Appendix A
Botanical, Avian and Terrestrial Mammalian Surveys Conducted for the Auwahi Wind Farm Project, ʻUlupalakua Ranch, Island of Maui

Botanical, Avian and Terrestrial Mammalian Surveys Conducted for the Auwahi Wind Farm Project, ʻUlupalakua Ranch, Island of Maui

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Introduction

Auwahi Wind Energy, LLC, a subsidiary of Sempra Generation, Inc. proposes to develop a wind energy project, called the Auwahi Wind Farm ("Project"), on 'Ulupalakua Ranch land in the southern part of the Auwahi *ahupua'a*, Maui Island, Hawai'i (Figure 1). The primary purposes of the surveys reported here are 1) to assess the botanical, avian, and mammalian resources in the Project area, and 2) to determine if any species listed as endangered, threatened, or proposed for listing under either federal or the State of Hawai'i endangered species programs occur within, or in the immediate vicinity of, the Project. Information regarding federal and state listed species and their status comes from the Division of Land and Natural Resources (DLNR, 1998) and the U.S. Fish & Wildlife Service (USFWS, 2005, 2010).

Initial biological surveys for the Project were undertaken for ShellWind Energy, Inc. in mid-2007 and a draft report of results and recommendations issued in early 2008. In October 2009, Sempra Energy acquired the development assets of the proposed project from Shell. Recommendations for additional surveys from the draft report were implemented beginning in May 2010, and the report presented here is a significantly revised and expanded version of the 2008 draft report. The current report reflects Sempra Energy's revised project design and footprint as detailed up through October 2010. Minor additional surveys may be needed to cover adjustments in layout of Project elements as engineering of the Project nears completion. These surveys, if needed, will insure that no listed plant species occur in impact areas not previously surveyed; and would not alter the conclusions made in this report.

Project and Site Description

The proposed project consists of three main components: a) the wind farm site, b) a transmission line corridor, and c) a construction access road. Each of these components is shown on Figure 2, and is described below.

Wind Farm Site

The wind farm site consists of approximately 1,500 acres of the Auwahi *ahupua'a*, and is located on 'Ulupalakua Ranch property. The northern site boundary is located along Pi'ilani Highway at approximately 1,600 feet (470 meters) above sea level (ASL), and the southern boundary is located approximately 1,300 feet inland from the shore (at about 200 feet or 90 meters ASL). The site is bound to the east and west by the *ahupua'a* of Luala'ilua and Kanaio, respectively. The site is currently used for cattle grazing by 'Ulupalakua Ranch, although much of the topography is rugged 'a'ā lava flows. The majority of the site is dominated by alien scrub vegetation, although numerous stands of *wiliwili* (*Erythrina sandwicensis*) occur within this site.

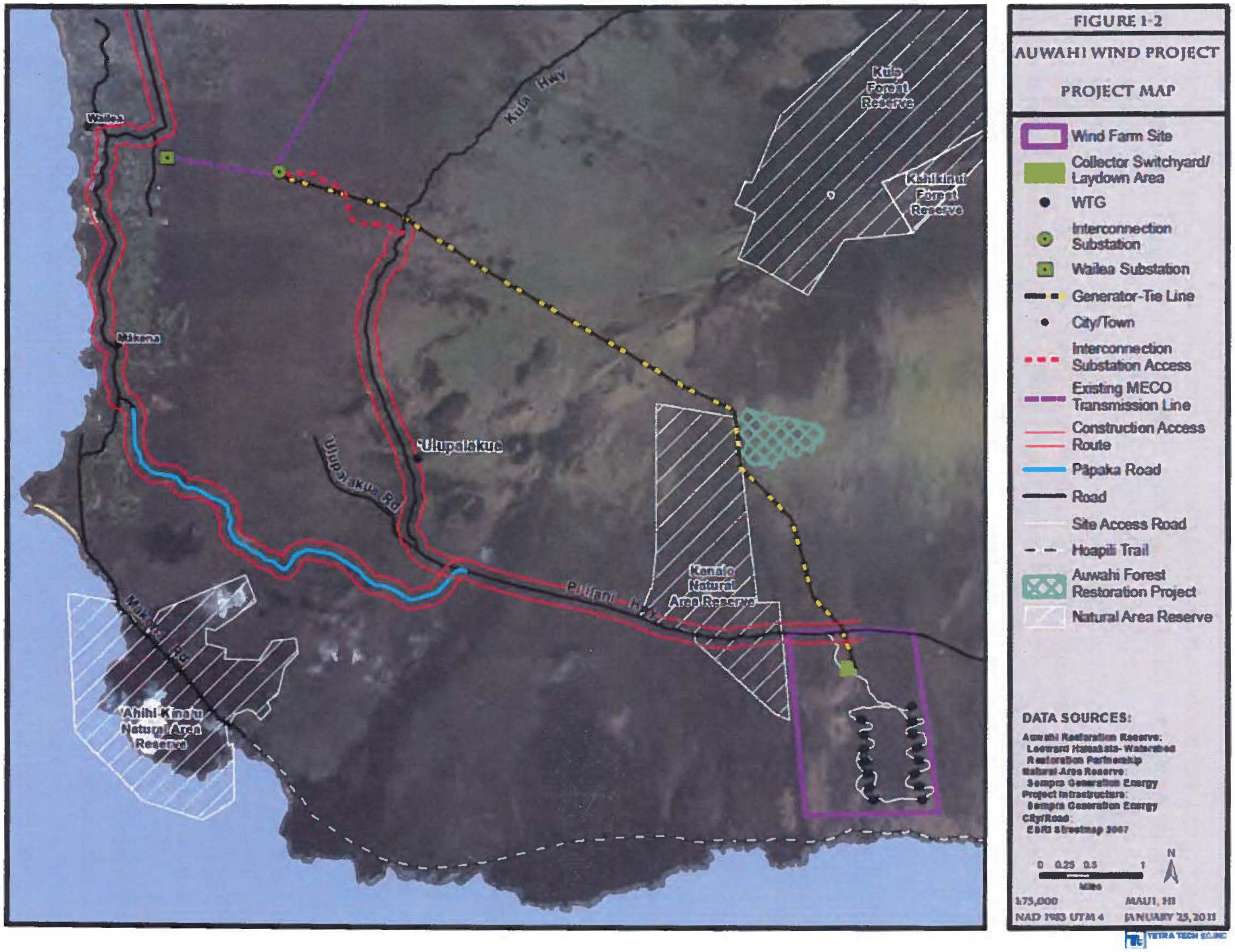

Figure 1. Auwahi Wind Farm Map of southwest East Maui Mountains showing Project components and biologically sensitive areas

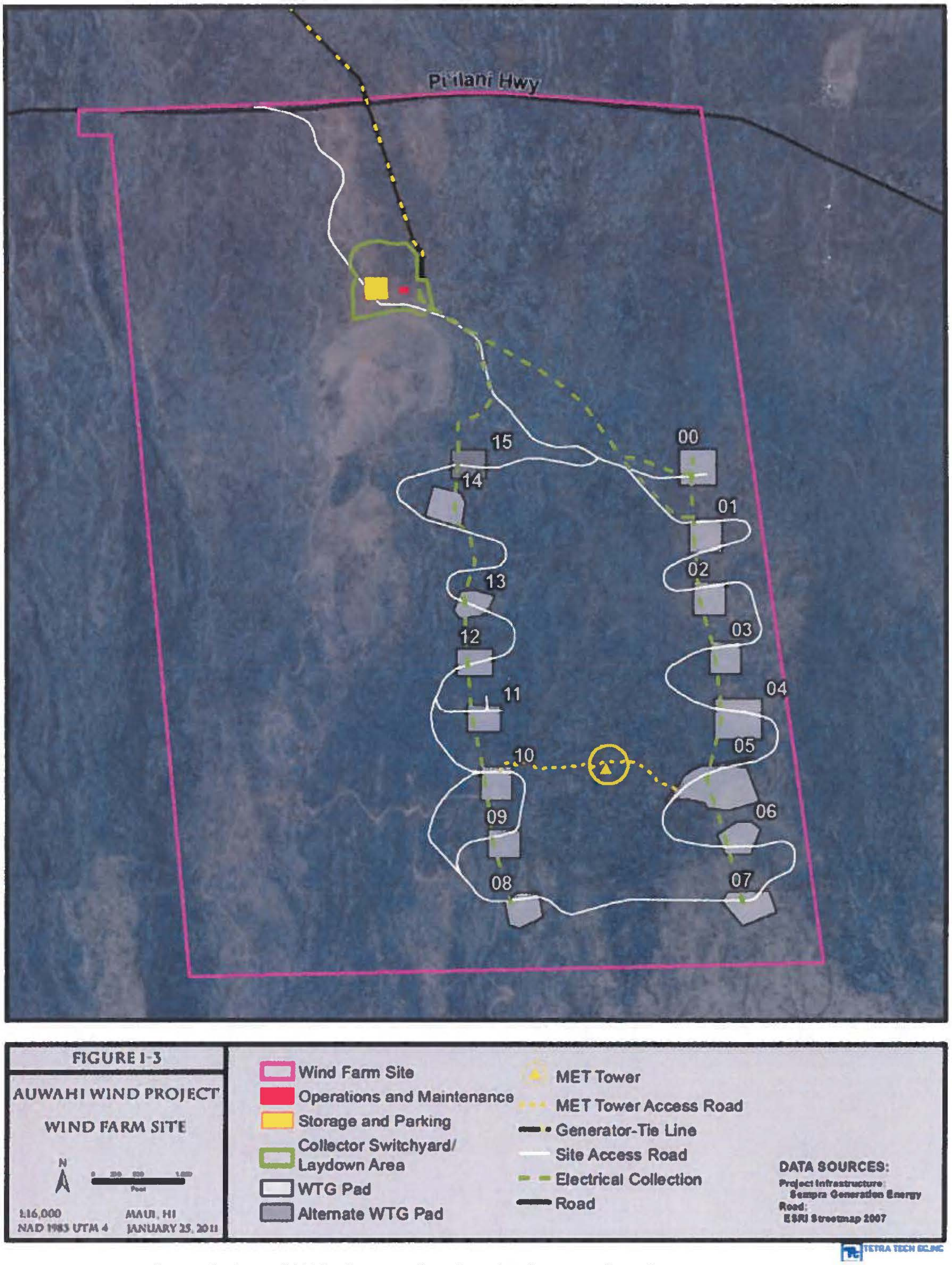

Figure 2. Auwahi Wind Farm site showing layout of Project components

Generation Tie-Line Corridor

Power generated by the wind farm will be transmitted to the Maui Electric Company (MECO) grid via an approximately nine-mile long, 34.5 kV generator tie-line. The generator tie-line will run north from the wind farm site, cross Pi'ilani Highway and continue upslope (*mauka*) through mixed dryland scrub and pasture. West of Pu'u 'Ouli, at approximately 4,200 feet (1,280 meter) ASL, the generator tie-line will turn westward across the East Maui volcano, southwest rift. The environment in this location is treeless and consists of high elevation pasture dominated by Kikuyu grass (*Pennisetum clandestinum*).

The generator tie-line will cross the ridgeline of the rift zone at approximately 4,400 feet (1,340 meters) ASL and continue downslope to connect with the MECO grid at 1,000 feet (305 meters) ASL. This part of the route is entirely within pastureland of 'Ulupalakua Ranch. The dominant grasses in this pastureland change with elevation, influenced mostly by the rainfall regime along a gradient of decreasing rainfall with decreasing elevation. The strictly grassland of the upper slopes gives way to a savanna (grassland with scattered *kiawe* trees) well below Kula Highway, at around 1,200 feet (370 meters) ASL.

Construction Access Road

The construction access road (Papaka Road) will consist of improvements to approximately 4.6 miles (7.4 kilometers) of existing pastoral and unimproved quarry access roads located between Mākena (at the intersection with Alanui Road) and Pi'ilani Highway. The land along much of its length is currently used for cattle grazing.

Methods

Plant names follow *Hawai'i's Ferns and Fern Allies* (Palmer, 2003) for ferns, *Manual of the Flowering Plants of Hawai'i* (Wagner et al., 1990, 1999) for native and naturalized flowering plants, and *A Tropical Garden Flora* (Staples and Herbst, 2005) for ornamental plants. Avian phylogenetic order and nomenclature follow *The American Ornithologists' Union Check-list of North American Birds 7th Edition* (American Ornithologists' Union, 1998), and the 42nd through the 51st supplements to *Check-list of North American Birds* (American Ornithologists' Union, 2000; Banks et al., 2002, 2003, 2004, 2005, 2006, 2007, 2008, Chesser et al., 2009, 2010). Mammal scientific names follow *Mammals in Hawaii* (Tomich, 1986). Place names follow *Place Names of Hawaii* (Pukui et al., 1974).

Hawaiian and scientific names are italicized in the text. A glossary of technical terms and acronyms used in the document, which may be unfamiliar to the reader, is included at the end of the narrative text.

Botanical Survey Methods

Field Survey

The methods used for the initial botanical surveys in 2007 involved pedestrian or wandering "transects" across the terrain in proposed Project areas, noting all plant species as they were encountered. Photographs were taken and, in some cases, specimens collected, to verify field identifications. Later surveys (2010) involved recording specific plant locations (positions) with a GPS unit within designated buffer areas established for various Project elements. On these surveys, only native plants (and tree-tobacco) were surveyed. During the 2010 surveys any species not recorded in 2007 was added to the flora listing for the area.

Plant surveys were conducted in May 2007 through October 2010 in the following areas:

- May 29, 2007 – General reconnaissance of Project locations for survey planning.
- May 30, 2007 – Survey of construction access road, Pi'ilani Highway to Mākena.
- May 31, 2007 – Survey of generator tie-line route on west mountain slope, downslope from Kula Highway all the way to MECO Wailea Substation.
- June 1, 2007 – Survey of generator tie-line route on west mountain slope, upslope from Kula Hwy. to the 4000-foot elevation.
- June 2, 2007 – Survey of generator tie-line route on south mountain slope, upslope from Pi'ilani Highway to the 4200-foot elevation.
- June 3, 2007 – Survey of wind farm site.
- June 4, 2007 – Survey of wind farm site.
- March 20, 2008 – Accompanied entomologist (S. Montgomery) on general reconnaissance of project locations and surveyed area close to upslope end of Kanaio Natural Area Reserve (NAR) around 4000-foot elevation.
- July 7, 2010 – Survey mapping (using GPS) distribution of native plants (mostly *wiliwili*) along construction access road from old quarry site at about 800-foot elevation down to Mākena.

- July 8, 2010 – Survey mapping distribution of native plants (mostly *wiliwili*) along construction access road from Pi'ilani Hwy to old quarry; mapping natives along existing entrance road at wind farm site.
- July 9, 2010 – Survey mapping of native trees in the upper part of the wind farm site from proposed new entrance road to just east of Pu'u Hōkūkano.
- July 27, 2010 – Survey mapping native trees and shrubs for upper turbine pad sites and turbine access roads.
- July 28, 2010 – Survey mapping distribution of native plants (mostly *wiliwili*) and tree-tobacco on construction access road alternative behind golf course in Mākena; Mapping native trees and shrubs for generator tie-line on south mountain slope from 4200-foot elevation (above Kanaio NAR) down to 2000-foot elevation.
- July 29, 2010 – Mapping native trees and shrubs at turbine pad sites and access roads in lower half of wind farm site. Visit to possible "stream" outlet at the coast. Mapping native trees on generator tie-line routes (including alternative) immediately upslope of Pi'ilani Hwy. to 2000-foot elevation.
- October 12, 2010 – Mapping native trees and shrubs in buffer for generator tie-line route between 3100 and 3900-foot elevations (proximal to Kanaio NAR).

The 2007 surveys covered the project site, generator tie-line route, and construction access road in a complete, but general manner because exact locations of project components had not been firmly established at that time. The results of the general botanical surveys were provided in an interim report with the recommendation that detailed surveys would be needed for specific areas where native plants were common. The 2010 surveys utilized GIS shape files provided by Sempra. These files—loaded into the GPS field units (Trimble GeoXT and GeoXM)—made detailed plant surveys practical by limiting survey areas to pre-defined buffers surrounding each Project component (wind turbine generator pad sites, site access roads and facilities, generator tie-line route, and construction access road improvements and alternatives). The buffers provide for small position adjustments during final design and construction. For all roads, the buffer was set at 20 meters (65 feet) to either side of the proposed centerline. For the generator tie-line, the buffer was 10 meters (33 feet) to either side of the proposed route. For wind turbine generator pad sites, the buffer was variable, but typically a rectangle 100 to 125 meters (330 to 410 feet) on a side. Mapping typically extended a short distance outside the buffer to ensure completeness, and in a few areas the terrain forced movement well outside the buffer.

Plant checklists were compiled for the different areas from field observations made primarily during the 2007 surveys, but added to with each subsequent survey in a given area. Although all species encountered are included in the flora lists, important botanical resources are those species that are (typically) rare, native species. These plants may or may not be protected by state or federal statute (such as the Endangered Species Act). Some occurrences of native species having botanical resource value in the survey area may be of unusual age, may be endemics of limited distribution, may be present in substantial numbers at the location (and generally rare elsewhere), and/or may be part of remnant populations of an otherwise degraded native plant community. Areas of mostly intact native plant communities also have high resource value. Such botanical resources are discussed further in the text where applicable to the present survey.

In the flora listings, entries are arranged alphabetically under plant family names. Included in the lists are scientific name, common name, and status (whether native or not-native) for each species. In addition to identifying the plants present within the study site, qualitative estimates of plant abundance were made. These are coded from rare to abundant/dominant[1] in the table and apply to observations made for each survey area. In some cases, a two-level system (letter-number code) of abundance is used: the letter providing the occurrence rating of a species throughout the survey area followed by a number indicating that, where encountered, abundance tended to be greater than the occurrence rating would suggest. For example, an abundance rating of "R" indicates that a plant was encountered once to several times within a survey area. However, a rating of "R2" indicates that a plant was very infrequently encountered, but several to many individuals were present where it was encountered. Because qualitative abundance ratings are entirely dependent upon the frequency that a species is encountered during the survey (as opposed to a number representing a count within an area), the added numeral corrects for species that tend to occur in clusters or in very limited parts of the survey area. An abundant species occurs everywhere and presumably is a population with high numbers within the survey area. An R3 species may likewise have a population of many individuals, but the "R" indicates clusters that are only rarely encountered.

Although abundance information is given for each project area, it should be noted that pronounced environmental gradients exist in the areas surveyed, especially along the proposed generator tie-line route. For example, a plant might be quite common at lower elevations and entirely absent at higher elevations, or vice versa. Because the ratings are given for component areas as a whole or in large blocks, it is difficult to correct for variations in species abundance across such a broad range of conditions (elevation, moisture, soil or edaphic characteristics), making estimating and reporting relative abundances more qualitative than quantitative.

Because these surveys were conducted during dry periods, it is expected that some plant species (especially weedy annuals) may have been missed or noted in abundances much lower than would be the case in wet periods. In general, this problem does not compromise the results with respect to the native flora, which consists mostly of perennial plants (exceptions are noted in the Discussion Section) that can be located and identified under such circumstances. In any event, repeat surveys, particularly at different times of the year, would likely yield more species.

[1] Sometimes called "DACOR abundance categories" for dominant, abundant, common, occasional, and rare, we use "AA" for the very abundant and dominant (in the particular stratum) species, and insert an "uncommon" ("U") between rare and occasional categories, reserving "rare" ("R") for species encountered three times at most.

Finally, abundance values in the plant species tables were developed in 2007. Return surveys made in 2010 encountered a much changed landscape due to drought conditions having prevailed since 2007 (Dicus, 2007; CWRM, 2010). As a consequence of low rainfall over a period of several years, many of the plants recorded during the 2007 surveys were not observed in 2010. In areas such as the wind farm site, native trees stood out in stark contrast to the introduced species that had previously dominated the visual landscape, but had either disappeared or were reduced to lifeless-appearing sticks. Thus, the 2010 surveys were able to better record locations of native trees than had been the case in 2007, but semi-quantitative estimates of herbaceous species could not be made in 2010, so only minor changes have been made to the 2007 report abundance estimates. Drought conditions at elevations above Pi'ilani Highway had ameliorated somewhat between the July and October 2010 surveys.

Botanical Mapping

A series of maps combining the results of species (feature[2]) positions recorded in the field and project components were prepared using ArcView 9. These maps show all plant species positions within designated buffers and recording of features is complete only for the buffers. Some feature positions occur outside the buffer boundaries and these represent either plant finds of particular interest to the botanist, plants recorded just outside the boundaries for completeness, or plants within component alternatives that were later abandoned. In general, native trees were individually recorded, but native shrubs, being too numerous in some areas, were not. However, in a dryland forest (and the upper elevation mesic forest), the distinction between trees and shrubs is not a sharp one; consequently, species generally regarded as trees (such as *Myrsine*), whether encountered as tree or shrub-like were recorded, whereas species generally regarded as shrubs (such as *Dodonaea* and *Wikstroemia*), even where tree-like, were not recorded. Also, in cases where dense concentrations of *wiliwili* trees were encountered (defined as a copse), a copse outline was recorded rather than each individual tree, to satisfy the purpose of mapping the *wiliwili* forest in relation to a project component. The only non-native species recorded in the GPS surveys was tree tobacco (*Nicotiana glauca*; typically a shrub), for its potential as rearing habitat for the listed Blackburn's sphinx moth (*Manduca blackburni*).

General vegetation maps encompassing Project areas were developed based on field observations and Bing Map satellite images imported into ArcMap. While the vegetation maps encompass a much greater area than the Project components, the vegetation maps are based entirely on interpretation from satellite images outside of areas actually traversed during the field surveys. Vegetation maps prepared by Jacobi (1989) were imported as a shapefile (from DBEDT, 2010) and provided descriptive and boundary guidance where applicable. However, these maps covered only the area near the upper elevation portion of the generator tie-line before it crosses the southwest rift zone, and thus were of limited utility.

[2] In GIS parlance, a "feature" is any item the position of which can be recorded by a GPS unit.

Stream and Wetland Survey Methods

Given the extreme dryness of all of the lowland areas surveyed and the high infiltration rates of the rocks and soils of the more upland areas, it is not surprising that streams and wetlands are absent from this part of Maui. Between Mākena (generator tie-line below 'Ulupalakua Ranch) and Luala'ilua Hills (east of proposed wind farm site), from the shore to the top of the mountain, only one "stream" is indicated on older USGS topographic maps (Mākena and Lualailua Hills quadrangles). This unnamed, intermittent stream lies along the western edge of the project parcel, west of the project wind turbine generator pads and roads. Selected sections of this gulch were visited and photographed in order to render an opinion as to whether the feature would be jurisdictional (a so-called "Waters of the U.S.") or not. Field observations and reference to the USFWS, "Wetland Mapper" (USFWS, 2010) were used to assess the presence of wetlands in project areas.

Avian Survey Methods

A total of eighty avian count stations were sited along linear transects running the length of the generation tie-line line corridor, the construction access road, and within the wind farm site. The count stations were placed at approximately 300-meter intervals equally spaced along these transects. Eight-minute point counts were made at each of the eighty count stations. Each station was counted once. Field observations were made with the aid of Leica 10 X 42 binoculars and by listening for vocalizations. Counts were concentrated between 07:00 a.m. and 11:00 a.m., the peak of daily bird activity. Time not spent counting was used to search the remainder of the project site for species and habitats that were not detected during count sessions.

Surveys were conducted in May 2007 through July 2010 in the following areas:

- May17, 2007 – General reconnaissance of the entire project site for survey planning.
- May 29, 2007 – General reconnaissance of project locations for survey planning.
- May 30, 2007 – Survey of construction access road, Pi'ilani Highway to Mākena.
- May 31, 2007 – Survey of generator tie-line route on west mountain slope, downslope from Kula Highway to Wailea.
- June 1, 2007 – Survey of generator tie-line route on west mountain slope, upslope from Kula Hwy. to the 4000–foot elevation.
- June 2, 2007 – Survey of generator tie-line route on south mountain slope, upslope from Pi'ilani Highway to the 4200–foot elevation.
- June 3, 2007 – Survey of wind farm site.
- June 4, 2007 – Survey of wind farm site.
- July 7 – 9, 2010 – On site conducting other surveys.

A separate set of ornithological radar surveys were conducted on the wind farm site by Hamer Environmental, L.P. between October 11 and 18, 2006 and May 25 and 30 2010 (Hamer Environmental 2010). Their surveys were designed to assess the impacts, if any, of the proposed project on two-listed pelagic seabird species, Hawaiian Petrel (*Pterodroma sandwichensis*), and Newell's Shearwater (*Puffinus auricularis newelli*).

Mammalian Survey Methods

With the exception of the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*), or *'ōpe'ape'a* as it is known locally, all terrestrial mammals currently found on the Island of Maui are alien species. Most are ubiquitous. The survey of mammals was limited to visual and auditory detection, coupled with visual observation of scat, tracks, and other animal sign. A running tally was kept of all vertebrate mammalian species observed, heard or detected by other means within the project area, while we were on the property conducting avian and botanical surveys. A separate set of radar surveys were conducted on the site by Hamer Environmental, L.P. in 2006 and 2010 in which they were tasked with surveying for nocturnally flying seabirds and bats (Hamer Environmental 2010).

Results

Botanical Survey

Wind Farm Site

The results of botanical surveys at the wind farm site (flora listing) conducted between 2007 and 2010 are summarized in Table. 1. Most of the site is dry, generally stony to rocky pastureland or scrub growth on rugged lava flows (mostly *a'a* flows in this area). The majority of species recorded in Table 1 were observed only in 2007 because of drought conditions (see Figure 3) in July 2010. It is worth noting, however, that the native trees were in general good health, and so flushed with leaves that they stood out in marked contrast to the drought-devastated non-native vegetation.

The plant listing with abundance ratings provides a general sense of the flora in the survey area. The status column in Table 1 shows that the majority of species present have no particular significance from a project impacts perspective. Most are introduced (non-native) species that have become naturalized in the Hawaiian Islands. Non-native *koa haole* (*Leucaena leucocephala*) is the most abundant species overall (Figure 3).

Figure 3. View upslope towards Pu'u Hōkūkano showing dry condition present in July 2010. Some *koa haole* shrubs (right) manage to retain leaves and even produce fruit under the severe drought conditions.

Of note with respect to native botanical resources are extensive groves of *wiliwili* and very scattered *hao* (*Rauvolfia sandwicensis*) and *naio* (*Myoporum sandwicense*) trees, several of large size and therefore probably of considerable age (Figure 4). *Wiliwili* and other native trees are most abundant on the more rugged terrain characterizing the middle of the site, although *wiliwili* is not limited to these essentially non-pasture areas. One rare native plant not recorded in 2007 but found in the follow-up surveys of July 2010 is the *'ohe makai* (*Reynoldsia sandwicensis*). Two tall specimens were encountered (the largest flushed with leaves). Unfortunately, drought conditions had become so severe that (presumably) goats or axis deer had chewed deep into the outer tissue of both plants completely girdling the trunk to a height of nearly 5 feet above the ground. By appearances, neither plant would be expected to survive this level of grazing damage.

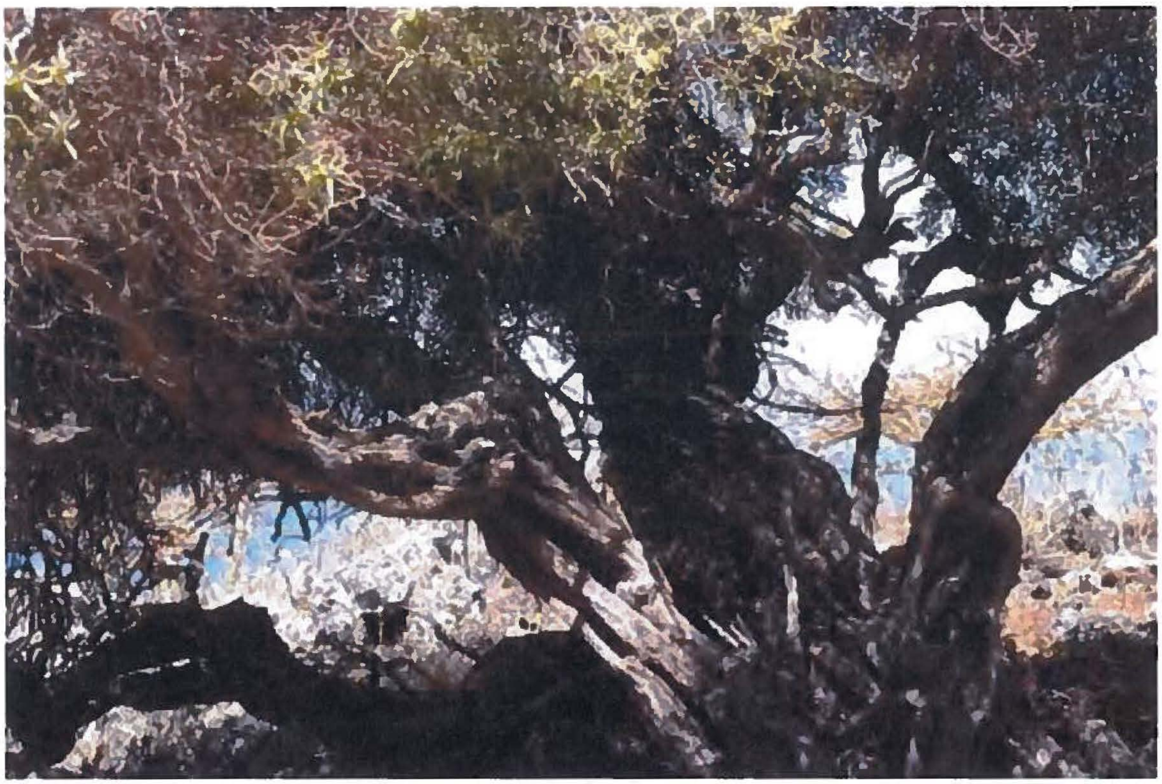

Figure 4. Lower part (multiple trunks) of a venerable old naio (*Myoporum sandwicense*) at the Auwahi Wind Farm site.

Soil conditions on Pu'u Hōkūkano and the low-sloping ground immediately north of the *pu'u* provide much deeper soils than is the case elsewhere at the site. However, these areas are extensively grazed by cattle and feral goats and currently support only non-native herbaceous plants (for example, grasses). *Wiliwili* trees border the pastureland north of the *pu'u* (Figure 5).

Table 1. Checklist of Plants Found on the Proposed Auwahi Wind Farm Site

Species	Common name	Status	ABUNDANCE	NOTES
	FLOWERING PLANTS			
	DICOTYLEDONES			
AMARANTHACEAE				
Amaranthus spinosus L.	spiny amaranth	Nat.	U	
ANACARDIACEAE				
Schinus terebinthifolius Raddi	Christmas berry	Nat.	--	(4)
APIACEAE				
Petroselinum crispum (Mill.) A.W. Hill	Parsely	Nat.	R	
APOCYNACEAE				
Rauvolfia sandwicensis A. DC	*hao*	**End.**	R1	(2)
ARALIACEAE				
Reynoldsia sandwicensis A. Gray	*'ohe makai*	**End.**	R	(2)
ASCLEPIADACEAE				
Asclepias physocarpa (E. Mey.) Schlecter	balloon plant	Nat.	--	(4)
ASTERACEAE (COMPOSITAE)				
Heterotheca grandiflora Nutt.	telegraph weed	Nat.	R2	(1,3)
Parthenium hysterophorus L.	false ragweed	Nat.	R	
Tridax procumbens L.	coat buttons	Nat.	R	
Xanthium strumarium L.	*kīkānia*	Nat.	R	
Zinnia peruviana (L.) L.	*pua pihi*	Nat.	C2	(3)
BRASSICACEAE				
Lepidium cf. *virginicum* L.	---	Nat.	U	
CACTACEAE				
Opuntia ficus-indica (L.) Mill.	*pānini*	Nat.	U	(1)
CARYOPHYLLACEAE				
Petrorhagia velutina (Guss.) P. Ball & Heyw.	childing pink	Nat.	R	(2)
CHENOPODIACEAE				
Chenopodium oahuense (Mayen) Aellen	*'āheahea*	End	R	
CONVOLVULACEAE				
Ipomoea indica (J. Burm.) Merr.	*koali `awa*	**Ind.**	--	(4)
CUCURBITACEAE				
Momordica charantia L.	balsam pear	Nat.	R	
Indet.	---	---	R	(3)
EUPHORBIACEAE				
Chamaesyce hirta (L.) Millsp.	garden spurge	Nat.	R	
Ricinus communis L.	castor bean	Nat.	U	
FABACEAE				
Acacia farnesiana (L.) Willd.	*klu*	Nat.	U2	
Chamaecrista nictitans (L.) Moench	partridge pea	Nat.	U	(1)
Crotalaria pallida Aiton	smooth rattlepod	Nat.	R	

Table 1 – Continued.

Species	Common name	Status	ABUNDANCE	NOTES
Desmanthus purnambucanus (L.) Thellung	virgate mimosa	Nat.	R1	
Desmodium incanum DC	Spanish clover	Nat.	R	
Erythrina sandwicensis Degener	*wiliwili*	**End.**	C2	
Indigofera suffruticosa Mill.	indigo	Nat.	U	(1)
Leucaena leucocephala (Lam.) de Wit	*koa haole*	Nat.	A	
Neonotonia wightii (Wight & Arnott) Lackey	---	Nat.	A	
Prosopis pallia (Humb. & Bonpl. ex Willd.) Kunth	*kiawe*	Nat.	O	
Tephrosia purpurea (L.) Pers.	*'auhuhu*	**Pol.**	R	(2)
LAMIACEAE				
Leonotis nepetifolia (L.) R.Br.	lion's ear	Nat.	U	
Ocium sp.	---	Nat.	C3	
Salvia coccinea B. Juss. ex Murray	scarlet sage	Nat.	--	(4)
MALVACEAE				
Sida fallax Walp.	*'ilima*	Nat.	O2	(2)
Sida rhombifolia L.	---	Nat.	R	
MYOPORACEAE				
Myoporum sandwicense A. Gray	*naio*	**Ind.**	U	(2)
NYCTAGINACEAE				
Boerhavia acutifolia (Choisy) J. W. Moore	*alena*	**Ind.**	R	
Boerhavia coccinea Mill.	false alena	Nat.	R	
PAPAVERACEAE				
Argemone glauca (Nutt. Ex Prain) Pope	*pua kala*	**End.**	R	(1)
Hunnemannia fumariifolia Sweet	Mexican tulip poppy	Nat.	--	(4)
PLANTAGINACEAE				
Plantago lanceolata L.	narrow-leaved plantain	Nat.	C	(1)
PLUMBAGINACEA				
Plumbago zeylanica L.	*'ilie'e*	**Ind.**	U2	(2)
PORTULACACEA				
Portulaca pilosa L.	---	Nat.	O2	
Portulaca sp "A"	---	---	R	(2)
RUBIACEAE				
Psydrax odorata (G. Forster) A.C. Sm. & S. Darwin	*alahe'e*	**Ind.**	U	(2)
SAPINDACEAE				
Dodonaea viscosa Jacq.	*'a'ali'i*	**Ind.**	U2	(1,2)
SOLANACEAE				
Nicotiana glauca R.C. Graham	tree tobacco	Nat.	R	
Solanum americanum Mill.	*pōpolo*	Nat.	--	(4)
Solanum linnaeanum Hepper & P. Jaeger	apple of Sodom	Nat.	R	
STERCULARIACEAE				
Waltheria indica L.	*'uhaloa*	**Ind.**	O	

Table 1 – Continued.

Species	Common name	Status	ABUNDANCE	NOTES
THYMELIACEAE				
Wikstroemia oahuensis (A. Gray) Rock	*'ākia*	**End.**	U	(2)
VERBENACEAE				
Lantana camara L.	lantana	Nat.	C	
Stachytarpheta sp.	---	Nat.	R	(1,3)
FLOWERING PLANTS				
MONOCOTYLEDONES				
AGAVACEAE				
Furcraea foetida (L.) Haw.	Mauritius hemp	Nat.	O	(2)
POACEAE (GRAMINEAE)				
Cenchrus ciliaris L.	buffelgrass	Nat.	C	(1)
Cynodon dactylon (L.) Pers.	Bermuda grass	Nat.	U	
Melinus repens (Willd.) Zizka	Natal redtop	Nat.	A	(1)
Urochloa maxima (Jacq.) R. Webster	Guinea grass	Nat.	U	

Table 1 Legend

Status = distributional status

- **End.** = endemic; native to Hawaii and found naturally nowhere else.
- **Ind.** = indigenous; native to Hawaii, but not unique to the Hawaiian Islands.
- Nat. = naturalized, exotic, plant introduced to the Hawaiian Islands since the arrival of Cook Expedition in 1778, and well-established outside of cultivation.
- **Pol.** = Polynesian introduction before 1778.

Abundance = occurrence ratings for plant species:

- R – Rare - only one or two plant occurrences seen.
- U - Uncommon - several to five plant occurrences observed.
- O - Occasional - found between five and ten times; not abundant anywhere.
- C - Common - considered an important part of the vegetation and observed numerous times.
- A - Abundant - encountered regularly and therefore present in large numbers; may be dominant over a limited area.
- AA - Abundant - abundant and dominant; defining vegetation type for the layer.

Numbers following an occurrence rating indicate clusters within the survey area. The ratings above provide an estimate of the likelihood of encountering a species within the specified survey area; numbers modify this where abundance, where encountered, tends to be greater than the occurrence rating:

1 – several plants present
2 - many plants present
3 – locally abundant

Notes:

(1) – Noted on Pu'u Hokukano (a grass-dominated cinder cone).
(2) – Found particularly and more abundant on rugged lava outcrops and flows.
(3) –.Mostly dead, dried material and/or plant lacked definitive taxonomic characters like flowers or fruit.
(4) – Seen near the site (e.g., in vicinity along Pi'ilani Highway); anticipated, but not recorded at this site.

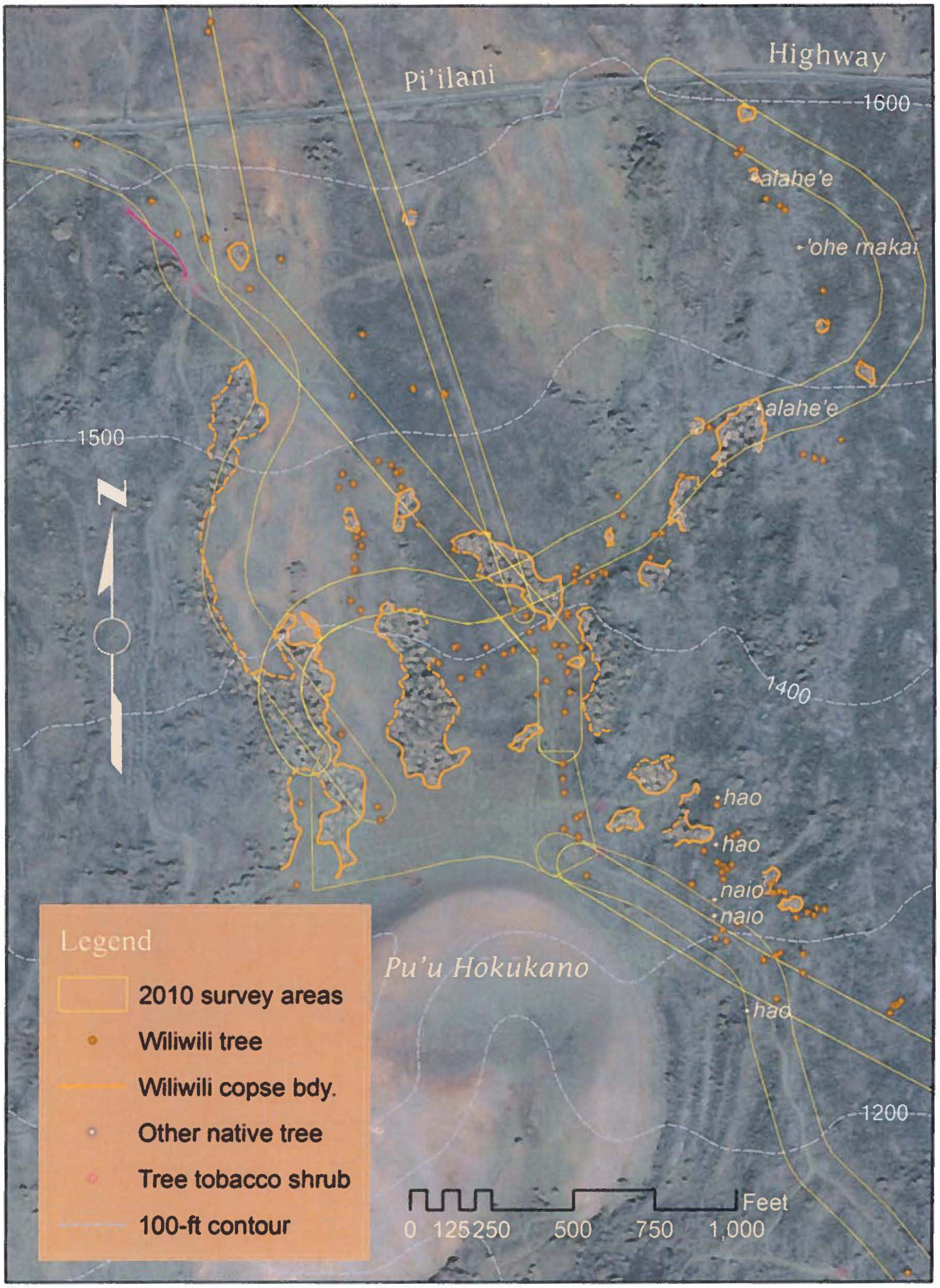

Figure 5. Botanical survey map for the wind farm site between Pi'ilani Highway and Pu'u Hōkūkano.

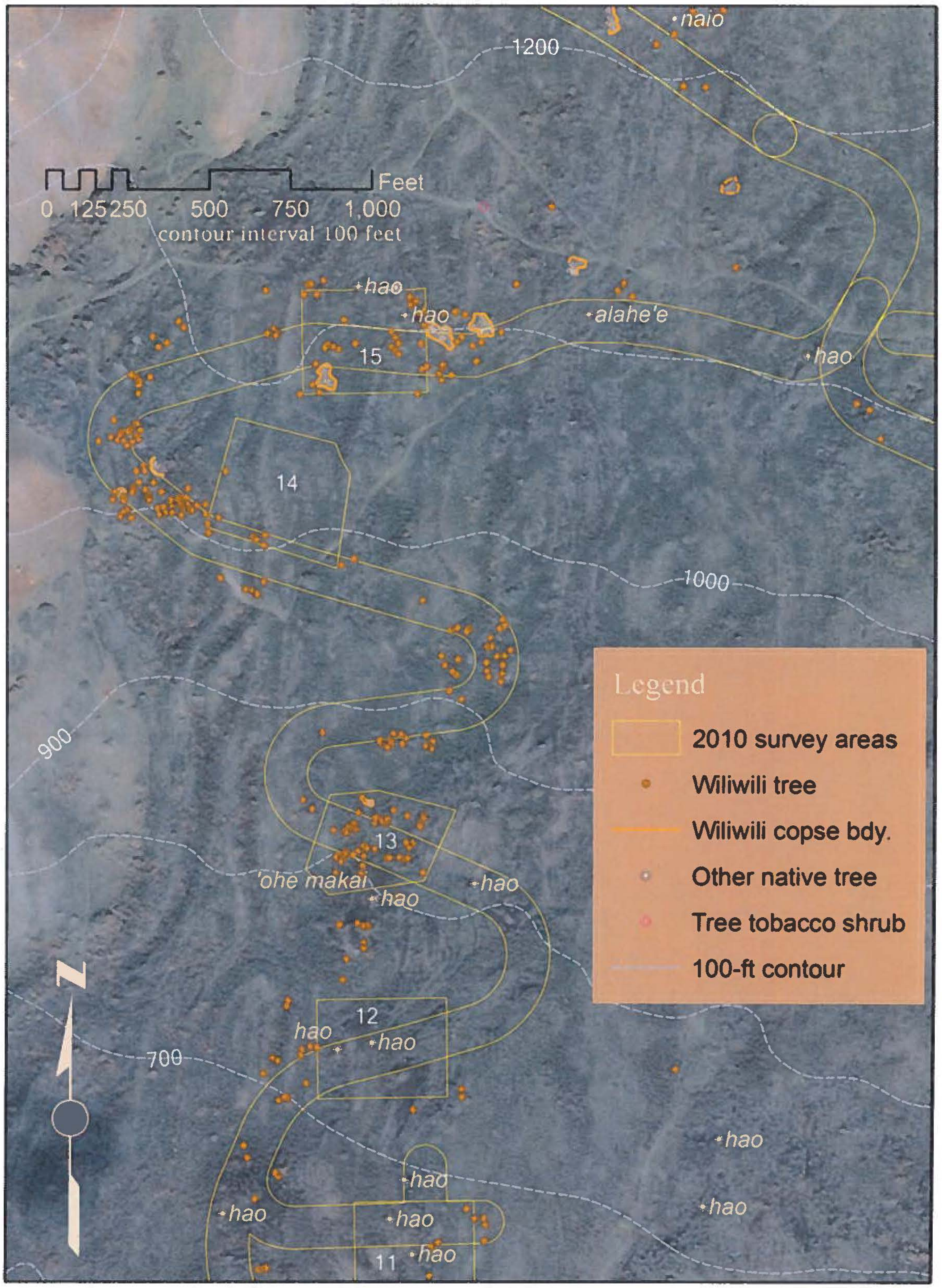

Figure 6. Botanical survey map for the wind farm site, wind turbine pads 11 through 15 and associated access roads (upper west side).

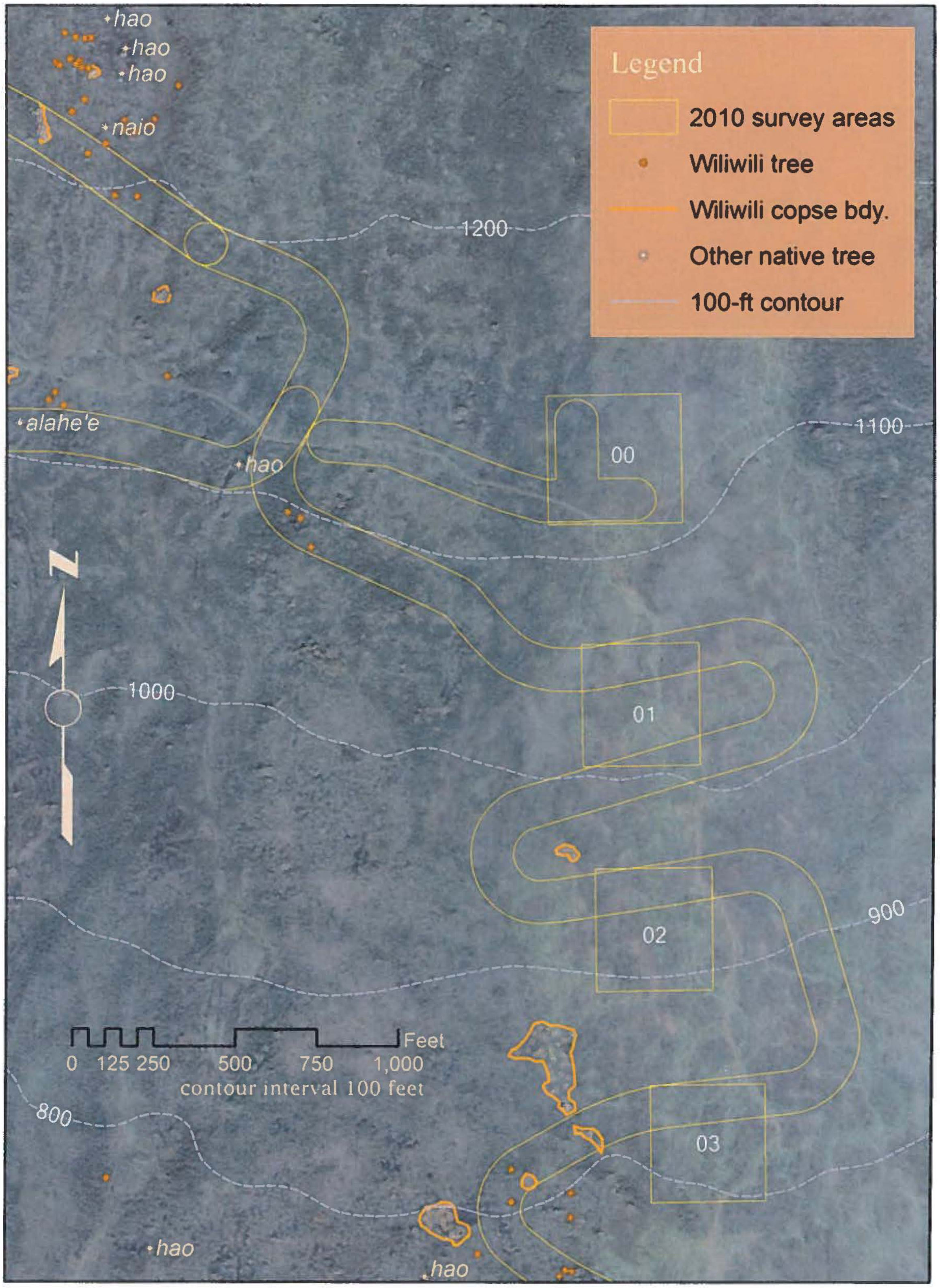

Figure 7. Botanical survey map for the wind farm site, wind turbine pads 00 through 03 and associated access roads (upper east side).

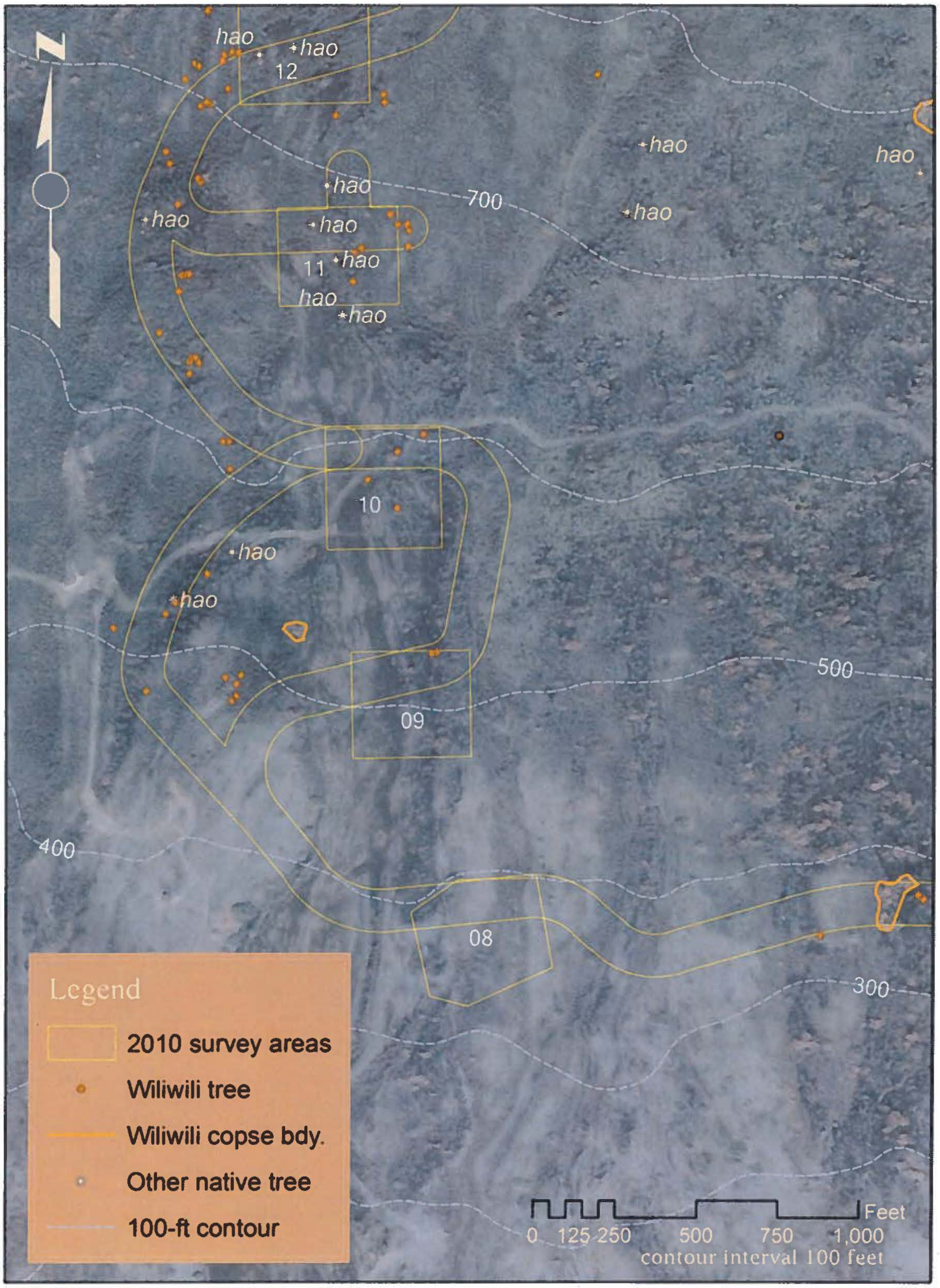

Figure 8. Botanical survey map for the wind farm site, wind turbine pads 08 through 12 and associated access roads (lower west side).

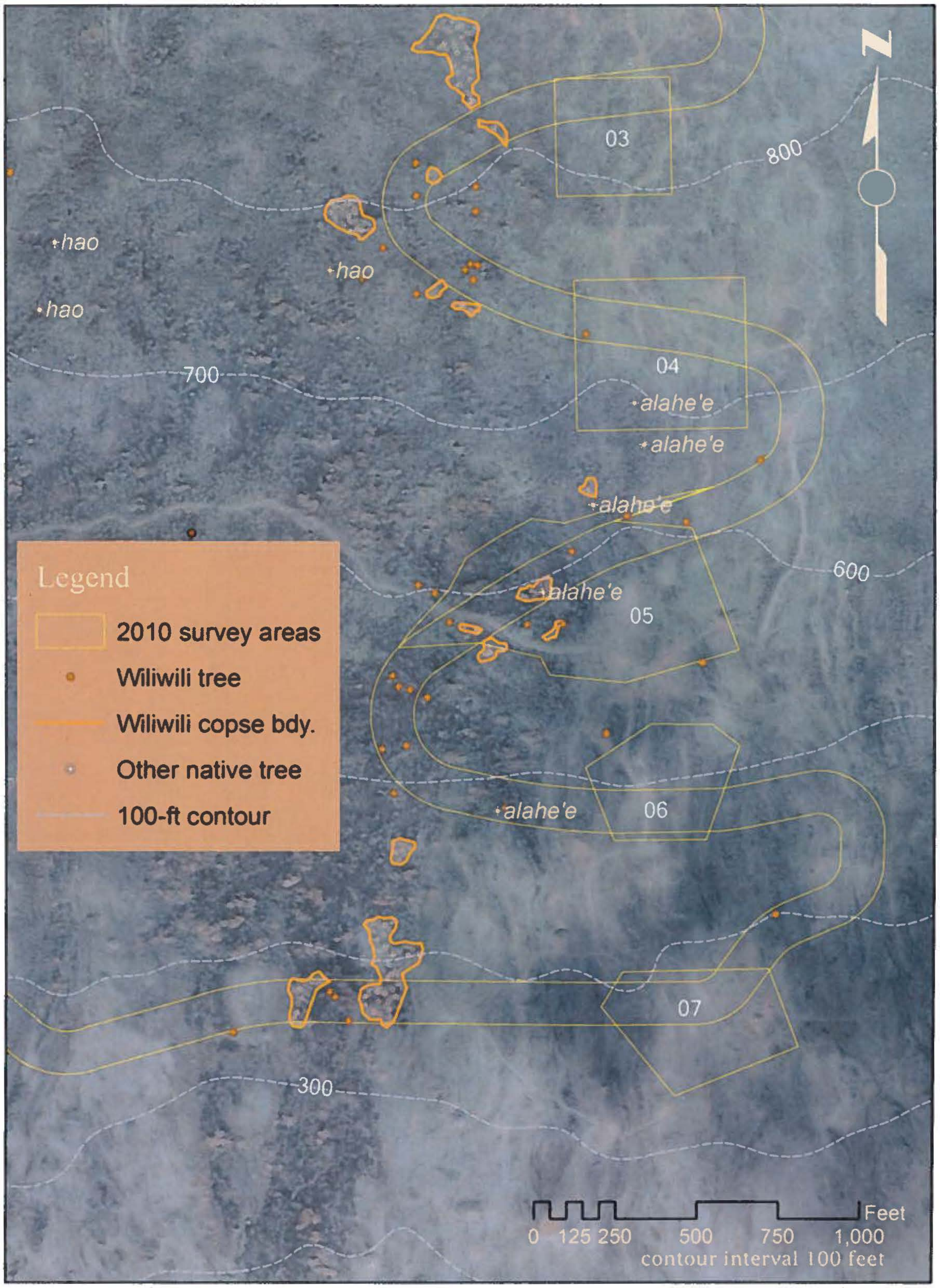

Figure 9. Botanical survey map for the wind farm site, wind turbine pads 03 through 07 and associated access roads (lower east side).

Generator Tie-line Corridor

The proposed generator tie-line route crosses dry scrubland as it climbs *mauka* from the wind farm site more or less following a ranch road that switchbacks up the slope. The vegetation in this area is mostly introduced species and subjected to grazing by cattle and feral ungulates. However, native shrubs—particularly *'ākia* (*Wikstroemia oahuensis*) and *a'ali'i* (*Dodonaea viscosa*)—and native sandalwood trees or *'iliahialo'e* (*Santalum ellipticum*) are common in the area (for *'iliahialo'e* distribution, see Figures 12 and 13; native shrubs are too numerous to map).

Moving upslope, an increase in moisture derived largely from cloud drip results in a transition from Montane Dry Shrubland to Montane Mesic Forest (Gagne and Cuddihy, 1990)[3] and the flora becomes an important botanical resource characterized by both an abundance and high diversity of native plant species, including many uncommon species of trees. The most significant remaining mesic forest in the general Project area is found within an adjacent, State of Hawai'i preserve: the Kanaio Natural Area Reserve System (NARS) site, located to the west of the generator tie-line corridor. This preserve is being fenced to control ungulate browsers (east side fence is completed; north side was under construction in 2007) and facilitate restoration of the native dryland forest found within its borders. The proposed generator tie-line has been routed to avoid the Kanaio NARS parcel.

Skirting westward above the NARS, the proposed generator tie-line crosses the southern face of Pu'u 'Ōuli (an old cinder cone). The route crosses roughly 300 yards (100 meters) of scrub growth before entering grass-dominated pasture at about the 4,200-foot (1,280-meter) elevation west of Pu'u 'Ōuli. This high elevation pasture is without trees and dominated by Kikuyu grass (*Pennisetum clandestinum*). The only feature of note here is a relatively recent lava flow[4] with a sparse growth of native plants behind (northeast of) Keonehunehune (an eruption cone) where the generator tie-line crosses the southwest rift at about the 4,400-foot (1,350-meter) elevation. The length of the traverse across the lava flow would be about 100 yards (90 meters) or less.

Down from the ridgeline marking the southwest rift zone to the Wailea substation, the proposed route is located entirely within pastures owned by 'Ulupalakua Ranch. The grasses that predominate in this pastureland change with elevation, influenced mostly by the rainfall regime along a gradient of decreasing rainfall towards the coast (lower elevation). The strictly pasture (non-native grassland) of the upper slopes, gives way to a savanna (grassland with scattered trees) below Kula Highway (at about 1,200-foot [370-meter] elevation), which remains the dominant vegetation type to the MECO connection

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[3] This vegetation type is referred to as a montane forest (Gagne and Cuddihy, 1990) because it is a remnant of an open-canopied forest type between 3000 feet (900 meters) and 6500 feet (2000 meters) on East Maui. However, at the elevation range we surveyed, this forest today (partly owing to ungulate grazing) is really a savanna in most places.

[4] This is a part of the historic flow of ca. 1750 (1790?) that erupted from a fissure "on the south slope of Kemehunehune, at 4200 feet". A majority of this eruption issued from Kalua o Lapa cone at an altitude of 575 feet and formed the western side of Keoneoio or La Perouse Bay (Bordner, 1995).

point at 1,000 feet (305 meters) ASL[5]. The only tree species in this savanna is *kiawe*, which shows a steady increase in density from 1,200 down to 400 feet (370 to 120 meters) ASL. Although some areas of native lowland vegetation are known from the general area (Altenberg, 2007), these populations appear limited to rugged ground not subjected to the long history of cattle grazing characterizing the generator tie-line corridor.

Table 2 is a listing of plants observed within the generator tie-line corridor and, where surveyed on the leeward mountain slope in 2010, associated buffer areas. The relative abundance columns divide this route into three segments: 1) "E1", the leeward slope from Pi'ilani Hwy to approximately 2,800 feet (850 meters) ASL, 2) "E2", the leeward slope from 2,800 to 4,500 feet (1400 meters) ASL at the ridgeline (E2), and 3) "W", the windward slope from the ridgeline, across Kula Highway at about 1,900 feet (580 meters) ASL and downslope to the Wailea substation at about 400 feet (120 meters) ASL (Figure 2).

Table 2. Checklist of Plants Found Along the Proposed Generator Tie-Line Route and Vicinity, Auwahi Wind Farm Project.

Species	Common name	Status	ABUNDANCE E1	E2	W	NOTES
FERNS & FERN ALLIES						
ANTHYRIACEAE						
Cystopteris douglasii Hook.	---	**End**	--	R	--	(2)
BLECHNACEAE						
Blechnum appendiculatum Willd.	---	Nat	--	--	R3	
Sadleria sp.	*'ama'u*	**End**	--	U	--	(2)
GLEICHENIACEAE						
Dicranopteris linearis (Burm. f.) Underw.	*uluhe*	**Ind**	--	R	U	(2)
GRAMMITIDACEAE						
Adenophorus tripinnatifidus Gaud.	---	**End**	--	--	R	
LINDSAEACEAE						
Sphenomerus chinensis (L.) Maxon	*pala'a*	**Ind**	--	--	R	
NEPHROLEPIDACEAE						
Nephrolepis multiflora (Roxburgh) Jarrett ex Morton	common sword fern	Nat	R	--	R1	
PTERIDACEAE						
Adiantum hispidulum Sw.	rough maidenhair	Nat	--	--	R3	
Pellaea ternifolia (Cav.) Link	*kalamoho lau li'i*	**Ind**	U	--	--	
Pteris cretica L.	cretan brake	**Ind**	--	U	R	
PSILOTACEAE						
Psilotum nudum Sw.	*moa*	**Ind**	--	--	R2	

[5] The end of the 2007 reconnaissance survey; the actual connection to an existing MECO service line would be at the 1000-foot (300-meter) elevation (see Figure 1).

Table 2 continued

Species	Common name	Status	ABUNDANCE E1	E2	W	NOTES
THELYPTERIDACEAE						
Christella sp.	wood fern	Nat	--	--	R	
FLOWERING PLANTS						
DICOTYLEDONES						
AMARANTHACEAE						
Amaranthus spinosus L.	spiny amaranth	Nat.	C	--	U	
Charpentiera obovata Gaud.	*pāpala*	**End.**	--	R	--	
ANACARDIACEAE						
Schinus terebinthifolius Raddi	Christmas berry	Nat.	C	--	O	
APIACEAE						
Ciclospermum leptophyllum (Pers.) Sprague	fir-leaved celery	Nat.	--	--	R	
APOCYNACEAE						
Ochrosia haleakalae St. John.	*hole'i*	**End.**	--	R	--	(5)
ARALIACEAE						
Tetraplasandra cf. *oahuensis* (A. Gray) Harms	*'ohe*	Nat.	--	--	R	(4)
ASCLEPIADACEAE						
Asclepias physocarpa (E. Mey.) Schlecter	balloon plant	Nat.	--	U	--	(3)
ASTERACEAE (COMPOSITAE)						
Ageratina riparia (Regel) R. King & H. Robinson	*hāmākua*	Nat.	--	--	R	
Bidens cf. *alba* (L.) DC	beggar's-tick	Nat.	R	--	R	(4)
Centaurea melitensis L.	star thistle	Nat.	--	--	R	(4)
Chromolaena odorata (L.) King & Rob.	Siam weed	Nat.	--	U	R	(3)
Cirsium vulgare (Savi) Ten.	Bull thistle	Nat.	--	R	U	
Conyza bonariensis (L.) Cronq.	Hairy horseweed	Nat.	--	R	O	
Cyanthillium cinereum (L.) H. Rob	little ironweed	Nat.	--	--	R	(4)
Emilia fosbergii Nicolson	Flora's paintbrush	Nat.	--	--	U	
Erigeron karvinskianus DC	daisy fleabane	Nat.	--	U2	R	(3)
Hypochoeris radicata L.	hairy cat's ear	Nat.	R	R	U	
Parthenium hysterophorus L.	false ragweed	Nat.	R	--	R	
Senecio madagascariensis Poir.	---	Nat.	U	O	O	(3)
Sigesbeckia orientalis L.	sm. Yel. Crown-beard	Nat.	--	--	R	
Sonchus oleraceus L.	sow thistle	Nat.	R	U	U	(3)
Taraxacum officinale W.W. Weber ex Wigg.	Common dandelion	Nat.	--	--	R	
Tridax procumbens L.	coat buttons	Nat.	R	--	--	
Verbesina encelioides (Cav.) Benth. & Hook.	Golden crown-beard	Nat.	R	--	U3	
Xanthium strumarium L.	*kikiāna*	Nat.	U	--	R	
BIGNONIACEAE						
Jacaranda mimosifolia D. Don	green ebony	Nat.	--	--	U	
BRASSICACEAE						
Lepidium virginicum L.	---	Nat.	R	--	R	(4)

Table 2 continued

Species	Common name	Status	ABUNDANCE			
			E1	E2	W	NOTES
Sisymbrium officinale (L.) Scop.	Hedge mustard	Nat.	O	R	R	(4)
CACTACEAE						
Opuntia ficus-indica (L.) Mill.	*Pänini*	Nat.	R	--	R	
CARYOPHYLLACEAE						
Petrorhagia velutina (Guss.) P. Ball & Heyw.	Childing pink	Nat.	--	U1	R	
CHENOPODIACEAE						
Chenopodium carinatum R. Br.	---	Nat.	U	--	U	
Chenopodium oahuense (Meyen) Aellen	*'āheahea*	**End.**	--	R	--	
Chenopodium sp.	---	Nat.	O2	--	U	(4)
CONVOLVULACEAE						
Ipomoea indica (J. Burm.) Merr.	*koali `awa*	**Ind.**	R	--	--	
CRASSULACEAE						
Kalanchoë pinnata (Lam.) Pers.	air plant	Nat.	--	--	U1	
EBENACEAE						
Diospyros sandwicensis (A. DC) Fosb.	*lama*	Nat.	--	R	--	(4)
EPACRIDACEAE						
Styphelia tameiameiae (Cham. & Schlechtend.) F. v. Muell.	*pūkiawe*	**Ind.**	U	O	--	(1)
EUPHORBIACEAE						
Chamaesyce hirta (L.) Misllsp.	garden spurge	Nat.	--	--	R	
Chamaesyce hirta (L.) Misllsp.	garden spurge	Nat.	--	--	R	
FABACEAE						
Acacia mearnsii De Willd.	black wattle	Nat.	--	U2	O3	
Chamaecrista nictitans (L.) Moench	partridge pea	Nat.	O	--	U	
Crotalaria sp.	rattlepod	Nat.	R	--	R2	(4)
Desmodium incanum DC	Spanish clover	Nat.	--	--	A	
Erythrina sandwicensis Degener	*wiliwili*	**End.**	U2	--	--	
Indigofera suffruticosa Mill.	indigo	Nat.	O	--	R	
Leucaena leucocephala (Lam.) de Wit	*koa haole*	Nat.	AA	--	O	
Macroptilium atrropurpureum (DC) Urb.	---	Nat.	--	--	R	
Macroptilium lathyroides (L.) Urb.	cow pea	Nat.	--	--	R	
Melilotus alba Medik.	white sweet clover	Nat.	--	U	C	
Neonotonia wightii (Wight & Arnott) Lackey	---	Nat.	A	--	A	
Senna occidentalis (L.) Link	coffee senna	Nat.	--	R	--	
Sophora chrysophylla (Salisb.) Seem.	*māmane*	**End.**	--	U	--	
Trifolium sp.	clover	Nat.	--	--	R	(4)
GERANIACEAE						
Geranium homeanum Turcz.	---	Nat.	--	U	R	
LAMIACEAE						
Leonotis nepetifolia (L.) R.Br.	lion's ear	Nat.	R	R	--	
Salvia coccinea B. Juss. Ex Murray	scarlet sage	Nat.	R	U	--	
Stachys arvensis L.	staggerweed	Nat.	--	--	R	
LYTHRACEAE						

Table 2 continued

Species	Common name	Status	ABUNDANCE E1	E2	W	NOTES
Lythrum maritimum Kunth	*pūkāmole*	Ind.	--	--	R	
MALVACEAE						
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	Nat.	U	O	U	
Malva parviflora L.	cheese weed	Nat.	R	--	R	
Malvastrum coromendalianum	false mallow	Nat.	U	--	O	
Sida fallax Walp.	*'ilima*	Ind.	--	--	O	
Sida rhombifolia L.	Cuba jute	Nat.	R	--	R	
Sida spinosa L.	prickly sida	Nat.	--	--	U	
MELIACEAE						
Melia azedarach L.	Chinaberry	Nat.	--	--	U	
MENISPERMACEAE						
Cocculus trilobus (Thunb.) DC	*huehue*	Ind.	R	--	R	
MYRTACEAE						
Eucalyptus citriodoira Hook.	lemon-scented gum	Nat.	--	--	R1	
Eucalyptus robusta Sm.	swamp mahogony	Nat.	--	--	U3	
Metrosideros polymorpha Gaud.	*`ōhi`a*	End.	--	O	R	
Psidium guajava L.	common guava	Nat.	--	--	U	
OLEACEAE						
Nestegis sandwicensis (A. Gray) Deg., I. Deg, & L. Johnson	*olopua*	End.	--	O	--	
OXALIDACEAE						
Oxalis corniculata L.	*'ihi'ai*, wood sorrel	Pol.	--	U	U	
PAPAVERACEAE						
Argemone glauca (Nutt. Ex Prain) Pope.	*pua kala*	End.	R	--	--	
Bocconia frutescens L.	tree poppy	Nat.	O	U	U	
PASSIFORACEAE						
Passiflora mollissima (Kunth) L.H. Bailey	banana *poka*	Nat.	--	U	R	
PLANTAGINACEAE						
Plantago lanceolata L.	narrow-leaved plantain	Nat.	A	--	O2	
PLUMBAGINACEA						
Plumbago zeylanica L.	*'ilie'e*	Ind.	R	--	R	
PORTULACACEA						
Portulaca oleracea	pigweed	Nat.	R	--	U	
Portulaca pilosa L.	---	Nat.	--	--	R1	
Portulaca sp "A"	---	---	U1	--	U	
PRIMULACEAE						
Anagalis arvensis L.	scarlet pimpernel	Nat.	--	R	R	
PROTEACEAE						
Grevillea robusta A. Cunn. Ex R. Br.	silk oak	Nat.	--	--	R	
ROSACEAE						
Osteomeles anthyllidifolia (Sm.) Lindl.	*'ūlei*	Ind.	--	U	--	
Rubus argutus Link	blackberry	Nat.	--	U	U2	(2)

Table 2 continued

Species	Common name	Status	ABUNDANCE E1	E2	W	NOTES
RUBIACEAE						
Sherardia arvensis L.	field madder	Nat.	--	R	R	
SANTALACEAE						
Santalum ellipticum	*'iliahi*	End.	R	--	--	(4)
Santalum freycinetianum var. lanaiense Rock	*'iliahi*	End.	--	R	--	<E>
SAPINDACEAE						
Alectryon macrococcus Radlk.	*māhoe*	End.	--	R	--	<E>
Dodonaea viscosa Jacq.	*'a'ali'i*	Ind.	O	AA	R	(1)
SAPOTACEAE						
Pouteria sandwicensis (A. Gray) Baehna & Degener.	*'āla'a*	End.	--	U	R	(1)
SOLANACEAE						
Datura stramonium L.	jimson weed	Nat.	R	--	R	
Nicotiana glauca R.C. Graham	tree tobacco	Nat.	R	--	--	
Nothocestrum latifolium A. Gray	*'aiea*	End	--	R	--	(5)
Solanum americanum Mill.	*pōpolo*	Nat.	--	--	R	
Solanum linnaeanum Hepper & P. Jaeger	apple of Sodom	Nat.	U	--	R	
Solanum torvum Sw.	---	Nat.	--	--	U	
STERCULARIACEAE						
Waltheria indica L.	*'uhaloa*	Ind.	C	--	U	
THYMELIACEAE						
Wikstroemia oahuensis (A. Gray) Rock	*'ākia*	End.	U	--	--	
TILIACEAE						
Triumfetta semitriloba Jacq.	Sacramento burr	Nat.	--	--	U2	
URTICACEAE						
Pipturus albidus (Hook. & Arnott.) A. Gray	*māmaki*	End.	--	R	--	(2)
VERBENACEAE						
Lantana camara L.	lantana	Nat.	A	O	O	
Verbena litoralis Kunth	*owi*	Nat.	U	--	U	
FLOWERING PLANTS MONOCOTYLEDONES						
AGAVACEAE						
Pleomele auwahiensis St. John	*hala pepe*	End.	--	O	--	
COMMELINACEAE						
Commelina diffusa N. L. Burm	*honohono*	Nat.	--	--	R	
CYPERACEAE						
Cyperus gracilis R. Br.	McCoy grass	Nat.	O2	--	O3	
Kylinga brevifolia Rottb.	*kili`o`opu*	Nat.	U2	--	U	
POACEAE (GRAMINEAE)						
Axonopus fissifolius (Raddi) Kuhlm.	nrw-lvd. carpet grass	Nat.	--	--	O	
Anthoxanthum odoratum L.	sweet vernalgrass	Nat.	--	U	A	(2)
Cenchrus ciliaris	buffelgrass	Nat.	A	--	--	
Chloris barbata (L.) Sw.	swollen finger grass	Nat.	--	--	U2	
Cynodon dactylon (L.) Pers.	Bermuda grass	Nat.	--	--	U	
Dichanthium sp.	---	Nat.	A	--	C3	

Table 2 continued

Species	Common name	Status	ABUNDANCE E1	E2	W	NOTES
Digitaria insularis (L.) Mez ex Ekman	sourgrass	Nat.	--	--	U1	
Eleusine indica (L.) Gaertn.	wire grass	Nat.	O	--	--	
Eragrostis pectinacea		Nat.	--	--	U	
Holcus lanatus L.	common velvet grass	Nat.	--	R	--	
Melinus minutiflora P. Beauv.	molasses grass	Nat.	--	--	R	
Melinus repens (Willd.) Zizka	Natal redtop	Nat.	C	--	U2	
Paspalum cf. *dilatatum* Poir	Dallis grass	Nat.	--	--	O	
Pennisetum clandestinum Chiov.	Kikuyu grass	Nat.	C	AA	AA	
Polypogon sp.	hare's foot	Nat.	--	--	U	
Sporobolis indicus (L.) R. Br.	West Indian dropseed	Nat.	--	O	O	
Urochloa maxima	Guinea grass	Nat.	--	--	C	
Vulpia bromoides (L.) S.F. Gray	brome fescue	Nat.	--	U	--	
indet. large bunch grass	--	---	--	--	O3	(4)

Table 2 Legend:

Status = distributional status

- End. = endemic; native to Hawaii and found naturally nowhere else.
- Ind. = indigenous; native to Hawaii, but not unique to the Hawaiian Islands.
- Nat. = naturalized, exotic, plant introduced to the Hawaiian Islands since the arrival of Cook Expedition in 1778, and well-established outside of cultivation.
- Pol. = Polynesian introduction before 1778.

Abundance = occurrence ratings for plants:

- R – Rare - only one or two plants seen.
- U - Uncommon - several to five plants observed.
- O - Occasional - found between five and ten times; not abundant anywhere
- C - Common - considered an important part of the vegetation and observed numerous times.
- A - Abundant - encountered regularly and therefore present in large numbers; may be dominant over a limited area.
- AA - Abundant - abundant and dominant; defining vegetation type for the layer.

Numbers following an occurrence rating indicate clusters within the survey area. The ratings above provide an estimate of the likelihood of encountering a species within the specified survey area; numbers modify this where abundance, where encountered, tends to be greater than the occurrence rating:

1 – several plants present
2 - many plants present
3 – locally abundant

AREA:
E1 – Leeward slope, below 2800 ft (850 m).
E2 – Leeward slope, above 2800 ft (850 m).
W – Windward slope.

Notes:

(1) – Especially part of shrub-scrub above 4000 ft (1200 m) for column E2.
(2) – On ca. 1790 lava flow at 4400 ft (1340 m) for column E2 .
(3) – Found mostly along roads above 4000 ft (1200 m); ruderal for column E2.
(4) – Material observed lacked definitive taxonomic characters (dried out in some cases).
(5) – Described by USFWS (2010) as a candidate for listing under the ESA.
<E> - A species listed as endangered (USFWS, 2010)

Figures 10 through 13, following, give mapping results for native trees along the portion of the generator tie-line surveyed in 2010. In these figures, bright yellow lines show buffer areas (essentially survey limits) for the generator tie-line. However, some native plants of potential interest were recorded outside of the buffer limits: either because these were on an eventually abandoned alternate route or, in a few cases, where encountered walking to the survey areas. Only a few of the native plant features are labeled due to crowding.

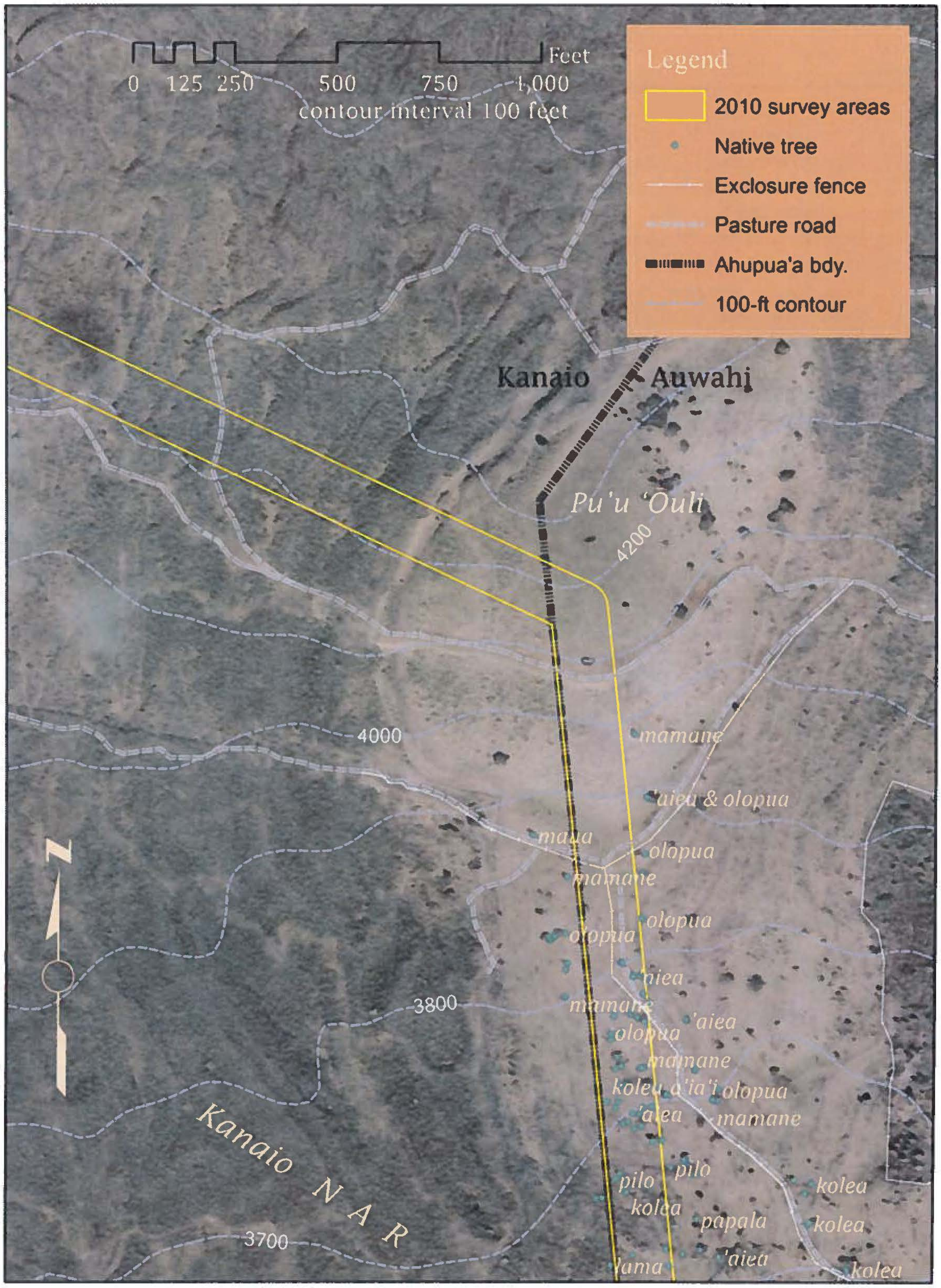

Figure 10. Botanical survey map for the upper east side generator tie-line between 3700 and 4300 feet ASL.

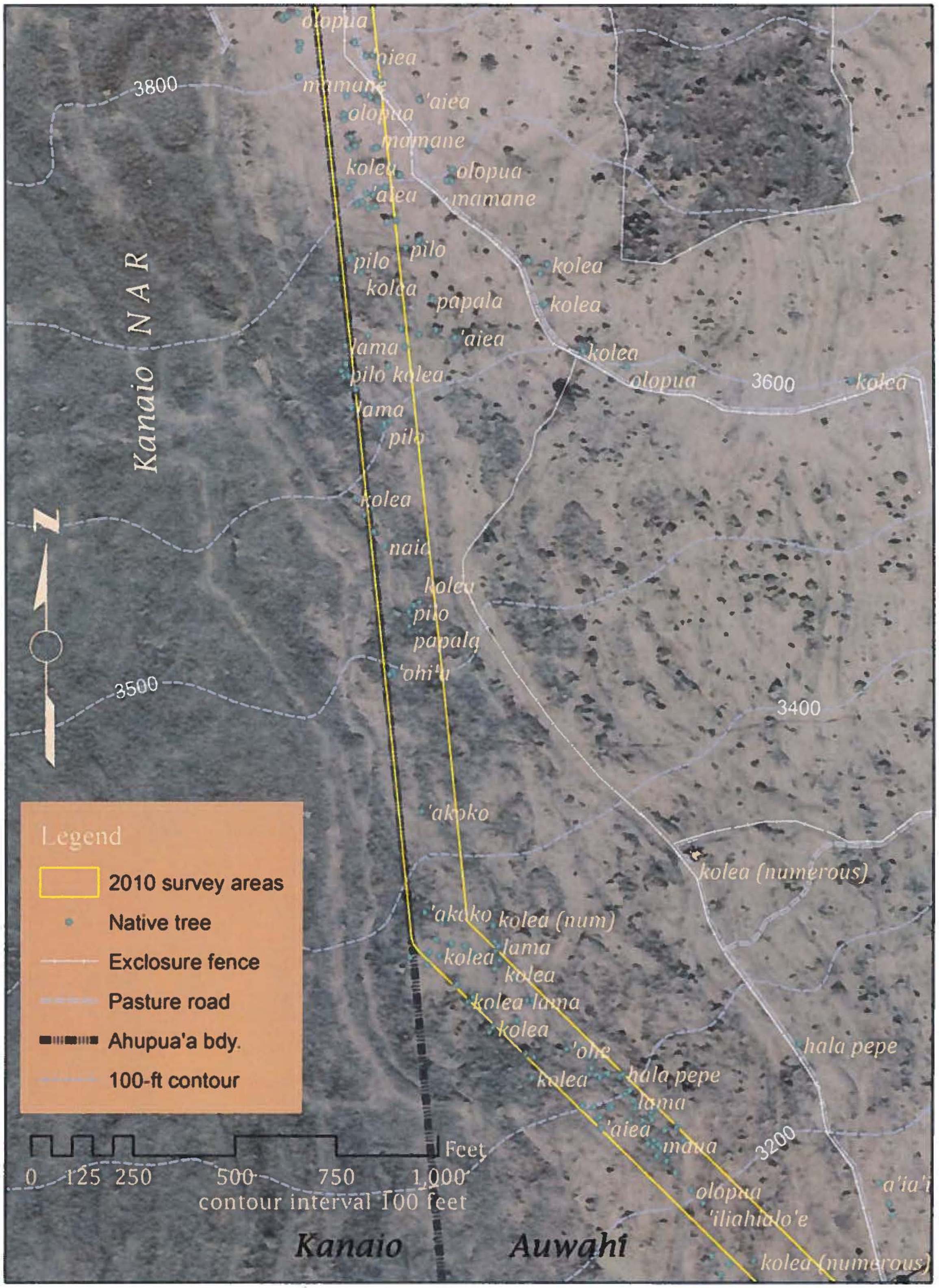

Figure 11. Botanical survey map for the upper east side generator tie-line between 3200 and 3800 feet ASL.

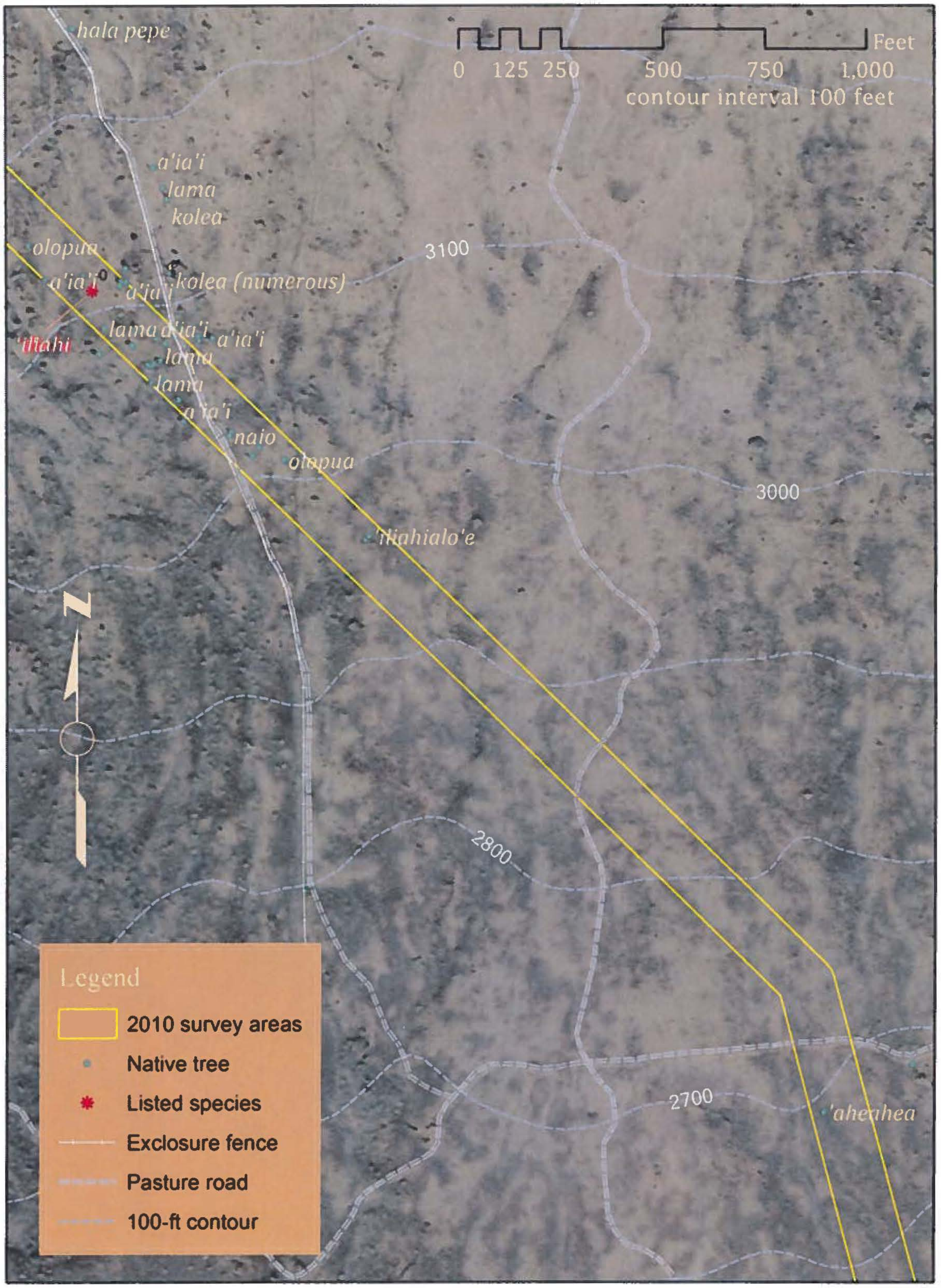

Figure 12. Botanical survey map for the east side generator tie-line between 2100 and 2600 feet ASL.

Figure 13. Botanical survey map for the east side generator tie-line between 2100 and 2600 feet ASL.

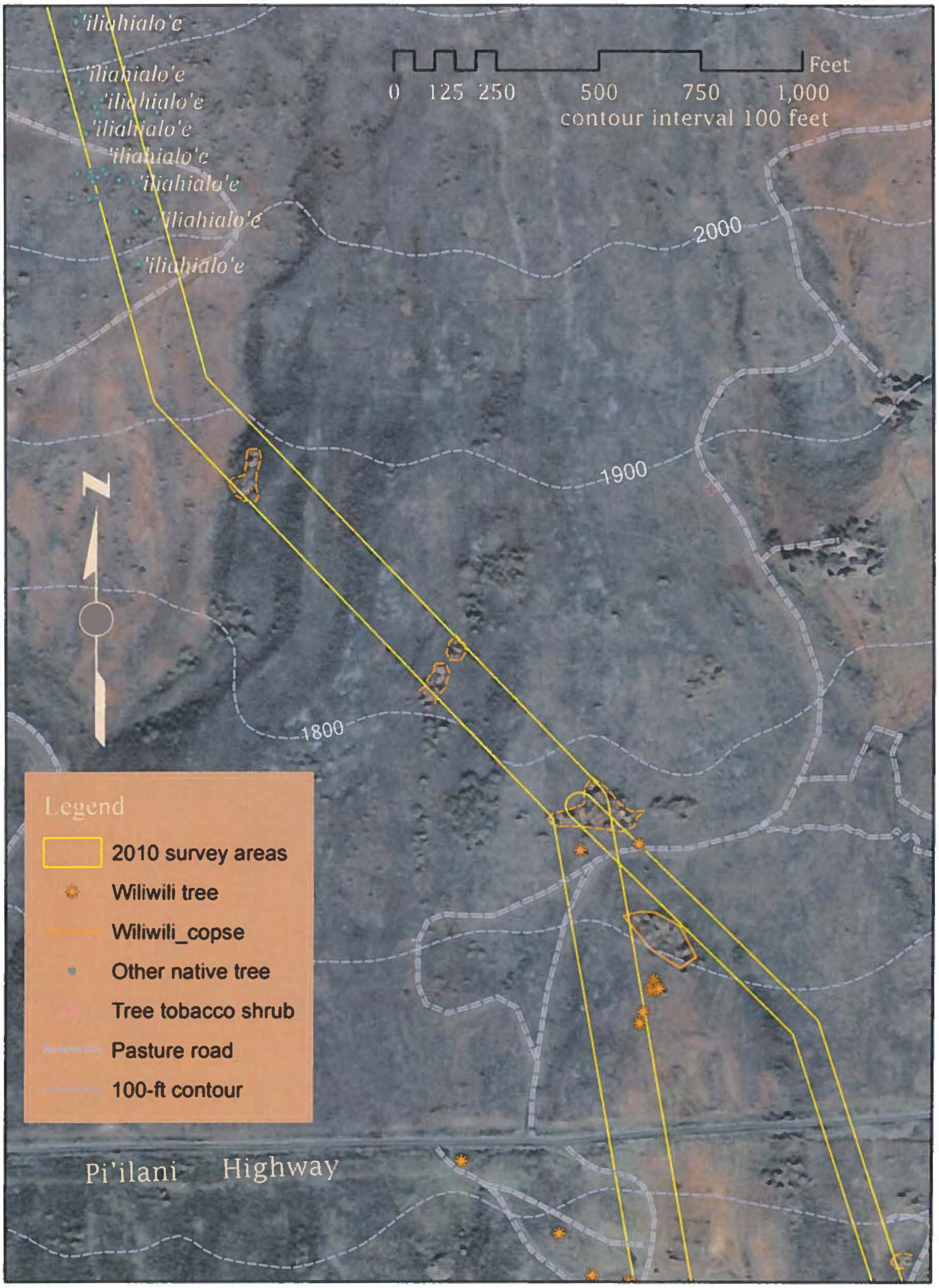

Figure 14. Botanical survey map for the east side generator tie-line between 1600 (Pi'ilani Highway) and 2100 feet ASL.

Construction Access Road

The results of botanical surveys for the construction access road, conducted in 2007 and 2010, are summarized in Table 3. The proposed construction access road covers 4.6 miles (7.2 kilometers) from Wailea Alanui Road to Pi'ilani Highway, with a change in elevation of approximately 1,500 feet (460 meters). The vegetation changes considerably over the course of the roadway.

The existing road is "paved" (although in poor condition) for much of the way between Mākena and a small quarry located on the southwestern slope of an unnamed cinder cone immediately west of Pu'u Naio. Upslope from this quarry to Pi'ilani Highway the condition of the ranch roads is somewhat variable: between tracks through rocky pasture and graded and graveled, 4-wheel drive roads. From just upslope of the *pu'u*, two routes were surveyed in 2007: one that wound upslope to Papaka Road (western alternative) to join Pi'ilani Hwy, and a second that went eastward and up across the slope (eastern alternative) to join Pi'ilani Highway about 1,000 feet (305 meters) east of Papaka Road. The two alternatives pass through distinctly different environments. The western alternative cuts through a more mesic environment of mixed pasture and open-canopied forest with non-native trees of mostly Chinaberry (*Melia azedarach*), silk oak (*Grevillea robusta*), and *kukui* (*Aleurites moluccana*). The terrain includes relatively recent cinder and spatter cones and lava that are part of the volcanics responsible for the narrow, rugged habitat along the west side of the Pu'u Naio cones. The eastern alternative cuts diagonally across a slope of increasing dryness, primarily stony pastureland, but also including extensive shrub/scrub vegetation. *Koa haole* (*Leucaena leucocephala*), indigo (*Indigofera suffruticosa*), *'ākia* (*Wikstroemia oahuensis*), *'a'ali'i* (*Dodonaea viscosa*), glycine vine (*Neonotonia wightii*), air plant (*Kalanchoë pinnata*), and *'uhaloa* (*Waltheria indica*) are common to abundant species in this area.

Downslope and west from the quarry area along Papaka Road, the vegetation changes gradually to a *kiawe*/buffelgrass (*Prosopis/Cenchrus*) association, which is the dominant vegetation type near the coast. However, across much of this area the *kiawe*/buffelgrass community occurs mixed with extensive stands of native *wiliwili* tree. Typically associated with the *wiliwili* as understory are native *'ilima* (*Sida fallax*), *'uhaloa*, and non-native Natal redtop (*Melinus repens*) on the more rocky ground where remnant *wiliwili* forest (Figures 15 and 16) tends to predominate. Although *wiliwili* trees become uncommon below 200 feet (60 meters) ASL, scattered trees occur all the way to the coast near Pu'u Ola'i.

Besides the extensive areas of *wiliwili*, the most botanically interesting area on the proposed route for the construction access road is the relatively recent lava flow that passes along the west side of the Pu'u Naio cinder cones. The age of the flow relative to the surrounding area makes it stand out as both geologically and floristically distinct. Plants observed on this flow west of the cinder cones are indicated in Table 3 by Note "(1)". These plants are not all native, though a significant proportion (some 7 species), are. Further, on the rugged lava, native species are relatively more common in comparison with non-native species. However, vegetative growth on the lava flow is sparse. With the exception of *maiapilo* (*Capparis sandwichiana*), the natives are commonly occurring species in the

Islands. Despite the severe dry conditions in 2010, several species were conspicuous by their general good health: *kiawe*, *wiliwili*, tree tobacco, and *maiapilo*.

Table 3. Checklist of Plants Found Along the Proposed Construction Access Road, Auwahi Wind Farm Site

Species	Common name	Status	ABUNDANCE E1	E2	NOTES
FERNS & FERN ALLIES					
NEPHROLEPIDACEAE					
Nephrolepis multiflora (Roxburgh) Jarrett ex Morton	common sword fern	Nat	--	O	(1)
PSILOTACEAE					
Psilotum nudum Sw.	*moa*	**Ind**	--	R	(1)
PTERIDACEAE					
Pellaea ternifolia (Cav.) Link	*kalamoho lau li'i*	**Ind**	--	U	(1)
FLOWERING PLANTS					
DICOTYLEDONES					
AMARANTHACEAE					
Amaranthus spinosus L.	spiny amaranth	Nat.	U	O2	
ANACARDIACEAE					
Mangifera indica L.	mango	Nat.	--	U	
Schinus terebinthifolius Raddi	Christmas berry	Nat.	--	O	
ASCLEPIADACEAE					
Asclepias physocarpa (E. Mey.) Schlecter	balloon plant	Nat.	--	O	
ASTERACEAE (COMPOSITAE)					
Ageratum conyzoides L.	*maile hohono*	Nat.	--	R1	
Bidens cf. *alba* (L.) DC	beggar's-tick	Nat.	--	R	(2)
Chromolaena odorata (L.) King & Rob.	Siam weed	Nat.	--	U2	(1)
Cirsium vulgare (Savi) Ten.	bull thistle	Nat.	--	R	
Conyza bonariensis (L.) Cronq.	hairy horseweed	Nat.	--	R	
Cyanthillium cinereum L.	little ironweed	Nat.	R	--	
Emilia fosbergii Nicolson	Flora's paintbrush	Nat.	--	U	
Parthenium hysterophorus L.	false ragweed	Nat.	O	O	
Pluchea carolinensis (Jacq.) G. Don	sourbush	Nat.	U	--	
Pluchea indica (L.) Less.	Indian sourbush	Nat.	U	R	
Pluchea x *fosbergii* Cooperr. & Galang	hybrid pluchea	Nat.	R	--	
Senecio madagascariensis Poir.	---	Nat.	--	R	(1)
Tridax procumbens L.	coat buttons	Nat.	--	O	
Verbesina encellioides (Cav.) Benth. & Hook.	golden crown-beard	Nat.	U2	R	
Xanthium strumarium L.	*kikiāna*	Nat.	R	--	
BIGNONIACEAE					
Heliotropium curassavicum L	---	Nat.	R	--	
BORAGINACEAE					
Jacaranda mimosifolia D. Don	green ebony	Nat.	--	R	
BRASSICACEAE					
Sisymbrium officinale (L.) Scop.	hedge mustard	Nat.	--	R	

Table 3 – Continued

Species	Common name	Status	ABUNDANCE E1	E2	NOTES
CACTACEAE					
Opuntia ficus-indica (L.) Mill.	*pānini*	Nat.	R	U	
CAPPARACEAE					
Capparis sandwichiana DC	*maiapilo*	**End.**	--	R	(1)
CARYOPHYLLACEAE					
Petrorhagia velutina (Guss.) P. Ball & Heyw.	childing pink	Nat.	--	R	
CHENOPODIACEAE					
Chenopodium carinatum R. Br.	---	Nat.	R	U2	
CONVOLVULACEAE					
Merremia aegyptia (L.) Urb	hairy merremia	Nat.	--	R	(2)
Ipomoea indica (J. Burm.) Merr.	*koali 'awa*	**Ind.**	R	R	
CRASSULACEAE					
Kalanchoë pinnata (Lam.) Pers.	air plant	Nat.	--	O3	
Kalanchoë tubiflora (Harv.) Raym.-Hamet	chandelier plant	Nat.	--	R	(1)
CUCURBITACEAE					
Momordica charantia L.	balsam pear	Nat.	R	--	
EUPHORBIACEAE					
Aleurites moluccana (L.) Wild.	*kukui*	**Pol.**	--	O2	
Chamaesyce hirta (L.) Millsp.	garden spurge	Nat.	U	--	
Ricinus communis L.	castor bean	Nat.	U	U	
FABACEAE					
Acacia farnesiana	*klu*	Nat.	U	U	
FABACEAE					
Chamaecrista nictitans (L.) Moench	partridge pea	Nat.	--	O	
Crotalaria pallida Aiton	smooth rattlepod	Nat.	U	R	
Desmanthus purnambucanus (L.) Thellung	virgate mimosa	Nat.	U	--	
Desmodium incanum DC	Spanish clover	Nat.	--	R	
Erythrina sandwicensis Degener	*wiliwili*	**End.**	O2	O2	(1)
Indigofera suffruticosa Mill.	Indigo	Nat.	C	C	
Leucaena leucocephala	koa haole	Nat.	AA	A	
Neonotonia wightii (Wight & Arnott) Lackey	---	Nat.	C	AA	
Prosopis pallida (Humb. & Bonpl. Ex Willd.) Kunth	*kiawe*	Nat.	AA	--	
Senna occidentalis (L.) Link	coffee senna	Nat.	O	O	
LAMIACEAE					
Hyptis pectinata (L.) Poir.	Comb hyptis	Nat.	--	U	
Leonotis nepetifolia (L.) R.Br.	lion's ear	Nat.	U	O	
Ocium sp.	---	Nat.	C3	--	(2)
Plectranthus parviflorus Willd.	*'ala 'ala wai nui wahine*	**Ind.**	--	R	(1)
Salvia coccinea B. Juss. Ex Murray	scarlet sage	Nat.	U	U2	
MALVACEAE					
Abutilon grandifolium (Willd.) Sweet	hairy abutilon	Nat.	O2	O	
Malvastrum coromendalianum	false mallow	Nat.	R	O	
Sida fallax	*'ilima*	**Ind.**	O2	O2	

Table 3 – Continued

Species	Common name	Status	ABUNDANCE E1	E2	NOTES
Sida spinosa L.	prickly sida	Nat.	O	R	
Sidastrum micranthum (St. Hil.) Fryx.	---	Nat.	--	R	(2)
MELIACEAE					
Melia azedarach L.	Chinaberry	Nat.	--	O3	
MENISPERMACEAE					
Cocculus trilobus (Thunb.) DC	*huehue*	**Ind.**	--	U2	(1)
MORACEAE					
Broussonetia papyrifera (L.) Venten.	*Wauke*	**Pol.**	--	R	
NYCTAGINACEAE					
Boerhavia coccinea Mill.	false alena	Nat.	--	U	
Mirabilis jalapa L.	marvel of Peru	Nat.	--	U	
PAPAVERACEAE					
Argemone glauca (Nutt. Ex Prain) Pope.	*Pua kala*	**End.**	--	R1	
Bocconia frutescens L.	tree poppy	Nat.	--	O	
PIPERACEAE					
Peperomia cf. *leptostachya* Hook. & Arnott	---	**Ind.**	--	R3	(1)
PLUMBAGINACEA					
Plumbago zeylanica L.	*'ilie'e*	**Ind.**	--	R	
PORTULACACEA					
Portulaca oleracea L.	pig weed	Nat.	--	R	
Portulaca pilosa L.	---	Nat.	U2	U	
Portulaca sp. "A"	---	---	--	U2	(1)
PROTEACEAE					
Grevillea robusta A. Cunn. Ex R. Br.	silk oak	Nat.	--	U	(1)
SAPINDACEAE					
Dodonaea viscose Jacq.	*'a'ali'i*	**Ind.**	--	O	(1)
SAPOTACEAE					
Nesoluma polynesicum (Hillebr.) Baill.	*keahi*	**Pol.**	--	R	
SOLANACEAE					
Datura stramonium L.	jimson weed	Nat.	--	R	
Nicotiana glauca R.C. Graham	tree tobacco	Nat.	U	O	
Solanum linnaeanum Hepper & P. Jaeger	apple of Sodom	Nat.	--	U	
Solanum seaforthianum Andr.	---	Nat.	R	--	
STERCULARIACEAE					
Waltheria indica L.	*'uhaloa*	**Ind.**	O	A	
THYMELIACEAE					
Wikstroemia oahuensis (A. Gray) Rock	*'ākia*	**End.**	--	O2	
TILIACEAE					
Triumfetta semitriloba Jacq.	Sacramento burr	Nat.	--	U	
VERBENACEAE					
Lantana camara L.	lantana	Nat.	--	O	(1)
Stachytarpheta australis Moldenke	---	Nat.	R	C	
Stachytarpheta cf. *jamaicense* (L.) Vahl	Jamaican vervain	Nat.	--	R	(2)
Stachytarpheta cayennensis (Rich.) Vahl	---	Nat.	--	U	(1)

Table 3 – Continued

Species	Common name	Status	ABUNDANCE E1	E2	NOTES
FLOWERING PLANTS					
MONOCOTYLEDONES					
AGAVACEAE					
Furcraea foetida (L.) Haw.	Mauritius hemp	Nat.	U2	--	
CYPERACEAE					
Cyperus gracilis R. Br.	McCoy grass	Nat.	--	O	
POACEAE (GRAMINEAE)					
Cenchrus ciliaris L.	buffelgrass	Nat.	AA	--	
Dichanthium sp.	---	Nat.	U	O2	
Digitaria insularis (L.) Mez. ex Ekman	sourgrass	Nat.	A	C	
Eleusine indica (L.) Gaertn.	wire grass	Nat.	--	R	
Eragrostis amabilis	love grass	Nat.	--	U	
Chloris barabata (L.) Sw.	swollen fingergrass	Nat.	--	O	
Cynodon dactylon (L.) Pers.	Bermuda grass	Nat.	--	U	
Melinus minutiflora P. Beauv.	molasses grass	Nat.	--	U	(1)
Melinus repens (Willd.) Zizka	Natal redtop	Nat.	O	C	(1)
Sporobolis indicus (L.) R. Br.	West Indian dropseed	Nat.	--	R	
Sporobolus sp.		Nat.	--	O	
Urochloa maxima (Jacq.) R. Webster	Guinea grass	Nat.	AA	A	

Table 3: Legend

Status = distributional status

End. = endemic; native to Hawaii and found naturally nowhere else.
Ind. = indigenous; native to Hawaii, but not unique to the Hawaiian Islands.
Nat. = naturalized, exotic, plant introduced to the Hawaiian Islands since the arrival of Cook Expedition in 1778, and well-established outside of cultivation.
Pol. = Polynesian introduction before 1778.

Abundance = occurrence ratings for plants:

R – Rare - only one or two plants seen.
U - Uncommon - several to five plants observed.
O - Occasional - found between five and ten times; not abundant anywhere
C - Common - considered an important part of the vegetation and observed numerous times.
A - Abundant - encountered regularly and therefore present in large numbers; may be dominant over a limited area.
AA - Abundant - abundant and dominant; defining vegetation type for the layer.
Numbers following an occurrence rating indicate clusters within the survey area. The ratings above provide an estimate of the likelihood of encountering a species within the specified survey area; numbers modify this where abundance, where encountered, tends to be greater than the occurrence rating:
1 – several plants present
2 - many plants present
3 – locally abundant

Area: E1 – Leeward slope, below 1000 ft (300 m).
E2 – Leeward slope, above 1000 ft (300 m).

Notes:
(1) – Found particularly and more abundant on rugged lava outcrops and flows.
(2) – Plant material observed lacked definitive taxonomic characters (dried out in some cases).
(3) – Described by USFWS (2010) as a "species of concern."

The results of mapping native trees along the construction access road are expressed in Figures 15 through 18. For this set of maps, besides *wiliwili*, the only natives recorded were *maiapilo* and a single *alahe'e* shrub. Areas of dense *wiliwili* (copses), within which individual trees were not recorded (only a light orange fill appears on the maps), are outlined in orange: solid lines where recorded in the field; dashed lines where interpreted from a satellite image.

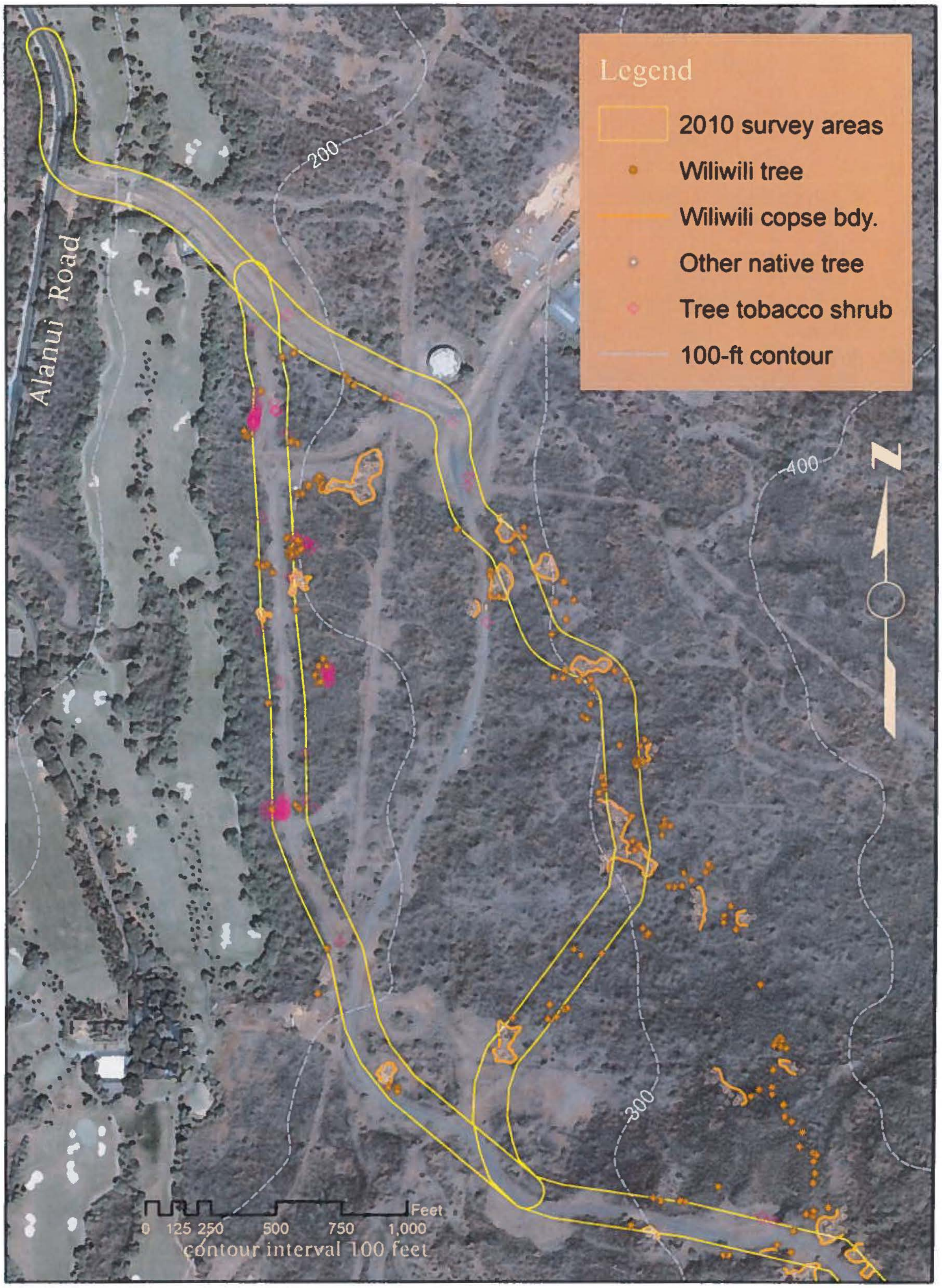

Figure 15. Botanical survey map for west end of construction access road between 100 (Alanui Road) and 350 feet ASL.

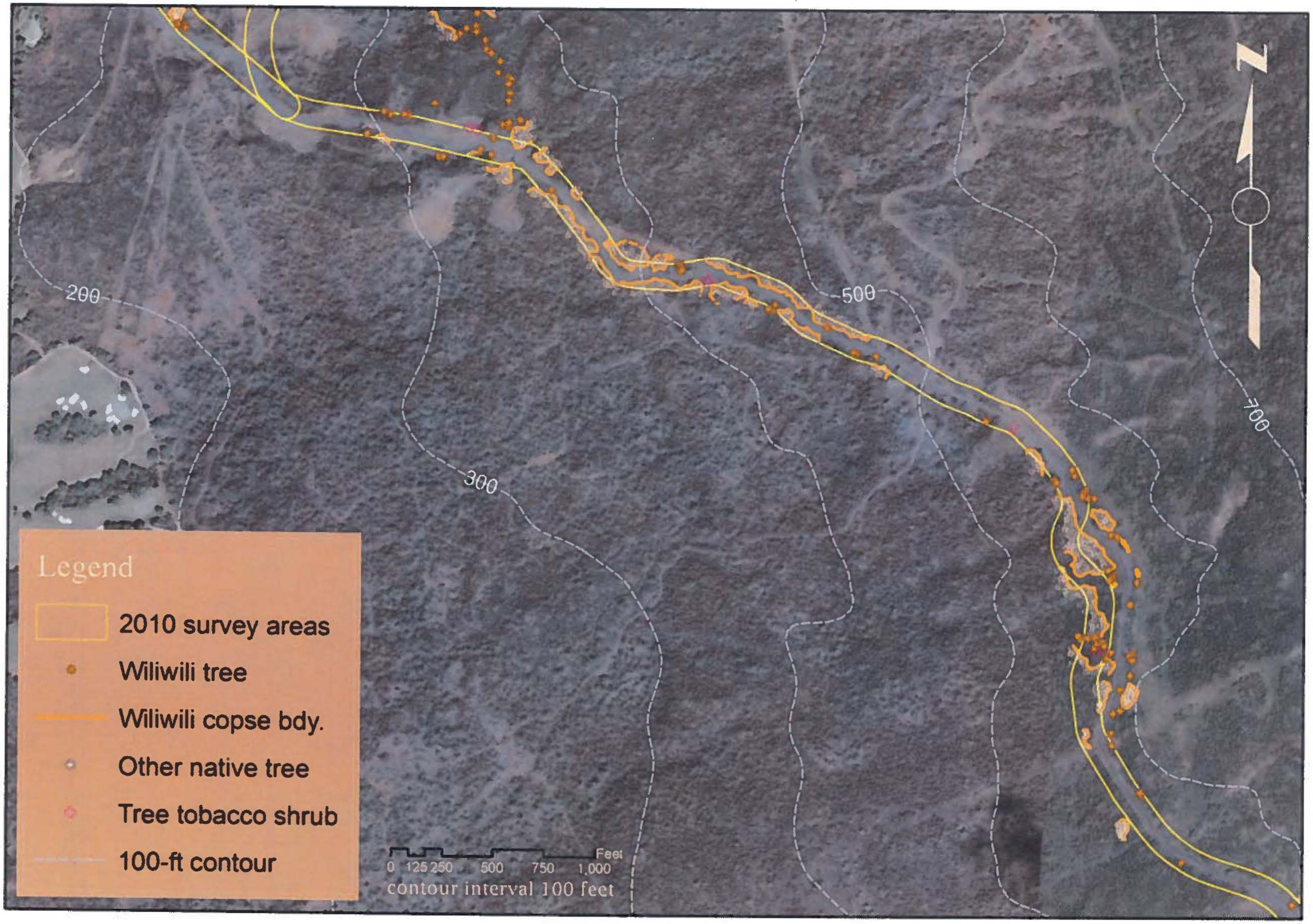

Figure 16. Botanical survey map for western part of construction access road between 250 and 550 feet ASL.

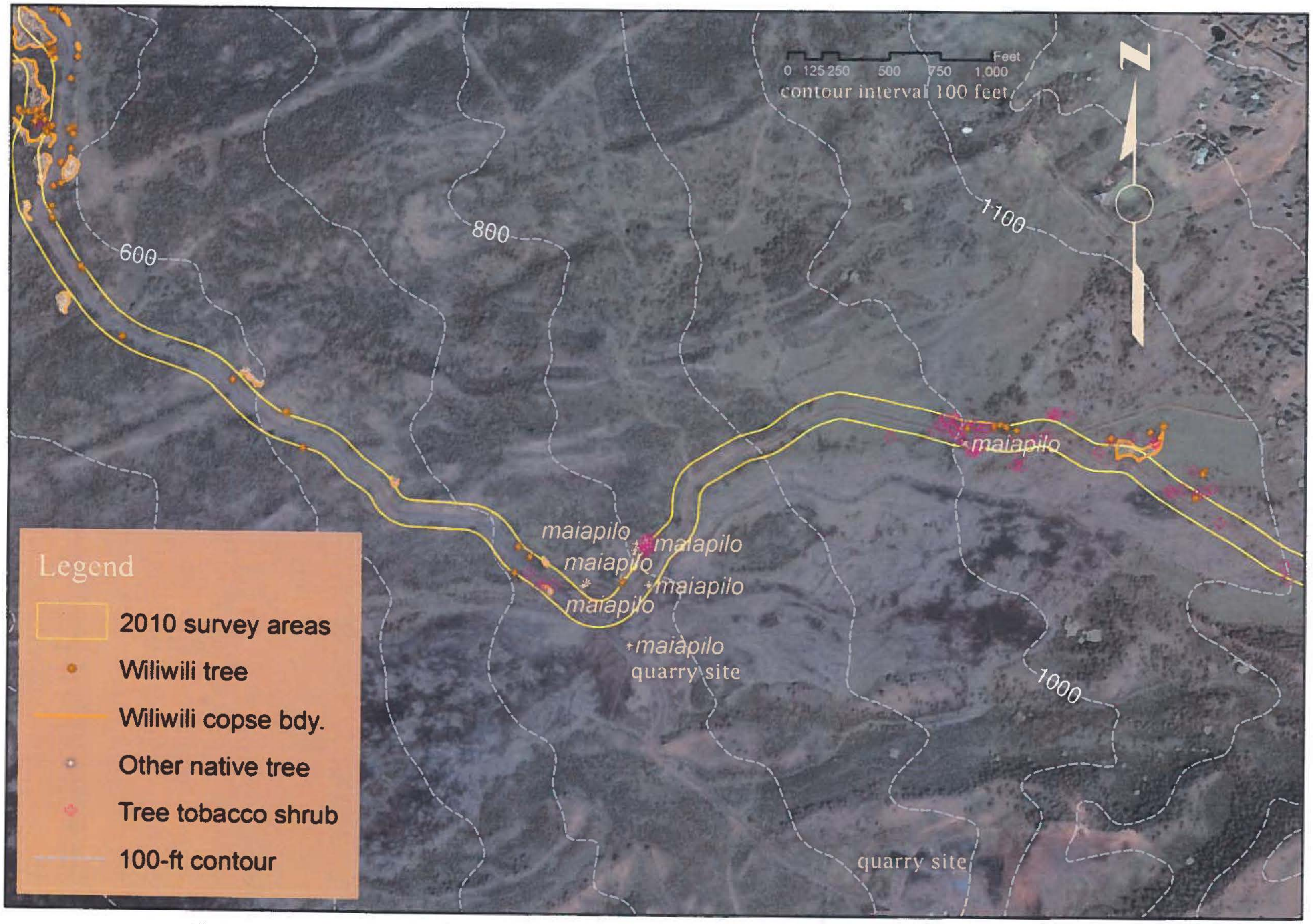

Figure 17. Botanical survey map for construction access road between 550 and 1100 feet ASL.

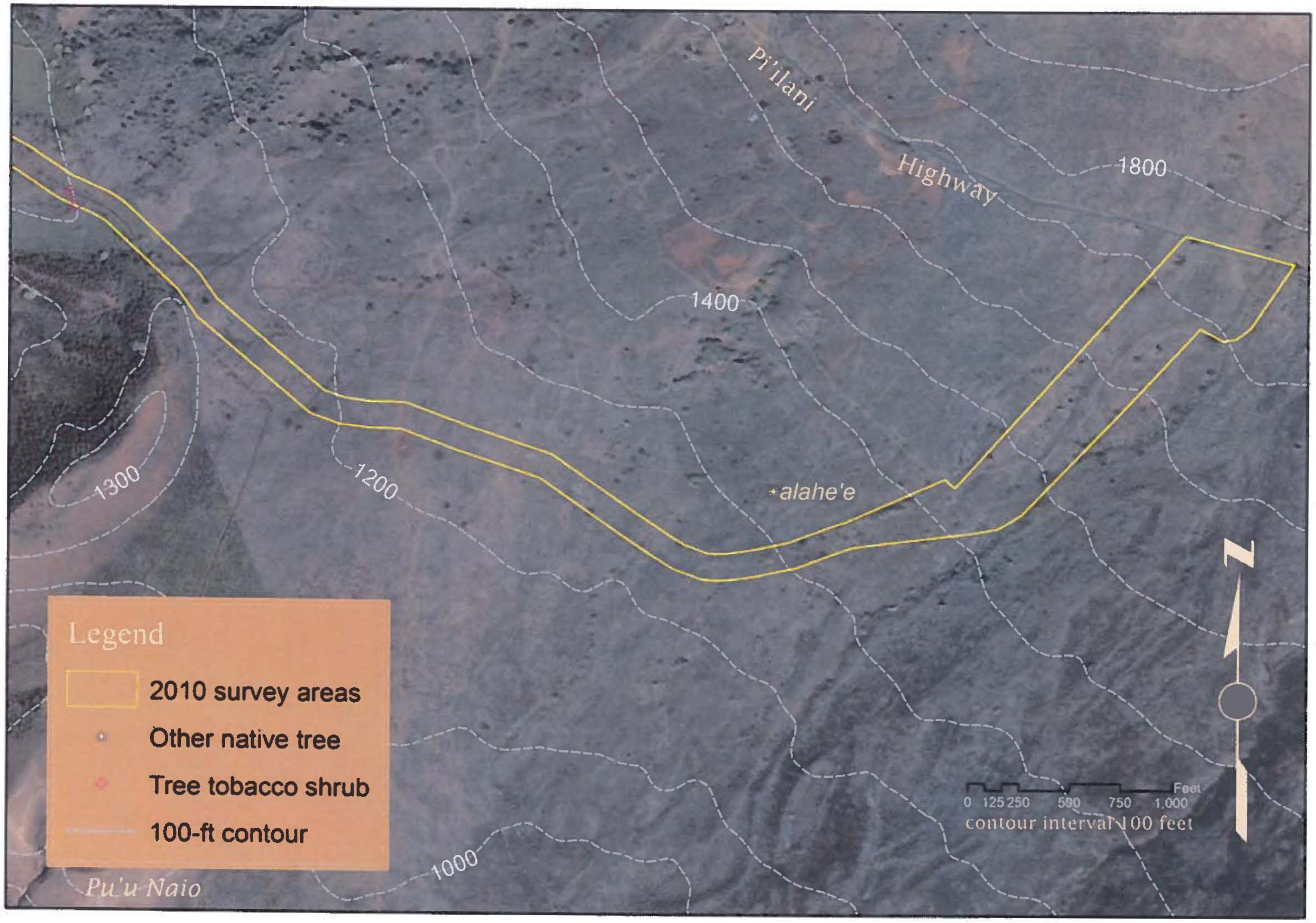

Figure 18. Botanical survey map for east end of construction access road between 1100 and 1750 feet ASL (Pi'ilani Higway).

Avian Survey

A total of 2,156 individual birds of 23 different species, representing 15 separate families, were recorded during station counts (Table 4). An additional two species, representing one additional family were recorded as incidental observations while transiting the site between count stations (Table 4). One of the species detected, Short-eared Owl (*Asio flammeus sandwichensis*), is a Hawaiian endemic subspecies. All other species detected are considered to be alien to the Hawaiian Islands. No species currently listed as endangered, threatened or proposed for listing under either the federal or State of Hawai'i endangered species statutes was recorded during the course of this survey.

Avian diversity and densities were relatively low, though in keeping with the habitat present on the site. An average of 27 individual birds were recorded per station count. Four species (17%), House Finch (*Carpodacus mexicanus*), Japanese White-eye (*Zosterops japonicus*), Black Francolin (*Francolinus francolinus*), and Sky Lark (*Alauda arvensis*), accounted for 49% of the total number of birds recorded during station counts. The most common avian species recorded was House Finch, which accounted for slightly less than 15% of the total number of individual birds recorded.

Table 4 Avian Species Detected, Auwahi Wind Farm Project.

Common Name	Scientific Name	ST	RA
	GALLIFORMES		
	PHASIANIDAE - Pheasants & Partridges		
	Phasianinae - Pheasants & Allies		
Chukar	*Alectoris chukar*	A	**I-5**
Gray Francolin	*Francolinus pondicerianus*	A	1.60
Black Francolin	*Francolinus francolinus*	A	2.86
Japanese Quail	*Coturnix japonica*	A	0.04
Red Junglefowl	*Gallus gallus*	A	0.10
Ring-necked Pheasant	*Phasianus colchicus*	A	0.74
Common Peafowl	*Pavo cristatus*	A	0.56
	ODONTOPHORIDAE - New World Quail		
California Quail	*Callipepla californica*	A	0.20
	CICONIIFORMES		
	ARDEIDAE - Herons, Bitterns & Allies		
Cattle Egret	*Bubulcus ibis*	A	0.84
	COLUMBIFORMES		
	COLUMBIDAE - Pigeons & Doves		
Spotted Dove	*Streptopelia chinensis*	A	0.30
Zebra Dove	*Geopelia striata*	A	1.45
Mourning Dove	*Zenaida macroura*	A	0.13

Table 4 - Continued

Common Name	***Scientific Name***	**ST**	**RA**
	STRIGIFORMES		
	TYTONIDAE - Barn Owls		
Barn Owl	*Tyto alba*	A	**I-27**
	STRIGIDAE - Typical Owls		
Short-eared Owl	*Asio flammeus sandwichensis*	IB	0.05
	PASSERIFORMES		
	ALAUDIDAE - Larks		
Sky Lark	*Alauda arvensis*	A	2.51
	SYLVIIDAE - Old World Warblers & Gnatcatchers		
	Sylviinae - Old World Warblers		
Japanese Bush-Warbler	*Cettia diphone*	A	0.56
	ZOSTEROPIDAE - White-eyes		
Japanese White-eye	*Zosterops japonicus*	A	3.59
	MIMIDAE - Mockingbirds & Thrashers		
Northern Mockingbird	*Mimus polyglottos*	A	1.15
	STURNIDAE - Starlings		
Common Myna	*Acridotheres tristis*	A	2.49
	EMBERIZIDAE - Emberizids		
Red-crested Cardinal	*Paroaria coronata*	A	0.10
	CARDINALIDAE - Cardinals Saltators & Allies		
Northern Cardinal	*Cardinalis cardinalis*	A	1.15
	FRINGILLIDAE - Fringilline and Carduline Finches & Allies		
	Carduelinae - Carduline Finches		
House Finch	*Carpodacus mexicanus*	A	4.24
	ESTRILDIDAE - Estrildid Finches		
	Estrildinae - Estrildine Finches		
African Silverbill	*Lonchura cantans*	A	1.40
Nutmeg Mannikin	*Lonchura punctulata*	A	0.93
Java Sparrow	*Padda oryzivora*	A	0.01

Key To Table 4

ST Status
A Alien Species
IB Indigenous Resident Breeding Species
RA Relative Abundance: Number of birds detected divided by the number of count stations (80)
I Incidental Observation – Species seen while transiting the site, followed by the number of individuals seen

Mammalian Survey

Eleven mammalian species were detected during the course of this survey. Their status in Hawai'i, relative abundance observed and detection type are displayed in Table 5. All 11 species recorded are alien to the Hawaiian Islands. We saw large numbers of cattle (*Bos taurus*), horses (*Equus c. caballus*), Axis deer (*Axis axis*), and goats (*Capra h. hircus*). We saw fairly small numbers of pigs (*Sus s. scrofa*), small Indian mongooses (*Herpestes a. auropunctatus*), dogs (*Canis f. familiaris*), and cats (*Felis catus*). We also recorded one roof rat (*Rattus r. rattus*) and one European house mouse (*Mus musculus domesticus*). We did not see any elk (*Cervus elaphus*), although we did encounter sign of this species along the Wailea side of the transmission line corridor. Hawai'i's sole endemic terrestrial mammalian species, the endangered Hawaiian hoary bat, was not detected during the course of this survey.

Table 5 Mammalian Species Detected, Auwahi Wind Farm Project.

Common Name	Scientific Name	ST	AB	DT
	RODENTIA - GNAWERS			
	MURIDAE - Old World Rats & Mice			
Roof rat	*Rattus r. rattus*	A	R	V
European house mouse	*Mus musculus domesticus*	A	R	V
	CARNIVORA – FLESH EATERS			
	CANIDAE – Wolves, Jackals & Allies			
Domestic dog	*Canis f. familiaris*	A	U	V, SC, SI
	VIVERRIDAE – Civets & Allies			
Small Indian mongoose	*Herpestes a. auropunctatus*	A	U	V, SC, SI
	FELIDAE- Cats			
House cat	*Felis catus*	A	U	V, SC, SI
	PERISSODACTYLA – ODD-TOED UNGULATES			
	EQUIDAE – Horses, Asses & Zebras			
Domestic horse	*Equus c. caballus*	A	A	V, SC, SI
	ATRIODACTYLA – EVEN-TOED UNGULATES			
	SUICIDAE – Old World Swine			
Pig	*Sus s. scrofa*	A	U	V, SC, SI
	CERVIDAE – Antlered Ruminants			
Axis deer	*Axis axis*	A	A	V, SC, SI
Elk (Red Deer)	*Cervus elaphus*	A	?	SI
	BOVIDAE- Hollow-horned Ruminants			
Domestic cattle	*Bos taurus*	A	A	V, SC, SI
Feral goat	*Capra h. hircus*	A	A	V, SC, SI

Table 5 – continued ....

Key To Table 5

ST	Status
A	Alien Species
DT	Detection Type
R	Rare - one animal during all time spent on the project site
U	Common - 1-5 animals detected each day
A	Abundant - 25-150 animals detected on a daily basis
V	Visual - one or more individuals were seen
SC	Scat - Scat of this species was encountered
SI	Sign - Sign, tracks, bark rubbing, wallows, dust bath depressions etc. of this species encountered

Wetland and Stream Resources

Occurrences of surface water in all areas potentially impacted by the Project are limited to manmade ranch watering structures and infrequent surface flows occurring during heavy rains. Even where the climate is generally wetter upslope—at and above the highest point reached by the generator tie-line—atmospheric moisture is delivered as cloud drip and does not generate surface water flows. The one "stream" indicated on older maps lies along the far western edge of the Project parcel. A brief assessment (Guinther, 2010) of this feature was prepared for the record and presentation to the U.S. Army Corps of Engineers (USACE); the lower end of the "stream" was visited a short time later in June 2010. The following description is taken from the assessment report:

> Owing to the relatively recent lava flows and generally dry climate that characterize the southwest rift zone of East Maui Mountain below 4000 ft (1220 m), flowing streams, natural ponds, and wetlands are absent, with but a very few exceptions. These exceptions are all located close to the coastline where either tidal flooding occurs or the basal water table is exposed by depressions in the ground surface (fish ponds and anchialine features). Inland and upslope, above a few meters elevation, and therefore in all of the areas potentially impacted by the Auwahi Windfarm Project (including the windfarm site, construction access roads, and electrical transmission lines), occurrences of surface water are limited to manmade ranch watering structures and infrequent surface flows occurring during heavy rains. Even where the climate is somewhat wetter far upslope—at and above the highest point reached by the [generator tie-line]—atmospheric moisture is delivered as cloud drip and does not generate surface water flows.
>
> The land in the project area shows some weathering, with evidence of surface flow within swales that extend to the coast. The USGS topographic map (Makena Quadrangle) shows only a single intermittent stream in the area. This unnamed "stream" is indicated as arising around the 3200-ft (975-m) elevation and descending to the coast east of Kanaloa. The feature appears to be following along the eastern edge of the lava flow dated 3000 to 5000 years before present (BP) on the much older surface of the mountain dated at between 13,000 and 50,000 years BP (Sherrod, et al., 2007). On May 17, 2010, this "stream" was visited in the area where it crosses Pi'ilani Highway, but which of several swales in this area was the stream could not be determined. The most likely swale (lowest apparent dip in the road) was photographed...[see cited report]

This feature is located on ʻUlupalakui Ranch land, but in an area where no Project components will be located. Like all of the gullies and swales on the Project area, this one carries water only during exceptional storms, with flow ceasing soon after the rainfall quits. While it is possible that rain storms of sufficient strength occur at least once each year, it is also the case that owing to drought cycles, flow in these tributaries may be absent for several years running. This feature could be defined as a non-navigable tributary that is not relatively permanent, and thus requiring a determination that a significant nexus with a traditional navigable water exists (Grumbles & Woodley, 2008); or it and all other swales on the property are erosional features characterized by low volume, infrequent, or short duration flow and not jurisdictional.

To further confirm that this specific feature carries flowing water to the ocean only very infrequently (less often than annually), and is not jurisdictional, the mouth at the shore was visited in July 2010. Here, geophysical processes are clearly dominated by wave energies and a stream outlet is barely perceptible. No standing water or evidence of wetness was observed. The gulch can be traced upslope from the mouth (Figure 19), but evidence of water flow occurs in very scattered locations.

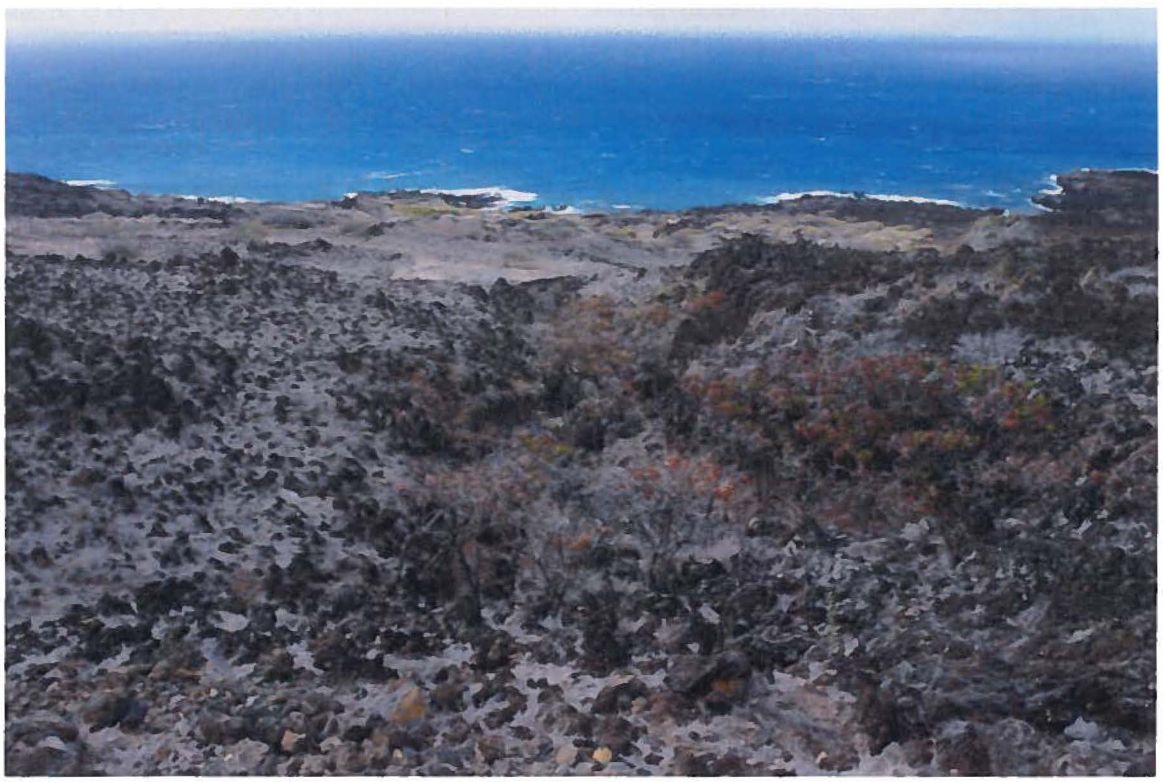

Figure 19. Swale of "intermittent stream" shown in Guinther (2010) seen from 250-ft elevation looking towards the outlet at the shore.

Discussion

Botanical Resources

The botanical resources of the southwestern end of East Maui are controlled by the local geology and physiography, and of course, land use patterns. A broad range of conditions with respect to temperature, wind, rainfall, and soil occur within the areas of potential impact from the proposed Auwahi Wind Farm, associated generator tie-line, and proposed construction access roadway improvements. These environmental factors interact with each other in complex ways to produce a range of habitat types that support more or less distinctive plant associations. It is beyond the scope of this report to explore in any detail these relationships, but to achieve an understanding of the floristic observations, it is necessary to attempt to relate these environmental factors to vegetation distribution, especially the occurrence of native vs. non-native plants, and sensitive vs. non-sensitive plant communities. The proposed wind farm covers a much smaller range of conditions as compared to the proposed generator tie-line corridor that covers the full range of elevation (and therefore rainfall) found within the Project area.

General vegetation maps for each of the project areas are presented as Figures 21, 24, 26, and 27, and are discussed in the text that follows describing vegetation types in the Project area. The purpose of this discussion is to provide the reader with a sense of the nature of the environments in which Project elements will be constructed. In this part of Maui, some (indeed most) vegetation types harbor few or only rare occurrences of native plants; others support many, or at least a diversity of natives. In a few types, native plants reach dominance. Given this variety of conditions with respect to botanical resources, it is not possible to summarize impacts as either unacceptable or minimal. In some vegetation types, considerable care will be required to minimize adverse impacts, particularly during the construction phase.

Physiography

The project area extends from just above sea level to an elevation of around 4,000 feet (1,200 meters) on the slope of the East Maui Volcano (called Haleakalā in some sources, although this name applies to the central crater-like valley of the mountain). The project area lies close to (and the generator tie-line and roadway corridors both straddle) the southwest rift of the volcano. Rift zones are areas where flank eruptions were concentrated in the distant past. The three rift zones of the East Maui Volcano contributed to the three-cornered shape of the mountain, which built outward especially along these axes. The southwest rift zone in particular is marked by a relatively narrow band of eruption cones from which the Kula Series lavas issued, this rift zone "extending southwestward... from the summit, forming a nearly straight line across the mountain" (Macdonald, Abbott, and Peterson, 1983).

The eruptive activity that gave rise to this part of Maui is significant to the extant flora in one respect: the more recent lava flows are distinct in having poorly developed soils, complex rocky outcrops, and flows little modified by time, and therefore provide a poor physiographic setting for agricultural uses. As a consequence, the older exposed surfaces have deeper soils and, in this part of Maui, have been extensively developed as pastureland by 'Ulupalakua Ranch and others.

Two other factors are important: elevation and position relative to the rain shadow effect that results in the very dry southern slopes of the East Maui Volcano. Elevation affects temperature, but more important to flora in the project areas, is the effect of elevation on rainfall. This part of Maui has two rainfall gradients: elevation and shadow effect. Average rainfall received (Taliaferro, 1959) increases in the upslope direction from the coastline (~10 in/yr or 250 mm/yr at Kīhei, but ~40 in/yr or 1000 mm/yr at Kula) reaching a peak value at around 5,000 feet (1,500 meters) of elevation. This gradient is weaker on the south flank, with annual rainfall amounts of around 20 inches (500 mm) at the coast and not much over 30 inches (800 mm) all the way up the mountain, decreasing above 4,000 feet (1,200 meters) to 20 in/yr along the southern crest of Haleakalā. The median annual rainfall differences may not seem great (after all, the north or windward face of the mountain receives around 100 in/yr or 2500 mm/yr), but are particularly influential on plant life during the driest months (May through September) when little or no rainfall occurs in the lowlands below either flank of the mountain, while an orographic effect (air forced to give up moisture as it rises upon encountering the mountain) brings some rainfall to the higher elevations of the 'Ulupalakua ranchlands facing to the northwest. Thus, the orographic or elevational influence on rainfall predominates on the northwest flank of the rift zone, while the shadow effect predominates on the southeast flank of the rift zone. The climate along the Kula Highway (between 2,000 and 3,000 feet or 600 to 1000 meters) is decidedly mesic upslope from the highway on the Kīhei (western) slope, and increasingly drier downslope. On the entire southern face of the mountain above and below Pi'ilani Highway, only a kilometer or less from the rift zone, the climate is dry.

Vegetation Zones

The physical factors discussed above strongly influence the nature of the vegetation found in the project area. In broad terms, we can identify the following types of vegetation within the project area: dry shrubland, grassland (includes pasture), and savanna (grassland with scattered trees). Some areas of mesic forest and dryland forest are present, although most of the mesic forest occurs along the rift zone ridgeline in areas not included in the survey. Dryland forest occurs as a remnant vegetation type on the southern flank of the mountain between about 1000 and 4000 feet ASL. The pattern of these vegetation types on the landscape is influenced by land use practices: extensive pastures at higher elevation are maintained as grasslands by the presence of cattle and the efforts of the ranch to minimize tree and shrub growth. Dry scrub and savanna lands are also utilized for pasturing cattle, but these occur in the driest areas and support lower densities of ungulates. It was apparent during our surveys that native plant species were well represented in the more rugged terrain representing the most recent lava flows. This conclusion seems to have been reached by nearly every botanist that has visited this part of Maui in the last half century or longer. Bordner (1995), an archaeologist, expressed it thus:

> *".... Since Rock's (1913) survey of indigenous trees and shrubs, it has been acknowledged that A'uahi contains one of the highest proportions of indigenous dryland forest left in the Hawaiian Islands (Lamb 1981). The survival of such a large number appears mainly to reflect the recent*

dates of the lava flows, which must have been so destructive of the very forest they now preserve. Small kipuka, isolated in fields of bare lava, are thus protected from much of the wanton grazing by goats and cattle which destroyed the former expanse of dry forest."

The conclusion that the preserved dryland forest is limited to, or even significantly occupies, *kīpuka* of any size is unlikely to be the case. It is the ruggedness of specific lava flows, directly a property of their youthful age relative to surrounding flows (including *kīpuka*) that confers protection, certainly from grazing cattle, but also from non-native plants less able to establish on the thin or non-existent soils of these recent flows located in a dry climate. Key as well to explaining the thinning and gradual disappearance of the native dryland forest in this area is the predominance of non-native Kikuyu (*Pennisetum cladestinum*) as the abundant pasture grass above about 2200 feet (670 meters) ASL. The "...smothering, thick, dense growth [of Kikuyu] prevents virtually any new [native] seedling establishment" (Wagner, Herbst, and Sohmer, 1990, p. 1579).

Table 6. Vegetation Map Key

Map Unit	Description	Coding*
DD	Developed or disturbed areas; farmland, house lots, golf courses, etc.	not applicable
Fk	*Kiawe* forest and *kiawe* coastal strand.	D: xt(xg)
Fkw	*Kiawe*, *koa haole*, and *wiliwili* mixed forest.	D: xt/nt(xg)
Fo2	Secondary forest; non-native.	M: xt(xg)
GP	Grassland; pasture.	D: xg
GPj	Savanna; pasture with scattered trees and shrubs, roughly corresponding to Jacobi (1989) mapping unit.	D: (xg,ns-xs)nt
GPr	Grassland with shrubs and herbs; very rocky pasture.	D: xg, ns-xs
R	Restoration area (active)	D: (ns)nt
Sc	Shrub/scrub vegetation	D: nx-xs
ScL	Scrub vegetation; dry shrubland usually on recent lava flows.	D: nx-xs
ScP	Scrub vegetation and grassland; pasture.	D: xs-ns(xg)
SvF	Savanna; forest with <25% canopy roughly corresponding to Jacobi (1989) mapping unit	D: nt (ns, xg/xs)
SvL	Lowland (*kiawe*/buffelgrass) savanna.	D: xt(xs)
SvU	Open canopy forest/savanna of upland trees.	M:(xg/xs)xt

Coding — Adapted from Jacobi (1989): D: = dry zone, M: = mesic zone; n = native, x = non-native; g = grass, s = shrub, t = tree; (...) = understory, t( ) = trees ≥ 25% cover, ( )t = trees < 25% cover.

Table 6 (above) is a key to the codes used in the vegetation maps presented in this discussion section. Note that areas of significant disturbance and/or development are mapped as ***DD*** where the vegetation is either absent or ornamental and maintained. Examples are urban areas, golf courses, and crop lands. The vegetation types mapped in Figures 21, 24, 26, and 27). These figures are discussed within the context of broader vegetation types (e.g., grassland, scrub, savanna) that predominate in the area of the project sites as shown on each map. A column of codes for each map unit type in the table and maps—adapted from the vegetation scheme presented by Jacobi (1989)—is useful for relating information on some characteristics (native vs. non-native, dry vs. mesic, shrub vs. tree, etc.) of the vegetation present. As an example, the coding for the Auwahi restoration areas (map unit "R") is "D: (ns)nt"; to be interpreted as "dry zone native savanna (tree canopy less than 25%) with native shrub understory."

Grassland/pasture

The proposed project occurs almost entirely on land that is utilized to a greater or lesser degree by 'Ulupalakua Ranch for cattle grazing. A majority of the area is pasture, or grassland maintained for agricultural pasturing (see Figure 20; ***GP*** on vegetation maps such as Figure 21; ***GPr*** as very rocky pasture in drier areas). These pastures support non-native grasses. Grazing of cattle is not limited to this just vegetation type and climatic and edaphic (soil) factors determine the appropriate extent of pasturing supportable in any given area. Areas of mostly grassland occur along the generator tie-line route from near where the line crosses the southwest rift down the west face of the mountain to around 1,000 feet (300 meters) ASL in the direction of Wailea. Below about 1000 feet (300 meters), the open grassland transitions to a grass/tree savanna (see Savanna below).

Figure 20. Typical pasture, here at around 3500 feet on the southwest rift. Note that a mesic forest covers the pu'u (Kalanapahi cinder cone) downslope, which is Not used for cattle grazing. Slope on right is Keonenelu cinder cone.

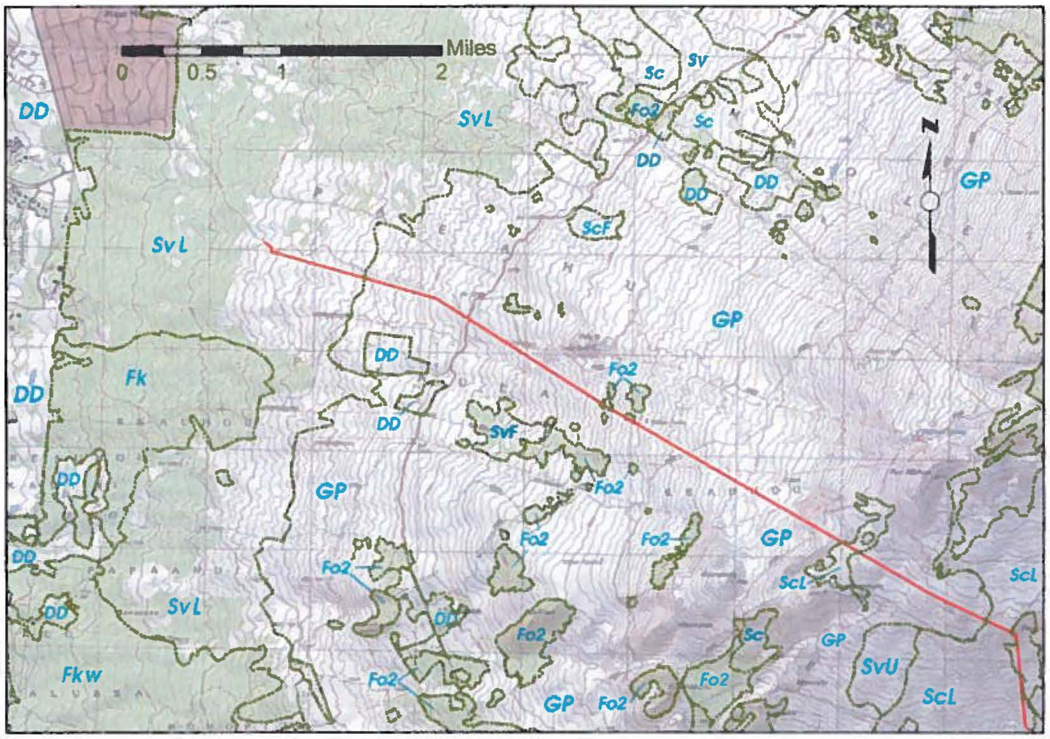

Figure 21. Vegetation zones for the western half of the generator tie-line (in red) crossing upland pasture and lowland savanna of 'Ulupalakua Ranch. For key see Table 6.

Savanna

Savanna is a vegetation type characterized by both grass and trees. Typically, a savanna has the appearance of a grassland with a varying density of tree species, but these are not so dense as to form a closed canopy shading out the understory grasses. Figure 22 shows a savanna in the project area consisting of pasture grasses and *kiawe* trees (***SvL*** in vegetation maps). This vegetation type is crossed by the proposed generator tie- line, downslope of where the line passes over the ridge of the Southwest Rift Zone and continues across pastureland above and below Kula Highway (State Rte. 31; here at about 2,000 feet or 600 meters). Savanna appears around the 1,200-foot (360-meter) elevation, with the density of *kiawe* trees increasing steadily in the downslope direction. It is not easily determined at which point savanna here becomes a dryland forest—by most definitions, "savanna" is characterized by "scattered trees," some definitions including concepts such as an open canopy and an unbroken herbaceous layer (Wikipedia, 2007). In the normally dry conditions on the lower slope of the mountain, *kiawe* trees do not create deep enough shade so the understory remains mostly dense grass with only scattered shrubs all of the way to the Wailea substation. It is arguable whether, in this area, a dryland forest is present, since the canopy remains sufficiently open to support a dense growth of grass beneath (see Figure 7). *Kiawe* forest (***Fk***) is mapped on the general vegetation map southwest of the generator tie- line. This forest type merges into a mixed *kiawe* and *wiliwili* forest (***Fkw***) further south towards the construction access road.

Figure 22. Typical savanna: grassland with scattered trees. (Around 1000 ft above Wailea looking towards Kaho'olawe).

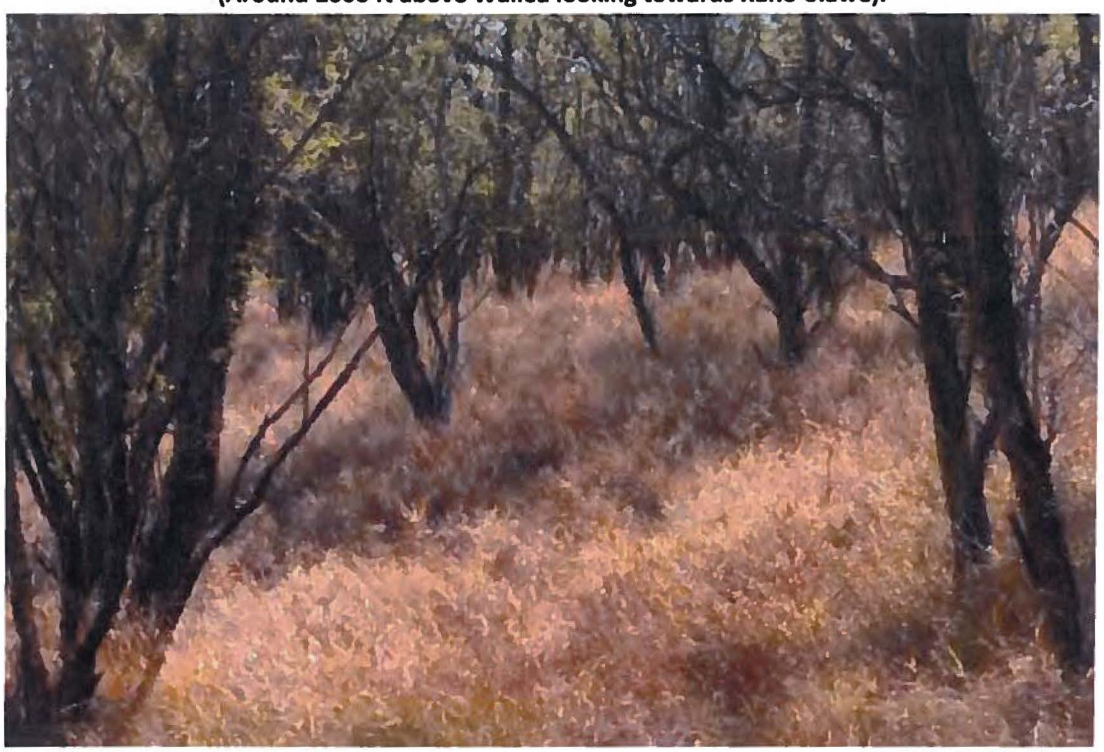

Figure 23. Savanna or dryland forest? The Prosopis/Cenchrus Association at lower elevations fits the definition of both vegetation types.

Secondary Mesic Forest

The term mesic describes moisture conditions between dry and wet; typically there is a dry season, but the moisture deficit is not prolonged (Gagne and Cuddihy, 1990). Upland areas that are mesic in character support forested slopes. On the west slope, in the vicinity of the generator tie-line (Figure 21), these are secondary forest copses (***Fo2***) representing, in most cases, old plantings of eucalyptus or gum trees. Mesic forest occupies scattered areas along the rift zone in the 'Ulupalakua area, especially near the upper end of the construction access road (west alternative) and in a few scattered locations mostly adjacent to the generator tie-line at its higher elevation. A few cases of very open canopy growth associated with these plantings is mapped as savanna (***SvF***). It is likely the case that in the absence of cattle grazing and active promotion of pasture development, much of the 'Ulupalakua Ranch land *mauka* of Kula Highway would be a mesic forest. The mesic forest in the areas surveyed are mostly dominated by non-native trees, but remnants of native mesic forest (dominated by *'ōhi'a*) occur in the area on relatively recent lava flows and as described following.

Native Mesic Forest

In the Project area of the upper generator tie-line on the south mountain slope, the vegetation is transitional between xeric (dry) and mesic (moisture from cloud drip becomes significant here)[6]. Further, the vegetation is a complex mixture of pasture (grassland), shrubland, and open forest or savanna, and cannot be mapped as a single type or map unit. The native vegetation occurs mostly in the **ScL, GPj and SvF** units mapped in Figure 24. The botanical significance of this area lies in the Montane Mesic Forest, here a remnant of a once more extensive *Olopua* (*Nestegis*) Montane Forest (Gagne and Cuddihy, 1990). These authors note that this forest type is "extremely rich in native tree species, especially in the Auwahi and Kanaio Districts on East Maui, where *olopua* may lose dominance and the community can be considered a montane Diverse Mesic Forest with no clearly dominant species."

This native "forest" type at Auwahi is protected by the Kanaio NAR, an area of high diversity of native plant species and considered one of the most intact "dryland" forest areas in the state (Wagner et al., 1990). In botanical references, Auwahi currently refers to a 5,400-acre stand of diverse forest at 3,000-5,000 feet (900-1500 meters) elevation surrounded by less diverse forest and shrubland on relatively recent lava flows. Auwahi contains high native tree diversity with 50 dryland species, many with extremely hard, durable, and heavy wood (Medeiros, Davenport, and Chimera, undated). A website (HEAR, 2007) provides the following history: "The area was first explored botanically in the early 20th century by Joseph Rock of the University of Hawai'i and Charles Forbes of Bishop Museum. In his seminal book, *Indigenous Trees of the Hawaiian Islands* (1913), Rock praised the area for its

[6] The difficulty of assigning mesic vs. xeric here is illustrated by the fact that Gagne and Cuddihy (1990, p. 99) classified the area as mesic, whereas Jacobi (1989) mapped it as "D" or dry (xeric), and many others describe the vegetation as a "native dryland forest." Since 2009-2010 was an uncommonly dry period for this part of Maui, we cannot reasonably support an opinion from experience either way. Xeric conditions very likely prevail on this slope below 3000 feet (900 meters) ASL, which encompasses the vast majority of Kanaio NAR.

botanical diversity calling it one of the richest districts in the State. Upon his return to the area some 20 years later in 1939, Rock is said to have wept over the dramatic deterioration during his absence".

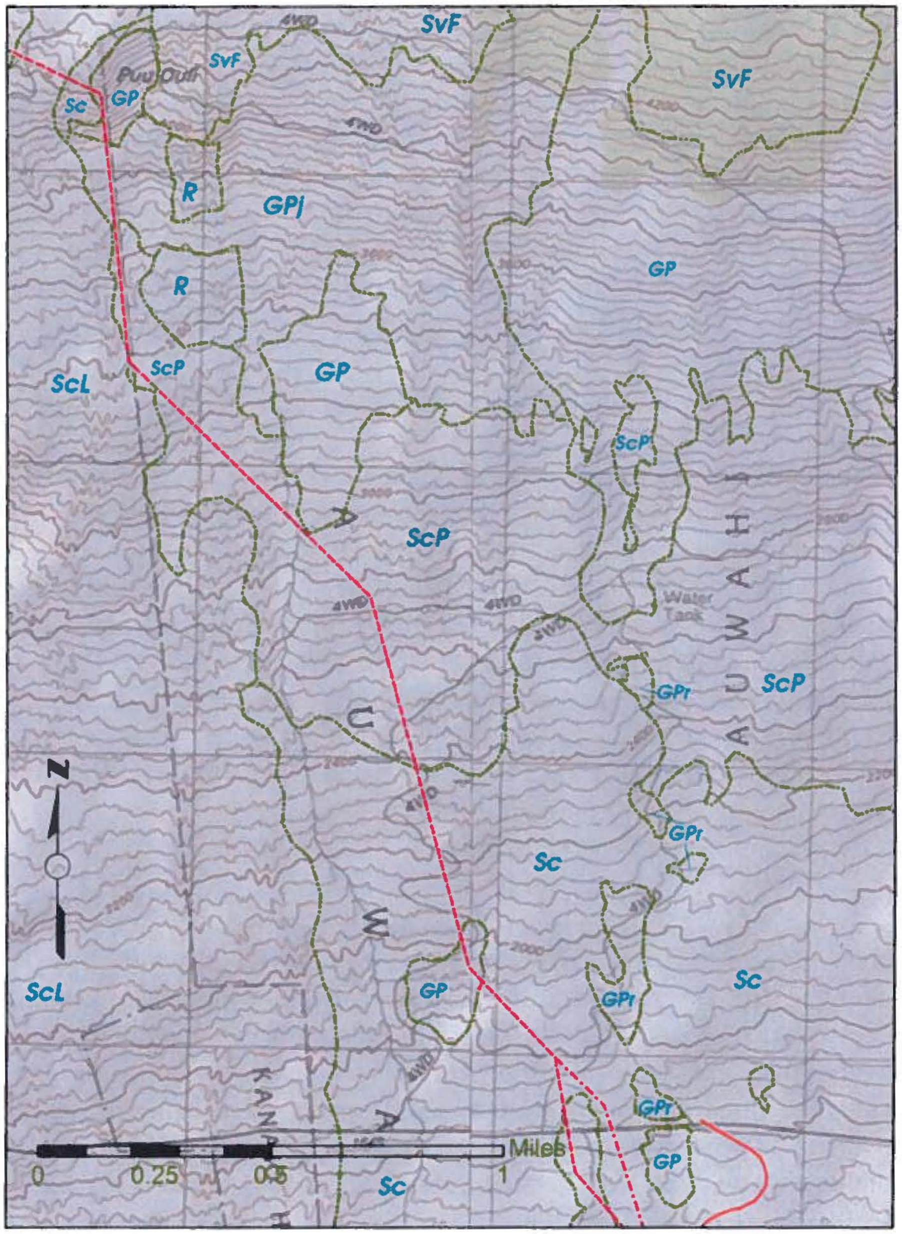

Figure 23. Vegetation zones for the eastern half of the generator tie-line (in red) crossing upland savanna and scrub pasture, scrub lands of 'Ulupalakua Ranch. For key see Table 6.

The following is from the HEAR website:

> *The first attempts at conservation at Auwahi were made in the late 1960's, when retired Territorial Forester Collin Lennox and The Nature Conservancy constructed a large exclosure[7] in an abortive restoration effort which unfortunately coincided with the invasion of the area by Kikuyu grass. USGS scientists (with National Park Service until 1993) began exploratory work, with the permission (and blessing) of the landowner, 'Ulupalakua Ranch, 19 years ago. A status report based on extensive field exploration in the early 1980s (Medeiros et al., 1986) called attention to continued deterioration of native vegetation on leeward Haleakalā and identified the Auwahi area as a prime area worthy of concerted conservation efforts.*

Table 7 is an "incomplete" list of plant species from the Auwahi "Reserve", East 'Ulupalakua Ranch (from the HEAR website)[8]. Federally listed species (USFWS, 2005) are indicated as either "threatened" (T) or "endangered" (E) in the final column. Non-native species have an asterisk (*) following the species name.

Table 7. Plant species from the Auwahi Reserve, East 'Ulupalakua Ranch

Scientific Name	*Common Name*	*Family*	*ST*
Alectryon macrococcus var. *auwahiensis*	*Mahoe*	Sapindaceae	E
Alphitonia ponderosa	*Kauila*	Rhamnaceae	
Alyxia oliviformis	*Maile*	Apocynaceae	
*Anagallis arvensis**	Scarlet pimpernel	Primulaceae	
*Anthoxanthum odoratum**	Sweet vernalgrass	Poaceae	
Argemone glauca	*Pua kala*	Papaveraceae	
*Asclepias physocarpa**	Balloon plant	Asclepiadaceae	
Asplenium adiantumnigrum	*Iwaiwa*	Aspleniaceae	
Bidens micrantha subsp. *kalealaha*	*Kookoolau*	Asteraceae	E
*Bidens pilosa**	Spanish needle	Asteraceae	
*Bocconia frutescens**	Tree poppy	Papaveraceae	
Carex wahuensis	Carex	Cyperaceae	
*Cerastium fontanum**	Common mouse-ear chickweed	Caryophyllaceae	
Chamaesyce celastroides var. *lorifolia*	*Akoko*	Euphorbiaceae	
Charpentiera obovata	*Papala*	Amaranthaceae	
Cheirodendron trigynum	*Olapa*	Araliaceae	
Cirsium vulgare *	Bull thistle	Asteraceae	
Claoxylon sandwicense	*Poola*	Euphorbiaceae	
Cocculus orbiculatus	*Huehue*	Menispermaceae	

[7] An "exclosure is a fencing intended to keep animals (typically grazing ungulates) out.

[8] The "Auwahi Reserve" is a project of the Auwahi Restoration Group, a coalition of private and public agencies spearheaded by the U.S. Geological Survey and 'Ulupalakua Ranch. It is located east of the generator tie-line corridor near the 4000-ft (1220-m) elevation.

Table 7 (continued)

Scientific Name	*Common Name*	*Family*	*ST*
Coprosma foliosa	*Pilo*	Rubiaceae	
Cyrtomium caryotideum	*Kaapeape*	Dryopteridaceae	
Diospyros sandwicensis	*Lama*	Ebonaceae	
Dodonaea viscosa	*Aalii*	Sapindaceae	
*Euphorbia peplus**	Petty spurge	Euphorbiaceae	
*Geranium homeanum**	Cranesbill	Geraniaceae	
*Holcus lanatus**	Yorkshire fog	Poaceae	
Korthalsella complanata	*Hulumoa*	Viscaceae	
*Kyllinga brevifolia**	Kyllinga	Cyperaceae	
*Lantana camara**	Lantana	Verbenaceae	
Lepisorus thunbergianus	*Pakahakaha*	Polypodiaceae	
Mariscus hillebrandii subsp. *hillebrandii*	*Mariscus*	Cyperaceae	
Melicope adscendens	Melicope	Rutaceae	E
*Melinis minutiflora**	Molasses grass	Poaceae	
*Melinis repens**	Natal red top	Poaceae	
Metrosideros polymorpha	*Ohia*	Myrtaceae	
Microlepia strigosa	*Palapalai*	Dennstaedtiaceae) (v. mauiensais	
Myoporum sandwicense	*Naio*	Myoporaceae	
Myrsine lanaiensis	*Kolea*	Myrsinaceae	
Myrsine lessertiana	*Kolea lau nui*	Myrsinaceae	
Nephrolepis sp.	Sword fern	Nephrolepidaceae	
Nestegis sandwicensis	*Olopua*	Oleaceae	
Nothocestrum latifolium	*Aiea*	Solanaceae	
Ochrosia haleakalae	*Holei*	Apocynaceae	
Osteomeles anthyllidifolia	*Ulei*	Rosaceae	
*Oxalis corniculata**	Yellow wood sorrel	Oxalidaceae	
Panicum nephelophilum	*Konakona*	Poaceae	
Panicum tenuifolium	Mountain pili	Poaceae	
*Passiflora subpeltata**	White passion flower	Passifloraceae	
Pellaea ternifolia	*Kalamoho*	Pteridaceae	
*Pennisetum clandestinum**	Kikuyu grass	Poaceae	
*Physalis peruviana**	Cape gooseberry	Solanaceae	
Pipturus albidus	*Mamaki*	Urticaceae	
Pleomele auwahiensis	*Halapepe*	Agavaceae	E
*Poa pratensis**	Kentucky bluegrass	Poaceae	
Pouteria sandwicensis	*Alaa*	Sapotaceae	
Psilotum nudum	*Moa*	Psilotaceae	
Pteridium aquilinum subsp. *decompositum*	Bracken fern	Hypolepidaceae	
Pteris cretica	Cretan brake	Pteridaceae	
*Rubus argutus**	Blackberry	Rosaceae	
Santalum ellipticum	*Iliahialoe*	Santalaceae	
Santalum freycinetianum var. *lanaiense*	*Iliahi*	Santalaceae	E
*Schinus terebinthifolius**	Brazilian pepper tree	Anacardiaceae	

Table 7 (continued)

Scientific Name	*Common Name*	*Family*	*ST*
*Sherardia arvensis**	Field madder	Rubiaceae	
Sicyos pachycarpus	Sicyos	Cucurbitaceae	
*Solanum americanum**	Glossy nightshade	Solanaceae	
*Solanum linnaeanum**	Apple of sodom	Solanaceae	
*Sonchus oleraceus**	Sow thistle	Asteraceae	
Sophora chrysophylla	*Mamane*	Fabaceae	
*Sporobolus indicus**	Smutgrass	Poaceae	
Streblus pendulinus	*Aiai*	Moraceae	
Styphelia tameiameiae	*Pukiawe*	Epacridaceae	
Tetraplasandra oahuensis	*Ohe mauka*	Araliaceae	
*Verbena litoralis**	Vervain	Verbenaceae	
Vicia sativa subsp. *nigra**	Common vetch	Fabaceae	
*Vulpia bromoides**	Brome fescue	Poaceae	
Xylosma hawaiiense	*Maua*	Flacourtiaceae	

Dry Shrubland

Dry shrubland (Figures 3, 25 and 26) occupies a majority of the southern flank of East Maui Volcano, and is thus the dominant vegetation type at the wind farm site as well as the generator tie-line route upslope from the wind farm site to the vicinity of the southwest rift zone (although above about 3000 feet, the area becomes more mesic in charascter). Dry shrubland also occurs along the construction access road. Shrubland is generally characterized by the dominance of shrubs, or low-growing woody plants. This vegetation type is mapped as ***Sc***. However, the shrubs may be dense and comprise the dominant vegetation, or they may be more scattered, with pockets of grassland or barren, rocky ground present or even prominent. In the latter case, typified on recent lava flows, coding is ***ScL***. In some area, rocky outcrops are mixed with areas of accumulated soil, resulting in a mixture of grasses and shrubs (mapped as ***ScP***) utilized as pasture. Shrubland typically develops where conditions (poor soil, low moisture, high salinity, etc.) are simply too harsh for trees to grow. Plant species that grow into trees in more hospitable locations may be present as low, scrubby growth in dry shrublands.

Dry shrubland or scrub (**Sc**) is the dominant vegetation type on the Auwahi wind farm site. Whereas native shrubs (such as *a'ali'i*) are not absent from the site flora, they are far less common than in Kanaio (to the west) or upslope of Pi'ilani Highway. At the wind farm site, *koa haole* (*Leucaena leucocephala*) is the overwhelming dominant species in this vegetation type (Figure 3). This species was reduced by drought conditions (in 2009-10) to scrubby, leafless trunks damaged by ungulate gnawing, although appears poised to recover quickly once rainfall returns to the area. An abundance of axis dear and goats ensure that seedlings of the widely scattered native plants have little chance of taking advantage of any drought-induced set-back to the non-native vegetation.

Figure 25. Dry shrubland on the southern flank of the East Maui Volcano.

Dryland Forest

Dryland forest is present near the coast in the Kīhei/Wailea area where the *kiawe* growth of the savanna gains a closed canopy . This *Kiawe* (*Prosopis*) Forest (Gagne and Cuddihy, 1990; see Figure 23, above) is considered a coastal dry forest type and mapped as ***Fk***. This forest occupies much of the undeveloped lowlands around Mākena and southward to the Kīna'u Peninsula, and is the forest encountered along the low elevation portion of the project construction access road and well downslope from the proposed generator tie-line route (west end). The forest has a closed to partially open canopy of *kiawe* trees with a dense growth of buffelgrass (*Cenchrus ciliaris*) covering the ground (by some definitions, this is not a forest, but a savanna. Nearly all of the components of this association are non-native, except for *'ilima* which can be locally abundant. Various shrubs may be present in low densities. The forest in the surveyed areas thins with increasing elevation, eventually becoming a savanna (Figure 22, above) not far upslope of Wailea. This transition occurs perhaps somewhere below 800 feet (200 meters) ASL west of the proposed generator tie-line route (see description of savanna, above), although extends much further upslope along the proposed construction access road where a mixed forest type (*kiawe/wiliwili/koa haole*; ***Fkw***) occurs (Figure 27). *Wiliwili* is also abundant in the wind farm area as scattered remnant forest pockets separated (typically) by extensive shrub vegetation (shrubland; ***Scw***).

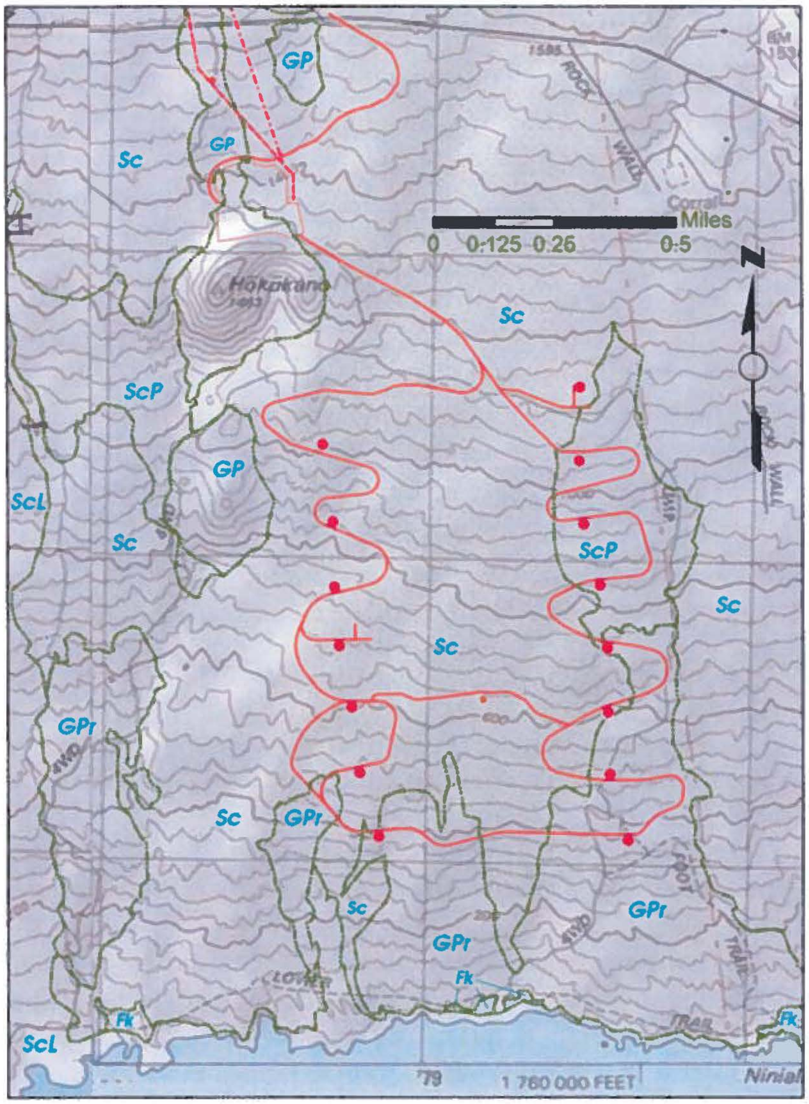

Figure 26. Vegetation zones for the Auwahi Wind Farm site. Scrub vegetation predominates on lava flows of various ages, with small areas of grassland pasture and very rocky pasture present in some areas. For key see Table 6.

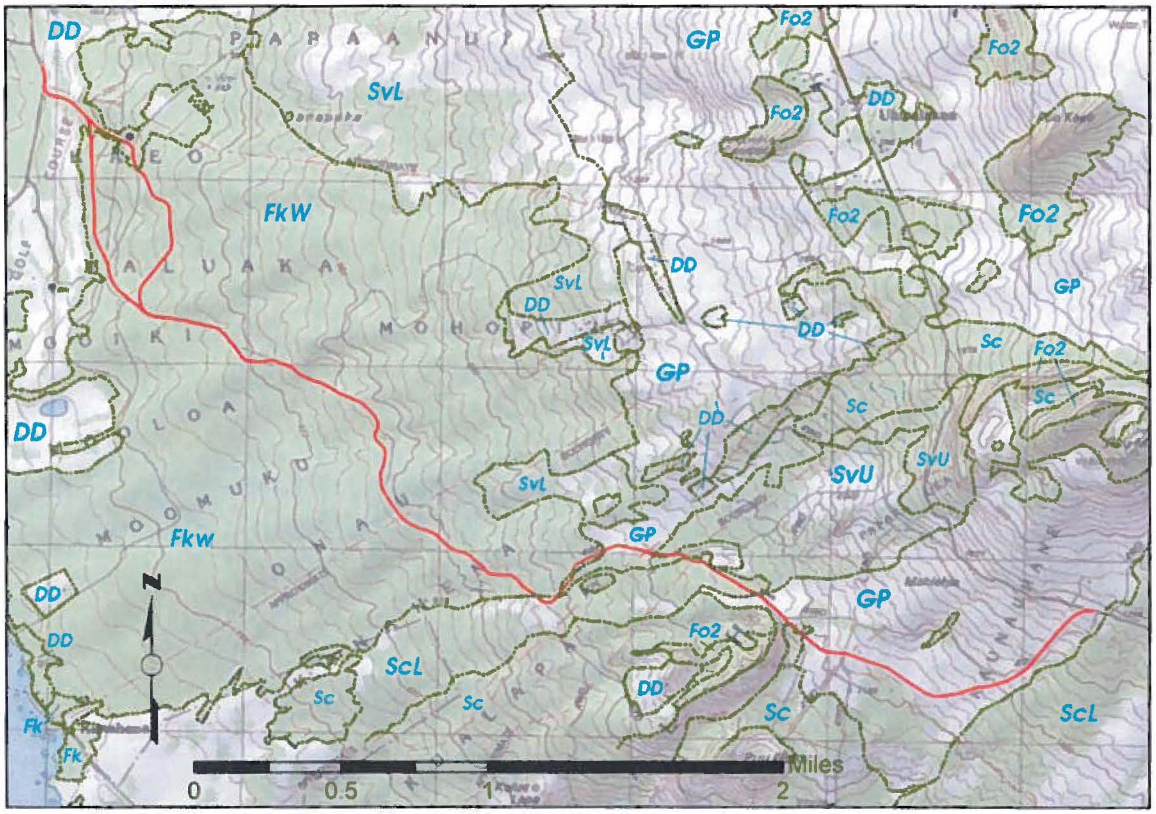

Figure 27. Vegetation zones for the construction access road (Papaka Road; in red) crossing mostly mixed kiawe/wiliwili forest and pasture of 'Ulupalakua Ranch. For key see Table 6.

Wiliwili (Erythrina) Forest is a vegetation type recognized by Gagne and Cuddihy (1990). The *wiliwili* is a summer deciduous tree and a Hawai'i endemic. This plant community type occurs on all the main islands, and is usually characterized by an understory of mixed native shrubs. This forest type is extensively degraded in most places where it occurs naturally on leeward slopes in the rain-shadow belt between about 1,000 and 5,000 feet (300 to 1,500 meters) in elevation (Gagne and Cuddihy, 1990). The prehistoric (pre-settlement) range of this dryland forest ecosystem on Maui covered vast areas of the lowland on West Maui, most of the Maui isthmus, and the west and south slopes of East Maui volcano to an elevation of around 5,000 ft (1,500 m).

The distribution of *wiliwili* forest ecosystem on East Maui in the general project vicinity is shown in Figure 28 (modified from Altenberg, 2007). The largest forest remnant recognized by Altenberg in this area is the "Kanaio" remnant. Next in size order are "Wailea 670," "La Perouse," and "Mākena." Only "Wailea 670" is entered by a project feature: the proposed construction access road near its western end. The large Kanaio remnant shown in Figure 26 lies roughly between the cinder cones, Pimoe and Hōkūkano, or within the western part of the Project site. Altenberg (2007, p. 5) points out: "the reason for the survival of *wiliwili* forest in the habitats that are left are believed to be due to their relative unsuitability for these causes: [fire, cattle grazing, buffelgrass, and kiawe]. The remnants are all on recent *'a'ā* lava flows whose soil cover is so sparse that it (1) produces an open canopy less able to propagate the fires that swept through many of these areas, (2) does not become choked with buffelgrass, and (3) is a rugged substrate discouraging to cattle." We recognized a similar theme for all of the vegetation in the Project impact areas: significant native vegetation growth is mostly on recent lava flows. For example, the Kanaio lava flow, through the Kanaio NAR, occurred only some 4070 years ago (Bergmanis, et al., 2000).

The remnant forest areas shown in Figure 28 are reportedly from a map by J. Price, and are described as "'areas of extent' rather than 'areas of occupancy'...in other words, the [green shapes] are meant to enclose scattered individuals in each of the populations rather than depicting contiguous forest filling each [shape area]." This description seems odd, since the actual distribution of *wiliwili* forest in this area is that of isolated trees and copses of crowded growth (Figure 28) and, we would suggest, far more extensive than shown, if one is attempting to enclose the distribution of the species on these slopes. This contention is validated by the *wiliwili* distribution surveys in relation to project elements that we made in 2010 (see Figures 16 and 17). On the other hand, the authors are familiar with the small forest remnant shown by Price behind (east and northeast of) Pu'u Ola'i at the coast labeled "Makena." A few *wiliwili* trees occur in this area, but more than half of the mapped area is dunes, wetland, golf course, houses, and kiawe forest. Thus, we might suggest that the scattered remnants of *wiliwili* along the proposed construction access road (and there are many) could be as significant as the areas mapped by Price (Altenberg, 2007) given that no density definition is provided or perhaps even implied by the latter. Our results would indicate, at least, that *wiliwil*i is far more common in this area than indicated by the Price map.

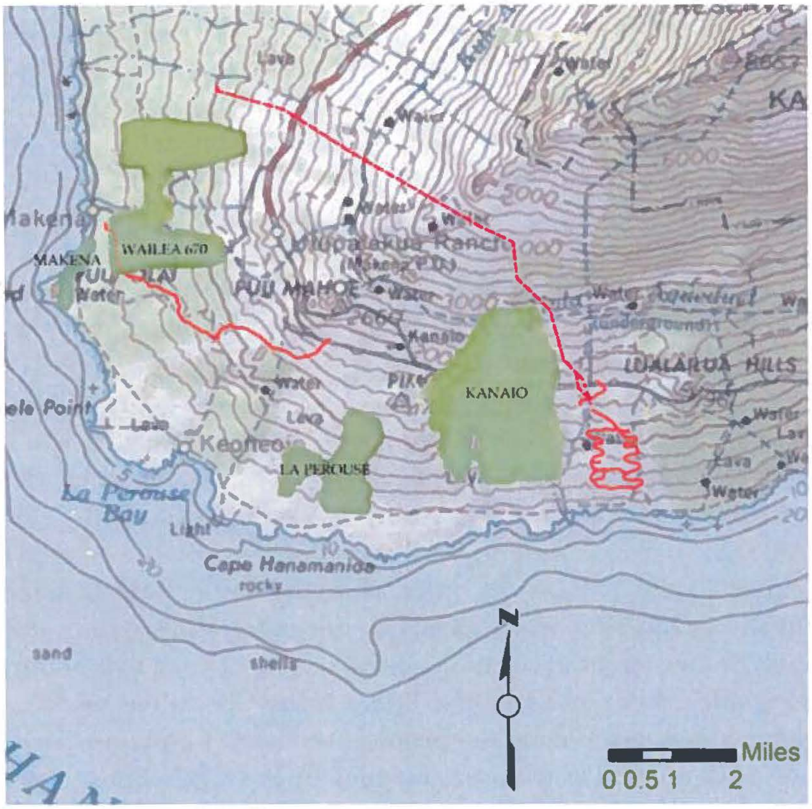

Figure 28. Wiliwili forest remnants (green areas) as mapped by Price (Altenburg, 2007) shown on a topographic map with Auwahi wind farm project elements in red.

Since 2005, an introduced insect (the Erythrina gall wasp, *Quadrastichus erythrinae*) has preyed exclusively on several *Erythrina* species in Hawai'i, killing most of the widespread ornamental species (*E. variagatis*, but not *E. crista-galli*) and agricultural windbreak species (*E. variegata* "Tropical Coral"), while severely damaging the native *wiliwili*. However, it appears that *E. sandwicensis* may not be as susceptible to the gall wasp as originally thought. The wasp appears to do most of its damage in the dry months, when *wiliwili* are without leaves. We noted that damage to *wiliwili* trees in the 'Ulupalakua Ranch lands appeared to be rather mild, and the trees were seen to be producing seeds, something that did not occur in 2006 (Art Medeiros, 2007). *Wiliwili* trees are abundant along the proposed construction access road, first appearing mixed in the lowland *kiawe* forest around the 200-foot (60-meter) contour and becoming increasingly numerous along the road as it climbs towards the quarry area at 800 feet (260 meters) west of Pu'u Naio. This forest area is generally degraded, although the *wiliwili* sometimes form dense copses with an understory of *'ilima* shrubs (Figure 29).

Although *wiliwili* is not a listed species and thus is not afforded legal protection, it represents an important component (so-called "keystone species") of the native dry forest, now considered by some to be the most endangered ecosystem in the Hawaiian Islands with less than 10% remaining statewide (HIARNG, 1999; Noss, LaRoe, and Scott, 2001). Our survey provides a detailed distribution of *wiliwili* along the construction road route (within the designated buffer). Although the impression from the maps (Figures 15 through 17) is one of numerous *wiliwili* in the path of the construction road, the width of the buffer (130 feet) was selected to provide leeway in designing roadway improvements and does not represent an area of actual impact. All of these *wilwili* trees are not threatened because road improvements will largely be within the footprint of the existing Papaka Road. Although this same reasoning applies with respect to the impact on *wiliwili* at the Auwahi Wind Farm site (Figures 5 through 9), proposed access roads follow existing ranch roads in only limited cases.

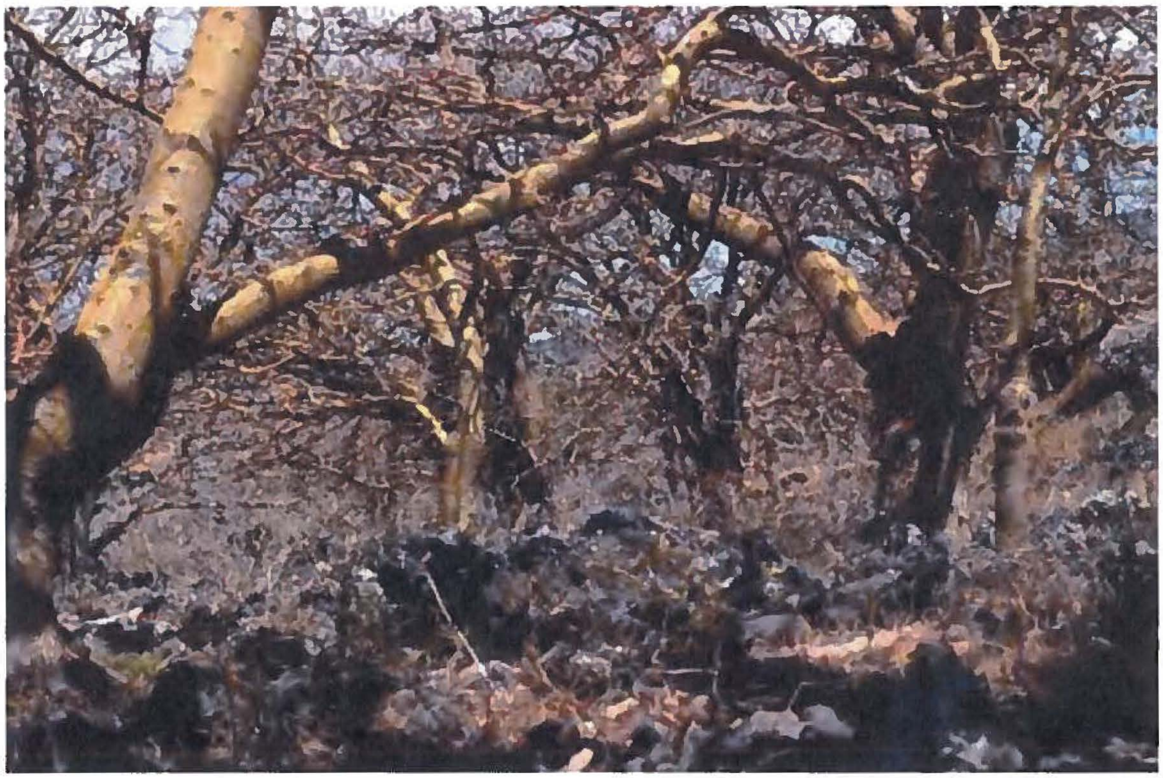

Figure 29. Inside a native *wiliwili* forest at the Auwahi Wind Farm site.

Listed Plant Species and Critical Habitat

The list of plants found in the Kanaio NAR and Auwahi Reserve (Table 7) represents recently documented occurrences of four of 70 listed (ESA) species historically found on the islands of Maui and nearby Kahoolawe (treated as a unit; USFWS, 2003a). The discussion here considers which of these 70 species might be in the general Project area and which have been documented or reported from the general Project area. Only one specimen of a listed plant was recorded in the areas surveyed (buffers) in 2010.

Both the Project area (wind farm and portion of generator tie-line) were part of "Maui H," an area of 34,843 ac (14,101 ha) of proposed critical habitat encompassing much of the western end of the south-facing slope of East Maui Mountain above about 900 ft (275 m). In a final determination (USFWS, 2003a), 'Ulupalakua and Haleakala Ranch lands were excluded from "Maui H". Units 09 and 13 in the final rule are east and west of the Project, respectively. Unit 13 is close to the proposed project; Unit 09 is not and therefore not discussed further.

Critical Habitat Maui Unit 13 encloses areas of designated critical habitat for 10 plant species: *Alectryon micrococcus, Bonamia menziesii, Cenchrus agrimonioides, Colubrina oppositifolia, Flueggea neowawraea, Melicope adscendens, M. knudsenii, M. mucronulata, Sesbania tomentosa,* and *Spermolepis hawaiiensis.* The unit is roughly in the form of a right triangle, with its base along the 900-foot (275-meter) contour, the vertical leg rising along the mountain slope to Pu'u Ouli at about 4000 feet (1,200 meters) ASL, and the hypotenuse through Kanaio. The eastern boundary of this area is the parcel boundary as shown in Figure 1[9]. Thus, the designated area includes, at its upper end, the Kanaio NAR site and is west of the proposed wind farm site and generator tie-line route. USFWS provides boundary points for subareas within Unit 13, but not the unit itself (USFWS, 2003a). However, from the maps provided at the critical habitat web data site (USFWS, 2011) and using the boundary points for *M. mucronulata* published by USFWS (2003a), the top of Unit 13 (the highest and northernmost two points) runs west from the Kanaio-Auwahi boundary at the 4000-foot elevation to almost the 4100-foot elevation[10], possibly corresponding with the upper boundary of the Kanaio NAR in this location. Therefore it is the case that the generator tie-line route, as shown in Figure 10, is always either east of or upslope of the unit. Unit 13 is also critical habitat for Blackburn's sphinx moth (USFWS, 2003b).

Seven of the plants with designated habitat areas in Unit 13 are shrubs or trees known from the dry to mesic native forest at higher elevations (i.e., Auwahi and Kanaio). The trees, *Colubrina oppositifolia* and *Flueggea neowawraea*, are presently not known to occur in Unit 13. Of the three species of *Melicope* (=*Pelea*), only a single individual of *M. adscendens*, a sprawling shrub, is known from Unit 13. Thirteen individuals of the small shrub, *'ohai* or *Sesbania tomentosa*, are known from Unit 13 on Pimoe and Pohakea cinder cones (at around 1200 feet [370 meters] elevation, west of the Auwahi Wind Farm site).

Cenchrus agrimonioides is a grass found on dry, rocky slopes. It is a moderately large, coarse grass, distinctive in form, and would be recognizable in the dry season if not heavily grazed by ungulates. Two of the listed species might not be observed if surveyed for during an extended dry period. *Bonamia menziesii* is a liana (a perennial, woody vine) found in dry to mesic forests. A few plants are known from the Kanaio NAR, but this plant could occur in the lowland dry *wiliwili* forest. *Spermolepis hawaiiensis* is an annual herb that would be difficult to observe in the dry season or during drought conditions, but has a known population of about 100 individuals in the Kanaio NAR, lowland dry shrubland (USFWS, 2003a).

[9] Being also the traditional boundary between the moku of Honoa'ula and moku of Kahikinui, and the boundary between the *ahupua'a* of Kanaio and "A'uahi" (Bordner, 1995) shown in Figures 10 and 11.
[10] This upper boundary would be located roughly midway between the ranch road at the base of Pu'u Ouli and the ranch road near the top of Pu'u Ouli.

Two listed species recorded from the Auwahi Reserve (Table 7), *Bidens micrantha* ssp. *kalealaha* and *Santalum freycinetianum* var. *lanaiense,* do not have designated critical habitat areas in Unit 13. *B. micrantha* is a perennial herb and has a critical habitat area within Unit 09, where a very few plants still exist. Unit 09 is located well east of both the generator tie-line route and the Auwahi Reserve. The rare variety of sandlewood known as the *Lāna'i 'iliahi* (*S. freycinetianum* var. *lanaiense*) has no critical habitat designated and recovery efforts are focused on the Lāna'i Island population (USFWS, 2009). Several hundred individuals of this listed variety are known from Auwahi (Medeiros, Davenport, and Chimera, undated). A single shrub-like individual was recorded within the generator tie-line buffer at a little above 3,100 feet (945 meters) ASL (see Figure 12 for location).

Stream and Wetland Resources

Although final determination rests with the local District Engineer, in our judgment, no aquatic features within the definitions of wetlands and streams subject to USACE jurisdiction are present on the project property or vicinity, and thus none would be impacted by the proposed project. USFWS (2010b) maps show no wetlands within or close to project areas.

Avian Resources

The findings of the avian survey are consistent with the habitat present within the three component parts of the proposed project. A total of 23 avian species were recorded during station counts (Table 4). Two additional species, Chukar (*Alectoris chukar*), and Barn Owl (*Tyto alba*) were recorded as incidental observations. We were a little surprised at the number of Barn Owls we saw; we recorded 27 sightings over the course of nine evenings. All but one of the species detected, Short-eared Owl, are considered to be alien to the Hawaiian Islands. No species currently listed as endangered, threatened or proposed for listing under either federal or State of Hawaii endangered species statutes was recorded during the course of this survey.

No indigenous migratory species were recorded during the course of this survey, which is not surprising since the surveys were conducted in June, a time of year when almost all of the regularly occurring indigenous migratory shorebird species normally encountered in Hawai'i are not present. It is likely that several migratory shorebird species are present on the site between late July and late April each year. The most likely species to be expected are Pacific Golden-Plover (*Pluvialis fulva*), Ruddy Turnstone (*Arenaria interpres*), and Wandering Tattler (*Tringa incana*). All of these species are commonly encountered in Hawai'i during the fall and winter months – they all nest in the high Arctic during the late spring and summer months, returning to their wintering grounds in Hawai'i, Japan, Okinawa, Polynesia, Micronesia, Melanesia, New Zealand, Australia, Indonesia, Philippines, southern China, southeast Asia, Bangladesh, Nepal, India, Sri Lanka, Pakistan, Iran, Bahrain, and northeast and southern Africa (Johnson and Conners 1996). Wintering birds usually leave Hawai'i for their trip back to the Arctic in late April or the very early part of May, and return to their wintering grounds in late July. Some individuals overwinter in Hawai'i, and thus are present all year.

It was beyond the scope of these surveys to conduct nocturnal surveys for two listed pelagic seabird species known to occur on Maui. The two species in question are the endangered Hawaiian Petrel, and the threatened endemic sub-species of the Newell's Shearwater, both of which likely over-fly the project area between April and the end of November each year.

Mammalian Resources

The findings of the mammalian survey are consistent with the habitats present within the three component parts of the Project. As previously mentioned, we detected 11 mammalian species during the course of these surveys. Although we did not encounter any Hawaiian hoary bats, Hawaiian hoary bats have been seen within the general area in low numbers over the years (Erdman, 2007), and would be expected to use resources within the Project site on a seasonal basis. However, considering the xeric conditions, relatively little use of the wind farm site by this species would be anticipated.

We saw one roof rat and one European house mouse within the study area. It is to be expected that the other two established rodent species present on the Island of Maui, Norway rat (Rattus norvegicus) and Polynesian rat (Rattus exulans hawaiiensis), use resources within the Project area on a seasonal basis. All of these introduced rodents are deleterious to remaining native ecosystems and the native floral and faunal species that are dependent on them for their survival.

As expected on an active cattle ranch, we encountered large numbers of cows, lesser numbers of horses, and several dogs, including two pit bulls that were seen harassing cattle on the wind farm site. We also encountered large numbers of axis deer and several large herds of goats, including one herd of over 150 animals. Habitats on the wind farm site and the land immediately mauka of Pi'ilani Highway clearly show the effects of the large number of both domestic and feral ungulates present within this extremely xeric setting.

Conclusions

Botanical Resources

The lands proposed for development of the Auwahi Wind Farm are floristically degraded grass and shrublands utilized as pasture for cattle, yet still harboring scattered remnants of the native forest and shrublands that occupied the area a little more than a century ago. It is evident that much of the preservation of the native flora is the result of the complex geology, and the presence of relatively recent volcanic activity that has occurred along the southwest rift zone of East Maui Mountain. In places at higher elevations crossed by the proposed generator tie-line, the remnant mesic forest is invaded by alien plants, but reasonably intact, supporting a high diversity of indigenous and endemic species found in few other places in the Islands.

Adherence to improving existing roads, to the extent possible, will minimize impacts to botanical resources. New roads will need to be put in to reach the wind turbines distributed across the Wind Farm site. With the exception of the many copses of wiliwili, which should be avoided to the extent possible, other natives on the site are few, being very scattered remnants of a native ecosystem that no longer exists at this location. No listed plant species are known from the Auwahi Wind Farm site.

The proposed improvements to the existing Pua Pala (or Papaka) Road between Wailea and Pi'ilani Highway (construction access road) will have no impact on protected species, as none was observed, nor are any known, from the route. However, three species of interest occur in this area: wiliwili, maiapilo, and tree tobacco.

With respect to the generator tie-line route, one listed species of plant (Santalum freycinetianum var. lanaiense) was observed within the buffer area. Although a detailed survey of the pasture and savanna on the western slope of East Maui Mountain was not undertaken in 2010, the 2007 survey revealed this area to have no potential for harboring listed plant species and only a small area on a recent lava flow (actually on the rift zone) around 4,100 feet (1250 meters) ASL where native plants were even recorded.

The same conclusion with respect to listed species applies to the proposed generator tie-line route between the Auwahi Wind Farm site and about the 3000-foot (900-meter) elevation on the south slope of the mountain. However between 3000 feet (900 meters) and 4000 feet (1200 meters) ASL the route passes through remnant native montane forest and shrubland known to support several listed species of plants (see Table 7). The mapping of individual native trees within this area (Figures 10 and 11) will allow placement of generator tie-line poles and grading of access roads to avoid both listed species and native trees that are important components of the montane "forest" ecosystem. Several ranch access roads already occur in the area, minimizing the need for substantial grading of additional roads.

Avian and Mammalian Resources

Faunal resources detected during the course of these surveys were predominately alien or non-native. These findings were to be expected given the habitat present in the majority of the three main component parts of the Project. We observed only one native avian species, and no bats.

Potential Impacts to Protected Species

Lāna'i 'iliahi

As noted above, only a single individual of a listed plant species (in this case a subspecies of sandalwood, *S. freycinetianum* var. *lanaiense*) was recorded from within the buffers established for the 2010 survey. The single, *Lāna'i 'iliahi* was recorded from the generator tie-line route (see Figure 12) and the subspecies is known from the area (Mederios et al., undated). An impact on this plant can be avoided by not placing either an access road or a support pole in the vicinity of the plant. However, in view of the fact that security from ungulate browsers could be compromised by proposed changes in the Kanaio NARS fence location, it is recommended that a separate exclosure be built around the plant.

Hawaiian Hoary Bat

As previously discussed, it is likely that Hawaiian hoary bats occasionally use resources in the general Project area on a seasonal basis. What impacts a wind generation facility would have on this listed species are not known. Within the continental U. S., hoary bats (*Lasiurus cinereus*), a sister species of the native bat, have been recorded being taken by wind turbines (Arnett et al., 2008).

Hawaiian Petrel and Newell's Shearwater

Wind turbines have the potential to take Hawaiian Petrels and Newell's Shearwaters; one Hawaiian Petrel has been taken by another wind farm on Maui in 2007 (William Standley, USFWS personal communication, 2007). It is beyond the scope of these surveys to address the potential threat that the proposed Project poses to either of these listed pelagic seabird species.

Recommendations

- Due to the potential for Hawaiian Petrels, or possibly Newell's Shearwaters, within the general Project area, if exterior lighting is installed in conjunction with the Project, it is recommended that lights be shielded to reduce the potential for interactions of nocturnally flying birds (Reed et al., 1985; Telfer et al., 1987).
- While no known listed species were identified on the Auwahi Wind Farm site, a number of large native trees (including *wiliwili* forest remnants) exist. These areas should be avoided to the extent possible.
- Plant species mapping for the segment of the generator tie-line route passing through the native mesic forest and/or shrubland below Pu'u O'uli should be consulted to minimize or avoid impacts to rare native plant species. At least one

individual of a listed species (a subspecies of *'iliahi*) was recorded in the area and must be suitably protected from generator tie-line construction impacts; a separate ungulate exclosure fence should be constructed around this sandalwood individual.

- Replanting of selected native plant species characteristic of the Auwahi/Kanaio area is highly recommended for locations where replanting may be required to mitigate impacts or for landscaping at the wind farm site. The lowland (windfarm site) species—notably *'a'ali'i* (*Dodonaea viscosa*), *naio* (*Myoporum sandwicense*), *'iliahi* (*Santalum ellipticum*), *alahe'e* (*Psydrax odorata*), and *wiliwili* (*Erythrina sandwicensis*)—are easily grown from seed or obtained from local nurseries and adapt well to landscape use. Once established, these plantings should require no or minimal watering. Native plant nurseries on Maui could also supply *hao* (*Rauvolfia sandwicensis*), *'ohe makai* (*Reynoldsia sandwicensis*), and *'akia* (*Wikstroemia oahuense*), providing additional interest and support for a variety of native trees, but these species are not widely used in landscaping. There are many herbaceous natives that do well in xerophytic situations that could be used to complement the landscaping at the site.

Glossary

'A'ā– Clinker lava formed by slow moving lava flows
Ahupua'a – Traditional Hawaiian land division, usually extending from the uplands to the sea.
Alien – Introduced to Hawai'i by humans.
Crepuscular – Twilight hours.
Edaphic – Produced by, or influenced by the soil
Endangered – Listed and protected under the Endangered Species Act of 1973, as amended as an endangered species.
Endemic – Native and unique to the Hawaiian Islands
Incidental observation – A species not counted during station counts, but seen within the project area.
Indigenous – Native to the Hawaiian Islands, but also found elsewhere naturally.
Kīpuka – An oasis in a lava flow usually containing vegetation, often a refugia for native species
Mauka – Upslope, towards the mountains.
Makai – Down-slope, towards the ocean.
Mesic - Neither very wet nor very dry with respect to the needs of the plant life.
Naturalized – An alien organism that has become established in an area that it is not native to over time, without further human assisted releases or plantings.
Nocturnal – Night-time, after dark.
Orographic – In this case the effects of mountains in forcing moist air to rise
Pelagic – An animal that spends its life at sea – in this case seabirds that only return to land to nest and rear their young.
Physiographic – Physical geography
Ruderal – Disturbed, rocky, rubbishy areas, such as old agricultural fields and rock piles.
Threatened – Listed and protected under the ESA as a threatened species.
Volant – Flying, capable of flight, as in flying insect.

DLNR – Hawaii State Department of Land & Natural Resources.
DOFAW – Division of Forestry and Wildlife
ESA – Federal Endangered Species Act of 1973, as amended.
GPS – Global Positioning System
MECO – Maui Electric Company
NARS – State of Hawaii, Natural Area Reserves System
USFWS – United States Fish & Wildlife Service.

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Appendix B
Auwahi Wind Project Revegetation Potential Plant List

Auwahi Wind Project Revegetation Potential Plant List	
Common Name	***Scientific Name***
Trees	
wiliwili	*Erythrina sandwicensis*
'iliahialo'e	*Santalum ellipiticum*
'ohe makai	*Reynoldsia sandwicensis*
alahe'e	*Canthium odoratum*
'akoko	*Chamaesyce celastroides*
naio	*Myoporum sandwicense*
hao	*Rauvolfia sandwicensis*
'aiea	*Nothocestrum latifolium*
koai'a	*Acacia koai'a*
keahi	*Nesoluma polynesicum*
lama	*Diospyros sandwicensis*
Shrubs	
'a'ali'i	*Dodonaea viscosa*
kulu'ī	*Nototrichium sandwicense*
'aweoweo	*Chenopodium oahuense*
maiapilo	*Capparis sandwichiana*
pua kala	*Argemone glauca*
'uhaloa	*Waltheria indica*
kolomona	*Senna gaudichaudii*
unknown	*Achyranthes splendens*
ma'o	*Gossypium tomentosum*
'akia	*Wikstroemia monticola*
Grasses	
pili	*Heteropogon contortus*
mountain pili	*Panicum tenufolium*
kawelu	*Eragrostis variabilis*
Guinea grass	*Panicum maximum*
Bufflegrass	*Pennisetum ciliare*
	Paspalum sp.
Ground Layer	
nehe	*Lipochaeta lavarum*
'ilihe'e	*Plumbago zeylanica*
'ilima	*Sida fallax*
'ala'ala wai nui	*Peperomia leptostachya*
'ulei	*Osteomeles anthyllidifolia*
'Āwikiwiki	*Canavalia pubescens*

List of Candidate Tree Species for the Waihou Mitigation Area	
Common Name	***Scientific Name***
'Ohia lehua	*Metrosideros polymorpha**
Koa	*Acacia koa**
'A'ali'i	*Dodonaea viscosa**
Kōlea lau nui	*Myrsine lessertiana**
Ulei	*Osteomeles anthyllidifolia***
'Ōlapa	*Cheirodendron trigynum***
Naio	*Myoporum sandwicense***
Māmane	*Sophora chrysophylla***
Maua	*Xylosma hawaiiense***
'Ohe mauka	*Polyscias oahuensis* (formerly genus *Tetraplasandra*)***
'Ohe 'ohe	*Polyscias kavaense* (formerly genus *Tetraplasandra*)***
Kawa'u	*Ilex anomala****
Pilo	*Comprosma foliosa vontempsky****
Olomea	*Perrottetia sandwicensis****
Ha'iwale	*Cyrtandra sp.****
'Opuhe	*Urera glabra****

*Will be most prevalently planted species

**Secondly most planted species

***Dependent upon availability and viability of seeds

Appendix C
Auwahi Wind Farm Fire Management Plan

Auwahi Wind Farm Project Fire Management Plan

Prepared by:

Center for Environmental Management of Military Lands
Colorado State University

on behalf of:

Auwahi Wind Energy LLC

February, 2011.

Executive Summary

Auwahi Wind Energy, LLC (Auwahi Wind Energy) has proposed constructing and operating a wind farm, generator tie-line, an interconnection substation and associated infrastructure on lands owned by Ulupalakua Ranch on the Island of Maui. Adding wind turbines, electrical and other infrastructure, and additional human presence all potentially increase the fire risk. Implementation of this Fire Management Plan (FMP) is intended to mitigate this fire threat.

The FMP analyzes available pertinent information including fuel conditions, weather and climate conditions, fire history of Maui, terrain, firefighter access, and other factors. Through a program of engineering, maintenance, and fuels management, the fire risk posed by the Auwahi Wind Farm and the associated infrastructure can be mitigated to acceptable levels. Mitigation measures include education of Auwahi Wind Farm employees of the fire risk, standard regular maintenance of all wind turbine and electrical components, fuels reduction in high priority areas via grazing, construction of firebreaks in high priority areas, and construction of a water source for aerial resources and ground based firefighters near high priority areas. The FMP also establishes the responsibilities of each stakeholder.

I hereby acknowledge that I understand the contents of this FMP and agree to implement the provisions herein:

____ Date: __________
Name
Auwahi Wind Energy

____ Date: __________
Sumner Erdman
President
Ulupalakua Ranch

____ Date: __________
Name
Construction Manager
Company Name

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List of Figures

List of Tables

List of Acronyms

CFPA	Confederation of Fire Protection Associations
DLNR	Department of Land and Natural Resources
DHHL	Department of Hawaiian Homelands
DOFAW	Division of Forestry and Wildlife
EIS	Environmental Impact Statement
FMP	Fire Management Plan
IC	Incident Commander
ICS	Incident Command System
LHWRP	Leeward Haleakalā Watershed Restoration Partnership
NAR	Natural Area Reserve
ac	Acres
ch/hr	Chains per hour
ha	Hectares
in	Inches
gal	Gallon
gal/min	Gallons per minute
g/m^2	Grams per square meter
km	Kilometers
l	Liters
l/min	Liters per minute
m	Meters
MECO	Maui Electric Company
mi	Miles
Mg/ha	Megagrams per hectare
mph	Miles per hour
mm	Millimeters
m/min	Meters per minute
m/s	Meters per second
t/ac	Tons per acre

Agencies and Organizations Contacted

Auwahi Wind Energy
Leeward Haleakala Watershed Restoration Partnership
Maui County Fire Department
Maui Electric Company
State of Hawaii Department of Land and Natural Resources Division of Forestry and Wildlife
Tetratech International
Ulupalakua Ranch
United States Air Force Combat Climatology Center
United States Fish and Wildlife Service, Pacific Islands
Wailea Fire Department
Western Regional Climate Center

1. Introduction

1.1.Setting

The Auwahi Wind Farm Project, as proposed by Auwahi Wind Energy, consists of the following elements: the wind farm site, the generator tie-line, the interconnection substation, and reconfiguration of Papaka Road. The project will be located primarily on private property, the majority of which is owned by Ulupalakua Ranch (Figure 1). The wind farm site is located entirely on land owned by Ulupalakua Ranch. The wind farm will consist of 8 to 15 wind turbines. The generator tie-line is also located on Ulupalakua Ranch property, although it crosses Pi'ilani Highway, which is within a Maui County easement, and Kula Highway, which is owned by the State. The generator tie-line will be 14.4 kilometers (km) (9 miles (mi)) in length. The interconnection substation is sited on Ulupalakua Ranch property at the terminus of the generator tie-line. Papaka Road will be used to transport construction materials and crosses a total of 14 parcels, most of which are owned by Ulupalakua Ranch. Four of the parcels are jointly owned by Ulupalakua Ranch and the State, one is jointly owned by Ulupalakua Ranch and another private party, and two are owned entirely by ATC Makena Holdings, LLC. Papaka Road is 7.4 km (4 mi) in length.

Areas to be developed include a wind farm site, generator tie-line corridor, interconnection substation site, facilities infrastructure, and roadway improvements for construction access. Development areas span an array of vegetation types and moisture regimes. The wind farm site and the interconnection substation site are characterized by low moisture and introduced perennial grasses. The generator tie-line corridor traverses varying moisture regimes ranging from roughly 500 millimeters (mm) (20 inches (in)) to almost 1,000 mm (39 in) annually that support introduced perennial grasslands, introduced deciduous shrublands, introduced dry forest, and small patches of native subalpine dry shrublands. Papaka Road traverses very dry moisture regimes at low elevation populated by introduced perennial grasslands, introduced deciduous shrublands, and introduced dry forest. Elevation ranges from approximately 180 meters (m) (591 feet (ft)) at the wind farm site to roughly 1,200 m (3,937 ft) at the highest point of the generator tie-line corridor, then back down to approximately 180 m at the interconnection substation site. The western end of Papaka Road lies at 23 m (75 ft). Topography varies widely across the sites to be developed as the volcanic lava origins have created diverse micro-topographies, but overall, slopes vary from 10% to over 40%.

1.2. Stakeholders

1.2.1. Auwahi Wind Energy

Auwahi Wind Energy is the proponent of the wind farm project and is responsible for its construction, operations, and maintenance. Auwahi Wind Energy is also responsible for implementation of this Fire Management Plan (FMP). Auwahi Wind Energy will work in coordination with Ulupalakua Ranch to ensure the fire mitigation measures identified by this FMP are properly implemented.

1.2.2. Ulupalakua Ranch

Ulupalakua Ranch owns the land on which the wind farm, the interconnection substation, and most of the generator tie-line will be built. Ulupalakua Ranch will work in coordination with Auwahi Wind Energy to maintain fire mitigation measures defined by this FMP.

1.2.3. State of Hawai'i Department of Land and Natural Resources

The State of Hawai'i Department of Land and Natural Resources (DLNR) manages land adjacent to Ulupalakua Ranch and a small portion of land adjacent to the proposed generator tie-line including an adjacent Natural Area Reserve (NAR). This land could potentially be affected in the unlikely event of a wildfire.

1.2.4. State of Hawai'i Department of Hawaiian Homelands

The State of Hawai'i Department of Hawaiian Homelands (DHHL) owns considerable acreages of land to the east of the project area. Though highly unlikely, it is possible this land could be affected by a wildfire.

1.2.5. Leeward Haleakalā Watershed Restoration Partnership

The Leeward Haleakalā Watershed Restoration Partnership (LHWRP) has worked closely with Ulupalakua Ranch to establish two restoration areas on Ulupalakua Ranch Property. A great deal of time and effort has been expended to plant trees, remove non-native species, and collect native seeds in these areas (LHWRP 2010). They both could potentially be affected in the unlikely event of a wildfire.

1.2.6. Neighboring Private Land Owners

A number of privately owned land parcels could potentially be affected in the unlikely event of a wildfire. The largest of these parcels are owned by Haleakalā Ranch to the north of Ulupalakua Ranch and WCPT/GW Land Associates LLC to the west.

1.3.Goals and Objectives

The goal of this FMP is to successfully mitigate the fire risk posed by construction and operation of the Auwahi Wind Farm through a program of engineering, fuels management, and pre-suppression fire fighting coordination, including the risk to federally and state-protected species.

The objectives of this plan are:

1. Use engineering and maintenance of the wind farm infrastructure and generator tie-line to limit fire ignitions from the wind farm infrastructure to an average of less than one per decade.
2. Use best management practices to minimize the probability of ignitions during construction.
3. Limit potential fire spread to less than 6.7 meters per minute (m/min) (20 chains per hour (ch/hr)) under 90th percentile weather and fuel conditions at the "pinch point" where the generator tie-line passes through a narrow area between the NARS land and the Auwahi Forest Restoration Project.
4. Within the generator tie-line pinch point, create a series of firebreaks and implement fuels management to prevent fire spread into the NAR and the Auwahi Forest Restoration Project under 90th percentile weather and fuel conditions.

1.4.Fire Management Plan Updates

This FMP shall be updated annually from the time construction of the Auwahi Wind Farm begins to its completion. After construction is completed, this FMP shall be updated once every five years throughout the life of the Auwahi Wind Farm. The FMP shall also be reviewed after every fire and updated as necessary to incorporate lessons learned.

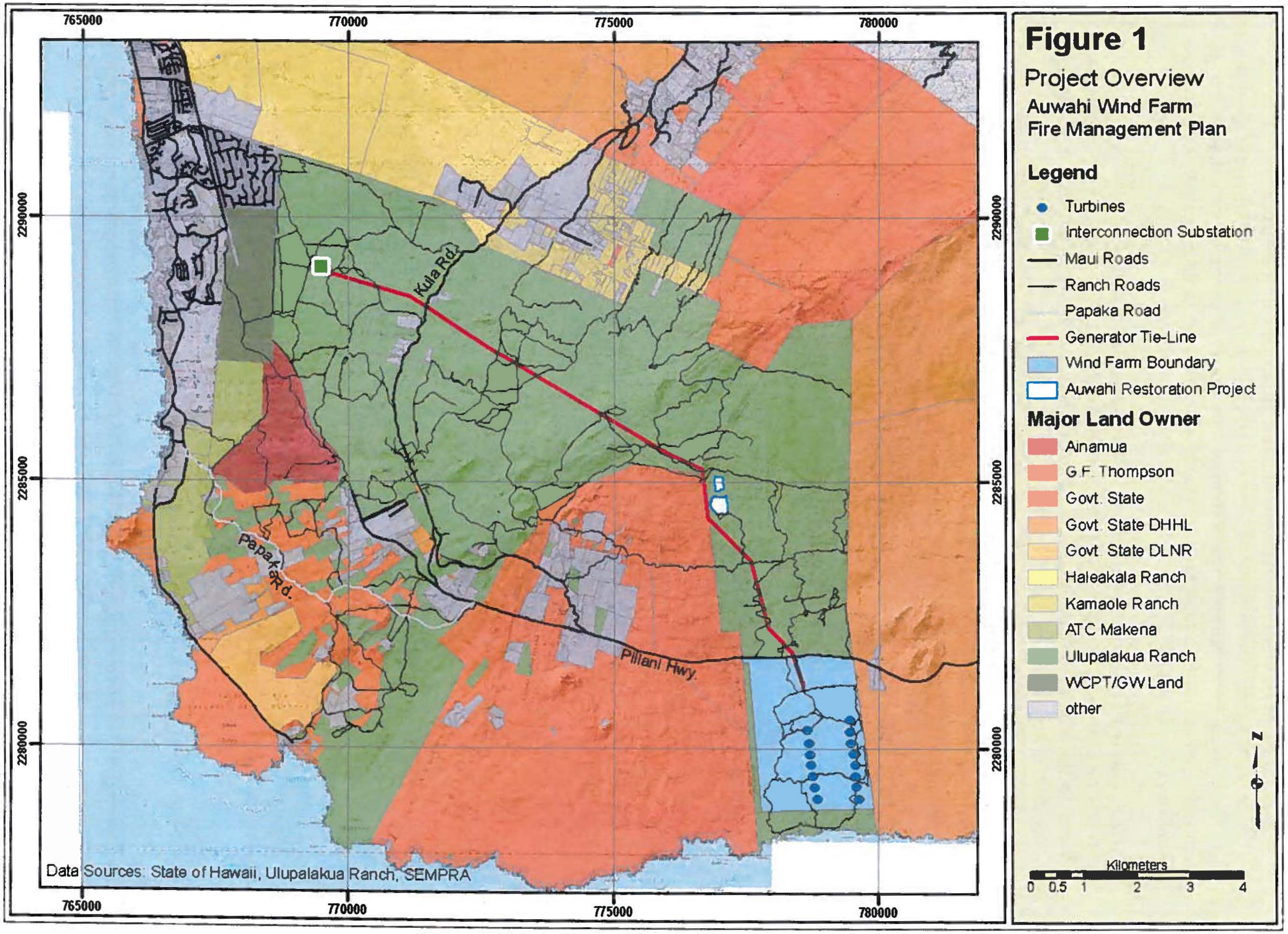


Figure 1
Project Overview
Auwahi Wind Farm
Fire Management Plan
Legend
Turbines
Interconnection Substation
Maui Roads
Ranch Roads
Papaka Road
Generator Tie-Line
Wind Farm Boundary
Auwahi Restoration Project
Major Land Owner
Ainamua
G.F. Thompson
Govt. State
Govt. State DHHL
Govt. State DLNR
Haleakala Ranch
Kamaole Ranch
ATC Makena
Ulupalakua Ranch
WCPT/GW Land
other
Kilometers
0 0.5 1 2 3 4
765000
770000
775000
780000
2290000
2285000
2280000
Kula Rd.
Papaka Rd.
Piilani Hwy.
Data Sources: State of Hawaii, Ulupalakua Ranch, SEMPRA

2. Data Analysis

2.1. Weather

The areas to be developed span a wide range of elevations, each with their own weather conditions. Climate data does not exist for all areas within the project area. However, there are weather stations in the areas of interest that provide sufficient climate data for the scope of this plan. Areas of focus are the wind farm site, the pinch point along the generator tie-line, and the power interconnection substation. Available weather station data was utilized to provide insights into climatic variables that affect fire.

Period of record data was acquired for a number of weather stations within and near the project areas. Only two of these provided a full suite of meteorological data. Given that weather conditions, particularly moisture regimes, change substantially over very short distances in Hawai'i, this leaves some room for uncertainty in the weather conditions that occur throughout the project area. However, the critical locations of the pinch point and wind farm site are well documented, though periods of record are short, meaning long term trends and annual variability remain unknown.

Wind monitoring heights varied between stations. We used corrective factors to adjust for wind friction with surface features and vegetation to give estimates of wind speeds at 6.09 m (20 ft), a standard height used for most fire weather observations.

2.1.1. Wind Farm Site

The wind farm site includes a meteorological tower (hereafter 'met tower') that holds instrumentation at 30 m (98 ft) and 48 m (157 ft) above the ground. The met towers are primarily designed to measure various wind attributes and they do not record relative humidity. We utilized wind and temperature data from the 30 m height from the 'Maui 3' met tower.

Temperature is relatively constant throughout the year (Figure 2). Winds are strongly dominated by the easterly trade winds with wind blowing directly from the east over 40% of the time (Figure 3). Winds from the west are exceedingly rare.

2.1.2. Pinch Point

A weather station maintained by the University of Hawai'i has been in place within the Auwahi Forest Restoration Project since 2001. This station is ideally located to provide weather information for the pinch point along the generator tie-line (Figure 6). The station stands approximately 2 m (6.6 ft) and records a full array of climate variables. Wind speeds were corrected to approximate speeds at 6.09 m (20 ft).

Temperature and relative humidity are relatively constant throughout the year (Figure 5). Minimum relative humidity is high, with average minimums near or above 60%. Precipitation shows a marked dry season from June through August. Wind speeds are comparable to the wind farm site, though the wind direction is more variable with a larger northerly component.

Figure 2. Temperature data at the wind farm site.

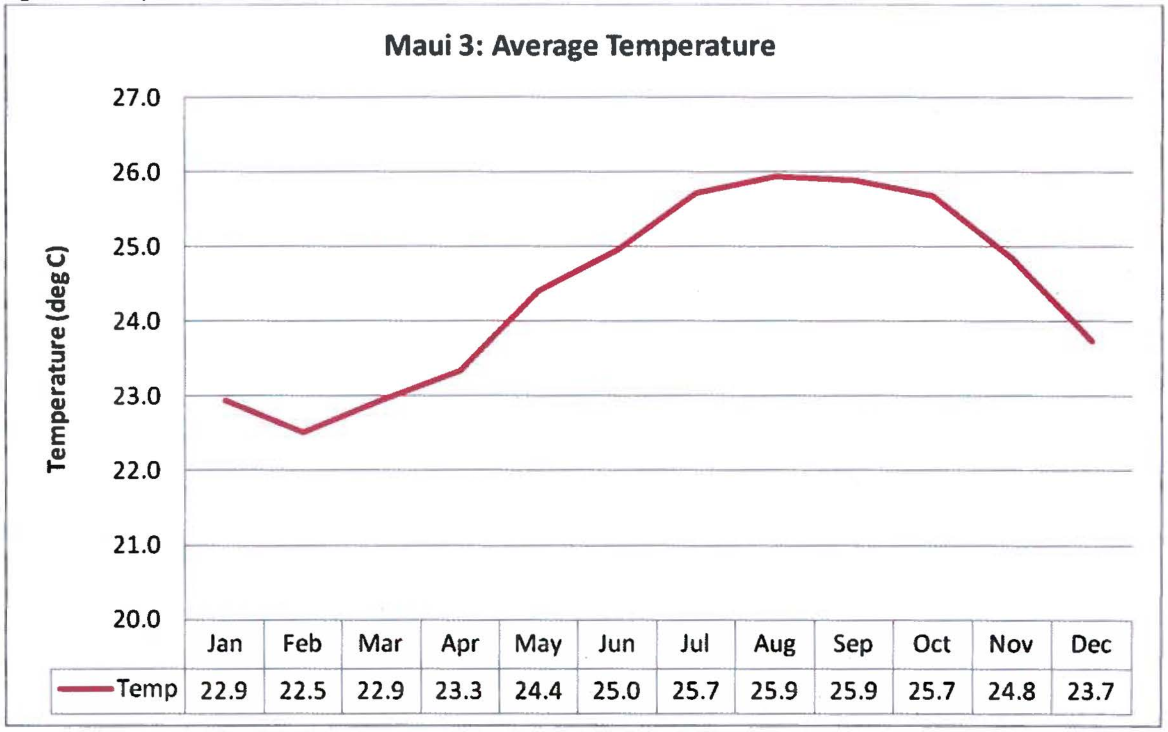


Figure 3. Wind rose for the wind farm site.

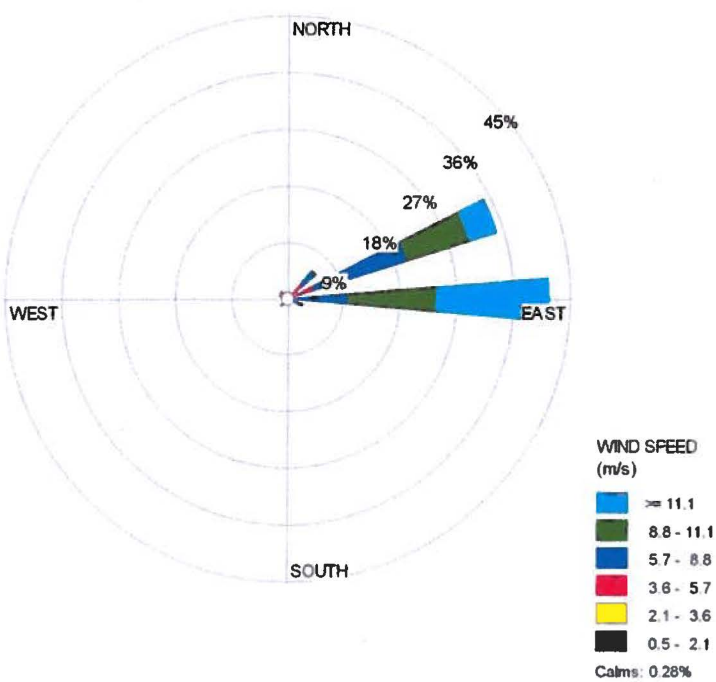
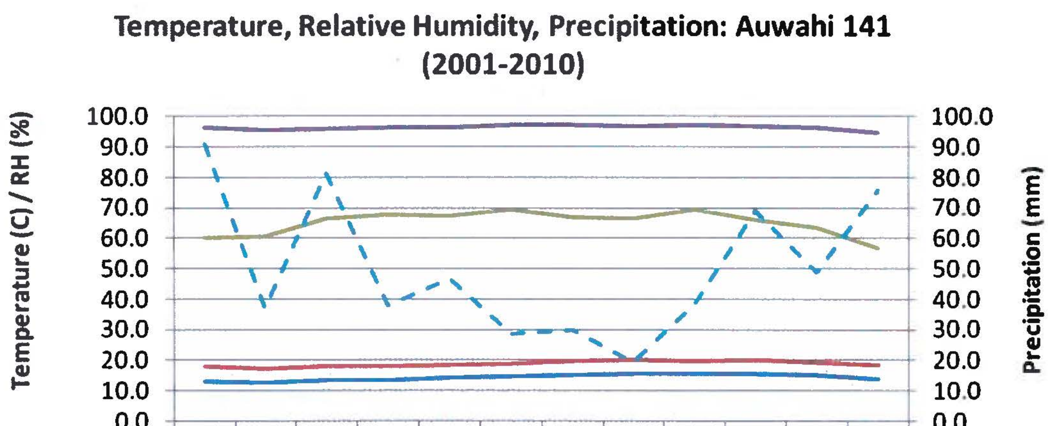
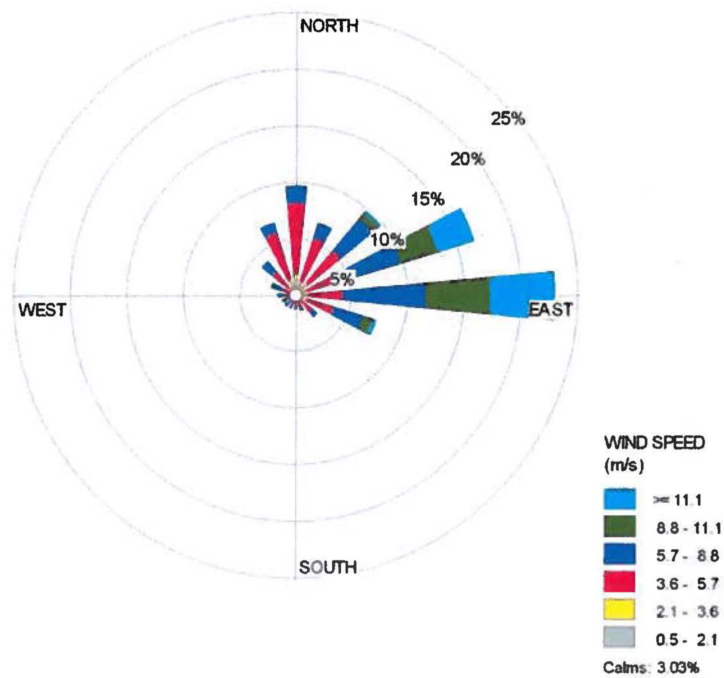


Figure 4. Monthly average maximum and minimum temperature, maximum and minimum relative humidity, and precipitation from the Auwahi 141 weather station.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MinTemp	13.2	12.6	13.4	13.4	14.2	14.7	15.3	15.7	15.6	15.6	14.9	13.9
MaxTemp	17.9	17.4	17.9	17.9	18.6	18.8	19.8	20.3	20.0	20.1	19.5	18.7
MinRH	60.2	60.6	66.4	67.7	67.2	69.5	67.0	66.5	69.5	66.3	63.4	56.7
MaxRH	96.4	95.7	96.1	96.2	96.2	97.3	97.1	96.7	97.1	96.6	96.5	94.9
Precip	91.0	37.0	81.1	37.8	46.6	28.7	30.1	19.4	38.4	68.9	49.0	75.9

Figure 5. Wind Rose from the Auwahi 141 weather station. Wind readings were adjusted to account for the low height at which they were measured.



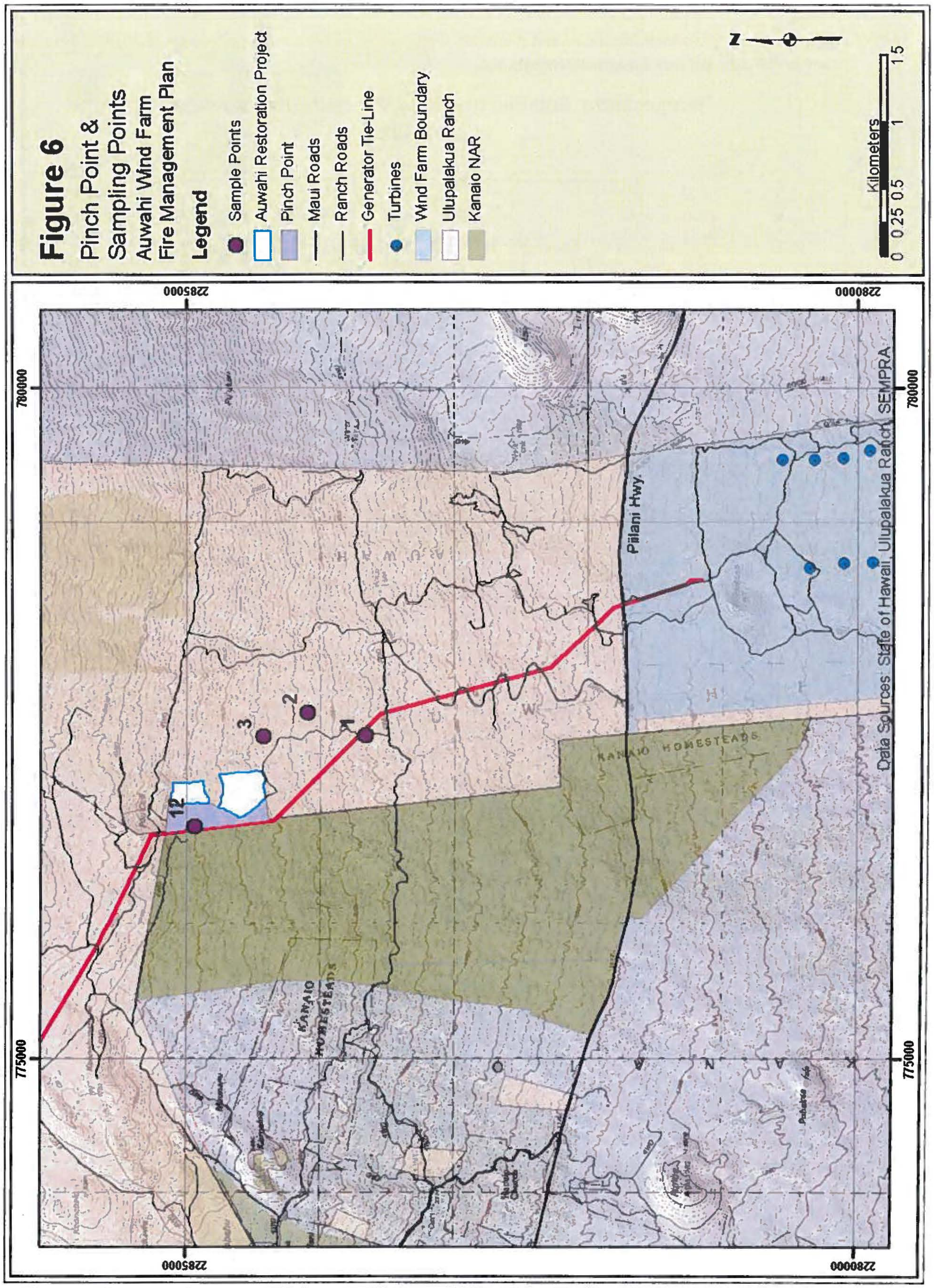


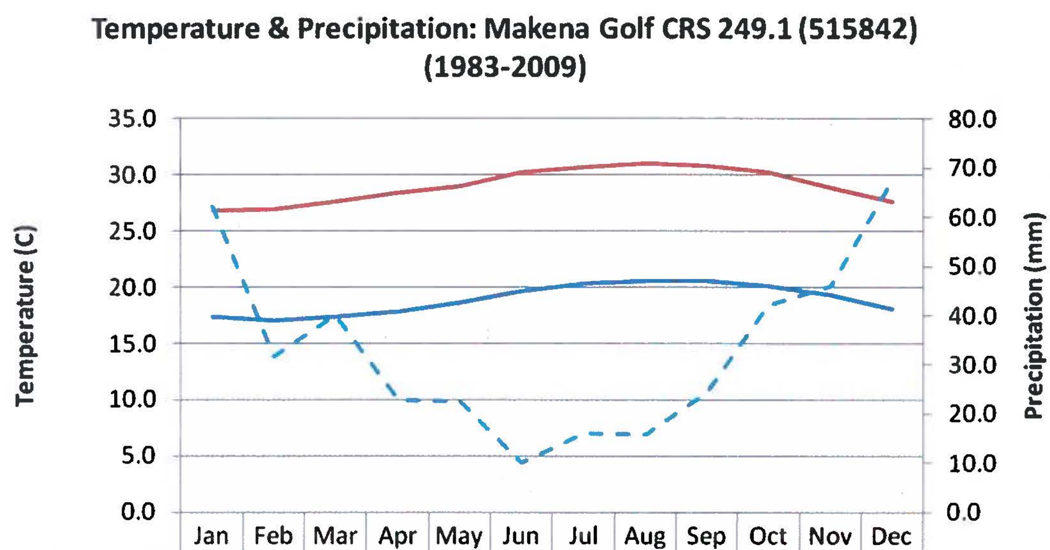
Figure 6
Pinch Point & Sampling Points
Auwahi Wind Farm
Fire Management Plan
Legend
Sample Points
Auwahi Restoration Project
Pinch Point
Maui Roads
Ranch Roads
Generator Tie-Line
Turbines
Wind Farm Boundary
Ulupalakua Ranch
Kanaio NAR
Kilometers
0 0.25 0.5 1 1.5
N
Piilani Hwy.
KANAIO HOMESTEADS
Data Sources: State of Hawaii, Ulupalakua Ranch, SEMPRA
775000
780000
2280000
2285000
1
2
3
12

2.1.3. Interconnection Substation

There are no weather stations with a full suite of weather variables near the interconnection substation. We utilized data from the Makena Golf Course weather station, approximately 7 kilometers (km) (4.4 miles (mi)) to the southwest of the interconnection substation, which only records daily values for temperature and precipitation. Wind and relative humidity are unknown in this location.

As at the other weather stations, temperature is relatively constant throughout the year, though it is substantially warmer in this locale. Precipitation is sparse in the summer months with less than 20 mm (0.9 in) per month falling from June through August on average. There is no wind data available for this site.

Figure 7. Monthly average temperature and precipitation from the Makena Golf Course weather station.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max Temp	26.8	26.9	27.6	28.5	29.0	30.2	30.7	31.0	30.8	30.3	29.0	27.7
Min Temp	17.4	17.0	17.4	17.8	18.7	19.7	20.3	20.6	20.6	20.1	19.4	18.0
Precip	62.3	31.7	39.9	22.9	22.6	9.9	16.0	15.9	24.4	42.0	46.0	67.5

2.2. Fuels

2.2.1. Fuel Type

Fuels vary by elevation and moisture regime (Figure 8). Low elevation sites are characterized by pyrophytic non-native grasses interspersed with patches of shrublands and small treelands. Trees and shrubs in these locales will not contribute significantly to fire spread though they may pose some fire containment issues.

Upper elevations receive more moisture and are characterized by extensive stands of kikuyu grass (*Pennisetum clandestinum*). Kikuyu is a perennial, rhizomatous, mat forming grass. Kikuyu produces thick beds of herbaceous fuels capable of carrying wildfire. As elevation and moisture increase, kikuyu grass is able to produce more biomass. During times of drought, these fuels can become desiccated and pose a wildfire hazard. Most of the kikuyu grass on Ulupalakua Ranch is frequently grazed, minimizing the fire threat.

The higher elevations also harbor remaining patches of native trees and shrubs. The native vegetation is also capable of carrying wildfire, particularly pukiawe (*Styphelia tameiameiae*). This shrub is quite flammable and when mixed with a grass fuelbed, as is the case here, it can produce substantial fire containment difficulties due to torching and spotting.

There are stands of a variety of eucalyptus species scattered throughout the western half of Ulupalakua Ranch. While fires in these timber stands are difficult to contain due to the heavy fuel load, flammability of the fuels and ease with which the tree canopy becomes involved in the fire, the stands are isolated and are located in areas where they do not threaten important resources other than the timber itself.

2.2.2. Fuel Load

We measured kikuyu grass fuel loads at three randomly located plots within and near the generator tie-line corridor (Figure 6). Each plot consisted of a single 100 m transect with five fuels sampling quadrats evenly spaced along the transect. Our results (Table 1) indicate a pattern of increasing fuel load with increasing elevation. This pattern is not statistically significant primarily because of the limited number of samples, but professional judgment of the author as well as the ranch owner both support the trend. We collected data from a fourth plot (plot 12) which was sited inside the State NAR land at 1,156 m (3792 ft) where no grazing occurs. This plot had a fuel load of 18.0 Megagrams per hectare (Mg/ha) (8.1 tons per acre (t/ac)), much higher than any of the plots located on Ulupalakua Ranch lands, indicating the importance of grazing to maintaining lower fuel loading.

Table 1. Kikuyu grass fuel load data.

Transect #	Fuel Load (Mg/ha)	Elevation (m)
1	5.7	867
2	11.7	951
3	12.4	1011
12	18.0	1159

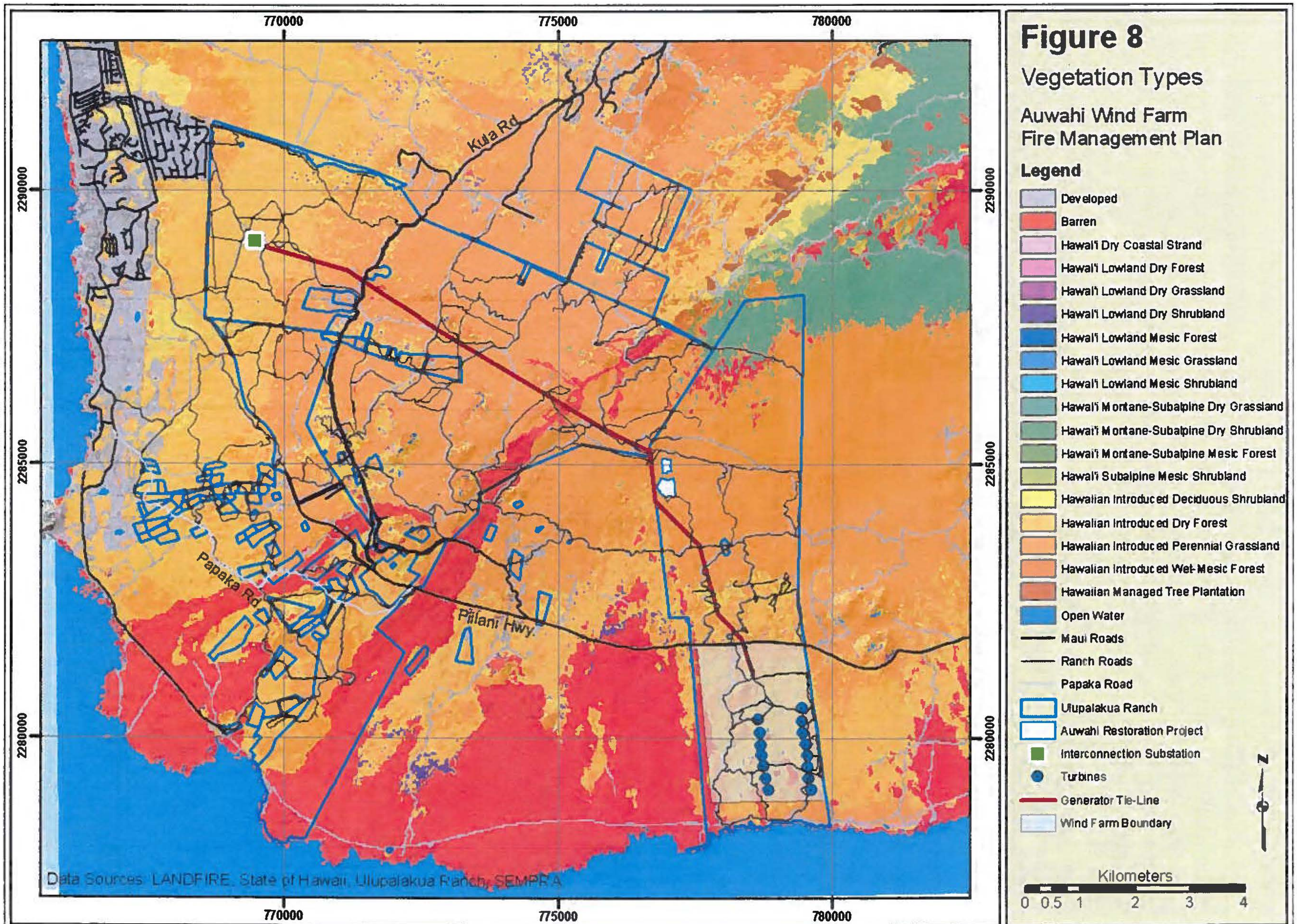


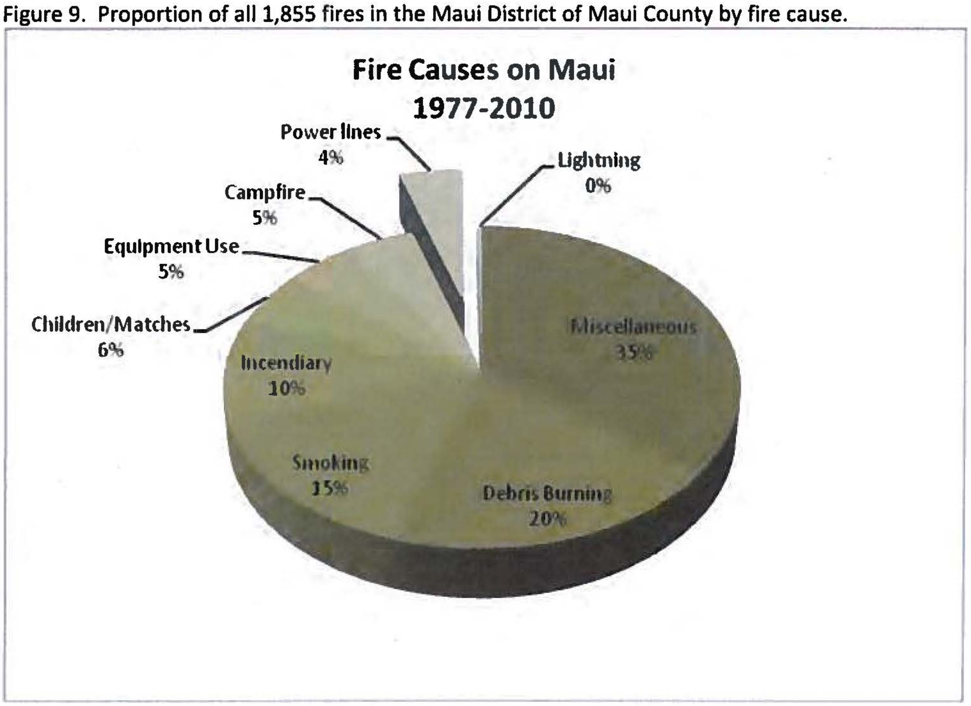
Figure 8
Vegetation Types
Auwahi Wind Farm
Fire Management Plan
Legend
Developed
Barren
Hawai'i Dry Coastal Strand
Hawai'i Lowland Dry Forest
Hawai'i Lowland Dry Grassland
Hawai'i Lowland Dry Shrubland
Hawai'i Lowland Mesic Forest
Hawai'i Lowland Mesic Grassland
Hawai'i Lowland Mesic Shrubland
Hawai'i Montane-Subalpine Dry Grassland
Hawai'i Montane-Subalpine Dry Shrubland
Hawai'i Montane-Subalpine Mesic Forest
Hawai'i Subalpine Mesic Shrubland
Hawaiian Introduced Deciduous Shrubland
Hawaiian Introduced Dry Forest
Hawaiian Introduced Perennial Grassland
Hawaiian Introduced Wet-Mesic Forest
Hawaiian Managed Tree Plantation
Open Water
Maui Roads
Ranch Roads
Papaka Road
Ulupalakua Ranch
Auwahi Restoration Project
Interconnection Substation
Turbines
Generator Tie-Line
Wind Farm Boundary
N
Kilometers
0 0.5 1 2 3 4
770000
775000
780000
2290000
2285000
2280000
Kula Rd
Papaka Rd
Piilani Hwy.
Data Sources: LANDFIRE, State of Hawaii, Ulupalakua Ranch, SEMPRA

2.3.Fire History

There are limited records of fires in and around the project area. Anecdotal records of wildfires on and around Ulupalakua Ranch have come from Mr. Sumner Erdman, the ranch owner, and the causes have been traced to anthropogenic sources such as campfires, burning debris, and automobiles. The fires that Mr. Erdman can recollect have started in non-native fuels and were fought by hand or, in rare cases, with the help of bull dozers.

The Maui District of the Hawai'i DLNR Division of Forestry and Wildlife (DOFAW) maintains fire reports with information about all wildfires that have been reported on Maui. Reports from 1977 to 2010 indicated that there were 1,855 wildfires within Maui County. Over 99% of these fires were human caused, but only 85, or just 4%, have been caused by power lines. Due to limited staff, none of these 85 fires were formally investigated so a power line cause was never confirmed. Many of the power lines that have caused fires are decades old and were not built to the higher standards of current power lines. Additionally, many of these fires were caused by distribution lines rather than generator tie-lines. Distribution lines, which are not a component of this project, would be expected to cause more fires than generator tie-lines because they are not as well maintained and there are many more miles of them.

Figure 9. Proportion of all 1,855 fires in the Maui District of Maui County by fire cause.



2.4. Values at Risk

2.4.1. Ulupalakua Ranch

The majority of lands to be developed and at risk of fire are within Ulupalakua Ranch property (Figure 1). Ulupalakua Ranch occupies roughly 8,094 hectares (ha) (20,000 acres (ac)) and operates on approximately 7,285 ha (18,000 ac) of that area. The Ranch runs 2,300 brood cows in its pastures. Calving occurs during winter, spring, and summer to concur with production of the various ecosystems found on the ranch properties (UR 2010). Ulupalakua Ranch depends on their lands to provide the forage needed to produce the high quality beef for which they are known. The development of the Auwahi Wind Farm will pose a wildfire risk to the ranch lands and, should a fire occur, could have negative effects on the land's productivity. The generator tie-line corridor represents the most extensive fire risk because of its length. The nine-mile corridor passes through a number of pastures and areas of high forage production which potentially could be negatively affected by fire.

2.4.2. Kanaio NAR

The State of Hawai'i owns land immediately adjacent to the generator tie-line corridor (Figure 1). The Kanaio NAR was established in 1990 to protect areas of native dry tropical forest and shrubland (Medeiros et al 1993) and is currently being expanded to include a large area of State land to the north of the currently designated area. A biological survey published in 1993 (Medeiros et al) identified three endangered native vegetative communities: *'A'ali'i* (*Dodonaea*) lowland shrublands, *Lama* (*Diospyros*) forest, and *Wiliwili* (*Erythrina*) forest. Several species listed under the Endangered Species Act occur within the NAR. These species are protected by federal law. Any area burned in the Kanaio NAR would severely impact the native vegetation and listed species occurring there and likely result in increased dominance of non-native perennial grasses.

2.4.3. Auwahi Restoration Areas

The Auwahi Forest Restoration Project is considered a high value property for its ecological and cultural significance. Since 2000, over 127 public and private volunteer trips have resulted in over 2,888 volunteers donating a total of over 10 years worth of labor to help plant 60,621 native plants (ARR 2010), giving an indication of the importance of this project to the local community. The Auwahi Forest Restoration Project lies adjacent to the State NAR on Ulupalakua Ranch property in two small parcels. These are remnants of biologically diverse native forest that have been restored by planting native species, fencing out mammalian herbivores, and controlling non-native species. The proposed route of the generator tie-line skirts along the western edge of the Auwahi parcel before it turns west and heads back down the mountain (Figure 1).

Beginning in 1997, the Leeward Haleakala Watershed Restoration Partnership was created. It is a partnership between landowners, government resource managers and scientists to develop methods in which to restore the unique and dwindling dryland forest ecosystem before it was lost entirely (Madeiros 2006). Since that time, a substantial effort has been undertaken to restore and improve the native forest within fenced exclosures.

Historically, this area had been considered to be one of the most biologically rich native Hawaiian ecosystems. Currently, less than 5% of the native dryland forest ecosystem remains on Maui (Medeiros & vonAllmen 2006) and the Auwahi parcel is an especially diverse example of these remnants. The native forest has experienced varying levels of habitat destruction, grazing by ungulates, competition from invasive plants, and wildfires. Because of the severe reduction of native forest cover, actions were taken to preserve the Auwahi parcel. The Auwahi parcel was fenced in 1997 to exclude ungulates in order to examine potential methods of restoring the native ecosystem. In addition to excluding ungulates the four acre parcel was weeded of kikuyu grass (*Pennisetum clandestinum*), broadcast seeded and outplanted with nursery stock of native species. The experimental restoration methods tested in the Auwahi parcel have yielded unassisted natural establishment of seedlings and saplings of native shrub-tree species.

Since the treatments have been applied, the exclosure has provided refugia for five endangered plant species. The Auwahi parcel has also protected two species of native tree, a`e (*Zanthoxylum hawaiiense*) and alani (*Melicope knudsenii*), with the alani tree being the only known survivor in its natural setting on Maui or Kaua`i. The non-native kikuyu grass that once covered over 70% of the ground now only covers 5% and native shrubs and trees are predicted to increase in dominance. The increase of native shrubs and trees will also harbor native shade-tolerant understory species that rely on the micro climate created by native overstory species.

These exclosures define one side of the pinch point and lie within 50 m (164 ft) of the proposed generator tie-line at the nearest point and 213 m (699 ft) at the furthest point. The NAR defines the other side. The area between the State NAR land and the Auwahi Forest Restoration Project was originally, and still is, used as a means to move cattle from one side of the ranch to the other.

2.4.4. Private Lands

There is minimal risk to private land holdings, but it is worth noting that a large fire could burn off of Ulupalakua Ranch lands and onto private land. The greatest risk is posed by construction traffic on Papaka Road. It passes through and very close to several private land holdings and the very dry climate in this area makes the probability of an ignition high.

2.5. Risk Analysis

Fuels throughout nearly all of Ulupalakua ranch are grazed regularly, reducing fuel loads though the possibility of a wildfire is still present. At low elevations where bunch grasses predominate and the mat forming Kikuyu grass is absent, grazing also helps to reduce fuel continuity, leaving clumps of grass rather than a continuous bed of vegetation. Grazing is a vital fire mitigation measure and no major changes in the grazing regime are expected at this time.

Kikuyu grass is a major component of the vegetation within the project area. A study of kikuyu grass by Blackmore and Vitousek (2000) found that ungrazed kikuyu grass produced 770 grams per square meter (g/m^2) (3.4 t/ac)) of biomass that was up to approximately 27 centimeters (cm) (10.6 in) deep. The resulting fuel loads were modeled to determine flame lengths and rate of spread. They determined that ungrazed kikuyu could carry capable of covering greater than 75 ha (173 ac) after one hour. They also tested grazed kikuyu areas where they found fuel loads of 229 g/m^2 (1 t/ac)that were unable to carry fast-spreading fires, though they could still carry fires that could to burn 1.4 ha (3.5 ac) in an hour.

We sampled fuels at several sites near the most important values at risk. Fuel loads at Ulupalakua ranch are typically higher than those we sampled due to drought conditions during the sampling period. Thus, they are also generally higher than the grazed grass measurements documented by Blackmore and Vitousek and we can assume fire behavior would be somewhat more vigorous as a result. However, even substantial increases in fire behavior from the values calculated by Blackmore and Vitousek would not pose serious containment challenges.

2.5.1. The Tropical Grass/Fire Cycle

The non-native perennial grasslands that are found throughout the areas to be developed have a strong relationship with fire. They produce copious biomass that, when dried by lack of moisture, provides substantial fuels to carry wildfire. Fires often burn through these fuels and into native vegetation. When this occurs, the native plant species, which are poorly adapted to wildfire when compared to their non-native competitors, almost never recover entirely. They do not regenerate as quickly or vigorously as many of the non-native species. This allows non-native species to establish or reestablish communities in burned areas where native plants previously dominated. Usually two to three successive fires is sufficient to completely remove native species from the system and as a result, there are almost no instances where a fire burning in a native ecosystem is considered acceptable.

2.5.2. Wind Farm Site

Ignition probability from the wind turbines is close to zero. Though there is no reporting requirement for fires in wind turbines, it is typical to report fires to the manufacturer. This is in the turbine owner's interest as each turbine represents a substantial financial investment. Auwahi Wind Energy is considering three possible wind turbines, two from Siemens and one from GE. Siemens has never received a report from anywhere in the world of a fire in the a nacelle of the type being considered for the Auwahi Wind Farm. These turbines include smoke detectors, a substantial lightning protection system, and the temperature of key components are monitored at all times. One of the Siemens turbines includes a design that does not require a gearbox, reducing the possibility of a fire even further. The GE designed turbine is widely used and over 15,000 of them have been installed in the past 10 years. During this time period, there were four reported fires representing a fire probability of 0.027%. GE fixed the problem in 2004 and since then there have been no reported fires. The GE turbines have similar fire prevention measures to the Siemens design.

Many locations within the wind farm site will not carry fire for extended distances due to a lack of contiguous fuels. The rocky substrate prevents a continuous cover of grasses and herbaceous plants. Shrub fuels are more evenly distributed but lack the density necessary to carry a well organized fire. Fires in this area are likely to creep and finger through the fuels, seeking out areas with more fuel, flaring up momentarily, then lying back down to smolder their way forward again. While unpredictable, these types of fires do not typically pose major fire suppression challenges except under the worst conditions.

Additionally, the predominant winds blow out of the east at this site and will push the vast majority of fires to the west where they will be halted by a large lava flow with insufficient fuel to carry fire.

To the north is Pi'ilani Highway, which provides quick access to the area and a logical firebreak to prevent fires from moving upslope. There are also several existing 4x4 roads within

Ulupalakua Ranch south of Pi'ilani Highway and more roads will be constructed for construction and maintenance of the wind farm. These interior roads will provide access and some will be large enough to serve as substantial firebreaks.

2.5.3. Generator tie-line

The risk of an ignition anywhere along the proposed generator tie-line for the life of the project is 0.5%. This figure is calculated from the fire history in section 2.3 and figures provided by the Maui Electric Company (MECO). A full set of calculations is available in Appendix 1.

Auwahi Wind Energy is committing to mitigate the very low risk of a fire ignition in two primary areas of concern along the generator tie-line. The first, and most important, is the pinch point between the land owned by the State of Hawai'i and the Auwahi Forest Restoration Project. The generator tie-line as planned will run less than 100 m (328 ft) east of the NAR. The proposed generator tie-line ranges from a maximum of 213 (699 ft) m to a minimum of 50 m (164 ft) from the western boundary of the Auwahi Forest Restoration Project. Given that response times to this area are on the order of 40 to 60 minutes at a minimum, in unaltered fuels fires could reach into both the State land and the Auwahi exclosures before firefighters arrive on scene.

The other primary risk area is on the last 2.5 km (1.5 mi) of the generator tie-line from the intersection with Kula Road to the power interconnection substation. In this area, pyrophytic grasses, including guinea grass (*Urochloa maxima*), make up the bulk of the herbaceous species. These grasses can produce heavy fuel loadings in a short period of time provided sufficient moisture is available. If extended rainfall is followed by a period of extended dry weather, these fuels could represent a serious fire risk.

Just east of Kula Road, there also exists a patch of barbed wire grass (*Cymbopogon refractus*) of roughly several hectares. This bunch grass produces extremely dense bunches that are highly flammable. The current distribution is insufficient to pose a serious fire containment threat, but it is near the generator tie-line corridor and is spreading every year (Erdman, 2010). If this species begins colonizing larger areas of 10 ha (25 ac) or more, some pre-suppression fire mitigation measures may be in order.

3. Pre-Suppression Actions

3.1. Ignition Prevention

A copy of this FMP shall be posted in a conspicuous location by Auwahi Wind Energy or its contractors so that all workers will be aware of its provisions and their responsibilities for fire prevention and suppression. Preventing ignitions at the wind farm site, along the generator tie-line, at the interconnection substation, and during any stage of construction is a top priority. The following mitigation measures can help to reduce the risk of ignition.

3.1.1. Construction Phase

The construction of the wind farm poses the most significant ignition potential of the project due to the requirement for large numbers of people, vehicles, and equipment and activities such as welding. Hot catalytic converters, exhaust systems, sparks, cigarettes, and other ignition sources will be present throughout the construction period. Proper ignition prevention procedures will be followed by all workers.

Vehicles will not be parked in vegetation of any kind whenever possible. In some locations, particularly along the transmission corridor this may not be feasible. In these locales non-diesel vehicles will not park in vegetation greater than 10 cm (4 in) in height. Smokers shall field strip their cigarettes immediately after smoking (remove tobacco from the butt and scatter it, ensuring that the tobacco is not lit), or properly dispose of cigarettes inside their vehicle. All welding, grinding, and other spark producing activities will occur no less than 9 m (30 ft) from the nearest contiguous vegetation. Exposed aerial welding (e.g. not inside the tower or the nacelle) at more than 15 m (50 ft) above the ground will be restricted to days when sustained winds are less than 11 meters per second (m/s) (approximately 25 miles per hour (mph)). A fire watch shall be put in place for no less than 30 minutes after any exposed welding ceases. All internal combustion engines will utilize spark arrestors.

3.1.2. Generator tie-line Corridor

As stated earlier, although fires have been documented from power lines, it appears that more have been caused by distribution lines rather than generator tie-lines. Generator tie-lines are built and maintained to a higher standard than distribution lines and thus are less likely to be damaged or worn and produce fires. Downed generator tie-lines represent a serious ignition threat but usually stem from a weather event or hazard tree coming into contact with the line itself. In addition to downed lines, poorly maintained power lines can produce sparks and arcing that may cause a fire ignition in rare cases. These circumstances will be mitigated through a program of regular generator tie-line and generator tie-line corridor maintenance as defined by the Auwahi Wind Farm EIS. There are few locations where trees or shrubs grow tall enough to threaten the line, but maintenance will nonetheless include an area cleared of combustible materials of no less than 5 m in radius around the conductor. The generator tie-line will be inspected no less than once annually and cleaned or repaired at the discretion of Auwahi Wind Energy. Though not required by this FMP, much of the land this generator tie-line crosses is regularly grazed, reducing fuel load, continuity, and height and associated fire risk.

Within the pinch point area, the proximity of the generator tie-line to State NAR land and the Auwahi Forest Restoration Project requires additional ignition mitigation. An irrigation system will be established to reduce the ignition probability of fuels in that zone by keeping the vegetation green. Irrigation will only be used during times of drought when the fire danger is high or greater (Table 2). The irrigation system will be utilized at the discretion of Ulupalakua Ranch in coordination with Auwahi Wind Energy. The irrigation system will cover the area within the pinch point to a width of no less than 20 m (66 ft) from either side of the generator tie-line - 40 m (131 ft) in total width. In addition to its fuels management utility, the irrigation system may also be turned on in the event of a fire in the vicinity of the pinch point. Though it is not properly aligned for this purpose and should not be relied upon as a primary fire fighting resource, it may reduce fire behavior in the unlikely event of a fire. Auwahi Wind Energy will finance the irrigation system's construction and maintenance costs and Ulupalakua Ranch will run it.

Water for the irrigation system will come from the 50,000 gallon (gal) (189,271 liters (l)) tank located roughly 2 km (1.2 mi) to the west. Water used for irrigation and electricity used to pump it to tank and from the tank to the irrigation system will be paid for by Auwahi Wind

Energy. Water for irrigation will be moved through the existing ranch water infrastructure to its intersection with the new irrigation water lines at the pinch point. Water from the tank will also be utilized during firefighting operations as a water source for both ground based and aerial resources (see section 3.2.2 for more detail).

3.1.3. Wind farm and Collection Substation Sites

As established in Section 2.5.2, the likelihood of a fire in a wind turbine is exceedingly remote. Nonetheless, maintenance of mechanical and electrical systems within the turbine and nacelle will occur regularly, as recommended by the manufacturer, to limit mechanical failures. An emergency plan in accordance with CFPA guidelines (2010) will also be prepared to help limit equipment losses and possible fire spread.

Table 2. National Fire Danger Rating adjectives and associated fuel conditions and fire behaviors

Fire Danger Adjective Rating	Typical Fuel Conditions	Typical Fire Behavior
Low	Vegetation is moist to the touch. Live herbaceous fuel moisture is greater than 150%.	Ignitions very unlikely. Fires will not spread.
Moderate	Dead vegetation is dry, but live vegetation is green and has a moisture content greater than 100%.	Ignitions are possible. Fires will spread with minimal severity.
High	Dead vegetation is dry, roughly half of the herbaceous vegetation is cured.	Ignitions are probable. Fires will spread with some intensity and will pose difficulties to containment crews in some situations.
Very High	Dead vegetation is dry and brittle. Dead twigs snap easily. Herbaceous vegetation is nearly completely cured.	Ignitions are a near certainty. Fires will spread with high intensity and will be difficult to control. Large fires are probable.
Extreme	Severe, extreme, or exceptional drought conditions exist. Herbaceous vegetation is completely cured. Leaves on shrubs may wilt during mid-day or fall off altogether.	Ignitions are a near certainty. Fires will spread with very high intensity and cannot be controlled.

3.2. Firebreaks, Fuelbreaks, Fuels Management, and Suppression Preparation

3.2.1. Wind farm site

As noted in section 2.5.1, there are several existing barriers to fire spread. Additionally, construction and operation of the wind farm will require several additional roads to be built. These roads will improve firefighter access and help to further compartmentalize the wind farm site. Roads directly related to the operation of the wind farm will be maintained by Auwahi Wind Energy to sufficiently allow passage of a Type VI brush engine (e.g. F-350 carrying 300 gal (1,135 l) of water). There is no requirement for additional firebreaks.

3.2.2. Generator tie-line

Where conductors are used along the generator tie-line a 5 m (16 ft) radius will be cleared of combustible material to reduce ignition potential from any sparking that may occur. This is the responsibility of Auwahi Wind Energy.

The generator tie-line will be placed in the middle of the pinch point corridor, equidistant from the State NAR boundary and the Auwahi Forest Restoration Project parcels. This requirement is subject to alteration based on engineering requirements.

The area between the NAR and the Auwahi Forest Restoration Project will be grazed to reduce the fuel depth to no more than 10 cm (4 in). This will likely remove the few remaining native plants from the pinch point. Ulupalakua Ranch shall have discretion to determine the appropriate animals and the grazing prescription necessary to accomplish this objective. Chemical and mechanical treatments may also be utilized to achieve the desired fuel height, though these are considerably more expensive and can have undesirable environmental consequences. Ulupalakua Ranch is responsible for financing and implementing this requirement.

Two firebreaks will be established within the pinch point. One will follow the State land boundary to the west and the second will follow the Auwahi Forest Restoration Project fence lines to the east. The alignment may deviate from the fence lines due to topography, erosion considerations, and other factors. These firebreaks will be a minimum of 3 m (10 ft) in width and will be engineered utilizing best management practices for roads including erosion prevention features. The roads will be maintained in a fuel-free state at all times utilizing methods at the discretion of Ulupalakua Ranch. This requirement will be financed by Auwahi Wind Energy and implemented by Ulupalakua Ranch.

The water tank used for irrigation will also be used to fight fires in the area. The water level in the tank will be maintained at 50% of capacity (25,000 gal (94,635 l)) or better at all times. The tank will be retrofitted with two valves spaced far enough apart to allow access by two fire fighting apparatus simultaneously. Each valve will be capable of quickly filling a fire engine or tender (minimum 200 gallon per minute (gpm) (757 liters per minute (l/min)) capacity). During aerial bucket operations, water from the tank will also be pumped to a dipping site for use by aerial resources. The exact location of the dipping site will be determined by Ulupalakua Ranch in coordination with State and contract helicopter pilots to ensure it is properly sited, but it will be within 1,000 m (3,281 ft) of the water tank. A pump or gravity feed system with a minimum capacity of 100 gpm (378 l) will be retrofitted to the tank to allow water to be pulled from the tank into the dipping site. The dipping site may be a permanent structure or a portable dip tank stored at the dipping site and protected from the weather and sun.

3.2.3. Interconnection Substation Area

There are numerous ranch roads in this area that will act as firebreaks. Fuels management where the generator tie-line connects with the interconnection substation will be considered, though it is not required since there are few resources at risk in the immediate vicinity and fire response times and access are much better than in the pinch point area. Fuel loads directly under the line from Kula Highway to the substation, or any portion of this length, could be reduced by more intensive grazing, and/or by making this a priority area to graze after moisture events when most grass growth occurs. Irrigation under the generator tie-line is also a possibility, though it would need to be accompanied by increased grazing pressure to account for the additional grass growth. Ulupalakua Ranch shall retain the discretion to make these decisions and is responsible for financing and implementing any grazing plan deemed necessary.

3.2.4. Invasive Species Control

Auwahi Wind Energy will conduct annual surveys for invasive species of fire prone grasses, with an emphasis on barbed wire grass, buffelgrass (*Pennisetum ciliare*) and fountaingrass (*Pennisetum setaceum*). The survey extent will include, at a minimum, all areas within 10 m (33 ft) of disturbance resulting from construction within the wind farm site and the connection substation site, and within 10 m (33 ft) of all roadways constructed or utilized more than once monthly for wind farm construction or maintenance. Any individuals or colonies observed will be expeditiously exterminated by Auwahi Wind Energy via a means that includes killing the root system. Consideration will also be given to killing individual plants before they produce seed whenever possible. Auwahi Wind Energy will consult Ulupalakua Ranch prior to application of any herbicide to ensure the ranch is aware of the location of application and the extent and types of herbicides being applied.

If any individuals are found, additional semi-annual surveys of the colonized area will be conducted for 2 years post-discovery and any additional individuals will be destroyed. Semi-annual surveys of colonized sites will continue until 2 years passes without any individuals being found.

3.2.5. Employee Training

Employees will receive basic instruction in the proper use of firefighting tools. These tools and training will allow crews to rapidly respond to any ignition that may occur. Early response to any ignition will greatly increase the likelihood that it will not escape containment efforts. Every new employee will receive this training within 3 months of beginning work. Refresher training will be provided to all employees bi-annually. Training may be provided by an Ulupalakua Ranch employee experienced in firefighting, or by a professional wildland firefighter. A record of training courses including dates, times, skills taught, teacher's name, and attendees will be kept by Auwahi Wind Energy.

3.3.Cooperative Agreements

Ulupalakua Ranch maintains informal agreements with other private land owners for mutual aid when wildfires break out. This arrangement has been highly successful in the past (Erdman, 2010). Ulupalakua Ranch will continue to maintain these relationships and will establish additional agreements and/or formalize existing agreements at their discretion.

3.4.Responsibilities

Auwahi Wind Energy and Ulupalakua Ranch share responsibilities for implementation of this plan. Each is responsible for the tasks listed in Table 3.

Table 3. Responsibilities of Auwahi Wind Energy and Ulupalakau Ranch.

	Auwahi Wind Energy		Ulupalakua Ranch	
	Financing	Implementation	Financing	Implementation
Wind farm site road maintenance	X	X		
Clearing fuels at conductor locations	X	X		
Grazing of fuels at pinch point			X	X
Construction and maintenance of pinch point firebreaks	X			X
Construction and Maintenance of irrigation system	X			X
Reducing fuels at interconnection substation			X	X
Fire prone invasive species control	X	X		

4. Fire Suppression Information

4.1.Fire Reporting Procedures

Anyone detecting a fire shall immediately report it by calling 911. After reporting the fire, they shall expeditiously notify Ulupalakua Ranch of the fire at 808-878-1202.

4.2.Fire Fighting Equipment

All construction, operations, and maintenance personnel shall carry in their vehicles a fire extinguisher, flapper, and shovel. Tools shall also be maintained at the designated locations described below. The contractor's water truck will be made immediately available to firefighters when a fire is detected.

4.2.1. Fire Tools

Construction Contractor(s) shall furnish fire tools to equip all of the personnel employed at each work site. Once construction is completed, Auwahi Wind Energy will be responsible for supplying tools for the life of the wind farm. During construction, fire tools shall be in serviceable condition and kept in two storage sheds at the wind farm site, one shed at the top (north end) and one at the bottom (south end) of the turbines. These locations may be adjusted at the discretion of Auwahi Wind Energy. The sheds may be used for other purposes as well. The door of the sheds shall be marked "Fire Tools" with letters at least 75 mm (3 in) high. A list of the fire tools contained in the sheds shall be posted on the inside of the door so it is visible when opened. The sheds shall be locked to prevent theft. Auwahi Wind Energy shall ensure that every employee or contractor has a key to the sheds or has access to a location on the wind turbine site where a key is kept. The sheds shall contain the numbers and types of tools in table 4.

In addition, for the duration of construction, one fire toolbox shall be maintained on each conductor pulling/tensioner machine used for the construction of the generator tie-line, at each turbine site during its installment, and near the pinch point. Toolboxes shall be marked "Fire Tools" with letters at least 75 mm (3 in) high. A list of the fire tools contained in the tool box shall be posted on the inside each box so it is visible when opened. The boxes shall contain the numbers and types of tools in table 4. The boxes at the turbine sites shall be locked and every employee or contractor will have a key to the lock or access to a location on the turbine site where a key is kept.

Table 4. Tools required in the fire tools shed and fire tools boxes.

Tool	Sheds	Boxes
Mcleod	2	1
Flapper	4	2
Shovel	4	2
Bastard File	4	2
10 lb. Fire Extinguisher	2	1
5-gallon backpack fire pump (filled with water)	2	1

Fire Extinguishers shall be located inside or immediately adjacent to the toolbox in a safe, readily available area. Fire toolboxes shall be placed at the following locations:

- Each pulling operation.
- Each turbine during its construction/installation.

For the duration of construction, a water/helicopter support location shall be located at the edge of the primary laydown area where it does not interfere with construction. At the discretion of Auwahi Wind Energy, a minimum of 100 gal (378 l) of water and four backpack pumps OR a helicopter water bucket with a minimum capacity of 50 gal (189 l) will be positioned at the water/helicopter support location. If a helicopter bucket is chosen, the water/helicopter support location shall be large enough to land a light lift helicopter (20 m (65 ft) diameter) and accessible to vehicles.

4.2.2. Fire Extinguishers and Equipment on Trucks, Tractors, etc.

In addition to the tools and fire extinguishers required in 4.2.1, each grader, truck, and/or tractor, shall be provided with chemical fire extinguishers meeting one of the following specifications:

- 1 each – 1.1 kilogram (kg) (2.5 pound (lb)) size or larger extinguisher of dry chemical type, or
- 1 each – 1.8 kg (4 lb) size or larger extinguisher of the carbon dioxide type.

All fire extinguishers required by this FMP will be tested at least once annually.

4.3. Fire Fighting Command and Control

Larger fires will require the assistance of County and State firefighters. Once County and State firefighters are in place, Ulupalakua Ranch firefighters will turn over fire fighting duties to them. It may be helpful to have a knowledgeable Ulupalakua Ranch employee present at the State or County Incident Command Post to help provide the Incident Commander (IC) with information about important resources to be protected, water and roads available, and other facts.

4.4. Contact Info

The following key individuals may be contacted during a fire fighting operations, during construction operations, or at other times to discuss fire related issues. Except during fires, individuals should contact Ulupalakua Ranch prior to reaching out to State or County fire departments.

This contact information will be updated once monthly during construction and a minimum of once per year after construction is completed. Contact information will also be updated prior to annual maintenance activities to ensure the viability of contact information for key personnel and designated firepersons.

Table 5. Firefighting agencies and individuals. Report all fires to 911 first. All area codes are 808.

Name	Agency/Company	Work Phone	Mobile Phone	Firefighting Resources Available
	DOFAW	984-8100		Personnel, Engines, Dozers, Helicopters
Ray Skelton	Goodfellow Brothers	879-7708	268-8153	Dozers
	Kula Fire Department	876-0044		Personnel, Engines
Al Duarte	Maui County Wildland Fire Crew	224-6400		Personnel, Engines
	NARS	873-3506		None
Bill Evanson	NARS	264-9325		None
Sumner Erdman	Ulupalakua Ranch	878-1202	280-0840	Personnel
Kaimi Konaaihele	Ulupalakua Ranch	878-1202	357-0082	Personnel
Jimmy Gomes	Ulupalakua Ranch	878-1202	268-8062	Personnel
	Wailea Fire Department	874-8520		Personnel, Engines

4.5.Maui Fire Fighting Resources

Wildland fire fighting duties on Maui depend on the location of the fire, but typically are the responsibility of the Maui County Fire Department and the State DLNR. Between these agencies, a full suite of fire fighting personnel and apparatus are available, including heavy machinery (dozers and graders) and helicopter support. Contact information is identified in Table 5 above.

4.6.Water Sources

Ulupalakua Ranch has a substantial water infrastructure that can support fire fighting operations. Throughout the ranch property there are numerous water tanks that are used to supply livestock with fresh water. Many of these tanks hold less than 10,000 gallons and may not support certain firefighting tactics, though any water source is potentially useful during a wildfire. There are a number that are over 10,000 gal (37,854 l), most of which can be used to pump water from and a few of which may be used as dip tanks. Figure 10 shows the location of the water sources in relation to areas that will be developed for the Auwahi Wind Farm. Near the wind farm site are a number of tanks that hold less than 10,000 gal (37,854 l) of water and may be useful for firefighters on the ground. Along the eastern leg of the generator tie-line there are few water tanks and no water tanks within 1.6 km (1 mi) of the pinch point. The western leg of the generator tie-line passes near a number of water tanks, two of which have a 10,000 gal (37,854 l) capacity. The interconnection substation location is near a single tank with a capacity of 10,000 gal (37,854 l).

4.7.Safety

Any fire fighting that is carried out by private resources (Ulupalakua Ranch and/or Auwahi Wind Energy) shall utilize the ICS with a single Incident Commander (IC), usually the most experienced person, and a hierarchical command system. Ulupalakua Ranch personnel shall take command of any fire on which they are present until relieved by County or State firefighters.

Personnel fighting fires shall ensure they have at least one escape route and a safety zone. Human safety is the top priority in every fire suppression operation. Ranch and wind farm employees should keep in mind that they are not professional firefighters and will retreat from any fire which they feel poses a substantial threat to their safety.

5. Post Fire Actions

5.1.Infrastructure Inspection

After every fire, an inspection of all wind farm infrastructure within the burn area shall be executed. All ignition producing deficiencies shall be immediately rectified.

5.2.Ignition Source Identification

Immediately following the cessation of fire fighting activities, an effort will be made by Ulupalakua Ranch, Auwahi Wind Energy, and, if present, an individual identified by the State or County IC to identify the fire's ignition source. Each fire's ignition source will be documented including the reasoning that led to the identification of the ignition source. Some fires may have multiple possible ignition sources and these will be noted. This need not be a formal investigation and will only be utilized to better protect resources, including wind farm infrastructure, from future fires. The report shall be kept on file by Auwahi Wind Energy as part of the post-fire report (see 5.3).

5.3.Post-Fire Reports

After every fire, Auwahi Wind Energy will write a short narrative of the fire. The report will include the following information at a minimum:

- Date fire reported
- Time fire reported
- Description of fire location and/or lat/long. Include a simple map (write on a printed image from Google maps or other web-based mapping application)
- Estimated acres burned
- Suspected ignition source

A copy of the report will be supplied to Ulupalakua Ranch.

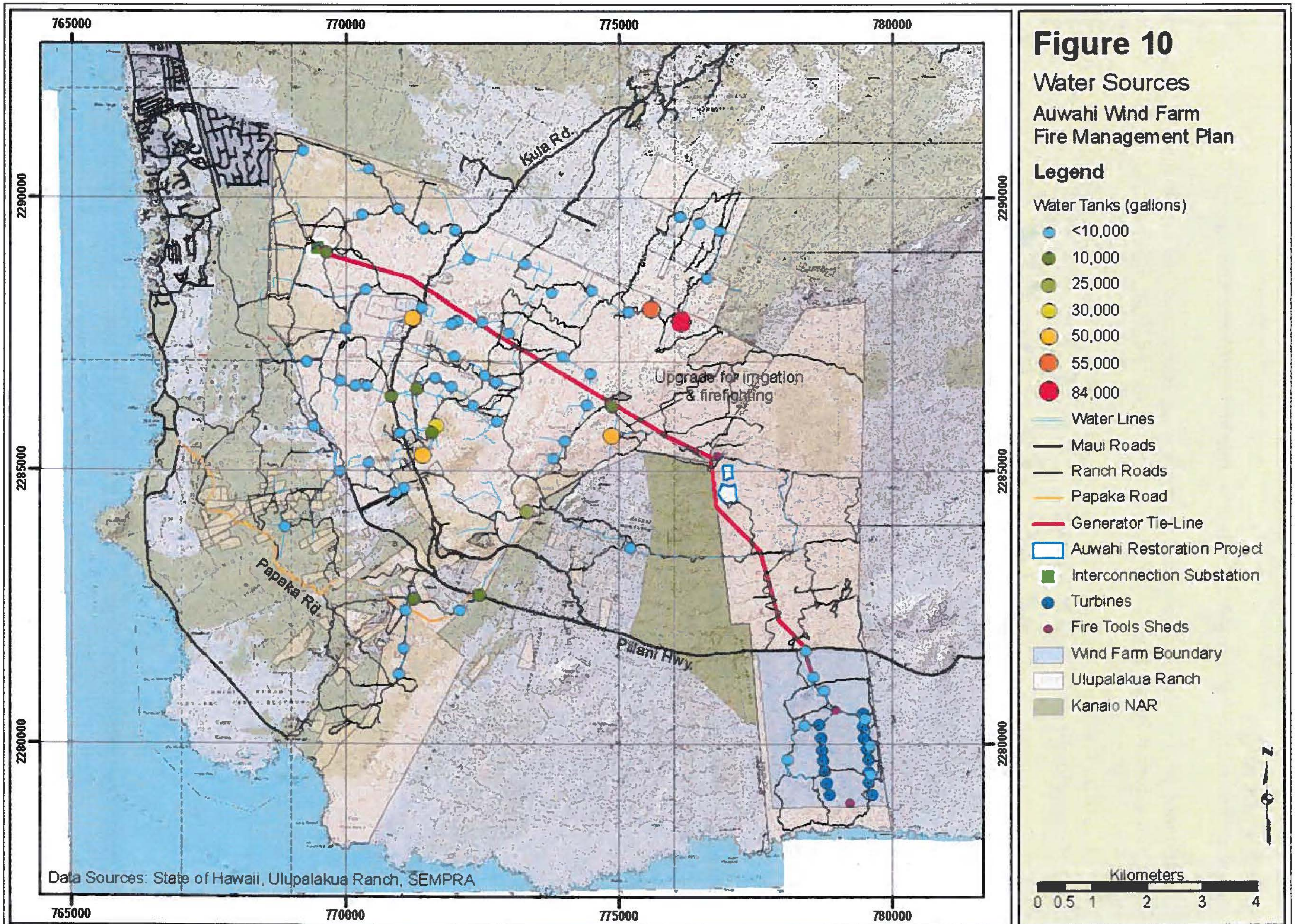


Figure 10
Water Sources
Auwahi Wind Farm
Fire Management Plan

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Appendix 1 - Generator Tie-Line Fire Probability Calculations

Inputs

Historic fire occurrence data from DLNR.
Stripped 1975 through 1981 out of the database because of the appearance of incomplete recording.

There were 82 electrical fires over 29 years.
The maximum number of fires in a given year is 7 electrical fires in 2010

Miles of electrical line from MECO.
MECO has approximately 240 circuit miles of transmission lines (23 kV and above) and 1500 circuit miles of distribution lines (below 23 kV).

Calculations

Probability of a fire occurring anywhere within the electrical system in any given year:

1 - (prob of no fire). In 29 years, there were 3 years with no fire. So, prob of no fire = 3/29 = 0 .1034.

Probability of a fire somewhere within the MECO transmission/distribution system over the lifetime of the Auwahi Wind Farm project, assumed here to be 50 years:

In 50 year lifetime of the project: 1 - (prob of no fire)^50 = 1 - (.1034^50) = ~1 (e.g. nearly 100%).

In any 2 year period: 1 - (prob of no fire)^2 = 1 - (.1034^2) = ~1 (e.g. nearly 99%).

Probability of a fire along the 9 miles of generator tie line associated with the Auwahi Wind Farm Project in the next 50 years = prob of fire somewhere within the electrical system * (number of miles of Auwahi generator tie line / total number of miles of electrical line):

1 * (9/1749) = 0.00515 (e.g. 0.5%)

Assumptions

1. This accounts for fires started during the operation of the generator tie line **only.** Other potential fire sources are construction activities and operation of the wind turbines.
2. The fire records record all fires that have occurred. There have likely been some fires that were never recorded, particularly in the 80's and early 90's.
3. There is no difference in the probability of a fire start from a generator tie line as compared to a distribution line (there is anecdotal evidence that distribution lines produce more fires).
4. There is no trend in fire occurrence in the historical record.
5. There will be no increase in fire occurrence in the future as a result of climate change.

Appendix D
Cultural and Archaeological Resources Avoidance, Minimization, and Mitigation

Avoidance and Minimization Measures

- The Auwahi Wind project was designed to avoid impacts to sites to the greatest degree possible. The Applicant's design engineers continue to consider construction methods and design modifications that can be adopted to avoid and minimize direct construction impacts to historic properties. Some design modifications include the following:
  - The decision by Auwahi Wind to reduce the number of Wind Turbines from fifteen 1.5 MW wind turbines to eight 3 MW wind turbines substantially reduced the total number of sites that would potentially be impacted by the Project.
  - Moving the original location of WTG Pad No. 2 and rerouting the internal access roads connecting WTG pads to avoid significant sites within the APE. If avoidance of remaining sites within the APE is not possible, these sites will be mitigated as appropriate.
  - Implementing the use spanning bridges to avoid direct impacts to lava tubes that may contain archaeological and cultural resources assessed as historic properties.
  - Avoiding, and thus preserving, all culturally significant sites (criterion "e") and sites assessed significant under criterion "c" during construction.
- The Applicant has prepared, in consultation with the Maui Lanai Island Burial Council and SHPD, a Burial Treatment Plan which will be implemented by the construction contractor to properly handle known and suspected burial sites. There are four known burial sites and several potential burial mound complexes in the APE. Features of the Burial Treatment Plan include:
  - Assessment of all confirmed burial sites and other sites possibly containing evidence of human remains.
  - Use of spanning bridges to avoid confirmed burial sites.
  - Measures for interim preservation during construction (protection buffer zones around known and potential burial sites, construction worker awareness training, and onsite archaeological monitoring of all ground-disturbing activities).
  - Measures for long-term preservation of iwi kupuna (ancestral remains) identified in the APE to secure these sites and protect them from vandalism or damage. Preservation-in-place for human burials has been identified as the preferred treatment by the Maui Lanai Island Burial Council. This will be done by sealing the openings of lava tubes, preserving the windbreak wall and cleared area around the site in place, and preserving the complexes of possible burial mounds in place. A small plexiglass plaque will be placed at each sealing wall or gate which will have text in Hawaiian and English to warn any explorer that the area is kapu.
  - Measures for the inadvertent discovery of human remains. These include halting construction in the area of the discovery and immediately contacting SHPD staff to determine the appropriate treatment of remains, which may include preservation-in-place, or disinterment and reburial adjacent to the location of discovery.
- During operation, the Applicant will implement additional measures to minimize the potential for theft and vandalism at recorded historic sites including fencing of sites,

development and implementation of a Worker Environmental Awareness Program, and possibly the monitoring and patrolling of significant sites.

Mitigation

Details concerning effects of the proposed project, as modified to address cultural and archaeological resources, are presented in the USFWS Draft Environmental Assessment. Considerable effort has been exercised to minimize the impact the project would have on the archaeological resources present in the wind farm site. The purpose of archaeological investigations is not only to inventory what archaeological resources are present and evaluate their significance, but to mitigate the effects caused by development through archaeological investigations. Some of the archaeological resources present within the project APE have been fully documented and will not require any further archaeological work; others will require further archaeological investigations in the form of detailed mapping and excavations to retrieve potentially significant information. Once retrieved, the destruction has been mitigated and there is no longer have an adverse effect. Additional detailed mapping and selected subsurface testing will be conducted within several site types including hydrological features, habitation sites, and field system terrace sites. The recommended mitigation measures to be implemented are summarized in Table 1.

Appendix E
Auwahi Wind Farm Project Post-construction Monitoring Plan

AUWAHI WIND FARM PROJECT
POST-CONSTRUCTION MONITORING PLAN

Prepared for

Auwahi Wind Energy, LLC

Prepared by

TETRA TECH EC, INC.

December 2011

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ATTACHMENTS

ABBREVIATIONS AND ACRONYMS

agl	above ground level
DOFAW	Hawai'i Department of Land and Natural Resources/Division of Forestry and Wildlife
DLNR	Hawai'i Department of Land and Natural Resources
ESA	Endangered Species Act
ft	foot or feet
GPS	global positioning system
HCP	Habitat Conservation Plan
HNP	Haleakala National Park
ITL	Incidental Take License
ITP	Incidental Take Permit
KWP	Kaheawa Wind Power
m	meter
PCMP	Post-Construction Monitoring Plan
TBD	To be determined
USFWS	U.S. Fish and Wildlife Service
WTG	wind turbine generator

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND AND PURPOSE OF THE POST-CONSTRUCTION MONITORING PLAN

Species listed under the federal Endangered Species Act (ESA) of 1973, as amended, and the State of Hawaii endangered species statutes, have the potential to occur in the vicinity of the Auwahi Wind Farm Project (Project), including the Hawaiian petrel, nēnē, and Hawaiian hoary bat. Individuals of these species could be killed or injured if they collide with wind turbine generators (WTG), or when bats fly close enough to experience barotrauma. In bats, barotrauma is tissue damage to the lungs caused by rupture of small blood vessels that results from the rapid air-pressure reduction near moving WTG blades (Baerwald et al. 2008).

Due to the potential for incidental take of these species, Auwahi Wind Energy LLC (Auwahi Wind) has consulted with the U.S. Fish and Wildlife Service (USFWS) and the Hawaii Department of Land and Natural Resources (DLNR) to acquire an Incidental Take Permit (ITP) and an Incidental Take License (ITL) issued by these agencies, respectively. These permits issued in accordance with Section 10(a) (1) (B) of the ESA and Section 195 D of the Hawaii Revised Statues, respectively, require the preparation of a Habitat Conservation Plan (HCP).

This post-construction monitoring plan (PCMP) has been developed as a means to document impacts or lack thereof to the Covered Species as a result of operation of the Project, and to ensure compliance with the authorized provisions and take limitations of the HCP and the associated ITP/ITL. Based on the results of post-construction monitoring, avoidance and minimization measures as outlined in the HCP adaptive management strategy could be modified, or additional measures identified and implemented, as necessary, should Project effects differ substantially from what was anticipated.

Although the PCMP is implemented to document any potential incidental take of threatened or endangered species, impacts to non-listed species will be recorded for informational purposes. Additionally, although survey efforts will focus on documenting mortality through standardized searches, all injuries and mortality associated with the project (e.g., vehicle strikes) will be documented.

1.2 COMPONENTS OF THE PCMP

Wind farm-related fatality estimation is based on the number of carcasses found during carcass searches conducted under operating WTGs. Both the length of time carcasses remain on site before being removed by scavengers (carcass removal rate) and the ability of searchers to locate carcasses (searcher efficiency) can bias the number of carcasses located during standardized searches. Therefore, this PCMP includes 1) methods for conducting standardized carcass searches to monitor potential injuries or fatalities associated with Project operation, 2) carcass removal trials to assess seasonal, site-specific carcass removal rates by scavengers or other means, and 3) searcher efficiency trials to assess observer efficiency in finding carcasses. Vegetation conditions also will be assessed and documented as part of the monitoring protocol when conducting carcass searches and carcass removal and searcher efficiency trials. The proposed field and analytical methods are consistent with post-construction monitoring being conducted, or proposed, for other wind projects in Hawaii and other U.S. locations (Johnson et al. 2000; Kerns and Kerlinger 2004; Fiedler et al. 2007; NWC and West 2007; Tetra Tech 2008; KWP 2006, 2011; Erickson 2009; Arnett et al. 2009a; SWCA 2010;

Poulton and Erikson 2010; Strickland et al. 2011), but have been adapted to the specific characteristics of the Project.

The PCMP protocol outlines the surveys and trials to be conducted and provides an adaptive management approach to post-construction monitoring. Methods and timing outlined in this protocol may be modified over time as project-specific information is obtained to maximize the effectiveness and efficiency of the monitoring program (e.g., search interval, the number of WTGs searched, plot size). Additionally, recent advancements in the science of post-construction monitoring have resulted in variations in the standard monitoring protocol based on site-specific conditions at individual wind farms, species of interest, study objectives, and statistical developments in the quantification of bias correction factors and mortality rates (Shoenfeld 2004; Jain et al. 2007, Arnett et al. 2009a; Huso 2010). It can be assumed that post-construction monitoring techniques will continue to be refined over the 25-year life of the ITP and ITL. Therefore, the intent of this protocol is to provide a sound framework that can apply the best available science over the long term. Any recommended changes to the protocol from the baseline provided herein would require review and approval by USFWS and DLNR/Division of Forestry and Wildlife (DOFAW).

1.3 OTHER NECESSARY PERMITS

Prior to initiating surveys, permits required to implement the monitoring program will be obtained, including the USFWS Special Purpose Permit and the DOFAW Protected Wildlife Permit. These permits grant permission and include provisions for handling wildlife and carcasses. They will be required for handling any native wildlife carcasses used in the searcher efficiency and carcass removal trials described below, unless other legal species, such as chickens are used.

2.0 STANDARDIZED CARCASS SEARCHES

The objective of the standardized carcass searches is to systematically search WTG locations for avian and bat casualties that are attributable to collision with Project facilities or barotrauma. Although all fatalities will be recorded, the PCMP focuses on listed species. For purposes of this PCMP, the casualties will be referred to as collision-related fatalities.

2.1 SAMPLING DURATION AND INTENSITY

The PCMP carcass searches to document avian and bat fatalities will begin once all WTGs are constructed and commissioning activities are complete.

Year 1 – Avian species - During the first year of operation, post-construction monitoring for potential avian fatalities focusing on seabirds will consist of systematic searches beneath each of the Project's 8 WTG (Table 2-1). Weekly searches will be conducted from March through June. Surveys will be conducted twice per week from July through November that includes the petrel fledgling period (October to the end of November). This timeframe will encompass movements of the Hawaiian petrel between nesting areas in Haleakala National Park (HNP) and the ocean during pre-nesting, nesting, and fledging (March through November; Simons and Hodges 1998). Monthly surveys will be conducted from December through late February when seabirds are not present on Maui..

Year 1 – Bats: Unless otherwise dictated by the results of carcass removal trials (Section 3.0), bi-weekly (two times per week) searches for potential bat fatalities will be conducted during the potential high activity period of Hawaiian hoary bats (Table 2-1). Hawaiian hoary bats are thought to breed in Hawai'i during April through August, although this has not been verified on Maui. The peak bat activity period at KWP 1 and 2 and the Auwahi Projects is July – November so those periods would have the highest potential for bats to be present in the Project area (Menard 2001, SWCA 2011, Auwahi unpublished data). Therefore, more intensive monitoring is proposed for this period. The purpose of the bi-weekly search interval for bats is to minimize the influence of searcher efficiency. The average carcass persistence time at KWP I is approximately 7 days; therefore, bi-weekly searches should give searchers two opportunities to detect a given carcass. The effect of this approach can be a significant improvement in search efficiency. For example, if searcher efficiency is 60%, the probability of missing the same carcass twice is only 14% (0.40 * 0.40).

Year 2 – During Year 2 of the PCMP, search frequency from January to March and from October to December will remain unchanged (Table 2-1) unless dictated otherwise by the results of Year 1 bias trials. The frequency of searches during the bat activity period (July-September) will be based on the results of bias trials conducted in Year 1, in coordination with and following approval from the USFWS and DOFAW.

Beyond Year 2 - Some level of monitoring may be required throughout the operational period of the Project; the scope and frequency of this additional monitoring will be determined by the rate of take documented at the Project and will be subject to the approval of USFWS and DOFAW (Section 7.0).

Table 2-1. Search Frequency by Month in Relation to Seasonality of Petrel and Bat Biology

	Month											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Petrel Biology	**Petrels not present**		**Petrel breeding periods**							**Petrel fledging period**		**Petrels not present**
Bat Biology	**Low bat use**			**Bat breeding season**			**Peak bat activity at KWP II and Auwahi***					**Low bat use**
Year 1	**1X month**	**1X month**	**1X week**	**1X week**	**1X week**	**1X week**	**2X week**	**2X week**	**2X week**	**2X week**	**2X week**	**1X month**
Year 2	**1X month**	**1X month**	**1X week**	**1X week**	**1X week**	**1X week**	**TBD ***	**TBD**	**TBD**	**2X week**	**2X week**	**1X month**

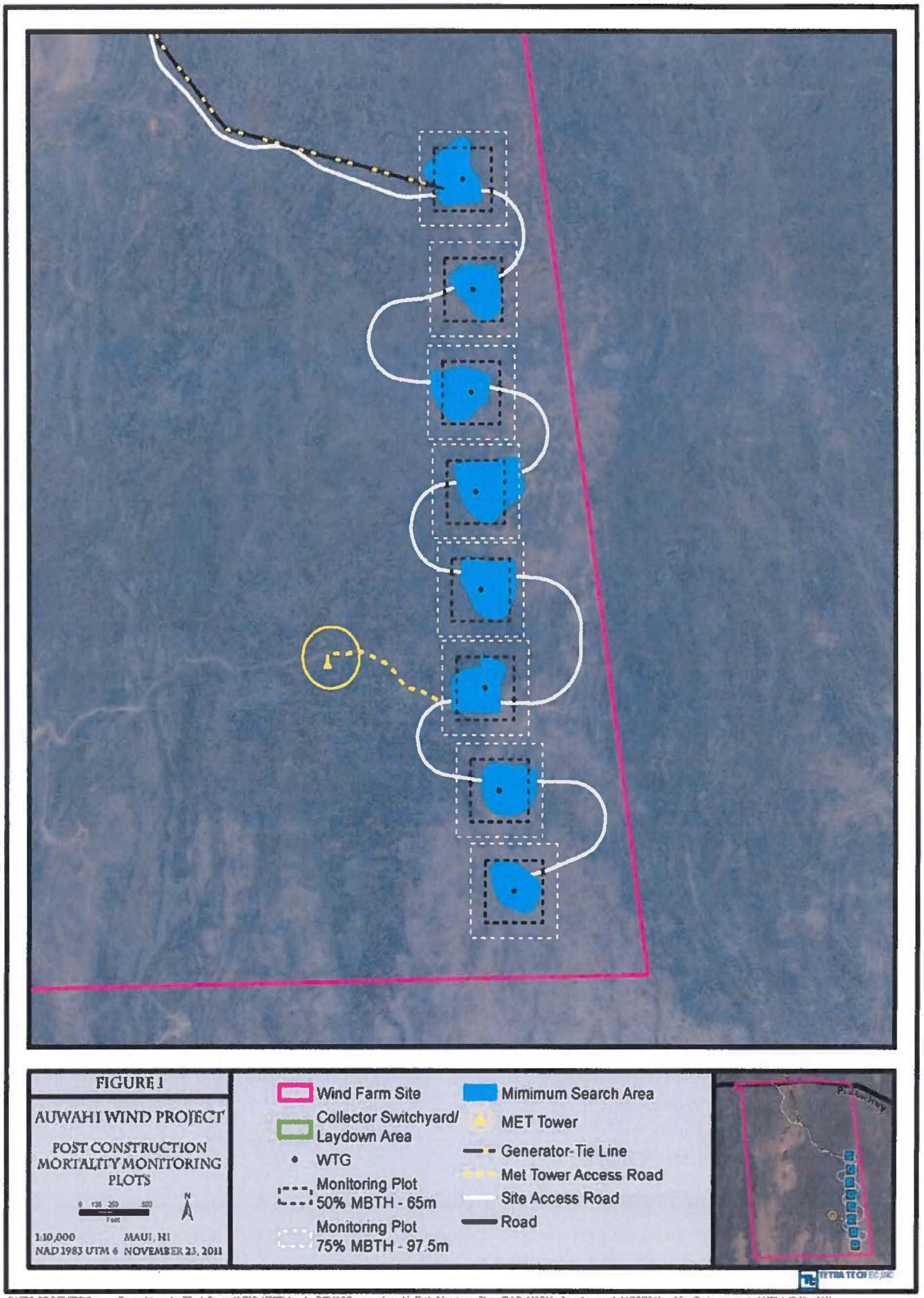
***Year 2 sampling frequency during bat activity period to be determined based on Year 1 data.**
TBD – to be determined

2.2 SAMPLING DESIGN

Search Plot Size and Configuration

Based on publicly available results from other post-construction monitoring programs at wind farms in Hawaii and the mainland, the majority of carcasses found during standardized carcass searches around individual WTGs have been found within a distance equal to 50 to 67 percent of WTG height. At the operating Kaheawa I project, 75 percent of carcasses attributed to WTG collisions found to date (including 9 carcasses of listed species: three Hawaiian petrel, four nēnē, and two Hawaiian hoary bat) were found within a distance less than 50 percent of the maximum time height of the WTGs where the area searched was 100 percent of WTG height (Hufana, S. pers. com. 2010). At the High Winds Wind Power Project, 96 percent of carcasses were found within two-thirds (67 percent) of WTG height (Kerlinger et al. 2005). Studies conducted at other wind energy facilities indicate that nearly all fatalities are found well within the WTG maximum tip height with over 80 percent of bat carcasses within a distance equal to 50 percent of the maximum distance from the tip height to the ground (Johnson et al. 2003; Young et al. 2003; Erickson et al. 2004; Arnett 2005; Kerns et al. 2005; Jain et al. 2007; Strickland et al. 2011).

The ideal search area for petrel fatalities (i.e., approximately 75 percent of WTG height) would have a radius of 97.5 meter (m) (Figure 1). The WTG has a hub height of approximately 262.5 feet (ft) (80 m) and blade lengths of 165.6 ft (50.5 m), resulting in a maximum tip height of 428.2 ft (130.5 m) above ground level (agl). The cleared and maintained turbine pad areas are not uniform among turbines, but are primarily rectangular in shape with sides between 295 ft and 492 ft (90 m and 150 m) in length (Figure 1). Therefore, portions of each search area not cleared by construction activity remain as rugged terrain. If the full area within the plot is determined not to be searchable based on low searcher efficiency or impassible terrain (depending on existing vegetation), the plot size will be reduced to the searchable area. Search areas will encompass maintained turbine pads and access roads, as well as adjacent unmaintained searchable areas. The actual area searched will be dependent on the configuration of the maintained areas, as well as the portion of the unmaintained area that can be realistically searched as determined during initial surveys (see Search Plot Mapping). Prior to conducting the first survey, a sweep survey will be completed within all search plots to clear all pre-existing carcasses from the search area. Ultimately, the monitoring plot sizes may not be consistent across WTGs or uniform in size in order to maximize search area and searcher efficiency. Density-weighted averaging will be used to estimate the number of carcasses that may have fallen in the non-search areas (Strickland et al. 2011; Section 5.0).



P:\GIS_PROJECTS\Sempra_Energy\Auwahi_Wind_Project\MXDs\HCP\Apndx_PCMM\Sempra_Auwahi_Fig1_MonitoringPlots_TabP_112311 - Last Accessed: 11/23/2011 - Map Scale correct at: ANSI A (8.5" x 11")

The ideal search area for bat fatalities (i.e., approximately 50 percent of WTG height) would have a radius of 65 m, and is a subset of the petrel search area. To maximize searcher efficiency, Auwahi Wind proposes to search all cleared areas within this ideal search area. On average, 58 percent of the ideal search area for each WTG consists of cleared area. Density-weighted averaging will be used to estimate the number of carcasses that may have fallen in the non-search areas (Strickland et al. 2011; Section 5.0).

Some of the terrain where WTGs are proposed is rugged and densely vegetated, which may in some instances make locating carcasses very difficult. Much effort would be spent searching these areas with an anticipated low searcher efficiency rate. Vegetation management would not be cost effective for this site; however, once the WTGs are operational and if it is determined that some vegetation can be managed for a reasonable cost, Auwahi Wind will consider this in order to increase the searchable area and searcher efficiency. Therefore, to maximize the potential for locating carcasses and use of resources, areas will be deemed realistically searchable if they consist of terrain that is safe for searchers to traverse and/or have a searcher efficiency rate of at least 70 percent for seabirds. The total search area for each WTG will be measured post-construction.

Transects will be established within search plots approximately 20 ft (6 m) apart, adjusted as necessary for vegetation type and visibility, and the searcher will walk along each transect searching both sides out to 10 ft (3 m) for fatalities. Personnel trained in proper search techniques will conduct the carcass searches. Protocol for documenting any fatalities or injuries is provided in Section 2.3.

The likelihood of collisions with a met tower on site is low. However, standardized searches will be conducted at the same search interval under the met tower within a plot extending 33 ft (10 m) from the base of the guy wires. Transects will be spaced approximately 20 ft (6 m) apart, but will be adjusted for vegetation type and visibility.

Search Plot Mapping

The Project site is topographically diverse with some proposed WTG locations in areas where safety issues may render portions of search plots unsearchable and vegetation management not feasible. This search area restriction influences the proportion of the actual fatalities that can possibly be detected (Huso 2010). To better estimate this potential influence, a global positioning system (GPS) will be used to map the boundaries of the actual area searched at each WTG. A density-weighted correction factor, based on this percentage of area searched and on the distribution of found carcasses, will be applied to the fatality estimate (e.g., Arnett 2005; Strickland et al. 2011). The proposed mortality estimator accounts for unequal searchable area across searched WTGs (Section 5.0).

Once the plot size is determined, vegetation types outside the maintained WTG pad within search plots will be mapped and classified according to varying levels of visibility (e.g., Arnett et al. 2009a,b). However, as previously discussed, search plot size and visibility may differ between WTGs. Therefore, it may be appropriate to group WTGs according to plot size and visibility and calculate fatality rates accordingly.

2.3 FATALITY DOCUMENTATION

2.3.1 Documentation of Turbine-related Fatalities

All carcasses found during standardized carcass searches will be labeled with a unique number, and searchers will record: species, sex, and age when possible; date and time collected; location (GPS coordinate and distance/direction from the WTG); condition (intact, scavenged, feather spot); and any comments that may indicate cause of death. If a carcass of a listed species is found, searchers will follow the project Downed Wildlife Protocol (Attachment 1) and complete a Downed Wildlife Incident Report (Attachment 3).

The condition of each carcass found will be recorded using the following categories:

- Intact/Complete—a carcass that is completely intact, is not badly decomposed, and shows no sign of being fed upon by a predator or scavenger.
- Scavenged/Dismembered—an entire carcass or most of a carcass which shows signs of being fed upon by a predator or scavenger, or a portion(s) of a carcass in one location (e.g., wings, skeletal remains, portion of a carcass, etc.), or a carcass that has been heavily infested by insects.
- Feather Spot—ten or more feathers at one location indicating predation or scavenging.

All casualties located will be photographed as found and plotted on a detailed map of the study area showing the location of the WTGs and associated facilities such as overhead power lines and met towers. A copy of the field forms for each carcass will be kept with the carcass at all times in a separate bag, if the carcass is removed from the field (examples provided as Attachments 2 and 3).

Carcasses will be double-bagged and frozen for future reference and possible necropsy or as otherwise directed by USFWS or DOFAW. Carcasses of non-listed species will be left in place or kept for searcher efficiency and/or carcass removal trials, or disposed of at an approved location as appropriate.

Searchers may discover carcasses incidental to formal carcass searches (e.g., while driving within the Project site). For each incidentally discovered carcass, the searcher will identify, photograph, and record data for the carcass as would be done for carcasses found during formal scheduled searches, but will code these carcasses as incidental discoveries.

Any injured native birds or bats found on the Project site will be carefully captured by a trained project biologist or technician and transported to a local USFWS- and DOFAW-approved wildlife rehabilitator (e.g., Maui Animal Rescue and Sanctuary located approximately 30 miles [48 kilometers] from the Project). Auwahi Wind staff conducting the surveys will be trained on how to handle any downed wildlife or carcasses found anywhere within the project area. Furthermore, a Downed Wildlife Incident Report (Attachment 3) will be completed for any injured animal or fatality.

2.3.2 Reporting Procedures

If a carcass of a listed species is found, searchers will follow the project Downed Wildlife Protocol (Attachment 1). This protocol includes agency contact information for reporting project-related incidental takes and from standardized surveys. Searchers will either provide the carcasses to the appropriate entity or store the carcass in the freezer for possible necropsy or take other action as directed by the USFWS and DOFAW. During the first 2 years of monitoring, all carcasses found attributed to incidental or during standardized surveys will be reported to USFWS and DOFAW.

3.0 CARCASS REMOVAL TRIALS

Carcass removal is the disappearance of a carcass from the search area due to scavenging, predation, or other means (e.g., wind, rain, decomposition beyond recognition). As previously discussed, the intensity of fatality searches should be conducted at a frequency that minimizes the amount of extrapolation that would be required in estimating mortality. Seasonal differences in carcass removal rates (e.g., changes in scavenger population density or type) and possible differences in the size of the animal being scavenged are typically taken into account when evaluating carcass removal rates.

The objective of the carcass removal trials is to document the length of time carcasses remain in the search area, and thus are available to be found by searchers, and, subsequently, to determine the frequency of carcass searches within the search plots. Carcass removal trials will be conducted during each season the first 2 years and will be used to adjust carcass surveys for removal bias.

Carcasses used in the trials will be selected to best represent the size, mass, coloration, and will have similar proportions to the Covered Species. For petrels and nene, carcasses may include legally obtained wedge-tailed shearwaters, a close taxonomic relative to Hawaiian petrels, if available; otherwise, commercially available adult game birds or cryptically colored chickens will be used to simulate seabirds. Auwahi Wind will coordinate with DOFAW and USFWS on availability of carcasses to be used during carcass removal trials. Bat carcasses will most likely not be available for scavenging trials, so a surrogate will be used. Carcasses of dark-colored mammals (e.g., small rats or mice) may be used to simulate bats. Legally obtained small passerines (e.g., house sparrows) or commercially available game bird chicks may be considered to simulate bats, although they are not ideal because of their differences in appearance and decomposition rates. Non-listed bird carcasses found during the surveys may be used for these trials.

3.1 SAMPLING INTENSITY

Given that carcass persistence times are currently unknown in the Project site, an initial carcass removal trial will be conducted for seabirds and bats after the Project is operational and just prior to the initiation of the PCMP to determine an initial carcass persistence rate. The search interval during the potential high bat activity period (July - November) will be established as the shorter of two time periods: two times per week or the interval after which at least 90 percent of trial carcasses remain. The resulting carcass removal data will be used during estimation of Project-wide avian and bat mortality. Should the desired search frequency not be met at any time due to reasons other than weather, health, or safety, Auwahi Wind will inform the agencies to discuss a course of action. These occurrences will be documented in annual monitoring reports. At the conclusion of Year 1 monitoring, the search frequency for Year 2 will be determined in consultation with USFWS and DOFAW.

Assuming adequate carcass availability, at least two trials will be conducted per season with up to eight carcasses of each size class (bat and bird) placed per trial, resulting in a total of up to 64 trial carcasses used in carcass removal studies for the entire year for the Project. Seasons will be defined based on the following annual dry and wet seasons experienced in Hawaii: dry season (May through October) and wet season (November through April). The trials will be spread throughout sampling period to incorporate the effects of varying weather, climatic conditions, and scavenger densities. The first trial will be conducted prior to initiating the monitoring program to establish the initial appropriate search interval.

3.2 CONDUCTING THE TRIAL

Each carcass used for the carcass removal trial will be placed at stratified random locations within the Project site near or within the search plots. Prior to initiating the trial, a set of random locations will be generated to determine the location of trial carcasses. These locations will subsequently be loaded into a GPS as waypoints to allow the accurate placement of the carcasses by field personnel. Carcasses will be dropped from waist high and allowed to land in a random posture. Each trial carcass will be discreetly marked (e.g., small tag or wire wrapped around one leg) prior to dropping so that it can be identified as a study carcass if it is found by other searchers or Project personnel.

Personnel conducting carcass searches will monitor the trial birds every day over a 21-day period during the first year of post-construction monitoring. By doing daily checks, Auwahi Wind will know the exact 24-hour period when the carcass is removed. Experimental carcasses will be left at the location until the end of the carcass removal trial.

When checking the carcass, searchers will record the condition as intact (normal stages of decomposition), scavenged (feathers pulled out, chewed on, or parts missing), feather spot (only feathers left), or completely gone. Changes in carcasses condition will be cataloged with pictures and detailed notes; photographs will be taken at placement and any time major changes have occurred. At the end of the 21-day period any evidence of the carcasses that remain will be removed.

3.3 CARCASS REMOVAL RATE ESTIMATION

Estimates of carcass removal rates or the time (measured in days) that carcasses remain on site and are available to be found by searchers are used to adjust carcass counts for removal bias. Mean carcass removal time ($\bar{t}$) is the average length of time a carcass remains in the study area before it is removed:

$$\bar{t} = \frac{\sum_{i=1}^{s} t_i}{s - s_c}$$

where t_i is the time (in days) a carcass remains in the study area before it is removed, s is the number of carcasses used in the trial, and s_c is the number of carcasses in removal trials that remain in the study area at the end of the trial period.

4.0 SEARCHER EFFICIENCY TRIALS

The ability of searchers to detect carcasses is influenced by a number of factors including the skill of an individual searcher in finding the carcasses, the vegetation composition within the search area, and the characteristics of individual carcasses (e.g., body size, color). The objective of searcher efficiency trials is to estimate the percentage of bird and bat fatalities that searchers are able to find. Estimates of searcher efficiency are then used to adjust carcass counts for detection bias. Searcher efficiency trials will be conducted during each season of the survey period during the first 2 years of monitoring to account for seasonal differences in searcher efficiency. Carcass acquisition for searcher efficiency trials will be the same as that described for carcass removal trials.

4.1 SAMPLING INTENSITY

Searcher efficiency trials will begin when WTGs are placed into operation and standardized carcass searches start. Personnel conducting the searches will not know when trials are conducted or the location of the detection carcasses. Trials will be conducted at least two times for each of the two seasons and will incorporate testing of each member of the field crew. Carcasses from both size classes (seabird and bat) will be included in the trials. A minimum of five carcasses per size class will be used in each trial. The number of trials conducted per season will be dependent upon carcass availability.

4.2 CONDUCTING THE TRIAL

All carcasses will be placed at stratified random locations within areas being searched prior to the carcass search on the same day so that searchers are not aware they are being tested. Carcasses will be dropped from waist high or higher and allowed to land in a random posture. Each trial carcass will be discreetly marked (e.g., small tag or wire wrapped around one leg) prior to dropping so that it can be identified as a study carcass after it is found. The number and location of the detection carcasses found during the carcass search will be recorded. The number of carcasses available for detection during each trial will be verified immediately after the trial by the person responsible for distributing the carcasses.

4.3 SEARCHER EFFICIENCY RATE ESTIMATION

Searcher efficiency rates will be estimated by searcher, carcass size and types, WTG, and season. These rates are expressed as p, the proportion of trial carcasses that are detected by searchers in the searcher efficiency trials, as provided in the fatality rate calculation discussion in Section 5.0.

5.0 FATALITY RATE CALCULATION

The estimate of total direct take will incorporate observed mortality, documented during standardized carcass searches, as well as unobserved mortality, or individuals that may have been killed by interactions with Project components but are not found by searchers for various reasons.

Specifically, fatality estimates will be calculated for seabirds and will take into account:

- Search interval;
- Searchable area around each searched turbine;
- Observed number of carcasses found during standardized searches during the monitoring year for which the cause of death can be attributed to facility operation;
- Carcass removal rates, expressed as the estimated average number of days a carcass is expected to remain in the study area and be available for detection by the searchers during removal trials; and
- Searcher efficiency, expressed as the weighted average proportion of planted carcasses found by searchers during searcher efficiency trials.

There have been many recent advances in post-construction monitoring techniques and fatality rate estimates, and there are a number of estimators available for calculating fatality rates. These estimators provide different methods to account for unobserved mortality, with some estimators treating searcher efficiency and carcass removal as separate factors and others treating them as interrelated (e.g., Shoenfeld 2004; Jain et al. 2007; Huso 2010). However, the most recent estimator developed by Huso (2010) is expected to be used until improvements to estimating fatality rates are available. Huso's estimator will improve the potential for reducing the inherent biases in the data and provide the ability to account for variable search ability (e.g., based on vegetation types or unsearchable areas) within the search plot. Take can also be calculated per turbine and per interval while adjusting for variables such as actual area searched or visibility class. The Huso (2010) estimator can be expressed as:

$$\hat{M} = \frac{c}{\hat{a}\ \hat{r}\ \hat{p}\ \hat{e}}$$

Where:

M = estimated total direct mortality
c = observed number of carcasses
a = the estimated density-weighted proportion of the plot searched
r = estimate of proportion of carcasses remaining after scavenging (scavenger efficiency)
p = estimated searcher efficiency (proportion of carcasses found)
e = effective search interval (days) calculated as the ratio of (days before 99 percent of carcasses can be expected to be removed/search interval) or 1, whichever is less.

6.0 WILDLIFE EDUCATION AND INCIDENTAL REPORTING PROGRAM

Auwahi Wind will implement a Wildlife Education and Incidental Reporting program for contractors, Project staff members, and other 'Ulupalakua Ranch staff who are on site on a regular basis. This training enables staff to identify the Covered Species that may occur in the Project area, record observations of these species, and take appropriate steps for documentation and reporting when any Covered Species is encountered during construction or operation of the Project including when downed birds or bats are found. The Wildlife Education and Incidental Reporting program will facilitate incidental reporting of observations within the Project site, as well as within the generator-tie line corridor where Auwahi Wind staff and 'Ulupalakua Ranch are regularly present during the course of normal Project and ranch operations. Incidental reporting will inform the Project post-construction monitoring program of any wildlife fatalities that occur outside of standardized fatality surveys within the Project, as well as providing supplementary information on impacts associated with the generator-tie line where standardized post-construction monitoring will not occur. The program will be prepared by a qualified biologist and will be approved in advance by the USFWS and DOFAW. Over the term of this HCP, the program will be updated as necessary.

The program will include wildlife education briefings to be attended by new Project staff and other contractors or ranch staff as appropriate. Staff members will be provided with printed reference materials that include photographs of each of the Covered Species and information on their biology and habitat requirements; threats to the species on site; and measures being taken for their protection under this HCP. The Project Biologist, who will coordinate the post-construction monitoring on site, will coordinate with the Construction Foreman and the Project Operations Manager to ensure that personnel receive the appropriate written material.

Staff members will be responsible for responding to and treating wildlife appropriately under all circumstances, including avoiding approaching any wildlife other than downed wildlife and avoiding any behavior that would harm or harass wildlife (including feeding). In conjunction with regular assigned duties, personnel will be responsible for:

- Recording any project-related wildlife incidents;
- Adhering to Project area road speed limits;
- Identifying Covered Species when possible (Hawaiian petrel, nēnē, Hawaiian hoary bat, and Blackburn's sphinx moth) and documenting observations by filing a Wildlife Observation Form; and
- Identifying, reporting, and handling any downed wildlife in accordance with the Downed Wildlife Protocol, including filing a Downed Wildlife Incidence Report form (Attachment 3).

7.0 SAMPLING BEYOND THE INITIAL TWO-YEAR PERIOD

Sampling duration, plot size, and survey intensity may be modified upon completion of the initial 2 years of monitoring or sooner, subject to approval by USFWS and DOFAW. It is anticipated that surveys conducted during the first two-year period will provide sufficient data on take to adequately describe carcass distribution and spatial and temporal trends in fatalities within the Project area. The PCMP data may provide justification for modifying search plot size, search frequency, or the number of WTGs searched, or for concentrating sampling efforts at specific WTGs or during certain times of year during subsequent years of monitoring. These data will also illustrate trends in searcher efficiency and carcass removal over time.

Should the documented searcher efficiency drop below an average of 50 percent, Auwahi Wind will collaborate with the USFWS and DOFAW to develop alternative search strategies (e.g., intensive vegetation management, trained search dogs). A searcher efficiency of 25 percent is considered to be the minimum required for statistical validity (Strickland et al. 2011).

Auwahi Wind proposes a long-term monitoring approach consisting of periodic intensive monitoring followed by interim years of less intensive but systematic monitoring. Intensive monitoring would occur every 5 years after the initial 2-year intensive sampling period (i.e., years 7, 12, 17, and 22), resulting in a total of 6 years of intensive monitoring during the life of the Project (Table 7-1). During intensive monitoring years, searcher efficiency trials and carcass removal trials would be conducted to determine if any variables have changed over time and if any modifications to search frequency are required (Table 7-1). During interim years, assuming trends in the monitoring data provide confidence in the estimate of take, the monitoring effort would be reduced to conducting systematic carcass surveys on a monthly or other less frequent basis. The frequency at which the surveys take place during interim years will be determined at the conclusion of the carcass removal trials for that 5-year period. It is assumed that searcher efficiency trials may have to be conducted more frequently depending on changes in staff. All adjustments to direct take during interim years would use the most recent estimates from the searcher efficiency and carcass removal trials. Revised methods will be evaluated in cooperation with USFWS and DOFAW.

Table 7-1. Schedule of Post-Construction Monitoring over the ITP/ITL Term

Year of Permit Term	Standardized Carcass Searches	Searcher Efficiency and Carcass Removal Trials
1	Intensive Monitoring	X
2	Intensive Monitoring	X
3-6	Systematic Monitoring	--
7	Intensive Monitoring	X
8-11	Systematic Monitoring	--
12	Intensive Monitoring	X
13-16	Systematic Monitoring	--
17	Intensive Monitoring	X
18-21	Systematic Monitoring	---
22	Intensive Monitoring	X
23-25	Systematic Monitoring	--

This approach is designed to inform Auwahi Wind where take levels are in relation to the established tiers outlined in the HCP and to provide a mechanism for continually assessing and adjusting the sampling scheme to ensure data accuracy. Continuous standardized monitoring will provide shorter-term benchmarks for evaluating whether take is higher or lower than anticipated over a several-year period, recognizing that take may fluctuate during years of operation. Thus, Auwahi Wind will be able to gauge easily when a given tier of take is being approached, signaling the need to engage the USFWS and DOFAW in additional discussions regarding Project status and to begin preparation for implementation of additional mitigation. This information will be used to inform any other decisions related to adaptive management as described in the HCP.

8.0 REPORTING

An annual report for the Project will be submitted to USFWS and DOFAW. The report will include the following:

- A summary of the results of the post-construction monitoring surveys including a list of detected carcasses;
- Results of the carcass removal trials and searcher efficiency trials;
- Documented take, if any, of each covered listed species;
- The identification of any recommended changes to the monitoring protocols, and
- Any proposed protocol modifications.

The reporting schedule is outlined in the Monitoring section of the HCP.

A Downed Wildlife Incident Report will be filed with the USFWS and DOFAW within 3 business days (Attachment 3) of the discovery of a federally and state-listed species and cumulative adjusted take will be reported to the agencies within 3 weeks. Auwahi Wind will consult with the USFWS and DOFAW to review take limits and will discuss changed circumstances or adaptive management measures as necessary. Carcasses of non-listed species will be reported to DOFAW and USFWS on a monthly basis.

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ATTACHMENT 1

DOWNED WILDLIFE PROTOCOL

DOWNED WILDLIFE PROTOCOL

Downed birds or Hawaiian hoary bats may be dead or injured at discovery. Birds or bats will be labeled with a unique number, and searchers will record species, sex and age when possible, date and time collected, location (GPS coordinate, and distance/direction from the turbine), condition (injured or carcass that is either intact, scavenged, feather spot) and any comments that may indicate cause of death. After the downed bird or bat is photographed, USFWS or DOFAW Staff will be contacted if it is a threatened or endangered species.

DEAD BIRD OR HAWAIIAN HOARY BAT:

- After the appropriate documentation has been completed, leave the carcass in place for DOFAW or USFWS to inspect and collect or bag and freeze as directed by DOFAW or USFWS.

- Contact DOFAW or USFWS staff about find:
  1. Fern Duvall, DOFAW 808-264-0922
  2. Sandee Hufana, DOFAW 808-587-4148
  3. Dawn Greenlee, USFWS 808-792-9469

INJURED BIRD OR HAWAIIAN HOARY BAT:

Procedure

1. Gently pick up and place bird or bat into carrier equipped with turf/carpet.
2. Mark exact spot of find(s) with stake(s)
3. Call DOFAW or USFWS - as above if listed species.
4. Move or transport bird/bat from site subsequent to notification or instruction of DOFAW or USFWS staff.

ATTACHMENT 2

CARCASS SURVEY FIELD FORMS

Auwahi Wind Farm Project Post-construction Monitoring Field Form

Date (MM/DD/YYYY) ___________ **Surveyors** ________________

Precipitation ______ (L) light rain (R) rain (D) dry (F) fog **Cloud Cover** _____ (C) clear (P) partly cloudy-25% (L) light-50% (M) moderate-75% (H) high-100%

Wind _____ (0) <0 mph (1) leaves barely move (2) leaves rustle/sm. twigs move (3) sm. twigs move (4) sm. branches move (5) lg. branches move/trees sway (6) variable

Standardized Carcass Searches

Tower No./Met tower[1]	Search Plot (50 or 75 %)	Start Time	End Time	Total Minutes	Fatalities Detected[2]	Other Observations (other wildlife, tracks, sign)
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			
		___:___	___:___			

[1] If a scheduled carcass search cannot be conducted due to weather or other safety concerns note the tower number and provide justification.

[2] List unique identifying number to correspond with casualty mmddyyyy_ turbine#_species code_ # (optional if more than one carcass of the same species is found)

ATTACHMENT 3

DOWNED WILDLIFE INCIDENT REPORT

Auwahi Wind Farm Project Downed Wildlife Incident Report

CASUALTY INFORMATION

Date ______________ **Time**__________ **Observer**______________________

Type of Find (check one): Scheduled Carcass Search_____ Incidental Find_____

Identification number ____________________________ **Photo No.**____________________
(mmddyyyy_ turbine#_species code_# (optional if more than one carcass of the same species is found))

Species ______________ **Sex (circle):** male female unknown **Age (circle):** adult juvenile unknown

Condition (circle one): injured intact scavenged dismembered feather spot other

Estimated Time Since Death/Injury___________

Comments: (e.g., behavior observed in bird/bat is injured; detail of carcass—body parts missing, injuries, number of feathers in feather spot; indications of cause of death)

LOCATION

Plot Type (circle): turbine met tower other **Turbine No.** _______

Location if not on plot ________________

Habitat ____________________________

Location Relative to Nearest Turbine/Tower:

Description	Distance (meters)	Bearing (degrees)
Part 1 ______________	___________	______________
Part 2 ______________	___________	______________
Part 3 ______________	___________	______________

Comments: (if carcass is estimated to be less than a week old, note weather conditions that occurred at or before the estimated time of death/incident)

AGENCY CONTACT

USFWS Contact: Date _______ **Time** _____ **Contact Person(s)** __________________________
Comments:

DOFAW Contact: Date _______ **Time** ______ **Contact Person(s)** __________________________
Comments:

Disposition of Find ________________________

Transport to Freezer (circle): yes no **Date** ______________ **Time** _______________

Appendix F
Avian Risk of Collision Analysis for the South Auwahi Wind Resource Area, Maui, Hawai'i

AVIAN RISK OF COLLISION ANALYSIS

FOR THE

SOUTH AUWAHI WIND RESOURCE AREA

MAUI, HAWAII

PREPARED FOR:

Sempra Generation

101 Ash Street

San Diego, CA 92101-3017

PREPARED BY:

Hamer Environmental L.P.,

P.O. Box 2561

Mount Vernon, WA, 98273

6 October 2010

EXECUTIVE SUMMARY

- We utilized ornithological radar and audiovisual survey methods to record movement rates and flight heights of the Hawaiian Petrel (*'Ua'u*) (*Pterodroma sandwichensis*) at the proposed Auwahi Wind Resource Area (AWRA) from 25-30 May 2010 (nesting season) and 11-18 October 2006 (fledging season) for a total sampling time of 41.5 hours.

- Study objectives were to: 1) use surveillance (horizontal) and vertically oriented radars to measure movement rates (birds/hr) and flight heights of Hawaiian Petrels and Newells Shearwaters during nesting and fledging seasons at the AWRA, 2) estimate an annual passage rate of birds that would pass through the AWRA, and 3) estimate annual collision and fatality rates for Hawaiian Petrels for each of the three wind turbine configurations. Newell's Shearwaters were excluded from this collision risk analysis due to low likelihood of shearwater presence in south Maui.

- Petrel flights recorded during spring 2010 and fall 2006 radar surveys were 164 petrel flights in spring and 229 petrel flights in the fall.

- The peak hourly movement rate for nesting and fledging season was 9.45 petrel flights per hour. We adjusted the movement rate for portions of the turbine array not sampled by radar, portion of the night not sampled, and mean flock size of petrels. The mean movement rate was 43.67 petrel flights per day.

- We calculated the yearly passage rate for Hawaiian Petrels based on their breeding period of 231 days. We estimated 11,642 Hawaiian Petrel flights passing over the AWRA 1.5 km radius study area annually. This estimate is likely based on birds passing through the AWRA multiple times during the entire survey period rather than individual birds passing through the AWRA only once. Hence, this annual estimate does not represent a population size.

- To estimate collision risk for petrels at the proposed AWRA, we used a site-specific adjusted avian passage rate, flight altitudes and wind data as model inputs. In addition, we used wind turbine characteristics and Hawaiian Petrel body dimensions to run the Hamer Risk of Collision Model for 36 different model configurations. The Monte Carlo sampling method used in the Hamer Model simulated 1,000,000 "typical" flight paths for each of the 36 model configurations in order to generate an estimate of mean collision probability.

- We selected a range of avian avoidance rates for Hamer Risk of Collision Model simulations, assuming 90, 95 and 99% of Hawaiian Petrels will avoid collisions with moving portions of wind turbines in the AWRA. We assumed 99% of petrels will avoid fixed portions of wind turbines.

- We estimate that between 0.662 to 3.450 Hawaiian Petrels may be at risk of collision annually with turbine structures at the AWRA, depending on the turbine configuration and a collision avoidance rate between 99% to 95%. Similarly, we estimate between 0.067

to 0.312 Hawaiian Petrels may be at risk of collision annually per turbine, depending on the turbine configuration and a collision avoidance rate between 99% to 95%. We assume that all avian collisions with structures will result in mortality, so these collision estimates are also annual mortality estimates.

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INTRODUCTION

Sempra Generation (Sempra) is proposing to construct a wind energy development on the Auwahi parcel of Ulupalakua Ranch, located on the southern coast of East Maui. The project was recently purchased by Sempra from Shell WindEnergy, Incorporated (Shell) of Houston, Texas. As part of the assessment of environmental impacts for the project, ornithological radar surveys were conducted to determine the relative use of the Auwahi Wind Resource Area (AWRA) by a state and federally listed avian species, the endangered Hawaiian Petrel (*'Ua'u*) (*Pterodroma sandwichensis*).

Based on the previous success of using modified marine radar to study these species in the Hawaiian Islands (Cooper and Day 1994, 1995, 1998, 2003, Day et al. 2003a,b, Reynolds et al. 1997), the use of ornithological radar was chosen as the primary survey method, with supplemental assistance from an audio-visual observer. Upon review of 2006 avian radar surveys conducted by Shell, Sempra determined spring/summer nesting season surveys should be redone in 2010 for two reasons:

1) the radar location in summer 2006 was located close to the Pi'ilani Highway due to limited road access and coverage designed for a previously proposed turbine configuration. This resulted in poor radar coverage (41-49% coverage depending on the turbine configuration) of the current proposed AWRA. The location of the spring 2010 radar surveys is the same as fall 2006 to attain the most complete coverage of the proposed wind development and to ensure maximal cross-season comparisons.
2) summer 2006 surveys were conducted in mid-July, which may have been too late to capture peak nesting activity of the target bird species. Surveys were conducted May 25-30, 2010 to replace the 2006 summer surveys. The timing of the 2010 spring survey effort captured peak movement rates of birds passing through the proposed AWRA.

Data collected by avian radar surveys was utilized to model potential avian collision risk for Hawaiian Petrels transiting through the proposed AWRA study area (1.5 km radius). The Hamer Risk of Collision Model (Hamer Model), an improved extension of the industry standard Tucker Model (Tucker 1996), was utilized to model avian collision risk. The Hamer Model incorporates site specific wind turbine design and configurations, wind data (from a meteorological tower), petrel passage rates, flight directions, flight speeds, and flight heights (from radar data), and also accounts for collision risk of stationary portions of the wind turbine to determine the risk of collision at the AWRA.

Three different turbine models are being considered for the AWRA (GE 1.5 xleWE, Siemens SWT 2.3-101 and Siemens SWT 3.0-101). The number of wind turbines proposed, their configuration on the landscape, and the turbine dimensions/specifications are different for each turbine model. Therefore, avian collision risk was modeled independently for each of the three turbine models. In this report, we will summarize the avian passage rates determined by radar surveys conducted at the AWRA study area (fall 2006 and spring 2010), and review the height distribution of Hawaiian Petrel targets. Using this data and the Hamer Model, we then provide an estimate of the mean collision risk and annual fatality of Hawaiian Petrels for each of the three possible wind turbine configurations.

BACKGROUND

Species Composition

Based on known seabird populations nesting on Haleakala, we assumed that all birds transiting the AWRA were Hawaiian Petrels but Newell's Shearwaters were potentially present in extremely small numbers. Newell's Shearwaters were not detected during avian radar and audio-visual surveys conducted at the AWRA study area in spring 2010 and fall 2006. Additionally, a study conducted at multiple sites on Maui in 2003 detected only Hawaiian Petrels and no Newell's Shearwaters at the Nuʻu Bay site closest to the AWRA (Cooper and Day 2004). Fern Duvall (DOFAW biologist, pers. comm.) concured that over 99% of seabirds transiting the AWRA would be Hawaiian Petrels (Fern Duvall, pers. comm.). Hawaiian Petrel were the only species assessed in the following risk of collision analyses.

Hawaiian Petrel

The Hawaiian Petrel is a large, nocturnal gadfly petrel endemic to Hawai'i. Prior to the arrival of Polynesians, sub-fossil evidence indicates the Hawaiian Petrel was common throughout the main Hawaiian Islands (Olson and James 1982). The species was federally listed as endangered in 1967 (USFWS 2005a). It is also listed as endangered under the State of Hawai'i endangered species statutes (DLNR 1998).

Hawaiian Petrel nesting colonies have been documented on Maui, Hawai'i, Lana'i and Kaua'i (Figure 1). The islands of Kaua'i and Maui are estimated to support the majority of the nesting adults. Based on calls heard during the breeding season the Hawaiian Petrel is also suspected to breed on the island of Moloka'i (Simons and Hodges 1998).

Figure 1. Breeding distribution of Newell's Shearwaters and Hawaiian Petrels in the Hawaiian Islands. (Source: Birds of North America [Ainley et. al. 1997]).

On Maui, most of the known Hawaiian Petrel nest sites can be found in and around Haleakala National Park. Vegetation associated with nesting areas is characterized primarily as subhumid and subalpine. In these dry habitats, vegetative cover is generally low and plant community is dominated by several shrub species. In more humid areas at lower elevations, petrels burrow extensively along soil-covered slopes. Natividad Bailey (2009) states that Hawaiian Petrels in Haleakala National Park nest in burrows, most of which are located along the steep cliffs of the western rim of Haleakala Crater.

There are currently more than 1,000 known burrows, of which about 60% are occupied by Hawaiian Petrels each year. Hawaiian Petrels are present at Haleakala from February through October and are absent from November through January. Haleakala National Park staff search for new burrows and check existing burrows at least once a month while the petrels are present. Petrels fly over land only at night and can be detected by distinctive calls. Calls are commonly heard throughout Haleakala Crater from March through September each year. The population of Hawaiian Petrels on Haleakala is estimated at 900-1,300 individuals, (450-650 breeding pairs) (Simons 1984, 1985, Simons and Hodges 1998). A small sub-colony has also been located along the more densely vegetated south rim of the crater (Simons and Hodges 1998).

Typical summer flight patterns for the Hawaiian Petrel includes flights landward at dusk and seaward at dawn. Collisions with human-made objects on Maui (Hodges 1994) and Kaua'i (Telfer et al. 1987, Cooper and Day 1998, Podolsky et al. 1998) have caused documented mortality. Hawaiian Petrels occasionally become grounded after being disoriented by lights in urban areas. Although only 15–20 petrels are reported grounded on Maui and Kaua'i in an average year, the maximum number of reported groundings has been as high as 20 birds on Maui, and 29 on Kaua'i (Simons 1983, Hodges and Nagata 2001, Reggie David pers. comm.). Groundings on Maui are concentrated in urban areas, as on Kaua'i, and are more likely to occur on overcast or moonless nights (Telfer et al. 1987).

Newell's Shearwater

The Newell's Shearwater is the Hawaiian endemic sub-species of the Townsend's Shearwater (*Puffinus auricularis auricularis*), a medium sized "Manx-type shearwater". Due to low overall population numbers and restricted breeding distribution, the sub-species was federally listed as threatened in 1975 (USFWS 2005b). It is also listed as threatened under the State of Hawai'i endangered species statutes (DLNR 1998). Newell's Shearwater were once widespread in the main Hawaiian Islands; they are now known to breed mainly on Kaua'i, Hawai'i, and Moloka'i with possible small numbers on O'ahu, Maui and Lana'i, (Ainley et al. 1997, Reynolds and Richotte 1997, Reynolds et al. 1997, Day et al. 2003a, b) (Figure 1). On Maui, injured, dead or grounded Newell's Shearwater adults in summer (Pyle 1983), and juveniles in autumn have been confirmed, though it is believed that fledgling specimens probably were individuals attracted to shore from elsewhere by coastal lights (Ainley et al. 1997). Wood and Bily (2008) reported possible nesting grounds on the east side of Maui (see below), though this report is unconfirmed since their detection of nocturnal, terrestrial-based vocalizations on a single night did not visually confirm species identity or breeding activity. Thus, if they do nest on Maui, their nesting distribution and habitat use are still unknown and unpublished. Due to their nocturnal habits (Day and Cooper 1995) and inaccessible and remote mountainous terrain where most nesting colonies are located, obtaining accurate information on their distribution, abundance, and population trends has proven difficult.

Nesting sites have been observed within steep mountainous terrain where they burrow under matting fern species such as *Dicranopteris linearis*, *Diplopterygium pinnatum* and *Sticherus owhyhensis*, and are frequently associated with sparse *Metrosideros* and *Cheirodendron* tree cover with a varying presence of understory native shrubs. Substantial numbers of Newell's are also known to nest on sparsely vegetated cliffs in remote valleys such as the dry leeward side of Kaua'i (Wood et al. 2001). Wood and Bily (2008) suggest that Newell's Shearwater utilize the *Sadleria* ('ama'u) mixed shrubland community found on East Maui for at least one nesting site, based on the aforementioned aural records and their impression of potential suitable habitat. This fern community is found within the upper Pi'ina'au headwater region situated within the Ko'olau Forest Reserve and just above the western wall of Ainahou Bowl of Ko'olau Gap.

STUDY AREA

The AWRA is located on the lower southern slopes of a ridge system that runs northeast toward Red Hill and the Haleakala Crater. Sheltered on the leeward side of Mount Haleakala, the vegetation in this area is characteristic of dry coastal shrublands and volcanic landscapes. The AWRA is on the Ulupalakua Ranch; bordered by the Pacific Ocean to the south, the Kanai'o parcel to the west, and the Lualailua parcel to the east (Figure 2).

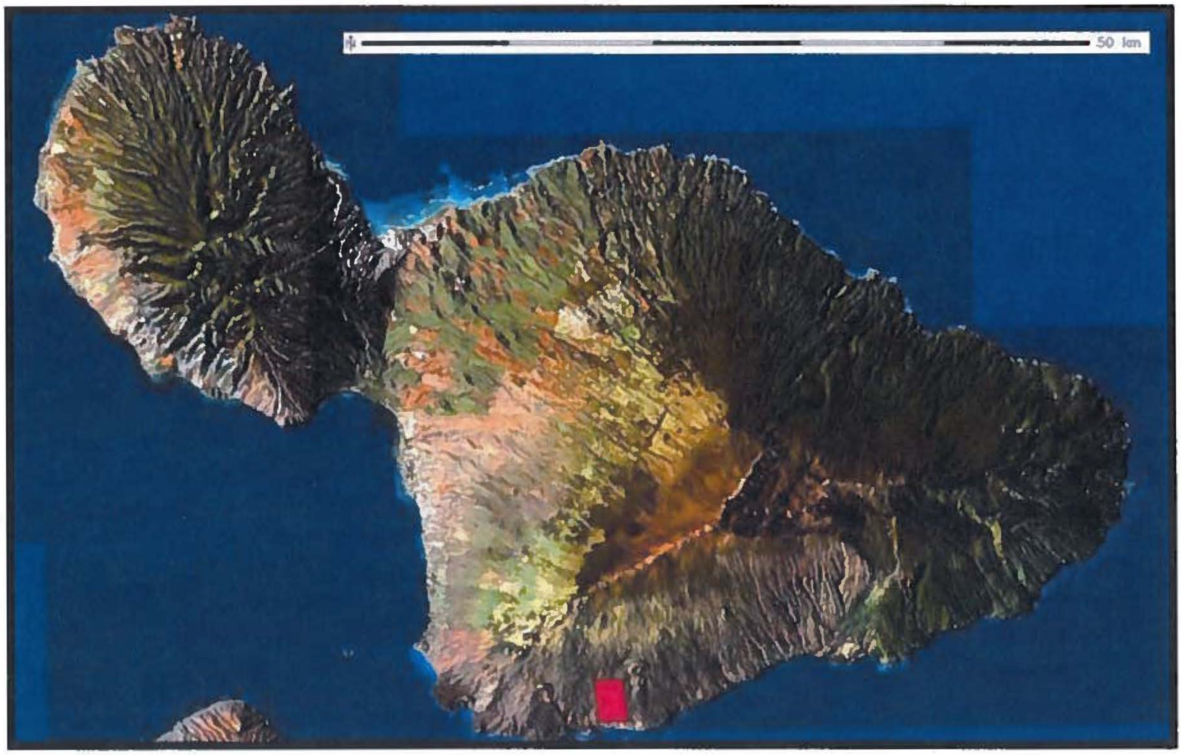

Figure 2. Location of proposed AWRA on the island of Maui, Hawai'i.

The Auwahi parcel is bisected into a northern and southern section by Pi'ilani Highway, with the proposed AWRA located south of Pi'ilani Highway. The spring 2010 and fall 2006 radar survey station was located at 20.60322 lat, -156.32518 long, at an elevation of 330 m above sea level (ASL) (Figure 3). The proposed AWRA encompasses the area south of Pi'ilani Highway and is approximately 3 km long and 2.5 km wide (Figure 3).

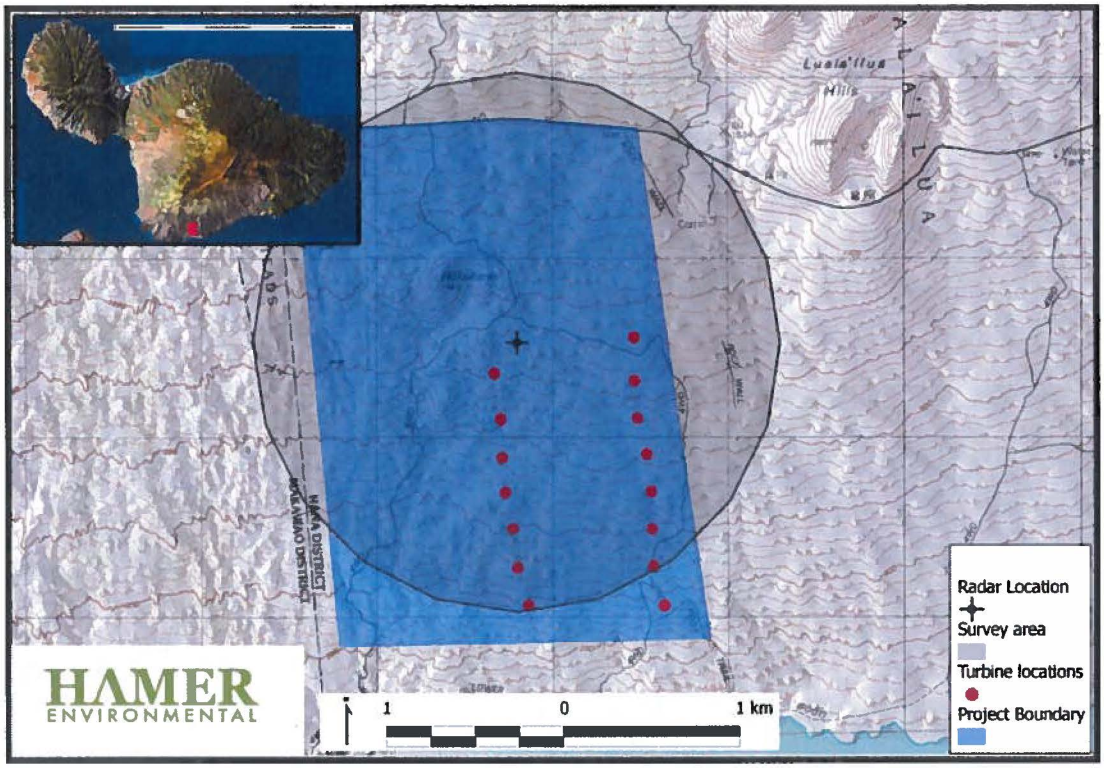

Figure 3. Location of the AWRA (blue), GE turbine configuration, with radar survey coverage (gray circle), Ulupalakua Ranch, Maui, Hawai'i.

METHODS

Radar Surveys

We used standard marine radar systems which we modified to enable their use for terrestrial ornithological studies. Our systems consisted of Furuno Model FR-1510 Mark 3 X-band marine radars transmitting at 9,410 MHz with a peak power output of 12 kW. The radars were operated at the 1.5 km scale and a pulse length of 0.07 μsecond. We tilted the horizontal radar scanners up 30° to reduce ground clutter. Because of these modifications and the selection of optimal survey sites, the amount of ground clutter at this site was less than 10%, and likely did not affect our ability to detect birds within the range of the radar.

We conducted radar observations of bird activity from 25 to 30 May 2010 and from 11 to 18 October 2006. The spring 2010 and fall 2006 studies were scheduled to correspond with the peak nesting and fledging periods, respectively, of both the Hawaiian Petrel and Newell's Shearwater. We sampled the site for five consecutive days each season during both the peak dusk movement (~1830-2130) and the peak dawn period (~400-600).

Data collected by horizontal radar included: the event number, time, direction of flight and tangential range. We recorded the flight behavior, flight speed, and number of birds. We also recorded the flight direction of each bird and whether the targets were heading landward, seaward or other directions. We used the surveillance (horizontal) radar and vertical radar systems for both the spring and fall seasons. The vertical radar system enabled us to collect information on bird flight heights. On the vertical radar, we recorded only the birds that were confirmed by the surveillance radar as likely petrel targets. For every bird detected on the vertical radar, we recorded the closest distance to the ground along with the bearing from the radar, enabling us to calculate the height above ground level and horizontal distance from the radar to each bird.

We used Microsoft Excel 2007 to enter all radar and outside data collected. We then generated counts of birds during each sample session. These counts were converted to estimates of movement rates (bird flights/hr for the entire 3 km diameter radar sampling area), based on the number of minutes sampled.

Passage Rate Calculations

Some assumptions were implicit to create an annual adjusted passage rate of Hawaiian Petrels transiting across the AWRA study area. The total passage rate is not necessarily equivalent to the number of individuals that pass through the AWRA, since a single bird may pass through the AWRA multiple times throughout the year. Furthermore, a single bird could fly over the AWRA as often as twice in one day during the morning foraging (seaward) flight and the evening (landward) flight to the nest. Our modeling approach assumes the population of Hawaiian Petrels remains constant throughout the year, even if there is a chance of mortality due to avian/turbine collision (sampling with replacement). This approach can be justified if the estimated number of annual collisions is significantly less than the daily passage rate.

<u>Survey Hours and Peak Activity Period</u>

Radar observations of bird activity were conducted during nesting (spring) and fledging (fall) periods of Hawaiian Petrel. Radar sampling of the AWRA study area was conducted for five consecutive days each season during both the peak dusk and dawn activity periods for a total of 41.5 sampled hours. One day was rained-out in the fall and could not be repeated due to record rainfall and flooding of the area.

Hence, a total of 9 days were successfully sampled for both survey visits with only 99 minutes when the radar sessions were affected by periods of rain causing clutter on the radar screens. During periods of light rain, rain clutter on the screen is often somewhat transparent, and echoes of birds can often be tracked and measured through the clutter. We could not collect horizontal or vertical radar data during periods of moderate to heavy rain because the electronic filtering required to remove the echoes of the precipitation from the display screen also removed bird targets. As a result, we recorded the number of minutes of each survey where ≥50 percent of the radar monitor contained clutter due to rain. During these portions of the survey period the radar scan was compromised by rain to the point where we could no longer reliably detect petrel type targets. Therefore, these compromised survey minutes were excluded from mean passage rate calculations. The numbers of petrel type targets detected during the sampling periods were divided by the total sampled hours unaffected by rain to determine a mean hourly passage rate. The daily movement rate was determined by dividing the total numbers of petrel type targets detected by the total number of days sampled.

Hawaiian Petrel peak flight periods occur around dawn and dusk when most birds are transiting between inland nest sites and open ocean. Thus, radar and audio-visual surveys were conducted during peak dusk and dawn periods. Peak dusk movement (when birds would be expected to be flying landward toward their nesting colonies) occurred just after sunset (~1845-2115). Peak dawn movement (when birds would be expected to be flying toward the ocean away from nesting colonies) occurred before sunrise (~0345-0545). The peak hourly movement rate was calculated by dividing the total number of Hawaiian Petrel flights detected by radar by the total number of radar survey hours.

To calculate a daily passage rate, we combined dusk and dawn sessions into one survey "day" by defining each survey day to begin near sunset (e.g., 1845) and end the next day at sunrise (e.g., 0545). Though most petrels fly during peak dusk and dawn periods, smaller portions of birds are known to fly throughout the night (Day and Cooper 1995, Sanzenbacher and Cooper 2009). To estimate the proportion of birds expected to pass over during the portions of the night when we did not sample, we used an adjustment derived by comparing peak and all night sampling passage rates from data collected on Kaua'i in 1993 (Day and Cooper 1995). The adjustment for the proportion of flights occurring during the un-sampled nocturnal period was 12.6% of the total nightly passage rate (Cooper and Day 2004). Therefore, our total nightly passage rate was calculated by multiplying our mean movement rate from our peak sampling periods (targets/day) by 1.126.

Flock Size

Radar detections of multiple birds flying close together may sometimes appear as a single echo on the radar screen and thus be recorded as a single target. For that reason the nightly passage rate was adjusted by the expected mean number of birds per radar target (flock size) following the methods of Cooper and Day (2004). Their estimate of 1.025 birds/flock was derived by taking the mean flock size of petrel and shearwater targets from data they collected on Kaua'i (Day and Cooper, unpubl. data). Therefore, our mean nightly passage rate was multiplied by 1.025.

Breeding Season

We determined the total number of days Hawaiian Petrels are expected to be on land for the breeding season, which includes nesting and incubation in the spring and summer months through young fledging in the fall. Adults and sub-adults are at-sea and not transiting across the island outside of the breeding season. To account for this activity pattern, we multiplied our daily passage rate by the length of the breeding season (231 days for Hawaiian Petrels), to estimate the total number of petrel flights per year passing through the AWRA.

The Hawaiian Petrel breeding season was calculated based on detailed breeding phenologies augmented with local records of species observations at nesting colonies (Simons 1985, Simons and Hodges 1998). According to breeding phenology literature, Hawaiian Petrels arrive at nesting colonies in mid-April and the young fledge in October and November for a breeding season of 230 days (Simons and Hodges 1998). On Haleakala, however, Hawaiian Petrels are observed returning to nesting burrows as early as the last week of February (Simons 1985) (+52 days = 282 maximum breeding days) and fledging is over before the month of November (Simons 1985) (282 max. breeding days -30 days of November = 252 breeding days). Additionally, Hawaiian Petrel adults exhibit a pre-laying absence from the colony and nest site for three weeks (21 days) immediately prior to egg laying (Simons 1985, Warham 1990). This pre-laying absence (also known as pre-laying exodus) is exhibited by many species in the Procellariiformes group, which includes petrels, shearwaters, albatrosses and other seabirds (Warham 1990). The pre-laying absence occurs at the time females develop their eggs and allows males time to store up fat reserves for the first egg incubation shift (Warham 1990). To determine the Hawaiian Petrel breeding period we subtracted the pre-laying absence period from the number of breeding days, for a total annual breeding period of 231 days (252 breeding days – 21 day pre-laying absence = 231 breeding days). Hawaiian Petrels on Maui follow the same general breeding patterns as other Hawaiian Petrels (i.e., same general length of nest building, egg laying, incubation and fledging). Although petrels may arrive at nest sites on Maui earlier than petrels on other Hawaiian Islands, we have no evidence of longer incubation, fledging, or other breeding periods. For this reason we would not expect the entire breeding season for Hawaiian Petrels on Maui to be greater than for other Hawaiian Petrels. The calculated breeding period of 231 days is very close to the 230-day breeding period listed for Hawaiian Petrels by Simons and Hodges (1998).

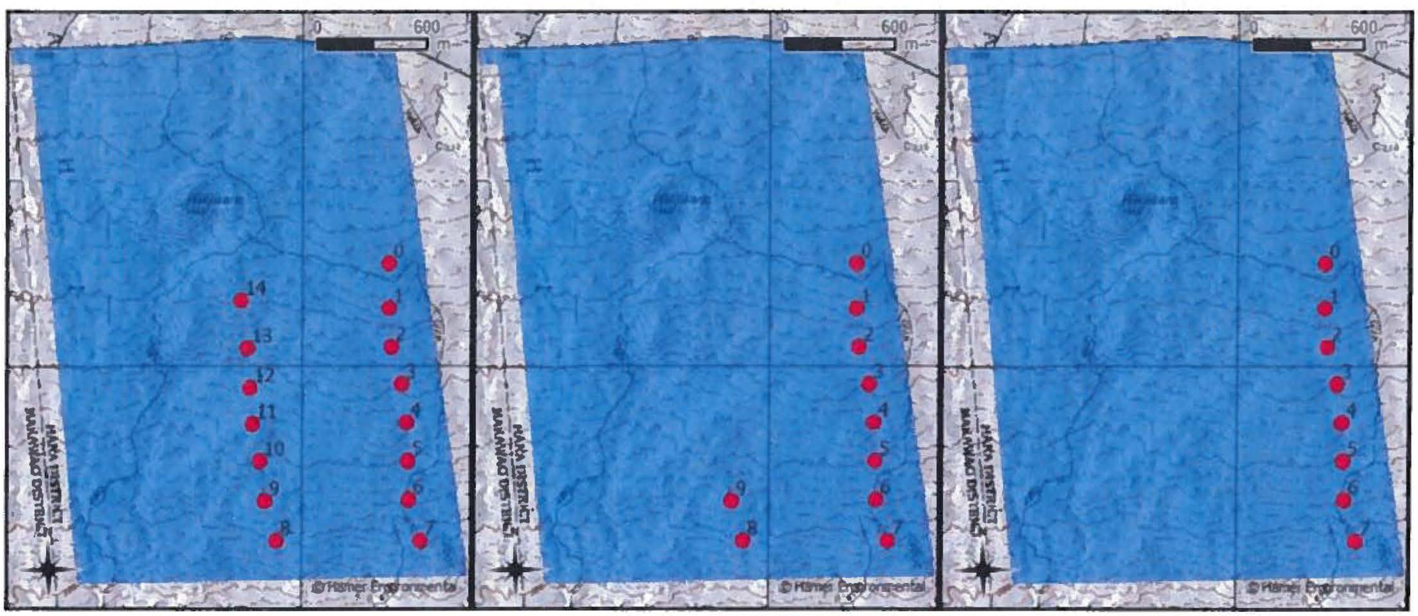

Figure 4. Three possible wind turbine configurations for the AWRA, GE 1.5xleWE (15 turbines, left), Siemens SWT 2.3-101 (10 turbines, center) and Siemens SWT 3.0-101 (8 turbines, right), Ulupalakua, Maui, Hawaii.

Modeling of Collision Risk

The Hamer Avian Risk of Collision Model was used for the estimation of collision risk at the AWRA. The goal of the modeling process was to estimate the expected number of annual avian/turbine collisions for Hawaiian Petrels under three proposed wind turbine configurations (Figure 4). Because the collision risk and passage rate are dependent on the time of day, time of year, turbine configuration, and avoidance rate, a number of different model configurations were used to arrive at our final annual collision estimates. Each model configuration was specified by a permutation of the following variables, resulting in 36 total configurations:

Turbine Type: GE 1.5xleWE (15 turbines), Siemens SWT 2.3-101 (10 turbines), Siemens SWT 3.0-101 (8 turbines)

Time of Year: Spring, Fall

Time of Day: Dawn, Dusk

Bird Avoidance Rates: 90%, 95%, 99%

The modeling process (Figure 5) consists of 4 primary phases: 1) the collection of model inputs, 2) estimation of the probability distribution functions (PDFs), 3) running the Monte Carlo simulations and, 4) estimation of the annual collision rates from the different model outputs.

Model Inputs

The Hamer Model is designed to account for a number of inputs that may have a significant effect on bird mortality. Some of these inputs are not dependent on observed field data, and include turbine locations, turbine characteristics (Table 1), and Hawaiian Petrel body dimensions (average body length and wingspan). Comparable studies and available data of bird behavior were used to estimate avian avoidance rates (see Discussion). Other inputs are site-specific and were determined by observed bird flight behavior and meteorological data at the AWRA. Bird flight inputs included flight path direction, speed, passage rates and flight height. Meteorological data was obtained from on-site meteorological towers and included time dependent wind directions and speeds.

Probability Distribution Functions

In order to simulate "typical", or probable, wind conditions and petrel flight paths through the AWRA study area for different turbine configurations and peak flight periods, it was necessary to estimate the distributions of flight and wind parameters under these conditions. This estimation process was driven by observed, site-specific data and resulted in a set of probability distribution functions (PDFs) for each variable (e.g., flight height). If these data were a good fit for a parametric distribution function (e.g., Gaussian or gamma) then the parametric distribution was estimated using a maximum likelihood algorithm. Otherwise, kernel smoothing methods were used to estimate the PDFs.

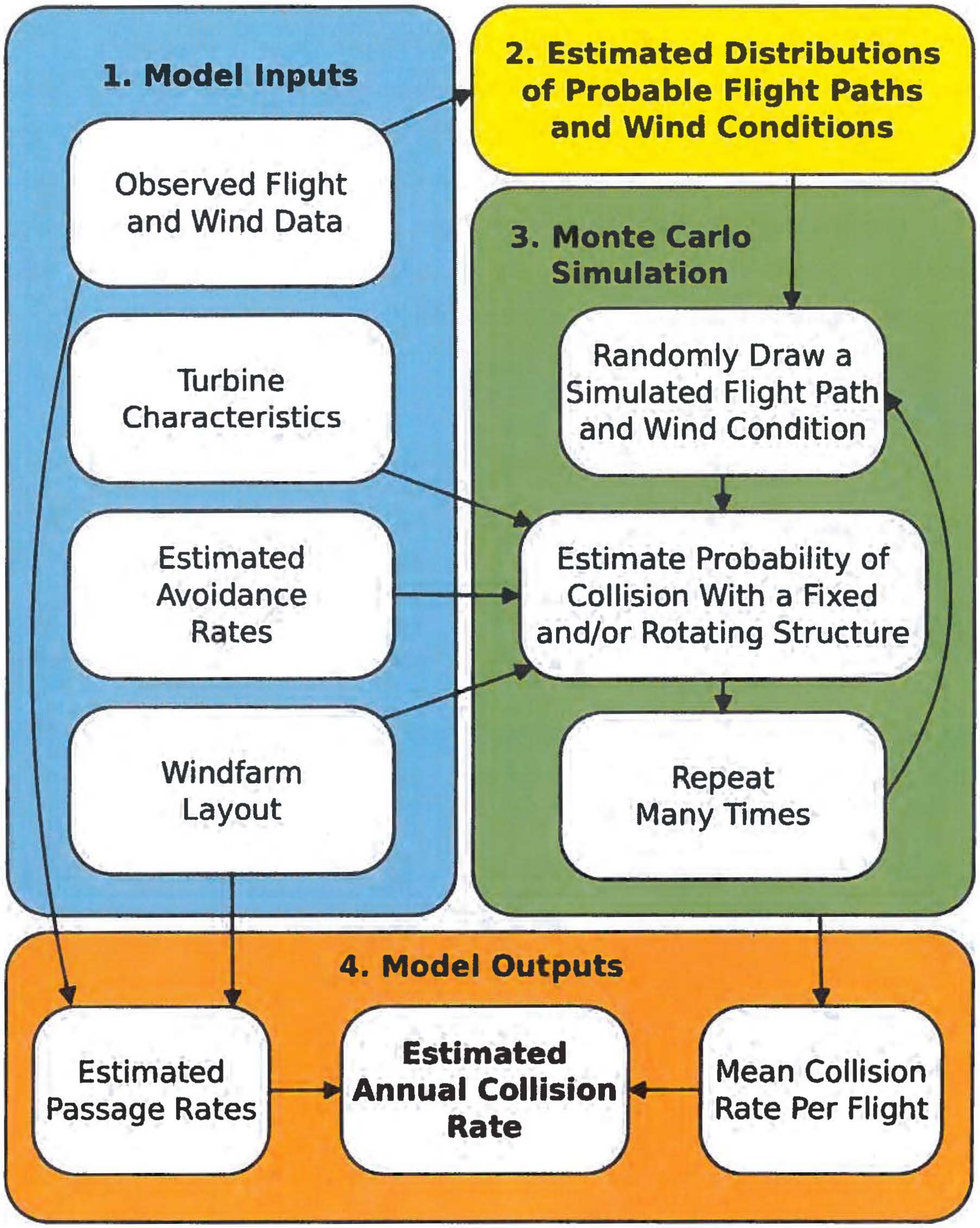

Figure 5. Workflow for the Monte Carlo simulation based Hamer Model.

Table 1. Wind turbine characteristics used for the Hamer Model.

Turbine Manufacturer	GE	Siemens	Siemens
Turbine Model	GE 1.5 xleWE	SWT 2.3-101	SWT 3.0-101
Turbine MW	1.5	2.3	3.0
Height to top of blade (m)	121.25	130.5	130.5
Lowest rotor swept height (hub height- rotor radius) (m)	38.75	29.5	29.5
Rotor height (Zone of Risk) (m)	45 - 121	30 - 131	30 - 131
RPM	9 – 20	6 – 16	6 – 16
Cut in wind speed (m/s)	3.5	4	4
Cut out wind speed (m/s)	25	25	25
Rotor Radius (m)	41.25	50.5	50.5
Blade Width at Hub (m)	1.9	2.4	2.4
Blade Width at Widest Point [Chord Root] (m)	3.2	3.5	3.5
Radius at Widest Point on Rotor (m)	8	16	16
Blade Width at Tip [Chord Tip] (m)	1	1	1
Number of Rotor Blades	3	3	3
Monopole Diameter at Ground Level (m)	4.3	4.2	4.2
Monopole Diameter at Widest Point (m)	4.3	4.2	4.2
Elevation at Widest Point on Monopole (m)	0	0	0
Monopole Diameter at Hub (m)	2.6	2.4	2.4
Elevation at Hub (m)	80	80	80
Nacelle Height (m)	4	3.8	-
Nacelle Width (m)	3.6	3.5	-
Total Number of Turbines	15	10	8

Monte Carlo Simulation

Monte Carlo simulation was used to estimate the mean collision risk per "typical" flight through the AWRA study area for each model configuration. For each turbine type, bird species, and peak flight period, we were able to generate any number of probable bird flight paths through the AWRA study area by random sampling of the PDFs calculated from the observed data. The 1.5 km radius AWRA study area circle was centered over each of the proposed turbine configurations for model simulations (Figure 6). Each individual flight path was then analyzed for collision risk by checking to see if it intersected with any fixed wind turbine structures (towers, nacelles) and/or areas swept by rotor blades (Figure 6). Avoidance rates were applied to each interaction with fixed or rotating turbine components. Flight paths that intersected multiple turbines incurred an accumulation of collision risk.

For flight paths at risk of collision with rotor blades, the Hamer Rotor Sub-Model was used to estimate the probability of collision. This kinematic model accounts for numerous parameters, including wind speed, wind direction, bird flight speed, bird flight direction, bird body and wing dimensions, turbine dimensions, rotational speed of the turbine in relation to wind speed, and the precise point of entry into the rotor plane. The Hamer Rotor Sub-Model is an extension of the Tucker Model (Tucker 1996). Where the Tucker Model addresses rotor collision probability for cases where the bird's air speed is either parallel or perpendicular to the wind direction, our model handles the more general and common case of oblique angles of approach. Accounting for the angle of approach can significantly impact collision risk, and is an important feature enabling us to more accurately model risk with our simulation based approach.

By averaging the collision risks associated with the simulated flight paths and wind conditions for each model configuration, we calculated the mean, per flight collision risk:

$$Risk_{\text{turbine type, season, time of day}}$$

As the number of simulation iterations increases, so does the accuracy of these estimates. We performed 1,000,000 simulations for each of the 36 model configurations.

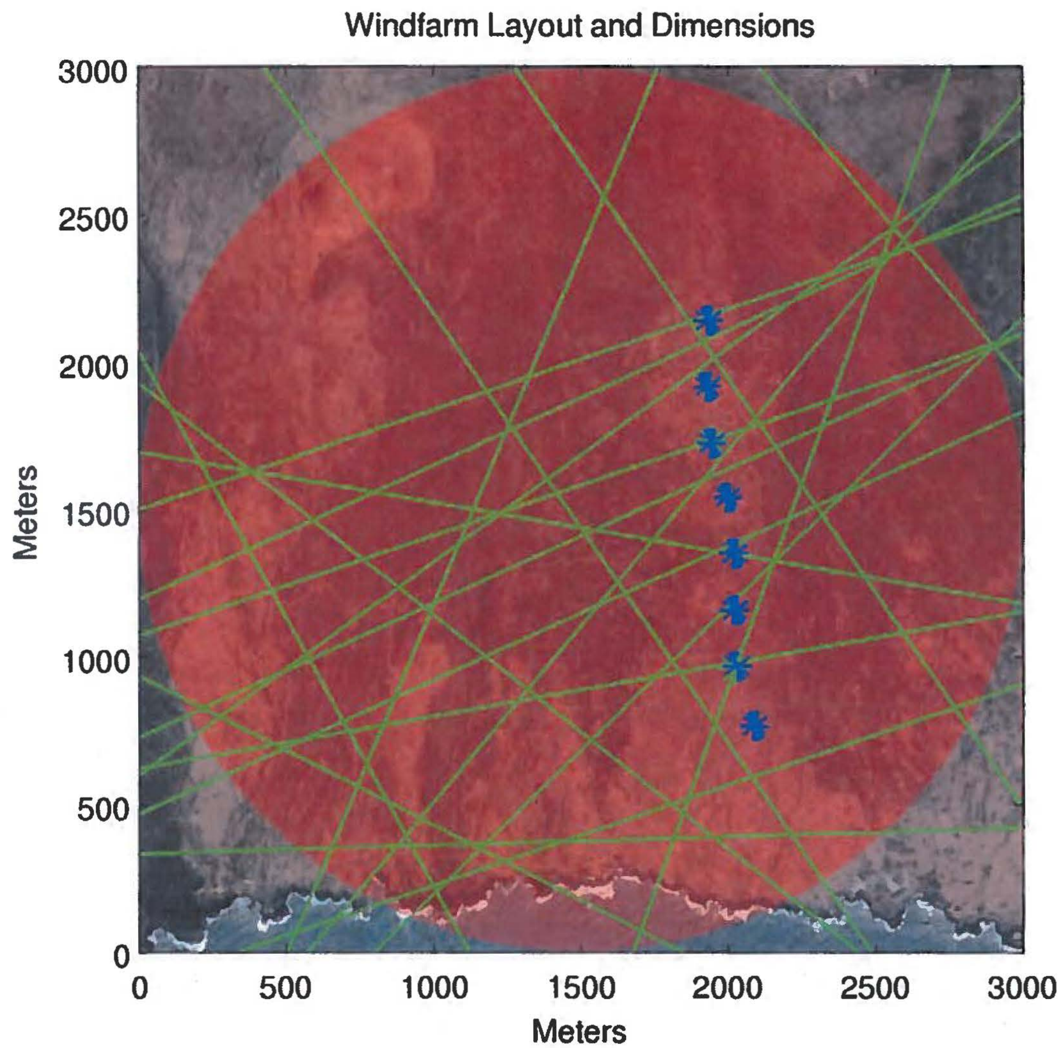

Figure 6. Visualization of a model run for the Siemens SWT 3.0-101 turbine configuration showing 20 randomly generated, but probable flight paths (green lines). All simulated flight paths are ensured to cross over the shaded polygon defined as the AWRA study area (1.5 km radius, red shaded region). Turbines always face upwind, creating the distribution of rotor orientations (blue). Collision is possible when the flight paths intersect solid structures (towers, nacelles) and/or the areas swept by rotor blades. For these flight paths, the Hamer Rotor Sub-Model is used to determine the probability of collision with a component of the turbine (possible rotor collisions are denoted by green asterisks).

Model Outputs

The Monte Carlo simulations resulted in different mean per passage collision risk estimates for each model configuration:

$$Risk_{\text{turbine type, season, time of day}}$$

We also estimated the total number of avian passages through the AWRA study area during peak flight periods (see Passage Rate Estimation):

$$Passage_{\text{season, time of day}}$$

To determine the estimated number of collisions for each turbine configuration, and peak flight period, the per passage collision probability is simply multiplied by the number of passages. For example, the estimated number of Hawaiian Petrel collisions at dusk during the fall for the GE configuration is:

$$Collisions_{\text{GE, fall, dusk}} = Risk_{\text{GE, fall, dusk}} \cdot Passage_{\text{fall, dusk}}$$

For each tower configuration, the annual collision rate was therefore calculated by summing the estimated number of collisions for each peak flight period:

$$Collisions_{\text{turbine type}} = \sum_{i \in \{\text{spring, fall}\}} \sum_{j \in \{\text{dawn, dusk}\}} Risk_{\text{turbine type}, i, j} \cdot Passage_{i,j}$$

Model Inputs

<u>Wind Turbines and Turbine Configurations</u>

Three different turbine models and spatial configurations: GE 1.5 xleWE (15 turbines with 1.5-MW output), Siemens SWT 2.3-101 (10 turbines with 2.3-MW output) and Siemens SWT 3.0-101 (8 turbines with 3.0-MW output) are being considered for the AWRA (Table

1). Proposed turbine configurations consist of one to two parallel rows of turbines running south to north and result in a 22.5 - 24-MW wind resource development (Figure 4).

The GE 1.5 xleWE is the smallest of the proposed turbines at 121.25 m height to top of rotor sweep, with a rotor radius of 41.25 m (Table 1). The Siemens SWT 2.3-101 turbine is the largest turbine at 130.5 m to the top of the rotor sweep and a rotor radius of 50.5 m. The Siemens SWT 3.0-101 has the same dimensions as the other Siemens turbine, but uses direct-drive instead of a gearbox and is therefore more efficient. Turbine dimensions and characteristics used in the Hamer Model were based on manufacturer specifications (Table 1).

Because rotor speed and blade characteristics have a large impact on collision probability, we modeled the angular rotor speed and rotor pitch as a function of the wind speed to match operational data. For wind speeds below the turbine's cut in wind speed, the rotors are assumed to be fixed and the rotor pitch equal to 0 degrees. As the wind increases from the cut in wind speed to the cut out wind speed, the angular rotor speed and pitch both increase to their maximum values. For wind speeds above the turbine's cut out speed, the rotors are again fixed and the pitch equal to 90 degrees. Operational data was obtained which described the relationship between wind speed and the angular rotor speed and rotor pitch for each the Siemens SWT 2.3-101 (Figure 7), Siemens SWT 3.0-101 (not pictured) and GE 1.5 xleWE (not pictured) turbines.

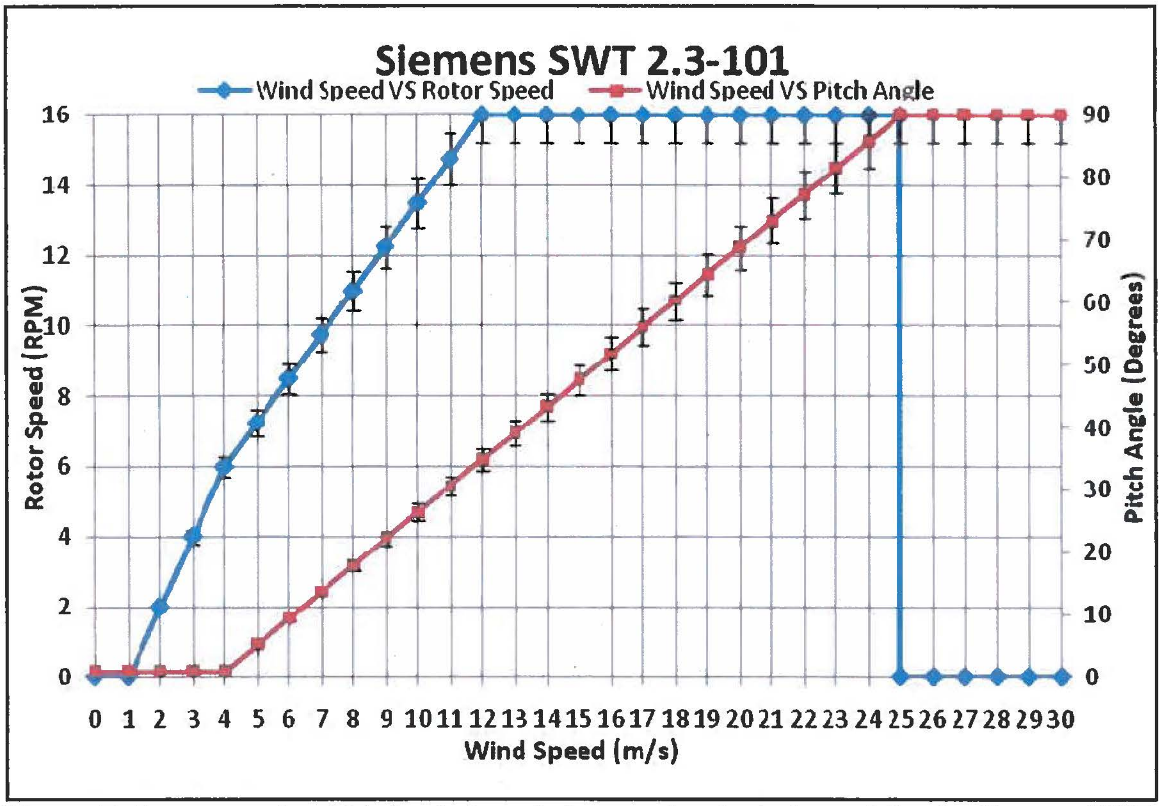

Figure 7. Rotor speed and blade pitch angle by associated wind speed for the Siemens SWT 2.3-101 wind turbine. Data provided by manufacturer.

Wind Characteristics

Wind data were available from two different meteorological towers (636, 637) in the AWRA, but were utilized from the tower located closest to the proposed wind turbines (tower 637) to match conditions most representative of those encountered by birds flying through the wind development. Meteorological tower 637 is located 42 m south of proposed turbine 13. Meteorological tower 637 stands 50 m tall and has anemometers to collect wind data set at 30.5 and 48.5 m. Wind experts at AWS Truewind used wind shear algorithms to extrapolate wind speeds to 80 m agl (above ground level) (Elliot et al. 1986). Wind speeds at 80 m agl were utilized for the Hamer Model as they represented wind conditions encountered by both turbine rotors and petrels facing collision risk.

Wind data collection at meteorological towers began December 2006 with data collection ongoing at time of report writing. Wind data were collected every minute and averaged over each hour, day, and month. We used wind speeds and directions for nesting and fledging seasons from 2007-2009 to best replicate wind conditions likely encountered by petrels. From the nesting and fledging months, hourly wind data from dawn (400-1000) and dusk (1800-2200) periods was utilized to best represent wind conditions encountered by petrels during peak daily movement periods.

The distribution of wind speeds was consistently bimodal, with a small peak around 4 m/s and a larger one around 12 m/s. Because of the non-parametric nature of this distribution, kernel smoothing was used to estimate this PDF (Gaussian kernel, automatic bandwidth selection).

Monthly averages of wind direction data were used to estimate the wind direction PDF. On average the wind was blowing either east-northeast or east 85% of the time (40% ENE and 45% E). However, the wind directions for wind speeds less than 4 m/s were not reported, so a uniform distribution of wind directions was assumed in these cases. Due to this dependence between wind speed and wind direction, wind characteristics were modeled as a 2-dimensional joint-PDF. These PDFs were estimated separately for spring/summer breeding and fall fledging seasons and for dawn and dusk peak activity periods.

Hawaiian Petrel Characteristics

Size

Hawaiian Petrel body dimensions were modeled using an average body length of 0.43 m and a wingspan of 0.91 m (Simons and Hodges 1998). Body dimensions of the seabird were held constant for model simulations.

Flight Speed and Direction

Flight speeds and directions were determined from flights of petrel type targets detected during fall 2006 and spring 2010 radar surveys. Due to the strong dependence of flight patterns on the time of day, different probability distribution functions were estimated for dawn and dusk targets. The distribution of dawn and dusk flight speeds were bimodal, with peaks near 16 and 25 m/s, respectively (Figure 9). These peaks were not as pronounced, however, for the dusk survey period. Dawn and dusk distributions of flight directions tended to be unimodal but had their peaks in different directions (200 vs. 300 degrees clockwise from north for the dawn and dusk flights, respectively) (Figure 8). None of these distributions were well described by normal distributions, so kernel smoothing was again used to estimate these PDFs (Gaussian kernel, automatic bandwidth selection). As opposed to wind speed and direction, no significant dependence was evident between bird speed and direction and each PDF was modeled independently.

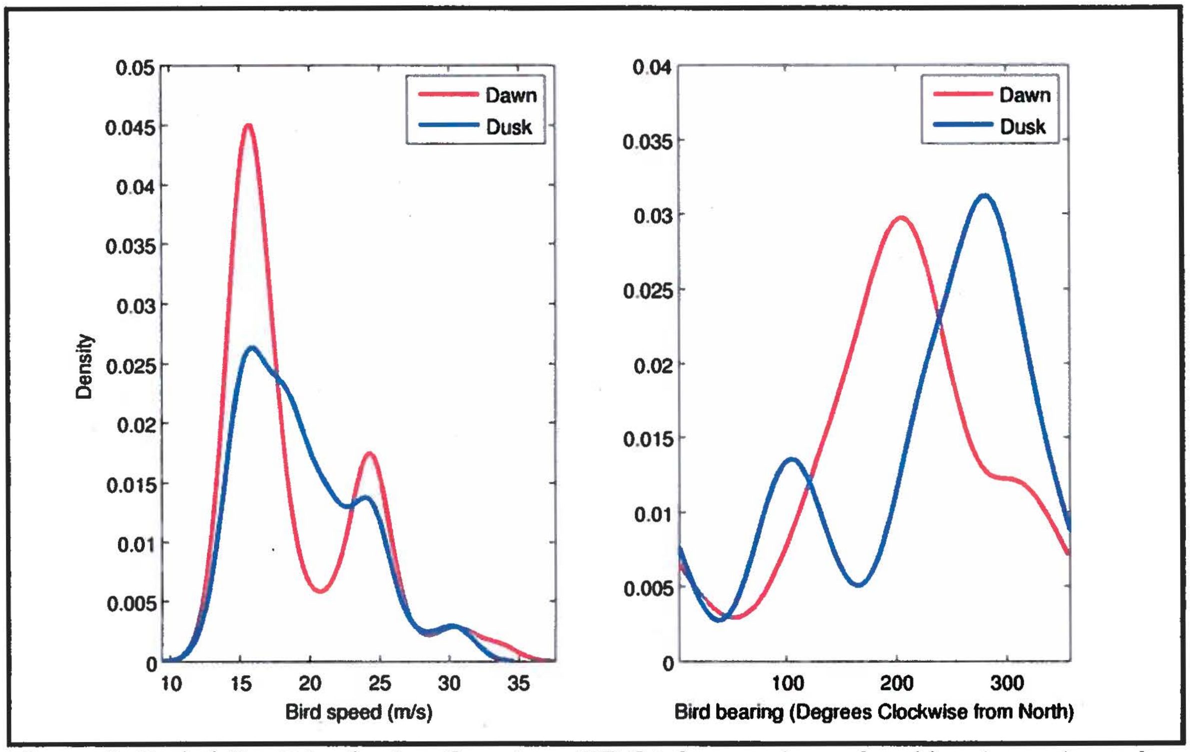

Figure 8. Probability Distribution Functions (PDFs) for petrel speed and bearing estimated from observed data. Dawn and dusk flight patterns were distributed differently, motivating separate model runs for each of these cases.

Flight Heights

We utilized vertical radar to collect minimum flight heights of birds transiting the AWRA study area. All flight heights collected by radar were utilized to create a flight height distribution for model simulations. Flight heights were fit to a gamma distribution for PDF estimation (Figure 9). This gamma distribution passed the Kolmogorov-Smirnov goodness of fit test (α=0.05).

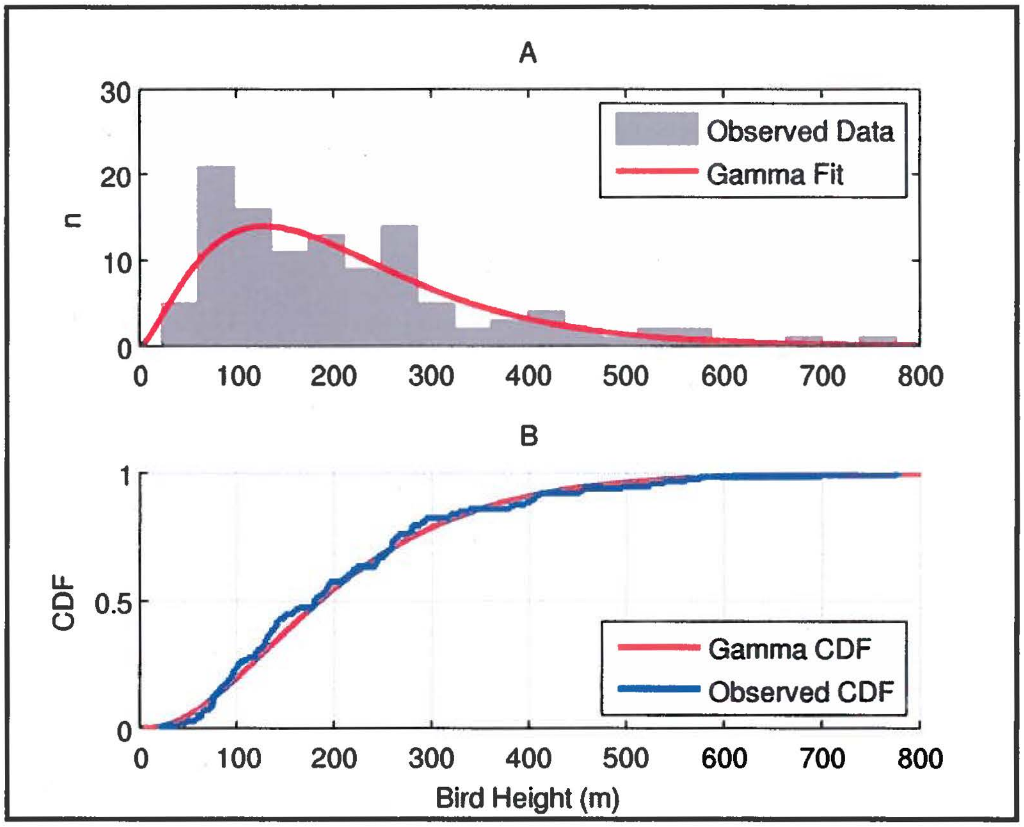

Figure 9. (A) Observed flight heights from spring 2010 and fall 2006 radar data (n=112) fit to a gamma distribution. **(B)** A comparison of the cumulative distribution functions (CDFs) of the observed data and the gamma distribution. Using these CDFs, the gamma distribution passed the Kolmogorov-Smirnov goodness of fit test (α=0.05).

<u>Avoidance and Fatality Rates</u>

For possible collisions with the moving components of the wind turbines, we modeled expected avian avoidance at 90%, 95% and 99%. The assumption of 90% and higher avian avoidance for Hawaiian Petrels is supported by post-construction mortality studies at the Kaheawa Pastures Wind Energy Facility on Maui (Sanzenbacher and Cooper 2009, Brian Cooper pers. comm. found 99% avoidance) and other avian avoidance studies at wind developments (Cooper, Day and Plissner 2007, Desholm 2006, Desholm and Kahlert 2005, Dirksen et al. 1998), which show that the majority of birds see wind turbines and avoid them. For portions of the turbine that are static (tower and nacelle) we assumed 99% avoidance by petrels.

We assumed that any petrel collision with a wind turbine (tower, nacelle or rotor) will result in a fatality. This assumption of 100% fatality is in line with Endangered Species Act's definition of "take". Though not all collisions with wind turbines may result in mortality, this 100% fatality assumption allows for a conservative estimate of collision and fatality risk.

RESULTS

Passage Rate Estimation

The peak hourly movement rate for nesting and fledging season is 9.45 petrel passes per hour (Table 2). We adjusted the movement rate for portion of the night not sampled and the mean flock size of petrel type targets. Explanations for the passage rate adjustments are described in the passage rate calculation section (see Methods, page 12). The final mean movement rate is 43.67 petrel passages per day (Table 2).

We calculated the yearly passage rate for petrels based on a 231-day (7.7-month) Hawaiian Petrel breeding period. We estimate 11,642 Hawaiian Petrel passages over the AWRA study area annually (Table 2). This adjusted rate was approximately 1.2 times higher than the unadjusted annual passage rate of 10,087 bird passages/yr (Table 2).

Table 2. Annual passage rate calculation for the AWRA.

PASSAGE RATE CALCULATION	
(A) Bird Targets within the AWRA in Spring	164.00
(B) Bird Targets Detected within the AWRA in Fall	229.00
(C) Total Number of Bird Flights Detected within the AWRA =A + B	393.00
(D) Total Hours Sampled by Radar (adjusted for lost survey time due to rain)	41.57
(E) Total Days Sampled by Radar	9.00
(F) Mean Rate During Daily Peak Movement Period (targets/hour) = C/D	9.45
(G) Mean Rate of Movement/Day (targets/day) = C/E	43.67
(H) Mean Proportion of Bird Flights During Off-peak Hours of the Night	0.126
(I) Mean Daily Movement Adjusted for Portion of Night Not Sampled (targets/day) = (G xH)+ G	49.17
(J) Number of Bird Flights/Radar Target (average flock size)	1.025
(K) Mean Movement Rate Adjusted for Flock Size (targets/day) =I x J	50.40
(L) Length of Breeding Season for Hawaiian Petrel (days)	231.00
(M) Unadjusted Annual Bird Passage Rate = ((A+B)/E) x L	10087.00
(N) Mean Hawaiian Petrel Flights/Year (adjusted annual passage rate) = K x L	**11642**

Collision Rate Estimates for the AWRA

Model simulations were summarized for each combination of model runs: wind turbine design, season, time of day (dawn/dusk), and avoidance rate (Tables 3, 4). The Hamer Model results represent the collision risk for one bird transiting the wind turbine configuration (Tables 3, 4). For the 90% avoidance rate, the model scenario that resulted in the highest risk of collision estimate was for a Hawaiian Petrel flying during dawn and spring breeding season through the GE turbine configuration of the AWRA, with a collision risk of 0.000574 (Table 3). The model scenario for the 90% avoidance rate resulting in the lowest collision risk estimate was for a Hawaiian Petrel flying during the dusk in the fall through the Siemens 3.0 turbine configuration, with a collision risk of 0.000401 (Table 3). In general, collision risk was highest for petrels under the GE turbine configuration.

Table 3. Estimated risk of collision for one bird transiting the AWRA study area, based on 1,000,000 flight simulations for each of 36 model combinations.

Turbine Type	Time of Year	Time of Day	Avoidance Rate		
			90%	95%	99%
GE	spring	dawn	0.000574	0.000304	0.000088
GE	spring	dusk	0.000554	0.000294	0.000086
GE	fall	dawn	0.000564	0.000299	0.000087
GE	fall	dusk	0.000549	0.000292	0.000086
Siemens 2.3	spring	dawn	0.000531	0.000277	0.000074
Siemens 2.3	spring	dusk	0.00051	0.000267	0.000071
Siemens 2.3	fall	dawn	0.000517	0.00027	0.000072
Siemens 2.3	fall	dusk	0.000501	0.000262	0.00007
Siemens 3.0	spring	dawn	0.000424	0.000221	0.000059
Siemens 3.0	spring	dusk	0.000404	0.000211	0.000056
Siemens 3.0	fall	dawn	0.000412	0.000215	0.000057
Siemens 3.0	fall	dusk	0.000401	0.00021	0.000056

We estimate that annually, 0.662-3.450 Hawaiian Petrels may be at risk of collision with turbine structures at the AWRA depending on the turbine configuration (95% and 99% avoidance, Table 4). Similarly, per turbine, we estimate 0.067-0.312 Hawaiian Petrels may be at risk of collision annually, depending on the turbine configuration (95% and 99% avoidance, Table 4). As a conservative measure, we assume all avian collisions with structures will result in mortality, so these collision estimates are also annual mortality estimates.

Table 4. Annual and per turbine avian collision estimates by turbine type and avoidance rate. Assumes 99% avoidance rate for all fixed portions of the wind turbine (nacelle and tower).

Turbine Type	Annual Collision Risk			Annual Per Turbine Collision Risk		
	Avoidance Rate			Avoidance Rate		
	90%	95%	99%	90%	95%	99%
GE						
Hawaiian Petrel	6.501	3.450	1.008	0.433	0.230	0.067
Siemens 2.3						
Hawaiian Petrel	5.973	3.122	0.833	0.597	0.312	0.083
Siemens 3.0						
Hawaiian Petrel	4.761	2.487	0.662	0.595	0.311	0.083

DISCUSSION

Passage Rate Estimate

The passage rate estimate in this report was derived from spring 2010 and fall 2006 radar detections of petrel targets. Spring 2010 surveys had better coverage of the AWRA than the summer 2006 radar study, and were conducted earlier in the season to capture peak flight activity of the target species during the breeding (nesting) season.

We estimated 11,642 petrel flights passed through the AWRA study area annually (Table 2). We believe this annual passage rate estimate to be conservative (estimated high) based on positive adjustments to account for flock size and nocturnal activity outside of peak movement times.

We assumed that the passage rate estimate represents target bird flights and not necessarily individual birds, as petrels may pass through the AWRA more than one time per year. Furthermore, the population estimate for Hawaiian Petrels nesting on Haleakala is 900-1,300 individuals, which represent significantly fewer birds than our passage rate estimate of 11,642 petrel flights (Simons 1984, 1985, Simons and Hodges 1998). If we had assumed that the passage rate represented individual birds, this would result in more than the entire petrel population on Haleakala flying over the AWRA annually.

Within the AWRA study area, the hourly peak passage rate was 9.45 petrel flights per hour (Table 2). This hourly passage rate was much lower than hourly petrel passage rates collected at three coastal sites in South Maui, which ranged from 68-93 petrel type targets per hour (Kaupo, Nu'u Bay and Mokuia Point, Cooper and Day 2003, Figure 10). Additionally, a study of petrels for a proposed tower near the Haleakala summit reported an average passage rate of 15.6 petrels per hour, with a range of 7.2- 26.8 petrels per hour depending on the site (Day and Cooper 2004).

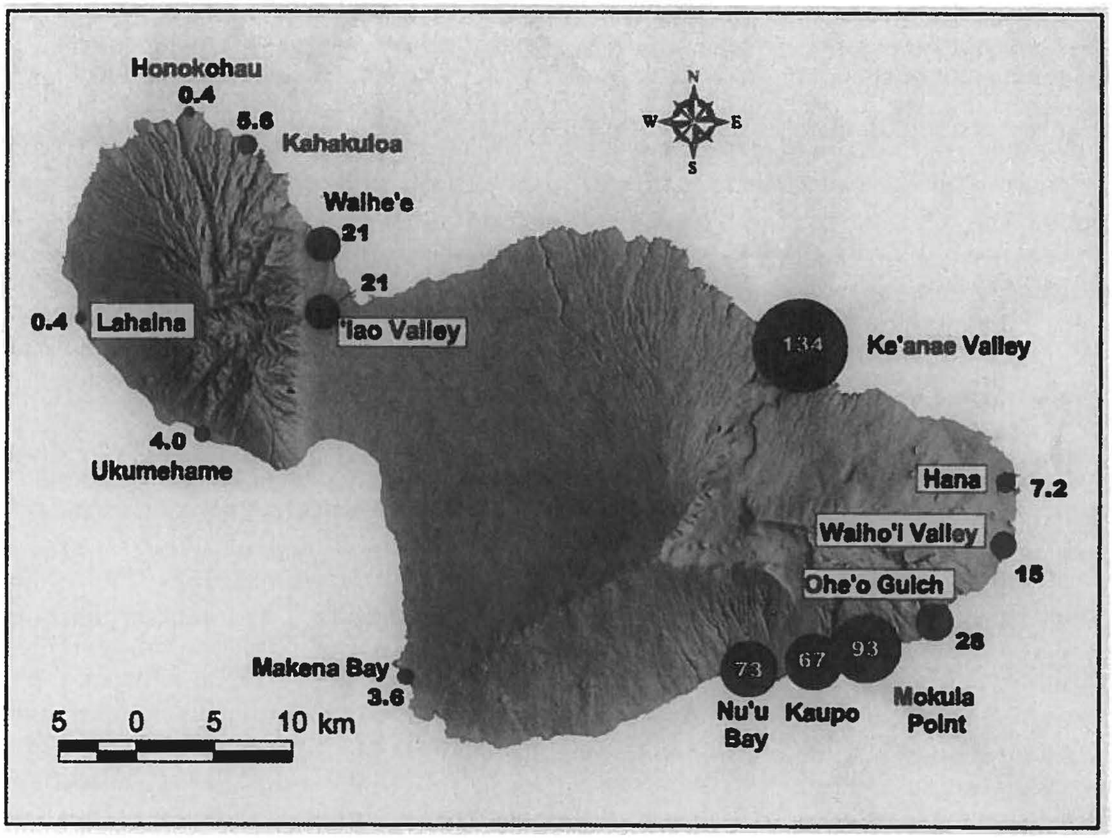

Figure 10. Geographic variation in mean movement rates (targets/hr) of petrels and shearwaters observed during 1900-2200 hours on radar around Maui Island, Hawaii, June 2001. Sizes of circles are proportional to the mean movement rate; numbers in/near circles are actual mean movement rates (targets/hr) (figure from Day and Cooper 2004).

Non-target Species

The radar passage rate was higher in fall 2006 than in spring 2010. Typically, fall passage rates at a given site are lower than the spring breeding season, as non-breeding adults have stopped visiting inland nesting colonies and breeding adults are making fewer trips inland to feed their young. This higher fall passage rate may indicate that non-target species such as Sooty Terns, were included as Ha aiian Petrel radar detections. During the fall 2006 sampling, the outside observer detected only a few Sooty Terns because the outside conditions were not ideal for bird observations (low clouds, light rain, dark skies). The Sooty Terns have a similar body size and flight speed to Hawaiian Petrels and Newell's Shearwaters and thus look similar on the radar. Additionally, many of the radar targets were flying at high altitudes over the AWRA study area, as confirmed by our vertical radar, thus the outside observer often had little chance of detecting them and confirming their identification.

Therefore, it is possible that some of the birds we recorded and analyzed as petrel type targets were actually Sooty Terns. The Sooty Tern is the most abundant seabird in the tropics, numbering about 60 million – 80 million birds (Schreiber et al. 2002) with stable populations in the Hawaiian Islands.

Hawaiian Petrels generally move during crepuscular periods (Day and Cooper 1995). However, some birds we recorded as petrel may have been Sooty Terns since they would also be expected to be active even after sunset or before sunrise. Sooty terns are known to be active during the day and night, especially at, or near, nesting colonies. Even with our attempts at filtering out non-petrel targets by focusing our survey efforts during crepuscular periods during the fall, likely similarities in body size, flight speed, flight behavior, and flight altitudes between birds we recorded as Hawaiian Petrel and Sooty Terns indicate that some proportion of the birds recorded on radar could be Sooty Terns.

Avoidance Rates

We selected a range of avian avoidance rates (90%, 95%, and 99%), but feel that the 95% avoidance rate likely best represents what current literature on avian avoidance of wind turbines suggests (Day et al. 2005, Desholm 2006, Desholm and Kahlert 2005, Madders 2004, Percival 2004). Avian avoidance behavior is the least understood parameter in all avian risk of collision models, while being one of the most important to resulting estimates of collision risk. Species specific studies on avian avoidance of man-made structures are needed to make better estimations of collision risk (Chamberlain et al. 2006, Desholm 2006, Fox et al. 2006).

However, in absence of species specific information, the high sensitivity to bird avoidance of turbines does not warrant the abandonment of risk of collision models (Chamberlain et al. 2006, Madders and Whitfield 2006). Avoidance data can be incorporated after calculating the mathematical turbine collision risk as they become available for species and site specific scenarios, but it is important that the base collision model be as accurate as possible. In the absence of detailed avoidance data, the results of the risk of collision model still proves useful in comparing relative collision risk between different wind park locations, wind turbine configurations, turbine models, and other factors, which is increasingly a common practice when siting wind power projects.

Very little is known about Hawaiian Petrel avoidance behaviors, but a few studies in Hawai'i have been conducted where Hawaiian Petrel avoidance behaviors were documented or can be inferred. A study for meteorological towers on Lana'i documented avoidance behaviors exhibited by 20 Hawaiian Petrels observed altering their flight paths to avoid collision with communication towers, with 100% successful avoidance of the structures (Cooper, Day and Plissner 2007, cited in Sanzenbacher and Cooper 2009). Post-mortality studies at the Kaheawa Pastures Wind Energy Facility in West Maui report an annual average of 1.2 Hawaiian Petrel and 0.0 Newell's Shearwater mortalities annually (Greg Spencer pers. comm., Sanzenbacher and Cooper 2009). This mortality rate corresponded to a 97.5% avoidance rate estimated by risk of collision modeling of the Kaheawa Pastures Wind Energy Facility prior to construction (Cooper and Day 2004). Based on the inclusion of 2010 data, the mortality rate at Kaheawa Pastures Wind Energy Facility corresponds to a 99% avoidance rate estimated by risk of collision modeling (Brian Cooper pers. comm.).

Avian Avoidance of Wind Developments

Our Hamer Model addresses behavioral avoidance by birds of individual wind turbines, but assumes no avian avoidance of the entire wind development. In the studies where wind park avoidance has been examined, the rate of avoidance has been high (Barrios and Rodriguez 2004, Desholm 2006, Dirksen et al. 1998, Masden et al. 2009, Smallwood and Thelander 2004, 2005). Particularly at wind developments with multiple turbine strings (rows of turbines), most birds alter flight paths to avoid the developments (Barrios and Rodriguez 2004, Desholm 2006). A study of migrating Common Eiders at Nysted offshore wind development SE of Denmark found that birds were more likely to avoid the entire wind development (by a factor of 4.5) than to fly through it (Desholm 2006). Although we believe some proportion of Hawaiian Petrels would be likely to alter flight paths to avoid the entire AWRA, this was not studied and is not possible to assess during the pre-construction phase. Therefore, we have assumed no avoidance of the entire wind development.

Risk of Collision Estimates

At the 95% avoidance rate, annual collision estimates for the proposed wind development were highest for the GE turbine configuration with an estimated 3.450 collisions between Hawaiian Petrels and turbines annually (Table 4). At the 99% avoidance rate, annual collision estimates for the proposed wind development were 0.662-1.008 depending on turbine configuration (Table 4). At the 99% avoidance rate, the GE configuration for the wind development poses the highest risk of collision to petrels, 18 to 34% higher avian collision risk than the Siemens 2.3 and Siemens 3.0 configurations, respectively (Table 4). Although the smallest of the three wind turbines proposed, the GE turbine configuration poses the highest risk of collision to petrels because it consists of the largest number of turbines (15 turbines, versus 10 turbines for Siemens 2.3 and 8 turbines for Siemens 3.0 configurations).

When assessed per turbine, the Siemens 2.3 model has the highest risk of collision at 0.312 Hawaiian Petrels per turbine per year (95% avoidance rate) or at 0.083 Hawaiian Petrels per turbine per year (99% avoidance rate, Table 4). The Siemens 2.3 model is 9.0 m taller than the GE model, and has significantly larger and wider turbine blades, which accounts for the higher collision risk to birds (Table 2). The Siemens 2.3 and Siemens 3.0 turbines are essentially identical, so the per turbine collision estimates are similar, (within 4% of each other, Table 4). The discrepancy between the Siemens 2.3 and Siemens 3.0 arises because the per turbine collision risk estimate takes into account the specific turbine configuration and the locations of the turbines relative to each other on the landscape.

Calculating the annual collision rate as a product of the collision risk per passage and the number of passages implicitly assumes that each passage represents a unique bird. Otherwise, the occurrence of a collision should reduce the passage rate for the remainder of the year and therefore reduce the estimated number of annual collisions. Because the annual passage rates we calculate may include multiple passages by individual birds, we are, in effect, sampling with replacement and assume that the occurrence of a collision does not have any effect on the annual passage rate. This approach can be justified if the estimated number of annual collisions is significantly less than the daily passage rate. This condition, which was found to be true at the AWRA, indicates that it is unlikely that collisions will significantly impact the annual passage rate. Therefore, sampling with replacement was justified for this study.

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