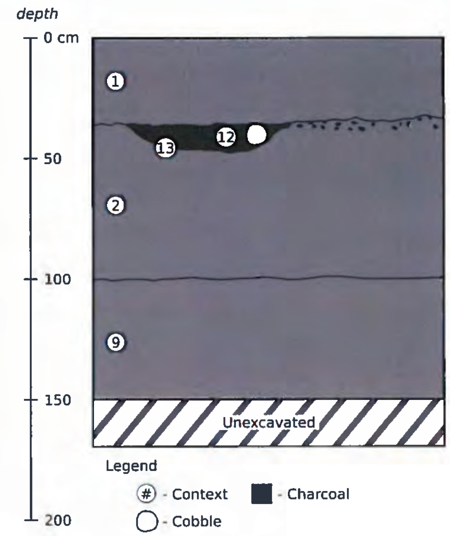

Figure 6: Stratigraphic profile of the south face of the backhoe trench showing the fire-pit, Site 50–40–98–1981, as contexts 12 and 13. Note that the fire-pit has been truncated by the plow zone, Context 1.

The research objectives of the proposed data recovery investigations include gathering data on the history of vegetation change on Lāna'i in an effort to date two periods of change, one during the traditional Hawaiian period and the other in the mid nineteenth century when sheep and goats were raised on the island [19], and to complete paired technological and geochemical sourcing analyses of the lithic artifacts to determine the reduction sequences for the flaked stone implements, and to determine likely source locations for the fine-grained, tool-grade basalt items in the collection.

The first period of vegetation change that will be investigated involves a process identified as landscape transport [3; 20], whereby the Polynesian settlers of Hawai'i established about 28 species of plants brought to the islands from a homeland in the southern hemisphere [29:321 ff.]. This process has been dated to the mid-fifteenth century on O'ahu Island [16], but thus far has proved elusive on Lāna'i, where native plants dominate firewood throughout the traditional Hawaiian sequence. For example, wood charcoal from five taxa introduced by Polynesians, including cf. *kou*, *ipu*, *kukui*, *'ulu*, and *'ōhi'a 'ai* was recovered in small amounts (generally less than 1% by weight) in all of the charcoal collections from two sites at the coastal settlement in Kaunolū [2]. Based on the available dating evidence, the charcoal collections at Kaunolū date to late in the

Figure 7: Stratigraphic profile of truncated fire-pit at Site 50–40–98–1981. Note the black plastic mulch in the deposit above the fire-pit. The scale is marked in 10 cm increments.

traditional Hawaiian sequence and to the early historic period. The lowland native forest at Kaunolū appears to have persisted into the early historic period. Similarly, several collections of firewood charcoal from Hulopo'e insecurely dated to the period AD 1300–1850 were composed primarily of native woods, with trace occurrences of *'ulu* and *kō* [25]. Two fire-pits dated to around the early historic period on the coast at Mānele [15] were fueled almost entirely with native species, and a somewhat earlier fire-pit located inland near Lāna'i City [14] also yielded predominantly native firewood.

The second period of vegetation change in the mid-nineteenth century involves the nearly complete collapse of the native lowland dry forest with the introduction of grazing herbivores [19]. To date, fire-pits from this recent period have not been identified and investigated on Lāna'i.

The research objective for the stone artifacts is to characterize the chaîne opératoire for the tools fashioned from fine-grained basalt. An attempt will be made to identify the source of the rock with non-destructive geochemical analysis, describe the reduction

sequence along the lines set out by Weisler [28], and classify tools according to function [26], as far as possible given the fragmentary materials.

2.3 Data Needs, Methods, and Curation

The data needed to address the research objectives were collected during the inventory survey and comprise the contents of the two fire-pits and the secondarily deposited stone artifacts collected at Site 50–40–98–1980.

Field methods are not required to acquire and analyze the data because exhaustive field collections were made during the archaeological inventory survey, when both fire-pits were fully excavated and diagnostic materials were collected from the secondary deposit of stone artifacts at Site 50–40–98–1980.

The laboratory work needed to carry out the data recovery investigation includes: i) identification of charcoal from the fire-pits at Sites 50–40–98–1980 and 50–40–98–1981 at the Wood Identification Laboratory of International Archaeological Research Institute (WIDL); ii) accelerator mass spectrometry (AMS) dating of a single specimen of identified, short-lived, wood charcoal from each of the fire-pits; iii) calibration of the AMS dating results with the BCal software package [6] to estimate calendar dates for construction and use of the fire-pits; iv) non-destructive geochemical characterization of the lithic materials collected from Site 50–40–98–1980 with the EDXRF facility at the University of Hawai'i at Hilo [22]; and v) observation of the adze rejects collected from Site 50–40–98–1980 to determine the primary reduction technique used in their manufacture.

The procedure for depositing collections after the conclusion of the data recovery project returned them to the Lāna'i Culture and Heritage Center, where they were previously stored.

The plan does not call for additional fieldwork. Thus, we do not anticipate that human burials will be disinterred.

Sites 50–40–98–1980 and 50–40–98–1981 were determined significant under criterion "d" for the important information on Hawaiian history and prehistory they have yielded [10:96]. Sites 50–40–98–1980 and 50–40–98–1981 were not determined significant for criterion "e," which pertains to sites that have "an important value to the native Hawaiian people or to another ethnic group of the state due to associations with cultural practices once carried out, or still carried out, at the property or due to associations with traditional beliefs, events or oral accounts–these associations being important to the group's history and cultural identity" (§13–275–6(b)(5)). Thus, there is no requirement that consultation with members of a relevant ethnic group be undertaken during preparation of this plan.

3 Laboratory Results

This section presents the laboratory results for the wood charcoal identification and dating, the EDXRF geochemical sourcing analysis, and observations on the reduction sequence for six adze rejects.

3.1 Wood Charcoal Identification and Dating

Wood charcoal collected from the fire-pits at Site 50–40–98–1980 and 50–40–98–1981 was submitted to the Wood Identification Laboratory at International Archaeological Research Institute for identification. Excerpts from the report filed by Jen Huebert follow.

> The freshly fractured transverse, tangential, and radial facets of selected charcoal fragments were examined with an epi-illuminated microscope at magnifications of 50–500×. Taxonomic identifications were made by comparing observed anatomical characteristics with those of woods in the IARII reference collection. Vouchers associated with this collection have been verified and archived at the Department of Botany, University of Hawai'i at Mānoa. Other published references, including books, journal articles, technical documents, and wood atlases, were also consulted.
>
> Samples were first reviewed under low-power magnification to assess the quality of the material and determine the range of plant parts present. For the most part, the charcoal in these samples is firm and somewhat hard. A selection of 40 fragments of various sizes and shapes were selected from each sample for taxonomic identification. These samples were not taxonomically diverse and consist mainly of various shapes and size classes of *'āweoweo* and *'akoko* (tables 1 and 2). All are genera that include native Hawaiian hardwood species.

Table 1: Taxa identified from charcoal

Family	Taxon	Name	Habit	Origin
Chenopodiaceae	*Chenopodium oahuense*	*'āheahea*	shrub-tree	native
Euphorbiaceae	*Euphorbia* sp.	*'akoko*	shrub-tree	native
Fabaceae	*Senna* sp.	*kolomona*	tree	?
Malvaceae	*Sida* cf. *fallax*	*'ilima*	shrub	native

Table 2: Charcoal identifications

Taxon	Part	Count	Weight (g)
Site 50–40–98–1981, Context 12			
Chenopodium oahuense	twig	33	16.6
Sida cf. *fallax*	twig	4	1.84
Euphorbia sp.	twig	1	0.27
Site 50–40–98–1980, Context 15			
Euphorbia sp.	twig	37	3.5
Senna sp.	wood	3	0.61

> It should be noted that while the native plant *S. fallax* is fairly common in archaeological assemblages there are several post-Contact *Sida*, including *S. rhombifolia* or Cuba jute, which was introduced in the 1830's [23:Table 2], and other species that are naturalized throughout the islands. In a brief review of several new wood specimens, I noted the wood anatomy of these taxa might not be diagnostic to species pending further investigation. *Senna* and *Euphorbia* also have naturalized species that are present today on Lāna'i and should be considered similarly.
>
> Please note the following:
>
> - Indeterminate material was too fragile or warped for taxonomic identification, or derives from small woody herb or fern stems which are rarely diagnostic. I have noted whether material was wood, herbaceous stems, grass stems, etc., whenever possible.
> - It is best to choose one fragment of material for radiocarbon dating to eliminate the chance of dating more than one event [4].
>
> Descriptions of the wood anatomy observed in the samples follow.
>
> ***Euphorbia* sp.** Smaller diameter vessels, most under 50 μm, round, often chained radially 2–4 (sometimes up to 8–10); fibers medium thickness, fine pits noted on fiber walls; rays uniseriate and sometimes up to 3–4 seriate with occasional radial canals, cells square or upright; intervessel pits oval, alternate, medium-sized.
>
> ***Sida* cf. *fallax*** Vessels small, under 40 μm diameter, solitary or by 2–3(4); surrounded by thin sleeve of axial parenchyma; fiber walls very thick; rays narrow, bi-seriate, extremely tall in TLS; intervessel pits alternate, 3-4 μm.
>
> ***Senna* sp.** Vessels approximately 100 μm diameter, solitary or in groups or chains of 2–3; fibers medium-thick; axial parenchyma wavy, surrounds vessels and intergrades with fibers; rays uniseriate occasionally widening to 2 cells, a few rays are 2-3 cells wide, short to medium heights, mostly of square and some upright cells; intervessel pits 4-5 μm and also wider, alternate; vessel-ray pits similar.

Two pieces of wood charcoal were selected for ^{14}C dating. A piece of *'ilima* charcoal from the fire-pit at Site 50–40–98–1981and a piece of *'akoko* charcoal from the fire-pit at Site 50–40–98–1980 were submitted to Beta-Analytic for AMS dating (appendix A). Beta-Analytic assigned the *'ilima* charcoal to Beta-510703 and reported a conventional radiocarbon age of 140 ± 30 BP. Beta-Analytic assigned the *'akoko* charcoal to Beta-510704 and reported a conventional radiocarbon age of 170 ± 30 BP. The calibrated age estimates indicate both fire-pits were used near the end of traditional Hawaiian times (fig. 8).

3.2 Reduction Sequence

Compared to island groups elsewhere in Polynesia, Hawaiian adzes are remarkably uniform. An early study that compared Hawaiian adzes with adze collections from the Society Islands, Marquesas, and Easter Island in East Polynesia remarked that "[n]o place in East Polynesian exhibits such a steadfast adherence to one form of adz as Hawaii"

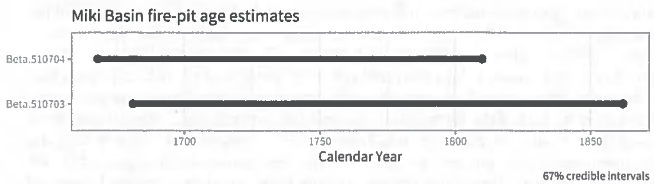

Figure 8: Estimated ages of the Miki Basin fire-pits. Beta-510703 has a 67% credible interval of AD 1681–1862, with a median of AD 1809. Beta-510704 has a 67% credible interval of AD 1668–1810, with a median of AD 1772.

[17:162]. The typical Hawaiian adze was described as "quadrangular (or rectangular) in cross section and, except for some small specimens and a few of medium size, are tanged" [17:162–163]. Adzes with trapezoidal, triangular, lenticular, or plano-convex sections, all common to varying degrees in the other East Polynesian assemblages are either rare or absent from Hawai'i. Hawaiian adzes were manufactured by flaking and grinding, without the pecking technique practiced elsewhere.

Recently, replication experiments have determined reduction sequences for quadrangular adzes from a variety of blank types, including cobbles, flakes, and tabular pieces of rock. The demonstrated

> feasibility of producing adzes from a wide range of blank types means that Hawaiians could have used basalt outcrops and concentrations of subrounded cobbles and boulders, and not simply specialised quarries where large flakes could be obtained. [8:82]

The wide distribution of adze rock in Hawai'i does not mean that adzes were easy to acquire or to produce. In fact, the common Hawaiian quadrangular cross section adze requires great skill to produce.

> Hawaiian quadrangular adzes require precise bidirectional flaking of four right-angled edges, while also creating flat faces on all sides. This is very difficult to achieve on tough basalt using basalt hammer stones. The extremely large and refined examples of prehistoric Hawaiian adzes indicate very high levels of skill and use of hammer stones of different sizes, weights and stone material. [8:71]

It has been estimated that reasonable skill in producing quadrangular section adzes in Hawai'i might have taken "several years of instruction and practice to achieve . . . [which] may explain the huge numbers of broken and rejected preforms on quarries across the Hawaiian archipelago" [8:82].

An early study of adze-making at the sources along the bench at the east end of the Pālawai Basin observed that "the corners of bowlders have been broken off to furnish the cores" [18:77]. Subsequently, a more detailed study determined that adze blanks at Kapohaku were flakes, rather than cobbles or tabular pieces of rock [28], consistent with Emory's observation. The striking platform of the flake became the poll of the finished adze and the flake termination became the cutting edge. Adzes made from flakes: i) are typically thin relative to width and exhibit a cross section that is rectangular, rather than square [8]; ii) often increase in width toward the cutting edge; and iii) are relatively lightweight. These characteristics identify tools suited for everyday household and gardening tasks, rather than felling large trees in old growth forests.

The six adze rejects collected during the inventory survey (fig. 9) are flakes that can be classified as adze blanks because they each lack the three bi-directionally flaked edges that identify a preform [7]. They appear to have been rejected early in the reduction sequence.

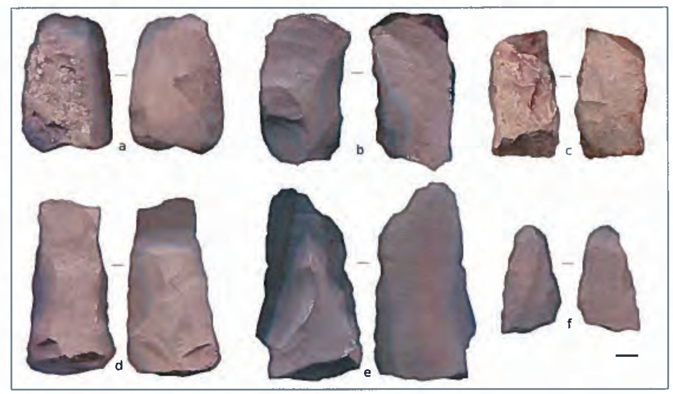

Figure 9: Dorsal (left) and ventral (right) surfaces of secondarily deposited adze rejects included in the EDXRF analysis: *a*, Lāna'i source assignation; *b*, Kīlauea source assignation; *c*, Waiāhole source assignation; *d*, Lāna'i source assignation; *e*, Kīlauea source assignation; *f*, Kīlauea source assignation. The scale bar is 1 cm.

3.3 Lithic Sourcing

Fine-grained rock suitable for adze manufacture is widely distributed around the islands. Exposures of the highest quality adze rock that were heavily exploited have been identified as "quarries" despite their being surface exposures that could be exploited without the deep excavation typically associated with quarrying [9; 24]. Adze-quality rock was also found outside the "quarries", perhaps most typically as cobbles and small boulders in stream beds, but also as boulder outcrops from which flakes might be removed. The large number of potential sources complicates efforts to identify the rock source of an adze or an adze reject.

Sourcing can be accomplished by a variety of means, including; i) description of thin sections and comparison with a reference collection of source thin sections [9]; ii) destructive analyses that yield high-quality geochemical data that can be compared to published analyses of geologic exposures [24]; and iii) non-destructive EDXRF analyses that yield limited geochemical data that can be compared to EDXRF analyses of source materials [22]. A two-stage characterization process is sometimes employed to maximize the utility of results and minimize the destruction of samples [21]. At the first stage, large numbers of samples are analyzed non-destructively with EDXRF to establish geochemical groups and identify outliers. At the second stage, a few samples are selected for destructive analysis, typically in the hope of identifying the local sources of groups and identifying imports among the outliers. For example, in a study of fine-grained basalt artifacts collected from habitation and ritual structures in the Kahikinui district of Maui, EDXRF analysis of 328 artifacts divided them into 17 groups. The EDXRF results were, in most cases, insufficient to assign groups to particular source locations or quarries. Nevertheless, plausible inferences based on the EDXRF results were followed up by destructive wavelength dispersive X-ray fluorescence (WDXRF) analysis of nine samples. WDXRF analysis typically yields results that can confidently assign samples to particular source locations or quarries based on published geochemical analyses. In the Kahikinui case, WDXRF was designed primarily to firm up the identification of one of the EDXRF groups, Group I, as having originated at the well-known Mauna Kea adze quarry. The adze rock at Mauna Kea is extremely fine-grained and isotropic, two qualities that enhance its value as a raw material for adze manufacture [9]. The WDXRF analysis yielded results that confirmed a Mauna Kea origin for six Group I samples, and this made it possible to assign the other four samples in Group I a Mauna Kea origin based on the EDXRF results [21].

The WDXRF analysis also matched EDXRF group D with a source at Kaunolū. Twenty-five of the Kahikinui artifacts were assigned to Group D, which would make Kaunolū the leading supplier of imported adze rock to the Kahikinui sites. About 8% of the adze rock analyzed from the Kahikinui sites originated on Lāna'i.

Adze rocks collected on Lāna'i have been analyzed with EDXRF at least twice, once for the Miki Basin 200 Acre Industrial Development project, and earlier for an unreported project that focused on artifacts held by the Lāna'i Culture and History Center. The non-destructive EDXRF analysis has obvious benefits for museum specimens with potential for public display, but, as noted above, it yields data that are unlikely to assign artifacts to particular source locations or quarries. As a preliminary stage of analysis, EDXRF can suggest a range of possible source locations or quarries, and it can usefully exclude some potential source locations or quarries. The information provided by EDXRF might point to certain artifacts as potential imports, with geochemical compositions unlikely to be found near the collection location, whose source location might be identified with

additional analysis. At the same time, the EDXRF analysis might also identify artifacts that cannot be sourced to a particular location, but whose geochemical composition is similar to what might be expected from sources near the collection location.

In these circumstances, a statistical framework that can be used to distinguish possible imports from likely local artifacts based on EDXRF information might prove useful. One way to do this is with a statistical technique known as discriminant analysis. Briefly, discriminant analysis uses so-called training data to establish a set of targets and then assigns instances from a set of test data to one or another of the targets. In the present case, the training data are EDXRF analyses of adze-quality rock from potential source locations, and the test data are the EDXRF analyses of the Lāna'i artifacts. In the ideal case, where all of the potential rock sources are included in the training data, and the geochemical analysis is able to distinguish among them confidently, then the discriminant analysis will correctly assign each instance of test data to its source location. In real-world situations that fall short of this ideal, the discriminant analysis assignments are best interpreted more loosely, as indications of a local or non-local source and as guides for future inquiry.

The discriminant model for EDXRF analysis of Lāna'i artifacts falls short of the ideal situation. Caution in the interpretation of results is clearly warranted. EDXRF training data from potential sources lacks information from many known quarry locations. The quarry data for the training set are found on the Geoarchaeology Laboratory, UH Hilo web site and include Kīlauea and Mauna Kea on Hawai'i Island, Nu'u and Haleakalā on Maui Island, and Waiāhole on O'ahu Island. In addition, training data were collected in 2011 by Mills and Lundblad from several locations on Lāna'i (fig. 10). These Lāna'i training data are lumped together in the analysis as a single Lāna'i source.

EDXRF analysis provides abundance estimates for several elements with varying degrees of precision and accuracy. Consequently, analyses of EDXRF results typically focus on a subset of elements chosen either because they are specifically applicable to the question at hand or because the EDXRF method yields relatively precise and/or accurate estimates for them. The present analysis focused on the elements Nickel (Ni), Copper (Cu), Rubidium (Rb), Strontium (Sr), Yttrium (Y), Zirconium (Zr), and Niobium (Nb). These are the elements chosen by the Hilo Geoarchaeology team for a principal components analysis of many of these same training data [21]. Using these seven elements, the discriminant analysis carried out here distinguishes Haleakalā, Nu'u, and Mauna Kea from the other potential sources (fig. 11). Nevertheless, the discriminant analysis based on the EDXRF estimates of the seven elemental abundances does not confidently distinguish the Lāna'i sources from the Kīlauea and Waiāhole sources.

The success of the classification yielded by the discriminant analysis of the training data can be assessed in several ways [5:108–110]. Two common assessments are the hold-out method, which holds out a random subset of the training data and then determines whether instances are correctly assigned to source targets established with the remaining training data, and the leave-out-one cross-validation method, which assesses whether each instance of the training data is correctly assigned to a source target established by the remainder of the training data. In practice, the two methods should provide similar results with a reasonably-sized training data set. The leave-out-one cross-validation

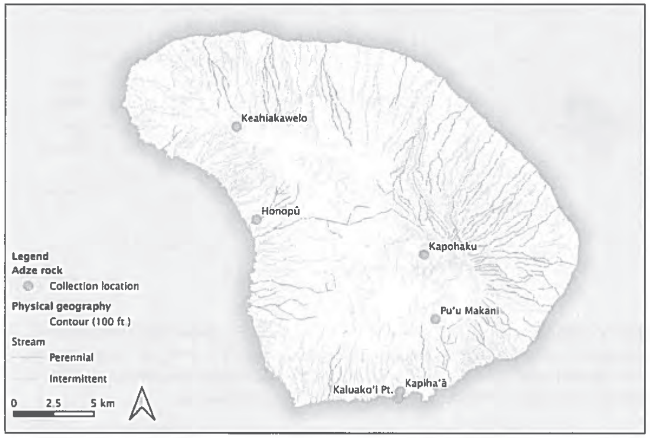

Figure 10: Potential adze rock sources on Lāna'i for which EDXRF training data are available. Note that data are also available for an outcrop in Ka'ā whose location hasn't been fixed.

method implemented by the MASS package of the R statistical software [27] correctly assigns sources to 97% of the samples in the training data set. As expected, all of the Haleakalā, Mauna Kea, and Nu'u instances were assigned to the correct source. The other potential sources fared less well: 97% of the Waiāhole instances were correctly assigned, as were 83% of the Lāna'i debitage instances and 63% of the Kīlauea instances. These results are confirmed by the hold-out method, which correctly classified 98% of a randomly selected hold-out set comprising 20% of the training data. This result indicates that the EDXRF method is sufficiently powerful to distinguish among the six sources included in the training data set. It is no guarantee that the EDXRF data would perform as well if other source locations were added to the training data set. In general, the greater the number of potential sources, the more difficult it is to distinguish among them. The same relationship holds for within-source variability. In the case of geochemical sourcing, as the known range of geochemical compositions from a source grows, the more difficult it is to distinguish that source from other sources that are geochemically similar. Thus, the success of the classification yielded by the discriminant analysis of the training data should be tempered by the understanding that it was likely aided by the formative state of the training data set, which lacks several known sources, and by the likely incomplete catalog of Lāna'i Island sources in the EDXRF database.

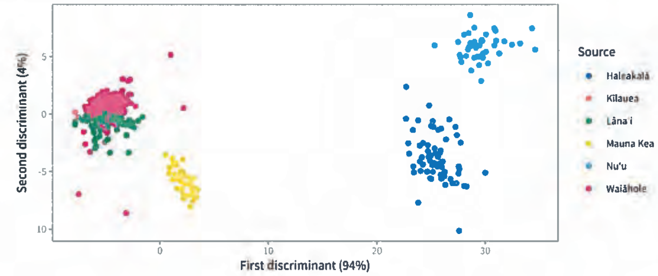

Figure 11: Graphical summary of the discriminant analysis. Note that the Haleakalā, Nu'u, and Mauna Kea sources can be distinguished with the first two discriminants, which together capture 98% of the variability in the full data set. In contrast, the Lāna'i sources are not clearly distinguished from Waiāhole and Kīlauea.

Six secondarily deposited adze rejects collected from the surface during the inventory survey (see fig. 9, p. 14) were analyzed with EDXRF in an effort to determine their source locations (appendix B). Using the training data described earlier, the discriminant analysis assigns two adze rejects to a Lāna'i source, three adze rejects to a Kīlauea source, and one adze reject to a Waiāhole source. As discussed, the discriminant analysis does not distinguish these sources confidently; the results should not be interpreted as indicating imports from Kīlauea and Waiāhole. Rather, these results indicate that there is no strong evidence that any of the adze rejects was made with imported rock. At the same time, the results do offer strong evidence that the adze rejects did not originate at Haleakalā or Nu'u on Maui, or Mauna Kea on Hawai'i Island.

4 Discussion

This section compares the ages and firewood composition of the fire-pits at Sites 50–40–98–1980 and 50–40–98–1981 with the ages and firewood composition of eight other fire-pits on Lāna'i Island. The ages and composition of the Lāna'i Island fire-pits are then compared with 33 fire-pits from coastal Waimānalo, O'ahu to distinguish tempos of vegetation change following Polynesian colonization of the islands.

Ten fire-pits on Lāna'i have been investigated with a combination of wood charcoal identification and controlled radiocarbon dating using single pieces of a short-lived taxon. The combination of wood charcoal identification and controlled radiocarbon dating yields both a roster of the woods used to fuel a fire and a precise estimate of when the firing took place. Assuming that fires were fueled with wood that was available in the vicinity of the fire-pit, combined identification and dating analyses potentially yield a record of regional vegetation change over time. The plausibility of the assumption and the ability of the combined identification and dating analyses to yield a record of regional vegetation change over time were established at Waimānalo, O'ahu, where replacement of the native lowland forest with canoe plants brought to the islands by Polynesian settlers was underway by the mid-fifteenth century [16].

The ten fire-pits investigated in this way on Lāna'i are located on the windward and south coasts and in the central basin and plateau (fig. 12). On the windward coast, the fire-pits include one exposed on the surface at Kahalepalaoa and two other buried fire-pits identified in a backhoe excavation [11]. The two fire-pits investigated on the south coast were found during excavation of a beach sand deposit that was buried under alluvium deposited during and after ranching had destabilized the island's soils [15]. The fire-pit on the central plateau at Site 50–40–98–01984 was exposed on an eroding surface located on the outskirts of an abandoned pineapple field. In addition to the fire-pits in the central basin investigated in this report, the two fire-pits at Sites 50–40–98–01986 and –01987 were discovered beneath the plow zone of an abandoned pineapple field [13].

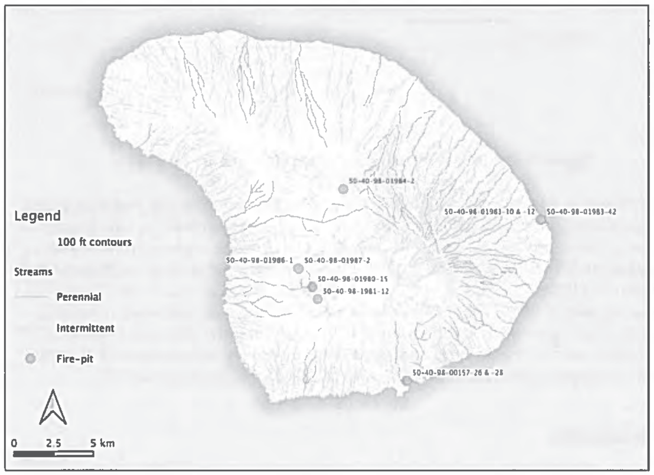

Figure 12: Location of fire-pit investigations on Lāna'i. *Sources:* Site 50–40–98–00157 [15]; Site 50–40–98–01980 and –01981 this report; Site 50–40–98–01983 [11]; Site 50–40–98–01984 [14]; Site 50–40–98–01986 and –01987 [13].

The calibrated ages of the individual fire-pits have already been reported [11; 13–15]. The reported dates can be used to investigate the tempo of fire-pit construction and use on Lāna'i by turning away from the estimated ages of individual fire-pits and asking instead when was the first occurrence of fire-pit construction and use, when was the second occurrence of fire-pit construction and use, etc. Posing the question in this way builds upon the event view of time used in the radiocarbon dating analysis to employ instead a substance view of time typically used to frame archaeological questions. The substance view of time focuses analysis on change, which is expressed on an absolute time scale. On present evidence, the occurrence of fire-pit construction and use on Lāna'i began in the late fifteenth century and continued into the historic period (fig. 13).

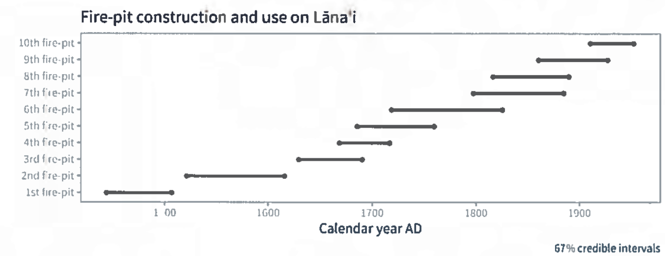

Figure 13: Occurrence of fire-pit construction and use on Lāna'i.

Identification of firewood used in the Lāna'i fire-pits indicates the prevalence into the historic period of native forest, with relatively little replacement of native species by canoe plants. This finding contrasts strongly with the documented transformation of the lowland forest at Waimānalo, where canoe plants were well established by the middle of the fifteenth century (fig. 14). At a time when most Lāna'i fire-pits were fueled exclusively with native woods, Waimānalo fire-pits regularly yield firewood assemblages dominated by canoe plants. The transformation of the lowland forest evidenced at Waimānalo started late on Lāna'i and had made relatively little progress before the island's vegetation history was radically altered during the ranching era [19].

5 Conclusion

Wood charcoal identification and dating lend support to the claim made by Hawaiian tradition that Lāna'i was settled relatively late. Current evidence from the island suggests that the first fire-pits were constructed 400–500 years after Polynesians discovered the islands. However, it is extremely unlikely that the earliest evidence for human activity on

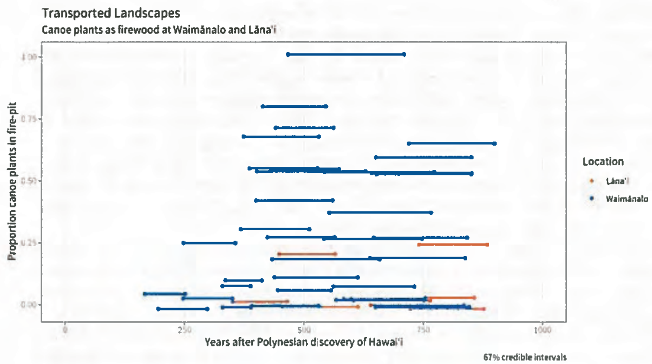

Figure 14: Canoe plants as firewood at Waimānalo and on Lāna'i.

Lāna'i has been identified. Most of the well dated fire-pits are from the island's interior and the dry southern coast, which are relatively unlikely locations for early settlement. A likely location for early settlement is the windward coast in the vicinity of Maunalei Valley. The combination of a perennial stream that could feed *lo'i kalo*, sand beaches, shallow water fishing grounds, and relatively easy access to Maui and Moloka'i Islands all point to the desirability of the island's windward coast for traditional settlement. Only a few fire-pits from the windward coast of Lāna'i have been identified and dated at Kahalepalaoa, a location that lacks the agricultural resources that would have been available at Maunalei, and would likely have been settled at a later time.

The windward Lāna'i coastline that Hawaiians knew is today deeply buried by sediment that eroded off the mountain during and after the ranching period, when large herds of grazing herbivores wreaked havoc on the native vegetation and destabilized soils over much of the island [19]. The widespread, severe erosion of upland soils that resulted likely had the effect of sealing early cultural deposits along the windward coast under a thick blanket of sediment that serves to protect them from erosion and disturbance. In the event the windward coast of Lāna'i is developed, one focus of historic preservation efforts should identify and recover evidence of this early settlement.

The canoe plants brought to the islands by Polynesian settlers had begun to replace native species in lowland forests by the middle of the fifteenth century at places like Waimānalo on O'ahu. This replacement of native forest by canoe plants favored by Polynesians is referred to by geographers as a process of landscape transport in which immigrants work to create settlements that resemble those of the homeland. The process

of landscape transport appears to have had relatively little effect on Lāna'i prior to the ranching era; fire-pits that date late in the traditional Hawaiian period and early in the historic period were fueled almost exclusively by wood from native plants that were well adapted to the island's dry conditions and were likely established in the island's primeval forests. Canoe plants are only rarely identified in fire-pits from the island–breadfruit from Kahalepalaoa, ki from Manele, and *kukui*, *'ōhi'a 'ai*, *'ulu*, and *ipu* from Kaunolū are exceptions that prove the rule of native firewood on the island. In this respect, one conclusion of an early inquiry into Lāna'i firewood at Kaunolū—that "many dryland forest taxa apparently persisted in this region until sometime after the abandonment of the Kaunolū settlement in the mid-1800's" [1]—appears to apply more widely and likely characterizes the vegetation history of the island as a whole.

Archaeological study of the island's stone tools is at an early stage. A reduction sequence in which an initial step removed a large flake from a boulder of suitable adze rock seems to have been most common. This reduction sequence based on flakes was practiced widely in Hawai'i and was particularly common during production of small adzes. The Lāna'i adze rejects sourced for the Miki Basin 200 Acre Industrial Development project were likely fashioned from local rocks, but there can be little doubt that imported adzes will be identified on the island with subsequent research. Adze rock collected from traditional Hawaiian sites in Kahikinui on Maui Island is reliably sourced to Kaunolū, so adze rock was definitely moving across the narrow channel between the islands. Additional research on Lāna'i stands a good chance of turning up evidence for the import of adze rock from islands nearby.

The discriminant analysis framework outlined in this report indicates that the non-destructive EDXRF analysis carried out by the Hilo Geoarchaeology Laboratory is sufficiently powerful to distinguish at least two Maui Island sources and the fine-grained adze rock from Mauna Kea from Lāna'i adze rocks. Other potential imports, from Waiāhole on O'ahu, Kīlauea on Hawai'i, and likely several other locations, will be difficult to distinguish from the local rock with EDXRF, although this situation might change once the variability of Lāna'i adze rock is more completely known through characterization of a wider range of source locations. Even with this additional work on source locations, however, it seems likely that a two stage process will be required for a study that confidently distinguishes Lāna'i sources from imports. Currently, there are several techniques that might yield information that would distinguish the local Lana'i rocks from most imports, including petrographic description of thin sections and various geochemical techniques such as WDXRF and microprobe. These more powerful techniques are all destructive in the sense that a piece of the artifact must be sacrificed to complete the analysis, are relatively expensive to undertake compared to EDXRF, and typically require an experienced geologist to interpret their results.

A ^{14}C Dates

Beta-510703 **140 ± 30**

$\delta^{13}C = -22.0‰$

Sample consists of one piece of *Sida* cf. *fallax* twig charcoal from Site 50–40–98–01981, Context 12. Submitted 2018–11–26. Context 12 is described as fire-pit in backoe trench 21. It is classified as a cultural event.

Comment: Sida cf. *fallax* twig is a short-lived material. The dated material has a highly probable association with the target event, which is fire-pit use. This short-lived material is confidently associated with use of the fire-pit feature. It provides the best estimate of when the fire-pit feature was last used. The submitted sample yielded ample carbon for dating and was processed normally in the laboratory.

Beta-510704 **170 ± 30**

$\delta^{13}C = -10.4‰$

Sample consists of one piece of *Euphorbia* cf. *celastroides* twig charcoal from Site 50–40–98–01981, Context 15. Submitted 2018–11–26. Context 15 is described as the base of a truncated fire-pit exposed in an erosion swale. It is classified as a cultural event.

Comment: Euphorbia cf. *celastroides* twig is a short-lived material. The dated material has a highly probable association with the target event, which is fire-pit use. This short-lived material is confidently associated with use of the fire-pit feature. It provides the best estimate of when the fire-pit feature was last used. The submitted sample yielded ample carbon for dating and was processed normally in the laboratory.

B EDXRF Data

Label	Ni	Cu	Rb	Sr	Y	Zr	Nb
Context 19	143.298	138.531	16.689	342.543	37.753	155.704	10.772
Context 18	127.073	113.949	15.004	343.271	96.07	143.251	10.646
Context 18	169.568	148.242	17.341	353.212	24.126	141.784	10.387
Context 0	172.385	160.297	16.541	356.349	57.311	137.105	10.452
Context 18	123.763	115.902	14.582	370.528	114.449	141.899	9.254
Context 0	117.062	89.686	14.488	350.596	35.178	139.206	9.72

Note: All data in parts per million.

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Miki Basin Industrial Park
Environmental Assessment

Exhibit B

Flora and Fauna Study

FLORA AND FAUNA STUDY

MIKI BASIN 200 ACRE INDUSTRIAL DEVELOPMENT

KALULU AND KAUNOLŪ, LĀNAʻI

by:

Robert Hobdy
Environmental Consultant
Kokomo, Maui
April 2018

Prepared for:
Pūlama Lānaʻi

FLORA AND FAUNA STUDY
MIKI BASIN 200 ACRE INDUSTRIAL DEVELOPMENT
KALULU AND KAUNOLŪ, LĀNAʻI

INTRODUCTION

The Miki Basin 200 acre Industrial Development project is located on the inner slopes of Miki Basin and a small portion of Pālawai Basin in southwestern Lānaʻi to the east of Lānaʻi Airport. Miki Road runs through the project area and the project area also surrounds the Maui Electric Company Power Plant within the Basin. All of the lands within and around the project area are owned and managed by Pūlama Lānaʻi.

SITE DESCRIPTION

The project area is situated on gently to moderately sloping lands that were part of a large pineapple plantation. These lands have lain fallow for 25 years since the plantation closed in 1992 and are now overgrown with a dense grassland and shrubs. Soils consist of three series characterized as Waikapū silty clay loam, 0 – 3% slopes, Molokaʻi silty clay loam, 3 – 7% slopes and Uala silty clay loam, 7 – 15% slopes which are all variants of deep, well-drained soils of the upland plateau of Lānaʻi, (Foote et al, 1972). Rainfall averages about 20 inches per year with winter maximums (Armstrong, 1983). Elevations range between 1,150 feet and 1,310 feet above sea level.

SURVEY OBJECTIVES

This report summarizes the findings of a flora and fauna study of the proposed Miki Basin 200 Acre Industrial Development Project that was conducted in April 2018. The objectives of the survey were to:

1. Document what plant and animal species occur on the property or may likely occur in the existing habitat.

2. Document the status and abundance of each species.

3. Determine the presence or likely occurrence of any native flora and fauna, particularly any that are federally listed as Threatened or Endangered. If such occur, identify what features of the habitat may be essential for these species.

4. Determine if the project area contains any special habitats which if lost or altered might result in a significant negative impact on the native flora and fauna in this part of the island.

BOTANICAL SURVEY REPORT

SURVEY METHODS

A walk-through botanical survey method was used to cover this 200 acre project area. All parts of this habitat were examined.

A complete inventory of all plant species was made with special attention focused on native plant species and whether any of these were federally protected Threatened or Endangered species that might require special attention or actions.

DESCRIPTION OF THE VEGETATION

The entire project area has lain fallow from agricultural use for 25 years, with some grazing occurring during a few of these years. The vegetation was a dense growth of grasses and shrubs. Thirty-nine plant species were recorded during the survey.

Two species were abundant throughout the project area, Guinea grass (*Megathyrsus maximus*) and lantana (*Lantana camara*). Another two species were common, sourgrass (*Digitaria insularis*) and Madagascar fireweed (*Senecio madagascariensis*). The remaining thirty-five species were either of uncommon or rare occurrence.

Just three common native plant species were found, ′ilima (*Sida fallax*), ′uhaloa (*Waltheria indica*) and ′a′ali′i (*Dodonaea viscosa*), all of which are widespread and common throughout Hawaii. These have persisted here in small numbers due to their hardy nature.

DISCUSSION AND RECOMMENDATIONS

The vegetation in this project area is dominated by hardy, invasive non-native species. Just three common native plant species, ′ilima, ′uhaloa and ′a′ali′i, were found here. None of these are of any conservation concern. No special habitats for native plants were found. Because of the above information, it is determined that there is nothing of special botanical concern with regard to this project. No recommendations with reference to plants are deemed necessary.

PLANT SPECIES LIST

Following is a checklist of all those vascular plant species inventoried during the field studies. Plant families are arranged alphabetically. Taxonomy and nomenclature of the flowering plants (Monocots and Dicots) are in accordance with Wagner et al. (1999).

For each species, the following information is provided:

1. Scientific name with author citation.
2. Common English or Hawaiian name.
3. Bio-geographical status. The following symbols are used:

   endemic = native only to the Hawaiian Islands; not naturally occurring anywhere else in the world.

   indigenous = native to the Hawaiian Islands and also to one or more other geographic area(s).

   non-native = all those plants brought to the islands intentionally or accidentally after western contact.

   Polynesian = brought by the Hawaiians during Polynesian migrations.

4. Abundance of each species within the project area:

   abundant = forming a major part of the vegetation within the project area.

   common = widely scattered throughout the area or locally abundant within a portion of it.

   uncommon = scattered sparsely throughout the area or occurring in a few small patches.

   rare = only a few isolated individuals within the project area.

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
MONOCOTS			
POACEAE (Grass Family)			
Andropogon virginicus L.	broom sedge	non-native	uncommon
Bothriochloa pertusa (L.) A. Camus	pitted beardgrass	non-native	uncommon
Cynodon dactylon (L.) Pers.	Bermuda grass	non-native	rare
Digitaria insularis (L.) Mez ex Ekman	sourgrass	non-native	common
Eragrostis pectinacea (Michx.) Nees	Carolina lovegrass	non-native	rare
Megathyrsus maximus (Jacq.) Simon & Jacobs	Guinea grass	non-native	abundant
Melinis repens (Willd.) Zizka	Natal redtop	non-native	rare
DICOTS			
AMARANTHACEAE (Amaranth Family)			
Amaranthus spinosus L.	spiny amaranth	non-native	rare
Dysphania ambrosioides (L.) Mosyakin & Clemants	Mexican wormseed	non-native	rare
Dysphania carinata (R.Br.) Mosyakin & Clemants	keeled wormseed	non-native	uncommon
APOCYNACEAE (Dogbane Family)			
Asclepias physocarpa (E. Mey.) Schlecter	baloon plant	non-native	uncommon
ASTERACEAE (Sunflower Family)			
Ageratum conyzoides L.	maile hohono	non-native	rare
Conyza bonariensis (L.) Cronq.	hairy horseweed	non-native	uncommon
Emilia fosbergii Nicolson	red pualele	non-native	rare
Heterotheca grandiflora Nutt.	telegraph weed	non-native	uncommon
Senecio madagascariensis Poir.	Madagascar fireweed	non-native	common
Verbesina encelioides (Cav.) Benth. & Hook.	golden crown-beard	non-native	uncommon
BRASSICACEAE (Mustard Family)			
Lepidium virginicum L.	Virginia pepperwort	non-native	rare
CARYOPHYLLACEAE (Pink Family)			
Polycarpon tetraphyllum (L.) L.	four-leaved allseed	non-native	rare
CONVOLVULACEAE (Morning Glory Family)			
Ipomoea cairica (L.) Sweet	koali 'ai	non-native	rare
Ipomoea obscura (L.) Ker-Gawl.)	---------------------	non-native	rare
Ipomoea triloba L.	little bell	non-native	rare
EUPHORBIACEAE (Spurge Family)			
Euphorbia hirta L.	hairy spurge	non-native	rare
FABACEAE (Pea Family)			
Chamaecrista nictitans (L.) Moench	partridge pea	non-native	uncommon
Desmanthus pernambucanus(L.) Thellung	slender mimosa	non-native	rare

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
Indigofera suffruticosa Mill.	'inikō	non-native	uncommon
MALVACEAE (Mallow Family)			
Malvastrum coromandelianum (L.) Garcke	false mallow	non-native	rare
Sida ciliaris L.	bracted fanpetals	non-native	rare
Sida cordifolia L.	flannel sida	non-native	rare
Sida fallax Walpers	'ilima	indigenous	uncommon
Sida rhombifolia L.	arrowleaf sida	non-native	rare
Sidastrum micranthum (St. Hil.) Fryx.	sand mallow	non-native	uncommon
Waltheria indica L.	'uhaloa	indigenous	uncommon
OXALIDACEAE (Wood Sorrel Family)			
Oxalis corniculata L.	'ihi 'ai	Polynesian	rare
POLYGALACEAE (Milkwort Family)			
Polygala paniculata L.	root beer plant	non-native	rare
SAPINDACEAE (Soapberry Family)			
Dodonaea viscosa Jacq.	'a'ali'i	indigenous	rare
SOLANACEAE (Nightshade Family)			
Solanum linnaeanum Hepper & P. Jaeger	apple of Sodom	non-native	uncommon
VERBENACEAE (Verbena Family)			
Lantana camara L.	lantana	non-native	abundant
Verbena littoralis Kunth	ha'u ōwī	non-native	rare

FAUNA SURVEY REPORT

SURVEY METHODS

A fauna survey was conducted in conjunction with the flora survey. All parts of the project area were covered. Observations were made with the assistance of binoculars. Notes were made of species, numbers and status as well as on tracks, scat and signs of feeding. An inventory was made of all of the animal species encountered.

In addition, an evening survey was conducted to observe crepuscular activities and calls, and to determine any occurrence of the Endangered Hawaiian hoary bat (*Lasirius cinereus semotus*) in the project area.

RESULTS

MAMMALS

Just one mammal species was observed in the project area. A herd of about 20 axis deer were seen and trails, tracks and feeding damage were everywhere. Nomenclature and taxonomy follow (Tomich, 1986).

A special effort was made to look for evidence indicating the presence of ōpe′ape′a or Hawaiian hoary bat by conducting an evening survey at two locations within the project area. A bat detecting device (Batbox III D) was employed, set to frequency of 27,000 Hertz that these bats are known to use when echolocating for flying insects. No bats were detected with the use of this device.

Other non-native mammals likely to frequent this area include rats (*Rattus* spp.), mice (*Mus domesticus*), feral cats (*Felis catus*) and occasionally domestic dogs (*Canis familiaris*).

BIRDS

Birdlife was of moderate occurrence in the project area. Twelve species were observed during three site visits, but none were particularly common. Taxonomy and nomenclature follow the American Ornithologists' Union (2018). Eight bird species were of modest occurrence, cattle egret (*Bubulcus ibis*), zebra dove (*Geopelia striata*), nutmeg mannikin (*Lonchura punctulata*), gray francolin (*Francolinus pondicerianus*), northern mockingbird (*mimus polyglottos*), common myna (*Acridotheres tristis*), Eurasian sky lark (*Alauda arvensis*) and Pacific golden-plover (*Pluvialis fulva*). The other four species were of rare occurrence.

Two native bird species were recorded, the indigenous and migratory kōlea or Pacific golden-plover and the endemic pueo or Hawaiian owl (*Asio flammeus sandwichensis*).

A few other non-native bird species may occasionally occur in this area, but this habitat is unsuitable for Hawaii's native forest birds or seabirds.

INSECTS

Insect life was rather sparse in this habitat during three site visits. Twelve non-native species were recorded, representing five insect Orders. Just one species was common throughout the project area, the monarch butterfly (*Danaus plexippus*). Two other species were uncommon, the cabbage butterfly (*Pieris rapae*) and the short-horned grasshopper (*Oedaleus abruptus*). Taxonomy and nomenclature follow Nishida et al (1992).

No native insect species were seen.

DISCUSSION AND RECOMMENDATIONS

The fauna recorded in this project area is largely non-native in character. Axis deer are abundant throughout the area and have significantly modified the habitat by reducing plant species to a few hardy dominants. This in turn has a somewhat limiting effect on resource availability for other mammals, birds and insects.

No Endangered Hawaiian bats were detected in the project area during the survey. They are rare on Lāna′i but could occur in this area occasionally. The U.S. Fish and Wildlife Service has guidelines that ensure that these bats are not harmed should they show up.

Just two bird species were native to Hawaii, the kōlea and the pueo. The kōlea breed and raise their young in the arctic and then migrate to tropical places like Hawai′i to overwinter. Many thousands of kōlea come to Hawaii every winter. Kōlea are quite common and have no endangered or threatened status.

The pueo is a race of the short-eared owl species that is endemic to Hawaii. It occurs on all the islands but is rare on O′ahu. It is wide ranging in grasslands and shrublands on Lāna′i. It carries no federal endangered or threatened status.

Two indigenous seabirds the Endangered ′ua′u and the Threatened ′a′o, while not nesting in the project area, do fly over it during dusk to access their burrows high in the mountains and again at dawn to head out to sea. Young birds taking their first fledging flights are inexperienced fliers. They often are disoriented by bright lights and crash into light structures where they become vulnerable to injury and predators. It is recommended that any significant outdoor lighting associated with the proposed project be hooded to direct the light downward to mitigate this threat.

No other recommendations with reference to fauna are deemed necessary.

ANIMAL SPECIES LIST

Following is a checklist of the animal species inventoried during the field work. Animal species are arranged in descending abundance within three groups: Mammals, Birds and Insects. For each species the following information is provided:

1. Common name

2. Scientific name

3. Bio-geographical status. The following symbols are used:

   endemic = native only to Hawaii; not naturally occurring anywhere else in the world.

   indigenous = native to the Hawaiian Islands and also to one or more other geographic area(s).

   migratory = bird species that spend the fall and winter months in Hawaii and the spring and summer months breeding in the arctic.

   non-native = all those animals brought to Hawaii intentionally or accidentally after western contact.

4. Abundance of each species within the project area:

   abundant = many flocks or individuals seen throughout the area at all times of day.

   common = a few flocks or well scattered individuals throughout the area.

   uncommon = only one flock or several individuals seen within the project area.

   rare = only one or two seen within the project area.

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
MAMMALS			
CERVIDAE (Deer Family)			
Axis axis Erxleben	axis deer	non-native	abundant
BIRDS			
ALAUDIDAE (Sky Lark Family)			
Alauda arvensis L.	Eurasian sky lark	non-native	uncommon
ARDEIDAE (Heron Family)			
Bubulcus ibis L.	cattle egret	non-native	uncommon
CARDINALIDAE (Cardinal Family)			
Cardinalis cardinalis L.	northern cardinal	non-native	rare
CHARADRIIDAE (Plover Family)			
Pluvialis fulva Gmelin	kōlea, Pacific golden-plover	indigenous	uncommon
COLUMBIDAE (Dove Family)			
Geopelia striata L.	zebra dove	non-native	uncommon
ESTRILDIDAE (Estrildid Finch Family)			
Lonchura punctulata L.	nutmeg mannikin	non-native	uncommon
MIMIDAE (Mockingbird Family)			
Mimus polyglottos L.	northern mockingbird	non-native	rare
PHASIANIDAE (Pheasant Family)			
Francolinus pondicerianus Gmelin	gray francolin	non-native	uncommon
Meleagris gallopavo L.	Rio Grande turkey	non-native	rare
Phasianus colchicus L.	ring-necked pheasant	non-native	rare
STRIGIDAE (Owl Family)			
Asio flammeus sandwichensis Bloxam	Pueo, Hawaiian owl	endemic	rare
STURNIDAE (Starling Family)			
Acridotheres tristis L.	common myna	non-native	uncommon

SCIENTIFIC NAME	COMMON NAME	STATUS	ABUNDANCE
INSECTS			
ARANAE - spiders			
ARANEIDAE (Orb Weaver Spider Family)			
Araneus diadematus Clerck	European garden spider	non-native	rare
DIPTERA - flies			
CALLIPHORIDAE (Calliphorid Fly Family)			
Calliphora vomitoria L.	bluebottle fly	non-native	rare
Eucalliphora latifrons Hough	blow fly	non-native	rare
SYRPHIDAE (Hoverfly Family)			
Symosyrphus grandicornis Macquart	Australian hoverfly	non-native	rare
HYMENOPTERA - bees, wasps, ants			
APIDAE (Honeybee Family)			
Apis mellifera L.	honeybee	non-native	uncommon
FORMICIDAE (Ant Family)			
Pheidole megacephala Fabricius	big-headed ant	non-native	rare
LEPIDOTERA - butterflies, moths			
CRAMBIDAE (Webworm Moth Family)			
Spoladea recurvalis Fabricius	beet webworm moth	non-native	rare
HESPERIIDAE (Skipper Butterfly Family)			
Hylephila phyleus Drury	fiery skipper	non-native	rare
LYCAENIDAE (Gossamer-winged Butterfly Family)			
Lampides boeticus L.	long-tailed blue butterfly	non-native	rare
NYMPHALIDAE (Brush-footed Butterfly Family)			
Danaus plexippus L.	monarch butterfly	non-native	common
PIERIDAE (White and Sulphur Butterfly Family)			
Pieris rapae L.	cabbage butterfly	non-native	uncommon
ORTHOPTERA - grasshoppers, crickets			
ACRIDIDAE (Grasshopper Family)			
Oedaleus abruptus Thunberg	short-horned grasshopper	non-native	uncommon

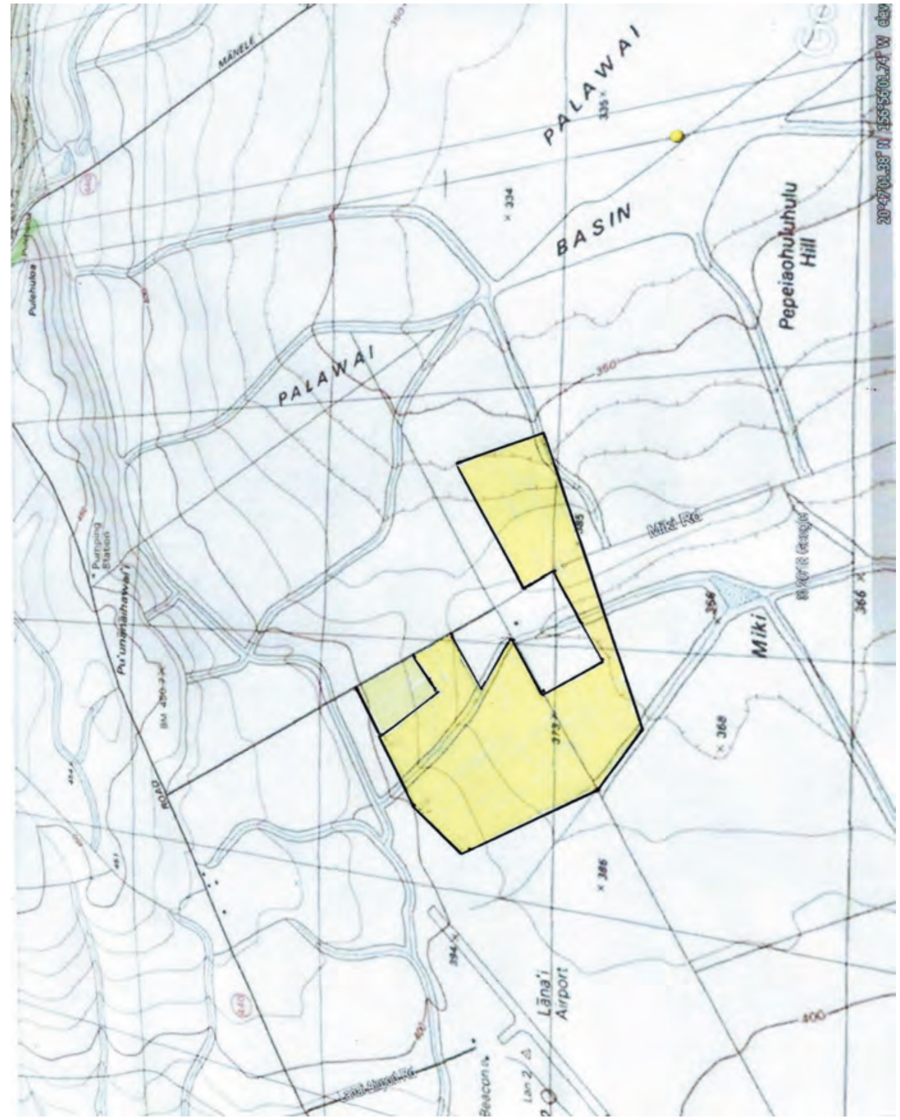

Figure 1. Miki Basin 200 acre Industrial Development Project Area in southwestern Lāna'i

Figure 2. View west showing the Guinea grass and lantana shrubland characteristic of western portion of the project area in Miki Basin

Figure 3. View northeast across the Pālāwai Basin portion of the project area showing a guinea grass and lantana shrubland

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