Prioritizing land for conservation purposes in East Maui, Hawai'i

by

Andrew Jacobson

Dr. Urban, Advisor

April 30, 2010

Masters project submitted in partial fulfillment of the
requirements for the Master of Environmental Management degree in
the Nicholas School of the Environment of
Duke University

2010

Abstract

Hawai'i has 25% of the United States' federally listed endangered species and nearly 75% of the nation's recorded extinctions. Although no such list or datasets exists for cultural and historical landmarks, these resources may be similarly threatened. Of the eight major Hawaiian Islands, Maui is the second largest and has the third largest population. The average number of daily visitors has increased 333% to 51,222 people from 1980 to 2007. The history of grazing and agriculture along with increasing resident and tourist populations has placed pressure on Maui's resources.

East Maui is the least developed part of the island and may be in a critical time period before becoming over-developed. Therefore, this study seeks to identify the parcels with the most relevant and important resources in and for the region today. Using primarily local interviews and historical data, I developed a conservation dataset linked to the region's tax parcels. The data were categorized into five resource groups: biological, recreational, cultural, historical and other. With the creation of a GIS-based tool, these categories can be given user-defined weights to highlight different conservation priorities. This will function as a decision support tool that will allow the land trust to explore different protection scenarios. This data, tool and document should provide a framework from which the land trust can base future conservation decisions regarding East Maui.

I conducted eight different scenarios and selected parcels with the highest values, or greatest conservation importance. These parcels were compared across the scenarios. These analyses highlighted that historical resources are relatively under-protected, that many resources are concentrated in a limited number of parcels, and that many top parcels are proximate to county-designated growth boundaries. These results should incentivize the conservation community; protecting a few parcels can save a significant number of resources and that action should be taken soon before development is proposed.

Acknowledgements

I'd like to thank many people and organizations for their help - this project could not have been completed without their support. Importantly, I'd like to thank the Edna Bailey Sussman Fund; their monetary support made this project possible. The Maui Coastal Land Trust was instrumental in this project's success, their guidance and support was crucial from start to finish. My advisor Dean Urban also played an integral role in shaping the outcome of this report. And with utmost sincerity, I'd like to thank all the interviewees for sharing their time and expertise. In many cases, they opened their homes, businesses and lives, trusting me with sensitive information. I hope that this project will meet or exceed their expectations. Finally, I hope that this report will provide useful information that will advance conservation efforts in East Maui and at some level support the creation of a more sustainable and just community.

Contents

List of Figures

Introduction

The Hawaiian Islands are some of the most isolated terrestrial sites on Earth, stranded over 3000 km from their nearest neighbor (the Marquesas), 4000 km from North America and 6000 km from Japan (Beletsky, 2000). This isolation has defined the islands' uniqueness, both biologically and historically. The Hawaiian Islands chain stretches approximately 2500 km itself, in a northwest to southeast direction. The majority of the length of the archipelago is the Northwest Hawaiian Islands which are primarily small reefs and atolls. The vast majority of the landmass is situated with the eight main Hawaiian Islands (Figure 1). Oahu is dominated by Honolulu, the economic and political capital of Hawai'i. The Big Island is by far the largest and the newest island with active volcanoes and the second largest in population. Maui is the second largest island at 1888 km^2, third most populated and located northwest of the Big Island of Hawai'i.

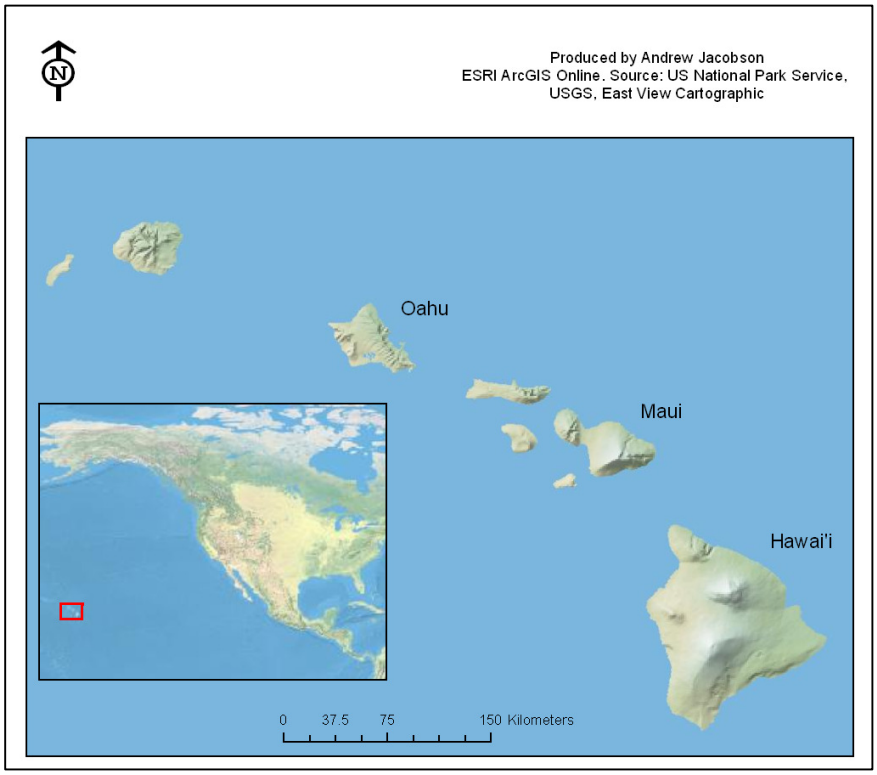

Figure 1. Location of Maui, Hawai'i in the Pacific Ocean.

Maui is comprised of two volcanic cones that merge just above present-day sea level. The northwestern volcano is smaller and has eroded so deeply that many call it the West Maui Mountains. Central Maui is an isthmus, a dry relatively flat valley where the largest population center is located (Wailuku-Kahalui). The massive 10,000 foot volcano, Haleakalā, composes the entire southeastern section of the island. The windward (primarily northern) slopes of the volcanoes support lush rainforests, steep erosional gullies and rocky, rugged coastlines. Beaches and resorts line most of the southern shores. A single loop road encircles both western and eastern sections of the island. Since Maui runs along a northwest to southeast axis, it is not neatly dividable into administrative districts and therefore East Maui is essentially the far eastern half of the island. The study area is in East Maui and sits on the north and eastern flanks of Haleakalā (Figure 2).

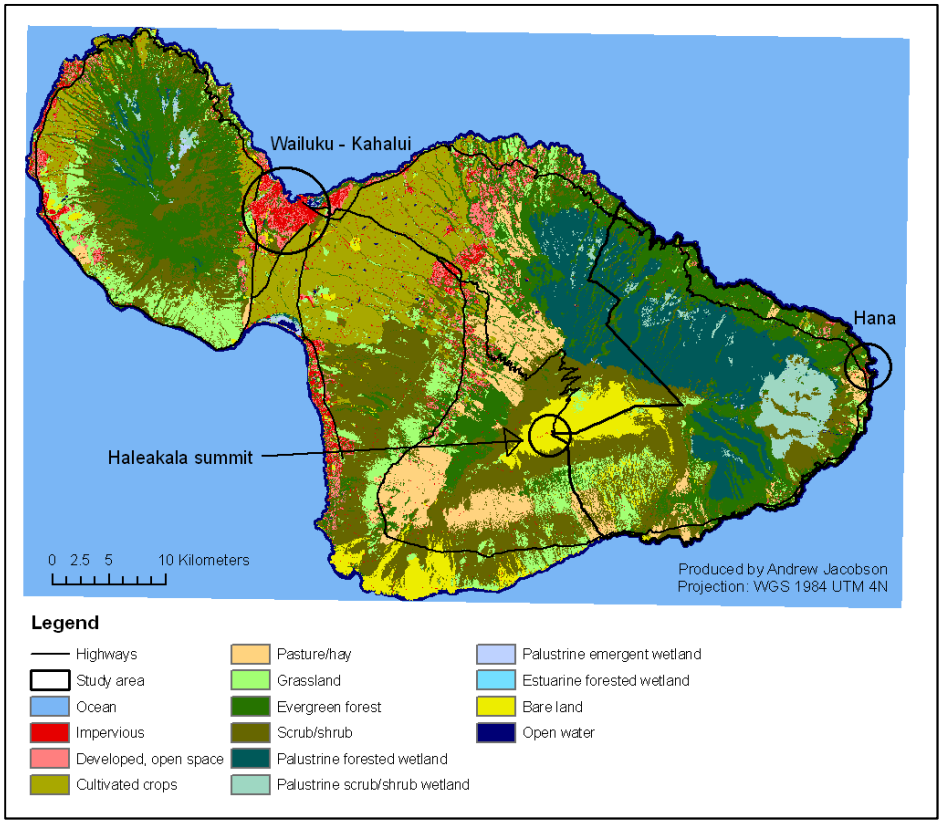

Figure 2. Land cover map of Maui from 2005 with the study area highlighted in the bold outline (NOAA Coastal Services Center). Some major landmarks are circled including the major population center of the island, the twin towns of Wailuku and Kahalui, the major population center for the study area, the town of Hāna, and the summit of the volcano Haleakalā.

East Maui is one of the more isolated areas in all of Hawai'i (The Trust for Public Land, 1998). The rainforests and steep terrain protect the area on its northern boundary, and recent lava flows and inhospitable living conditions insulate East Maui from the south. By road, Hāna (the population center of East Maui) is only 55 miles from Wailuku (the county seat) along the northern route and roughly 65 miles on the southern route. However, both of these routes take well over two hours to drive due to poor road conditions, with numerous hairpin turns, unpaved stretches and occasionally single lane road widths. This isolation has served to slow the development and protect some of the prominent features of the area including its natural resources, archaeological sites and cultural traditions (The Trust for Public Land, 1998).

Selection by Land Trust

Still relatively undeveloped, East Maui's culture and natural resources are threatened as continued population and visitor growth place increasing demands on the area. The Maui Coastal Land Trust (MCLT) believes that East Maui is in an essential time period before too much growth could irrevocably change the character of the region. Therefore, the land trust wants to focus on this special area in the coming years, and to effectively leverage the organization's resources for the greatest community benefit and conservation success. This prioritization study aims to help the land trust achieve that goal.

In 1997, The Trust for Public Land (TPL) sent questionnaires and held workshops throughout Hawai'i regarding conservation, and community needs and priorities. With this background, TPL created the "Hawai'i Community Assessment Report" (1997). One of the conclusions of the report was that an inventory of resources and approaches for conservation acquisition should be conducted (The Trust for Public Land, 1997). While this was not directed specifically at East Maui, it is apropos and fits with the desire of MCLT to identify locations of conservation importance.

Objectives

This study seeks to identify the tax map key (TMK) parcels with the most relevant and important resources in and for the region today. By emphasizing the importance of resources identified in interviews, this study highlights the resources most relevant currently. In addition, this research will allow the land trust to be more informed about the study area. The product of the research will be a Geographic Information System (GIS) map and tool provided along with this report. This will function as a GIS-based decision support tool that will allow the land trust to explore different protection scenarios. If the land trust decides to be more proactive, this study can help focus their activities on strategic areas. If MCLT is more reactionary, this research can guide their decision-making. This document will provide a framework from which the land trust can base future conservation decisions regarding East Maui.

History

East Maui and the town of Hāna in particular, have played an outsized role in Hawaii's history and legends. Due to East Maui's location and wealth of natural resources it was consistently fought over in pre-European contact times. Chiefs from the Big Island would frequently sail across the channel to fight for control of Hāna with chiefs from Maui. As Kamehameha I set sail from the Big Island in 1801 to conquer the rest of the Hawaiian Islands he made a special stop in East Maui to repair several important shrines including Lo'alo'a and Maulili. Kamehameha went on to secure control of all the Hawaiian Islands becoming the first Hawaiian ruler to do so. Around this time, East Maui was losing economic relevance to places with safer and deeper harbors like Lahaina or Kahalui.

The traditional Hawaiian land tenure system evolved to match the particular needs of the people with the island's provisions. Each island was called a mokupuni and broken down into several moku-o-loko (or moku). The moku were then subdivided into ahupua'a, generally a wedge of land extending from the ocean to the mountain top (Figure 3). This area was able to provide all the

necessities of island life from timber and rope to fishing and gathering sites. Many TMKs still follow ahupua'a boundaries. Several smaller divisions further subdivided the land.

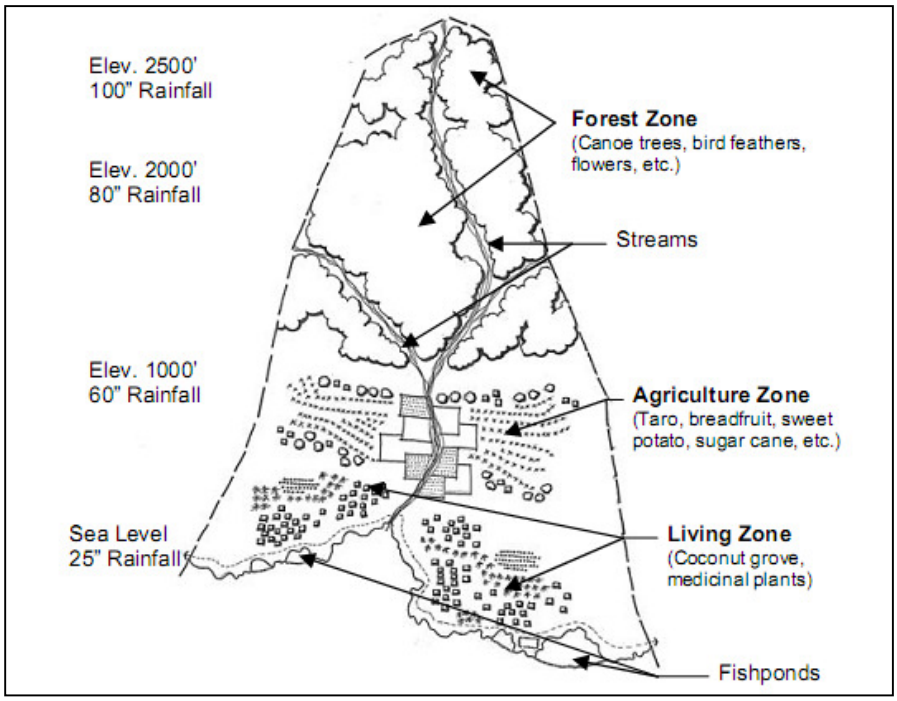

Figure 3. The ahupua'a is an integral component of the native Hawaiian land tenure system (County of Maui, 2009). These are the characteristics of the traditional ahupua'a which stretches from the summit to the sea.

This land tenure system eroded under Western influences. The 1848 Mahele or Division was the first great change in the land tenure system and redistributed land to three parties, the king, the ali'i or warriors and to the native Hawaiian commoners. The Kuleana Act in 1850 solidified the switch to Western-based land tenure by establishing fee simple ownership of property. Native Hawaiian tenants were required to make a claim on their land to establish their boundaries and rights. This division of land failed utterly with the Hawaiian tenants who were supposed to receive roughly one-third of the land but ultimately only claimed less than one percent of the land (The Trust for Public Land, 1998). The Mahele allowed foreigners to obtain fee simple title and in the years that followed, a massive transfer of land from Hawaiian to Western hands occurred. Westerners ultimately ended up owning the vast majority of the land with much of this ownership concentrated in relatively few hands.

Sugar cultivation was one of the initial western industries to impact the land and culture of East Maui. The sugar industry began on Maui in the late 1820's and was in full swing by the 1850's. By 1866, the Hawaiian Islands exported almost eighteen million pounds of sugar primarily to California (Speakman Jr., 1978). The rise of the sugar industry spurred development in central Maui and caused forest to be cleared for sugar plantations throughout East Maui with fields in Nāhiku, Huelo and Kīpahulu. The sugar industry also contributed to the degradation of Hawaiian culture and a decline in the standard of living for native Hawaiians (The Trust for Public Land, 1998). Many Hawaiians moved away or died, contributing to the need for large-scale immigration of East Asian laborers.

Sugar, being water-intensive as well as labor-intensive, led to the large-scale diversion of water from East Maui through an intricately-constructed ditch system that still works today. The entire ditch system collects an average of 164 million gallons-a-day of water from about 100 streams in Ko'olau and redirects it to dry central Maui (The Trust for Public Land, 1998). However, due to the vagaries in the price of sugar, the crop became less economically viable to grow. While sugar plantations continue today in central Maui, the Hāna Sugar Company ended the last sugar operations in East Maui in 1945 (The Trust for Public Land, 1998). Primarily, these sugar plantations were turned into ranch lands which preserved the open space. The one and only large hotel in the region, Hotel Hāna Maui, was built at this time near the center of Hāna town.

Before the end of the sugar era though, the industry inspired another project that would forever change East Maui; the Hāna Highway along the northern coast from central Maui to Hāna was finished in 1927. In 1962, the Hāna Highway was paved and large-scale tourism to the region accelerated. The Road to Hāna, as it is now called, is a very popular tourist drive. This road is the northern section of the loop road surrounding Haleakalā.

During the 1960s and 1970s Maui's population and economy boomed. With a determined focus to reverse population loss and improve the economic sector, business and political actors worked together to develop tourism (Blackford, 2001). Ka'anapali was the first megaresort in the 1960's and proved that the model could work. In the next two decades, condos were developed in Kihei and other large resorts developed at Kapalua, Wailea and Makena. Nearly all of this development was along south Maui and West Maui with East Maui largely insulated. No more hotels or large resorts were built in the region, although at least one had been planned; Hotel Hāna Maui remains the only large-scale hotel built.

Despite the relative lack of overnight tourist accommodations, East Maui is a popular place to visit, primarily because Haleakalā National Park (HNP) functions as a large tourist magnet on the far side of Hāna. HNP was initially designated in 1916 around the summit of the volcano, as part of Hawai'i National Park. It was redesignated as a separate entity in 1961 (The Trust for Public Land, 1998). Additions in 1951 and 1969 connected the Park from the summit to the pools of 'Ohe'o and the ocean. As of 2000, the park was 28,655 acres in size with nearly 70% in wilderness. In 1996, visitation reached nearly 1.6 million people annually (The Trust for Public Land, 1998).

For more information on the history of Hawai'i see Ruling Chiefs of Hawai'i by Samuel Kamakau and for a history more specific to East Maui see the "East Maui Resource Inventory" (The Trust for Public Land, 1998). The Digital Repository of the University of Hawai'i at Manoa Library also contains thousands of historical documents.

Study Area

The study area is a subsection of East Maui (Figure 4). East Maui, as defined by The Trust for Public Land (1998), contains seven districts. The political boundaries of the Hāna region include five of these districts. The study area is composed of four of the districts: Ko'olau, Hāna, Kīpahulu and Kaupō.

The study area is roughly 118,000 acres in size and contains 1881 parcels ranging from less than an acre to over 10,000 acres in size. Of this, the County of Maui's TMK parcel data indicate that over 53,000 acres are owned by the government and over 70,000 acres are classified as reserves. This means that roughly 45% of the study area is government owned and 60% is in reserves. Population or economic statistics are not readily available because the study area does not align with the other designations. The region includes the far eastern tip of the island, and wraps around but does not extend all the way to the summit of Haleakalā. The region looks like a greater than sign. The northwestern boundary starts at Makaiwa Bay and runs mauka (or up mountain) along 'O'opuola and Waikamoi streams. The area is bounded by the ocean and by moku delineations on the mauka side. The very southern edge of the district is Kanaloa Point and runs mauka along the boundary of Auahi and Kanaio. The study area includes most of HNP but not the crater or western parts of the park.

Hāna Town is the major population node of the region, located on the far eastern tip of the study area. The district contains several other small rural settlements such as Ke'anae, Wailuanui, Nāhiku, Kīpahulu and Kaupō. The region's economy focuses on diversified agriculture, tourism, government services and subsistence activities (County of Maui, 1994). Agriculture includes everything from large-scale ranching to tropical flower production and traditional taro growing.

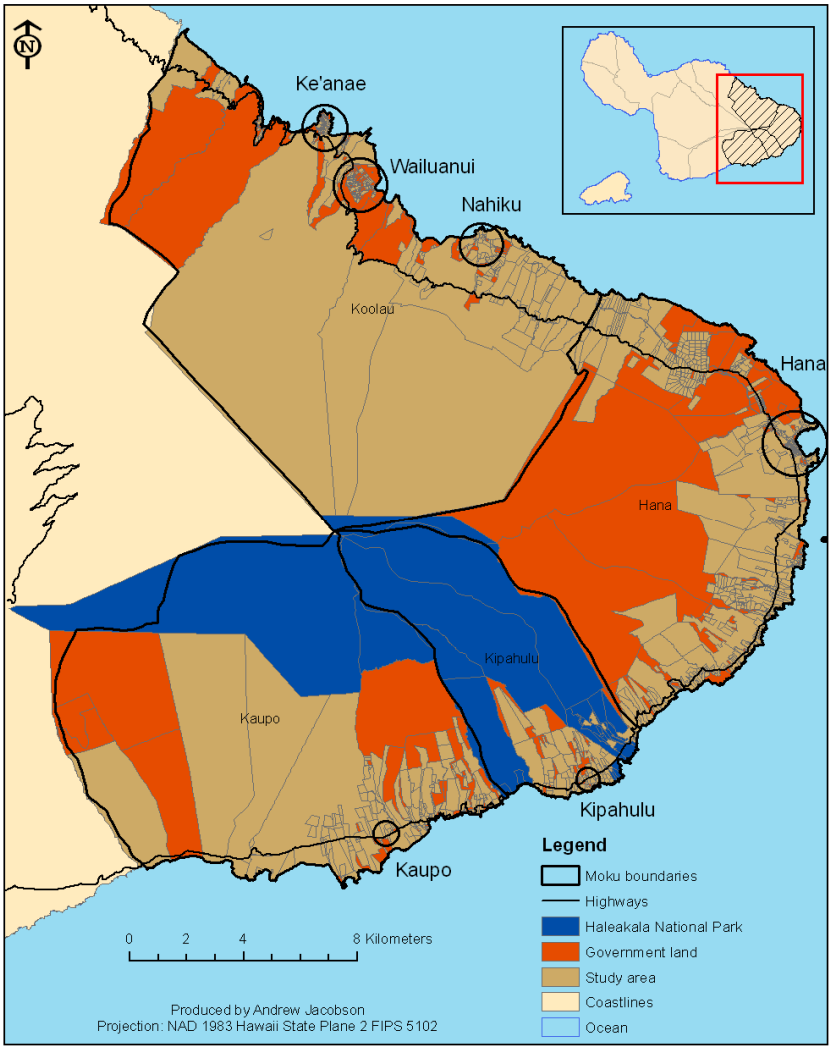

Figure 4. Extent of the study area; all colored parcels are within the study area. The four moku boundaries set a rough outlines but the borders of the TMK parcels are the actual delineation. The primary settlements of the study area are circled and labeled.

Biologically, Hawai'i is unique. An estimated 15,000 endemic species occur in the Hawaiian ecoregion (Eldredge and Evenhuis, 2003). Some families have extremely high endemism such as 90% endemism in native flowering plants and greater than 98% in native terrestrial invertebrates (Loope, 1999). However, associated with endemism is rarity and Hawai'i includes more endangered species than any other U.S. state (U.S. Fish and Wildlife Service, 2005). Hawai'i has 25% of the United States' federally listed endangered species and 72% of the nation's recorded extinctions (Noss and Peters, 1995). Little or

no native vegetation remains below 2,000 feet in elevation (The Nature Conservancy, 2006). Anthropogenic and alien-dominated communities dominate the lowlands, converted through decades of cultivation and grazing. However, East Maui does have some of the only native-dominated communities below 2,000 feet.

Wrapped around the north and eastern side of Haleakalā, East Maui contains a wide variety of ecological systems. The systems are driven by elevation and the distribution of rainfall; however, much of the lowland and dry land areas have been significantly disturbed. Along the northern coast, the area receives tremendous quantities of orographic rainfall. Over 150 inches of rain fall annually near Ke'anae leading to tropical rain forest. Some areas here are still dominated by native communities. Rainfall decreases gradually eastward and southward, such that areas just south of Kaupō only receive 20 inches a year. The size and abundance of streams mirrors this change in rainfall. Along the northern coast are a large number of perennial streams including some that still harbor native communities. Fewer and mainly seasonal streams exist in Kīpahulu and Kaupō. Along the northern side, the rainforest and steep terrain make the area tough to penetrate. Around Hāna, the area is flatter with a mix of pasture and forest. Parts of Kīpahulu and Kaupō are quite steep and wet at higher elevations although rain decreases as the elevation drops.

Ko'olau: The wettest moku by far, Ko'olau contains several settlements including Ke'anae, Wailuanui and Nāhiku. The many perennial streams in the region are bisected by ditches which capture much of the water and divert it to central Maui. An average of 164 million gallons of water daily is diverted from roughly 100 streams in Ko'olau into the ditch system (The Trust for Public Land, 1998). Water issues are very important because the settlements are based off taro farming which needs adequate supplies of water. Relatively more hui (groups or associations) and native Hawaiian lands exist in these areas compared to other regions. For more information

see “Kalo Kanu o ka ‘Āina: A Cultural Landscape Study of Ke’anae and Wailuanui, Island of Maui” (The County of Maui, 1997).

Hāna: Hāna was a major center of population and political power in ancient Hawai’i. It was fought over consistently and the site of numerous historical events, therefore it is unsurprising that Hāna is central in many Hawaiian legends and mythology. Pi’ilanihale, the largest recorded and remaining heiau (or temple) in Hawai’i is located at the Kahanu Gardens of the National Tropical Botanical Garden (NTBG). Hāna Bay and nearby beaches are the recreation centers for East Maui due to dangerous surf in most of the region. Hana Ranch owns hundreds of acres along the coastline and at lower elevations; ranching has allowed Hāna to maintain its open feel. Hotel Hāna Maui plays a central role in the town and community of Hāna.

Kīpahulu: Similar in climate to Hāna, Kīpahulu also experienced plantation agriculture which destroyed many of the historical remains in the area. As the sugar industry declined, cattle ranching replaced the plantations. Despite its similarity to Hāna, Kīpahulu has its own rich history and legends. The ‘Ohe’o gulch section of HNP is located within Kīpahulu. Kīpahulu is fairly well-populated but diffuse.

Kaupō: Kaupō today has but a fragment of its historical population; a large population existed up to the 1930s when a large earthquake hit and several of the area’s springs dried up. Several important landmarks are in the moku including Lo’alo’a heiau, Pōpōiwi heiau and the Huialoha church. The Kaupō General Store still operates along the highway and is the center of the small community in the area. Cattle ranching is the major economic activity in the now-arid locale. Nu’u Bay was formerly an important harbor and many petroglyphs and historic structures remain in the area. Nearby, Nu’u Pond shelters many threatened and endangered species.

Conservation features in the study area

East Maui contains possibly the most intact assemblage of resources anywhere in Hawai'i, with everything from natural resources to historical, cultural and recreational resources.

Natural resources: The natural resources of East Maui include everything from the sea to the upper slopes of Haleakalā. Good marine resources exist in areas such as Koali or at Mu'olea Point. Along the coastline tidal pools, fishponds and bays provide important protection for juvenile fish. Special anchialine pools and the Nu'u pond protect other indigenous and endangered species. Pristine streams feature endemic aquatic and riparian species. Some pockets of lowland indigenous forest exist in addition to forest reserves at higher elevations critically important to endangered, endemic birds. A few lava tubes exist although knowledge of them is fiercely protected with a lone exception which is commercially exploited.

Historical resources: East Maui is generously endowed with historical resources from pre-European-contact times up through the 20th century. Resources include the ancient Lo'alo'a heiau and many religious shrines, petroglyphs, settlement complexes and graves from pre-contact times. Several churches still exist from the 1800's. Home sites, bridges, landings, mills and stores exist from the 1900's.

Cultural resources: Many Hawaiians still living in the area practice subsistence hunting, fishing and gathering. This is a testament to the natural resources of the area as well as to its relatively undisturbed physical setting. People fish and gather along most of the coastline and streams. Almost the entire forest is hunted for pig and deer except HNP where it is illegal. Some traditional forest products are still gathered although in limited extent.

Recreational resources: Of all the resources in East Maui, recreational resources may be the rarest. The area is largely rural with active ranching still ongoing. Thus most recreational

activities are packed along the Hāna Highway or in the few parks along the way (such as Wailua Valley State Wayside Park, Wai'ānapanapa State Park, and HNP). Many spectacular waterfalls and pools punctuate the streams, although most are on private property and trespass issues are a concern. A few exceptional beaches with white, black, red and green sand dot the coastline. Typical ocean activities include swimming, surfing, sailing, boating, fishing and diving. Strong seas and rip currents limit the locations and times when surfing and swimming can be done.

Threats to conservation features in the study area

Before European contact, the Hawaiian Islands were quite well populated and population declined over time primarily due to introduced diseases and out-migration (The Trust for Public Land, 1998). This trend was similar for Maui and East Maui as well. The population of the island fell after European contact and reached its nadir around 1956. With a determined and successful focus on tourism and economic development, the island's population has expanded quickly since then (Table 1). The district of Hāna, slightly larger than the study area, had a population in 1836 of 3,792 which declined to under 1,000 by 1970 (The Trust for Public Land, 1998). However, the population of the district has more than doubled (205%) since 1970 and is projected to continue to increase at roughly 10% a decade (Long Range Planning, County of Maui, 2009).

Tourism is a major threat to conservation features. Tourism to Hawai'i began in the late 1800s with the first regularly scheduled steamship service. Tourism grew slowly to about 30,000 visitors per year in 1941 (Beletsky, 2000). After World War II however, tourism exploded and continued to rapidly increase when Hawai'i was made the 50th state in 1959. By this time, the airline industry had expanded commercial jet capacity and began advertising Hawai'i as a destination while simultaneously urging the islands to develop the appropriate tourist infrastructure (Kent, 1983). By 1971 almost 2 million tourists

were visiting per year. This has since increased to 6.5 million visitors to Hawai'i per year in 2000 (Beletsky, 2000).

Table 1. Demographic figures comparing the district of Hāna, Maui, and the state of Hawai'i (Long Range Planning, County of Maui, 2009). The Hāna District is slightly larger than the study area, encompassing one other traditional moku, Kahikinui. However, Kahikinui is largely unpopulated which means the Hāna numbers are fairly accurate for the study area.

Area	Population count (percent change)				
	1970	1980	1990	2000	2005
State of Hawai'i	769,913	964,691 (25.3%)	1,108,229 (14.9%)	1,211,537 (9.3%)	1,275, 194
Maui Island	38,691	62,823 (62.4%)	91,361 (45.4%)	117,644 (28.8%)	129,471 (10%)
Hāna District*	969	1,423 (46.8%)	1,895 (33.2%)	1,855 (-2.1%)	1,998 (7.7%)

Maui County has seen an explosion in the amount of tourism since the 1980s (Table 2). The number of average daily visitors has increased from 15,363 in 1980 to 51,222 in 2007, a 333% increase (Office of Economic Development, County of Maui, 2009). The County's decadal change was consistently higher than the State's, i.e. the County has been increasing at a faster rate than the State. Currently, Maui has the second-most tourists of any Island except Oahu (Office of Economic Development, County of Maui, 2009). Many of these tourists never make it to East Maui. However even as early as the 1970s, not long after the initial paving of the Hāna Highway, East Maui residents were expressing worry over the increasing number of travelers (Speakman Jr., 1978). The number of tourists has continued to grow, clogging the one-lane road into and out of Hāna. The number of tourists driving the Road to Hāna is unknown, but the Kīpahulu (or coastal) unit of HNP now attracts over 500,000 visitors annually (The Trust for Public Land, 1998).

Table 2. Average daily visitor census (Office of Economic Development, County of Maui, 2009). Maui County is composed of four islands: Maui, Molokai, Lanai and Kaho'olawe.

Area	Average daily visitors; arrivals by air (percent change)			
	1980	1990	2000	2008
State of Hawai'i	96,417	154,516 (60.3%)	168,637 (9.1%)	189,412 (12.3%)
Maui County*	15,363	37,657 (245.1%)	43,854 (16.5%)	51,222 (16.8%)

Biologically, native habitats and species are under threat from habitat loss, fragmentation, and degradation due primarily to development, agriculture, grazing and introduced species (Ricketts et al., 1999). Lowland mesic and dry forests have been largely eliminated, modified first by Polynesians and later by Europeans (Ricketts et al., 1999). Original native forests have been reduced by two thirds and moist forests by nearly that much (Noss and Peters 1995).

Other resources have been heavily impacted although there are no statistics or metrics of this type. Many native Hawaiian cultural traditions are closely linked to the biological integrity of the system. For instance, healthy systems support traditional Hawaiian fishing and gathering customs. Pig and deer hunting have also become customary although these species were introduced and are not native. Therefore, as biotic systems break down, the local culture loses its ability to practice its traditions. The influx of tourists and detailed visitor guides have also changed the dynamic at the few recreational sites in East Maui. Over the decades, cattle and sugar operations have damaged historical resources through direct disturbance and the trampling of historical sites and structures. Therefore, it could be expected that other types of resources have declined in comparable fashions to the biological features.

Existing conservation efforts in the study area

Several layers of conservation efforts already exist that limit the development and subdivision of East Maui. Government plays a major role in most types of protection, but public-private partnerships or pure private conservation efforts also exist.

A complex network of plans, rules and laws govern land use. Many planning documents exist from the County 2030 General Plan (County of Maui, 2009), to the Maui Island Plan (Long Range Planning, County of Maui 2009) and the Hāna Community Plan (County of Maui, 1994). The Maui Island Plan and Hāna Community Plan are currently being updated with the County General Plan recently adopted in March 2010. Among other things, these plans predict population growth, designate an

appropriate size and area where new development should occur and manipulate land use district boundaries if necessary. Appropriate zoning designations and ordinances are also manipulated if necessary to facilitate the goals in the plans. The Hawai'i Coastal Zone Management (CZM) Program was enacted in 1977 (Hawaii revised statues: Chapter 205A). The CZM program is a broad management framework with the goal of achieving greater coordination between various levels of authorities and existing laws in coastal areas (Hawaii CZM Program, 2006). The Special Management Area (SMA) is part of the regulatory system that manages coastal development within SMA boundaries. SMA boundaries encircle each island and can be anywhere from 100 yards to several miles wide (Hawaii CZM Program, 2006). A permit is required for projects within SMA boundaries and is designed to assure that projects are in compliance with CZM objectives. Each county is responsible for implementing its own SMA process. The SMA forces certain types of projects over $125,000 to go through a process often lasting more than six months (National Oceanic and Atmospheric Administration, 2005); however, it is unknown to what extent the SMA is discouraging or changing development patterns.

Other laws, ordinances and court decisions support the continuation of agriculture or traditional practices but these mechanisms do not guarantee protection from development. For instance, various economic and tax incentives are available statewide for agricultural lands. The continuation of cultural practices is supported by the State Constitution and other statutes such as the Kuleana Act of 1850 and the Hawai'i Coastal Zone Management Act. The Kuleana Act protects access, gathering and subsistence rights. In 1995, Hawaii's Supreme Court ruled that plaintiffs had standing to exercise traditional and customary practices in the Public Access Shoreline Hawai'i or PASH Decision. This decision gave native Hawaiians rights to access and gather for traditional practices (National Oceanic and Atmospheric Administration, 2005). The Coastal Zone Management Act provides protection for cultural practices with activities like the Native Hawaiian Access Project, which was developed in response to the PASH decision (National Oceanic and Atmospheric Administration, 2005).

Historic designations of sites can also affect what occurs on private or government property. A property can be placed on a state or national Historic Register. The listing allows the property to be eligible to receive grants and tax exemptions but also requires governmental review of projects that may affect the historic conditions. The review must occur before any state or county project is approved, permit is issued, or subdivision or land use change is allowed (The Trust for Public Land, 1998). For registered private properties, the land owner must notify the appropriate governmental unit to get permission before certain activities can occur.

The direct purchase or ownership of land by the federal, state or county government can ensure long-term protection. Approximately 45% of the study area is owned by the government although these are concentrated at higher elevations. The major extensions of HNP in 1951 and 1969 down Kīpahulu valley have not been the last expansions of the park. Coastal areas in Puhilele and Ka'apahu were added in 1998 and 1999 respectively (Haleakala National Park). Several state and county parks also exist in the area, the largest of which is Wai'ānapanapa State Park. To what extent continued expansion of government lands may continue is unknown.

The State created the Natural Area Reserves System (NARS) to protect wilderness lands. The NARS is legally mandated to perpetually preserve and protect natural communities to the fullest extent (Hawai'i revised statutes: Chapter 195-1). The Hanawī NAR occupies 7,500 acres bordering the Ko'olau Forest Reserve and extending down to the 2,000 foot elevation. It protects the highest density and number of endangered forest birds in the state (Department of Land and Natural Resources, 1989).

Partnerships provide a means of obtaining protection of natural lands without government ownership. Many of these agreements provide private land owners with government funding and management tools for stewardship of forest and conservation lands. The Forest Reserve System (FRS) was created by the State and is a public-private partnership to protect upland forestland for their public

benefits and values. Roughly an additional 20% of the study area beyond what is owned by the government is in either NARS or FRS reserves. Several forest reserves are in East Maui including the Ko'olau and Hāna Forest Reserves. In addition, the Natural Area Partnership Program provides matching funds for the management of private lands of "natural area" quality that are permanently dedicated to conservation (The Trust for Public Land, 1998). Several Watershed Partnerships are located in or border East Maui including the East Maui Watershed Partnership and the Leeward Haleakalā Watershed Restoration Partnership. These watershed partnerships are voluntary agreements between public and private landowners to implement programs that protect and monitor the native ecosystems.

Conservation by private entities is also an important conservation tool. The Nature Conservancy has an extensive Hawai'i program which has bought and transferred land to the government. Local organizations such as the Maui Coastal Land Trust are also impacting conservation efforts. MCLT works primarily through the donation of conservation easements but also purchases some property in fee title; MCLT holds several easements already in the study area. Conservation easements are legally-binding documents that put a set of restrictions on land for perpetuity, primarily including the abdication of the right to subdivide or develop the property. The ownership of the land does not change. Easements are also flexible to fit the needs of the owner, but once the easement is established it becomes static. Easements also do not restrict access or override other laws or regulations already in place. MCLT currently holds easements in East Maui, but a few other organizations do too, notably the National Tropical Botanic Garden at Kahanu Gardens and Na Mamu Mu'olea.

Decision support systems

Decision analysis is a discipline that studies the theory and methods of decision making and provides tools to approach complicated decisions in a formal, repeatable manner. Decision analysis involves correctly identifying the problem, structuring the issue and accounting for the uncertainty and

trade-offs inherent in alternative outcomes (Belton and Stewart, 2002). Decision-analysis does not provide answers or guarantee good outcomes, it merely creates a structure whereby complicated decisions can be broken down into manageable parts and evaluated.

Specifically, MCLT will face complicated decisions with inherent risks and multiple possible outcomes and should thus consider the application of multi-criteria decision analysis (MCDA). MCDA is a specialized form of decision analysis that creates a transparent process for evaluating multiple alternatives that often have competing interests. Belton and Stewart (2002) define MCDA as "an umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter." This definition implies three components: a formal approach, the presence of multiple criteria and decisions that can be made by individuals or groups. Additionally, MCDA is appealing and useful because (1) it takes explicit account of multiple, conflicting criteria, (2) it helps structure the management problem, (3) it proposes a model that serves as a focus for discussion, and (4) it offers a process that leads to rational, explainable and justifiable decisions (Belton and Stewart, 2002). Furthermore, MCDA can aid in group decision-making which must begin with correctly identifying the group's goals and core values. These abilities and characteristics of MCDA align it with a land trust's activities and needs.

In particular, this type of analysis is relevant to this study because the resources identified herein can be conflicting and not overlapping. For instance, some parcels contain more than one type of resource, but in some situations this is not the case. Oftentimes historical resources are located on different parcels than ones with recreational or biological resources. Therefore, choosing to protect one of these resources may result in other resource types being left unprotected. Identifying the land trusts core values and goals and creating a framework with which to make decisions could help MCLT balance competing interests and produce justifiable decisions.

Prioritization studies

With limited resources, conservation organizations need to make cost-effective selections of areas to preserve. Prioritization studies along with decision support systems can serve as a guide for organizations to make strategic investments. Many types of prioritization studies exist and some are inherently coupled to decision analysis frameworks and explicitly discuss tradeoffs associated with alternative choices. For many studies the typical approach is to identify conservation targets at broad landscape levels such as for a county or ecoregion (Strager and Rosenberger, 2007). This often presents a spatial mismatch because protection efforts are often implemented at the parcel scale. In addition, many prioritization studies are conducted based on GIS and specifically conduct raster-based analysis. This works well for capturing biological components of the study area such as fragmentation, species occurrences, stream locations, etc., but other types of resources are likely not incorporated into GIS. This means that the majority of prioritization studies can be conducted from an office with limited construction of new data sets, but these studies may overlook important historical or cultural resources.

Methods

This prioritization study attempts to address some of the issues that typical prioritization studies overlook through the extensive use of interview data. Data was collected through interviews and the collection of secondary sources. From this, resources with known locations were extracted, attached to the parcel(s) on which it was located and put into a spreadsheet. The resources were placed into five categories, the parcel was given a score based on the resources present and the scores were totaled for each parcel by category. Thus, each parcel was imbued with specific values corresponding to all of the resources present on that parcel. I created a GIS script that allows the user to place weights on the different resource categories and the tool creates new scores based on the parcel's specific values and

the user-assigned weight. The result is a map of the study area indicating each parcel's score given the weighting scheme. The most important parcels in that scheme can then be identified.

Data collection

Data collection was the central focus while in Maui. The study relied on three methods of data collection: conducting interviews, obtaining GIS data from Maui County (hereafter the County) and The Nature Conservancy (TNC), and gathering historical records and secondary sources.

I conducted 25 semi-structured interviews in which interviewees discussed the most important resource locations and features of the study area. Interviews were conducted in East Maui and other convenient locations. Contacts were obtained through snowball sampling, i.e. word-of-mouth. Snowball sampling is a form of chain-referral sampling used in social sciences (Goodman, 1961). Snowball sampling was used because of its efficiency in reaching convergence (Heckathorn, 1997) and for its convenience. Initial contacts were individuals whom the land trust knew and who either lived in East Maui or knew the area intimately. The interviews lasted anywhere from 30 minutes to two hours. I opened the interviews with questions about the subjects' personal history in the area. The bulk of the questions related to what areas were important to conserve and where certain resources were located in the community. Other interview questions probed people's knowledge of pending development plans and if there were other resources I should be aware of (both people and documents). The list of interview questions is in Appendix A. Interviews were not taped, but I took notes during the conversation specifically identifying resources and their location. USGS quad maps were also brought to interviews to elicit responses and to ensure the correct placement of resources. In some cases, resources were marked directly on the maps themselves by participants.

Data collection also consisted of searching for GIS data and historical records that I was referred to. The County had ample and relevant GIS data. Mike Napier, from the Long Range Planning Division,

shared their data with me in August, 2009 including updated TMK parcel data among others. In terms of historical documents, an unknown but great multitude of first and second-hand historical documents exist in local and state historical societies and museums but these sources were not used. I did not have the time to search for and use all of them, especially since many records resided in Oahu. Additionally, since some areas were better documented or the sources themselves were easier to obtain, I felt that using them would unfairly balance one area's resources over another's e.g. the sources I could find may not represent a difference in the amount or type of resources, merely that they were better catalogued and more accessible to me. This lopsidedness would play out in the analysis and affect the results because the number of times a resource is mentioned increases its value. Therefore, I only used historical records that I was referred to.

Resource categories and assignments

The data were compiled into spreadsheets. Each resource was listed, assigned a number, its source noted and placed into one of five categories. The five categories are based off the Ocean Resources Management Plan that MCLT wrote for the County. The five resource types are: Biological, Historical, Cultural, Recreational and Other. The Biological resources category includes things like natural resources, unique biological conditions and native species. The Historical resources category primarily represents physical objects such as fishponds, structures or trails but it also represents places mentioned in Hawaiian legend. The Cultural resources category is related to the State Supreme Court's PASH decision, and represents locations where traditional activities or pastimes such as fishing still occur. The Recreational resources category captures places that are valuable recreationally and also includes open space and aesthetic considerations. The final Other resources category includes things that do not fall into the initial categories, primarily buffers of protected lands, agriculture lands and places necessary to access other areas.

To facilitate understanding the data, the over 370 individual resources were categorized by their source (Table 3). Some sources contained information regarding all five of the resource categories whereas others were used in only one category. For example, interviews informed all five resource categories but a GIS layer such as anchialine pools only reflected biological resources. Table 3 includes all of the sources of information that were used in creating the dataset.

Table 3. Sources used to create the conservation dataset and color-coded by source: blue is interviews, pink is historical documents and brown is GIS. Resource categories that were informed by that source are marked with an "x". GIS data from the County was given to me by Mike Napier. If there is no date next to a GIS layer, it was downloaded in August, 2009.

Resources		Biological	Historical	Cultural	Recreational	Other
Interviews 1-22		X	X	X	X	X
Borthwick et al., 1992			X			
Clark, 1989		X	X	X	X	
County of Maui, 1997		X	x	X	X	
State Historic Preservation Division, 2009			X			
The Trust for Public Land, 1998		X	X	X	X	
State of Hawaii, 2010						
	Agriculture lands of Importance to the State of Hawaii (ALISH)					X
	National wetland inventory, DBET 2003	X				
	Proposed critical habitat, USFWS 2002	X				
	T and E plant habitat, DOFAW 1992	X				
	NAH trails		X		X	
Mike Napier, County of Maui, 2009						
	Anchialine pools	X				
	Coastal seabird nests (June 15, 2009)	X				
	Hunting areas				X	
	Fishponds		X	X		
	Streams aquatic resources	X				
	Streams cultural resources			X		
	Maui place names, 2003	X			X	
Produced						
	Buffers of protected areas and reserves					X

East Maui contains 1881 parcels that vary greatly in size. Resources were assigned to specific parcels within East Maui. In some cases, resources are large, stretching between many, possibly hundreds of parcels. In other cases, a resource is only present on a single parcel. In some situations, the exact location of a resource was not identified. I attempted to pinpoint the location the text or interview describes or at least the boundaries of the resource. If I was reasonably confident that I found the right location or boundaries for the resource, the data was used; resources that could not be assigned to parcels were thrown out. The source of the information, either from interviews, GIS resources or secondary sources, was also noted.

Different types of references to resources were weighted differently. If the interviewee mentioned an area specifically (such as Hāmoa beach) then it was given three points. If the interviewee commented in generalities about resources spread across many parcels, then each parcel that it overlapped only received one point. For example, many people indicated that the entire area makai (or seaward) of the Highway should be preserved for the protection of cultural resources. This resource was captured by giving one point to each parcel that was makai of the road, roughly 340 parcels. In addition, the different sources of information were weighted differently. Only the interview sources were given three points and this was only when they specifically identified a resource, the GIS and secondary sources were assigned one point. This was done because the resources that came up in interviews I assumed are more relevant to the community today.

For illustration purposes, let us continue with the beach example from above. Secondary sources indicated tidal pools were there, thus that parcel was given one point in the Biological resources category. Three interviewees as well as a secondary source indicated that teaching related to cultural practices occurred there, so the parcel was awarded three times three plus one point for a total of 10 points in the Cultural category. The beach is also makai of the road and was therefore given one point in

the Cultural category for each interviewee who mentioned the coastline as an important cultural area. This was continued for the Historical, Recreational and Other categories. Therefore a beach parcel may be given multiple points from the different sources that mentioned it, as well as points in multiple categories according to the type of activity that occurs there.

The parcel layer is the background on which the analysis is conducted. Each parcel is imbued or associated with the identified resources on that land. With all the resources associated with their respective parcels, the score for all of the resources in each category is summed. For each category, the highest value was found and all the parcels were divided by that score. This relativizes the scores and each parcel has a percentage from zero to one representing relatively how many resources are present on it. Thus each parcel has a percentage score in each of the five resource categories. Note that a higher percentage does not necessarily mean that a parcel has more resources or that they are "better" than another parcel's. The score is derived from a combination of the number of resources, how the resource was mentioned and the number of times it was mentioned. Therefore, a high percentage can indicate a parcel has many resources, resources that were mentioned frequently or a combination thereof.

To preserve the privacy of the exact locations of resources, only conservation scores will be shown in this report. The data collected for this report will be turned over to MCLT but will not contain exact coordinates of resources.

GIS tool

A comparative analysis among the parcels was conducted. Conceptually, this step is simple: the values from all five categories are combined and the parcels with the highest values are ranked the highest. However, I used the Python-scripting language to create a GIS-based tool that allows the user to input different weights for each of the five categories. This allows greater flexibility; different scenarios can be run depending on how the user wants to weight each category.

The tool is designed to allow the user control in choosing the weights of the five categories. Each category is then multiplied by the user-defined weight and added together to give a score ranging from 0 to 100. The higher the number, the greater its conservation value, or the more resources it has compared to other parcels. The highest numbers indicate parcels where further inquiry should be conducted regarding its value and possible conservation.

Inputs for the tool are quite straightforward: parcel information and resource scores. Maui County provided me their most recent parcel information in August, 2009. The resource scores were calculated as detailed above.

After discussions with MCLT, I placed a restriction on the size of parcels that are evaluated. Speaking generally, it is not feasible for the land trust to attempt easements or fee simple purchases on parcels that are too large or too small. Through discussion with MCLT and noting the size of the parcels in East Maui, I chose to restrict the analysis to a range of five to 5000 acres. This range may not always limit MCLT's activities, but it helps to focus the user on those parcels that are most appropriate for conservation.

The tool is very specific to this and similar data. The script could easily be made to accommodate other datasets but is currently configured just for this one. For instance, MCLT conducted and completed an Ocean Resources and Management Plan for Maui County in 2009 with data grouped into five categories very similar to this. That data could be apportioned on a per parcel basis and then the script could be similarly used to prioritize those coastal areas.

Several iterations of the tool were run to simulate how MCLT might use it. Eight scenarios were kept; these included five where each category was weighted 100%, one where every category of resources was weighted evenly and two scenarios tailored to the land trust (Table 4). The pure weight scenarios were chosen to highlight the parcels that were most valuable for that specific type of

resource. The even-weight scenario was used to simulate if there was no preference for different types of resources. The final two scenarios were weighting schemes that I created for the land trust. Scenario seven was based on the qualification criteria listed on their website (Maui Coastal Land Trust, 2007). Based on personal experience with the land trust, I felt that this scenario did not accurately capture their values; thus, I created the weighting scheme for scenario eight. These eight runs were then analyzed; the top one percent of parcels (roughly 20) from each iteration was selected and compared. These top parcels were also compared with the County-designated growth boundaries.

Table 4. Weighting schemes for the eight different scenarios. The brown colored columns are the pure runs and the last three purple columns are the scenarios with weights distributed among all five resource categories.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
Biological resources	100 %					20 %	38 %	20 %
Cultural resources		100 %				20 %	12 %	30 %
Historical resources			100 %			20 %	12 %	30 %
Recreational resources				100 %		20 %	19 %	10 %
Other resources					100 %	20 %	19 %	10 %

Government and nonprofit land is not excluded from the analysis. Resources were still assigned to these parcels. However, since MCLT is not interested in these lands, government and other non-profit owned lands were overlaid on the output. Thus, when comparing the top parcels, TMKs owned by government and non-profits were excluded.

Results

Results from various scenarios are conservation scores which are assigned to each parcel based on the unique weighting scheme in that scenario. Each scenario produced a map depicting conservation

scores per parcel. Examining maps from each scenario and comparing their similarities and differences is informative.

Five pure run maps were produced, one for each of the five resource categories. The map from the pure biology run indicates the top parcels with the most biological resources were spread widely across the study area (Figure 5). Some were coastal, others mauka, some along the northern coast and others near the southern boundary. Roughly 850 parcels had biological resources. This evenness was not apparent in all resource categories however. The pure culture run map shows top parcels clustered along the coast and are likely related to fishing, gathering and teaching activities (Figure 6). Roughly 800 parcels had cultural resources but the scores were highly skewed to the upper end. The map resulting from the pure historical run produced relatively few important parcels (Figure 7). Historically important areas were clustered at a few sites, around Hāna, and where important heiau were located. Only about 200 parcels had historical resources and they were highly concentrated in a limited number of parcels. Similarly, the pure recreational run map indicates that the resources were highly concentrated in a few parcels (Figure 8). These areas were along the coast and centered around Hāna where several beaches exist. Around 550 parcels held recreational resources. The map produced from the pure run of Other resources had two distinct important clusters of parcels, the more important one around Hāna town and a second, more diffuse area in Kaupō (Figure 9). Over 1200 parcels had resources in the Other category and there was less concentration at the higher end.

In comparing the pure-weight simulations, the parcels with greatest conservation value for each category shift around. For instance, the biological and historical resource maps are quite dissimilar. Yet, a few parcels do remain in the top category from simulation to simulation; the recreational and historical maps are fairly similar. In general however, the top parcels are not exactly the same comparing across the pure simulations.

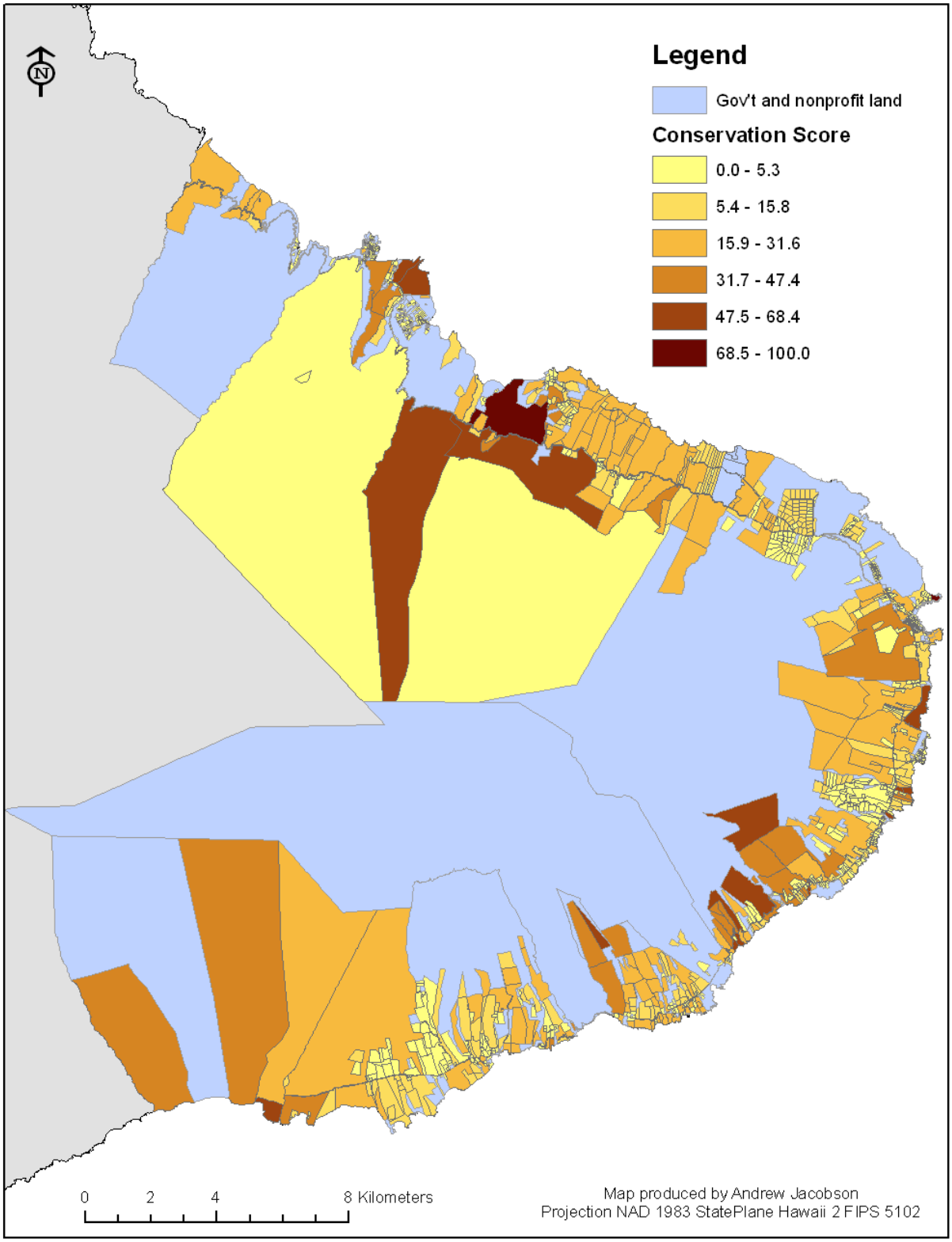

Figure 3. Results from scenario 1 in which the Biological resources category was weighted 100%. The darkest colors indicate greater amounts of resources and therefore parcels of greatest conservation importance.

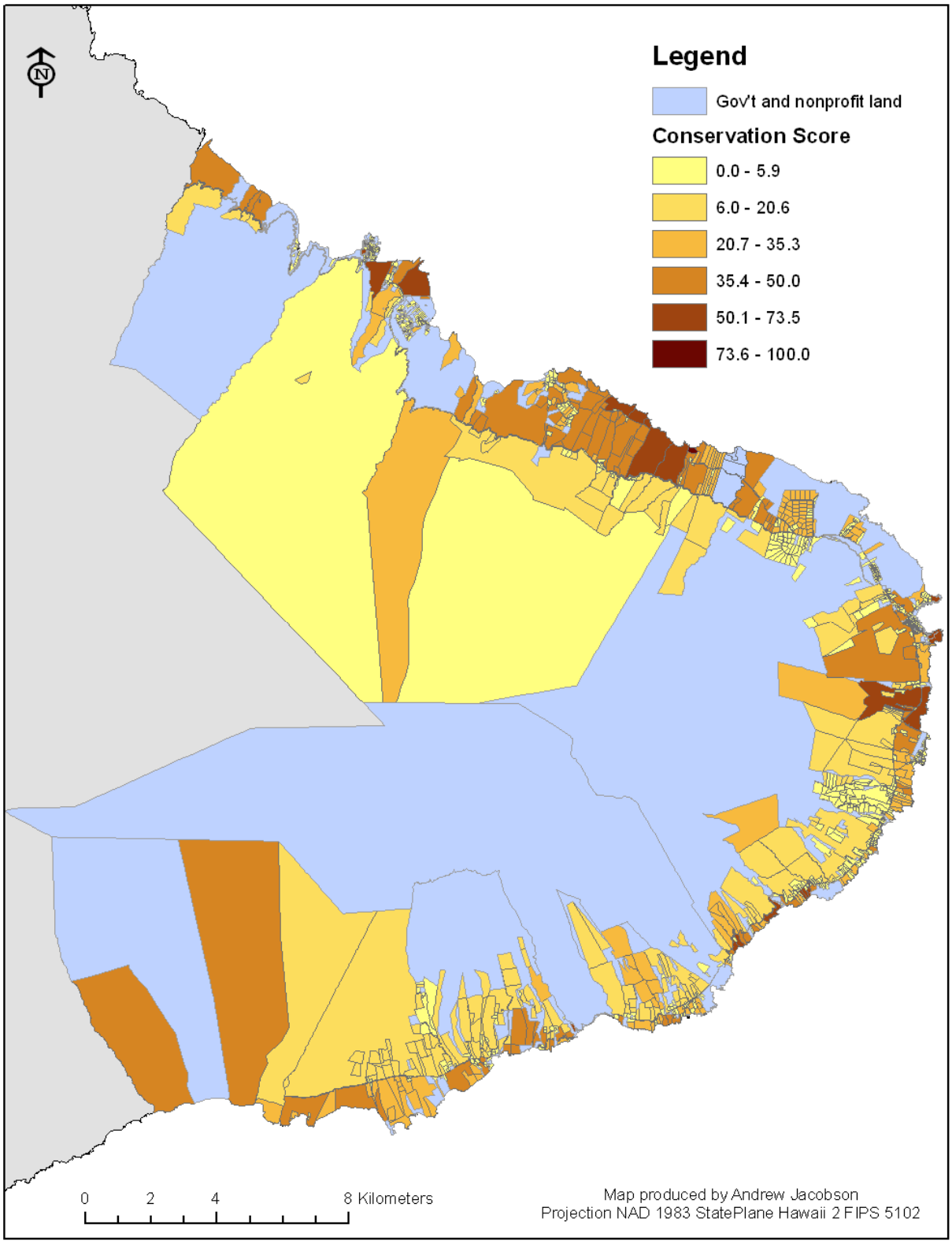

Figure 4. Results from scenario 2 in which the Cultural resources category was weighted 100%.

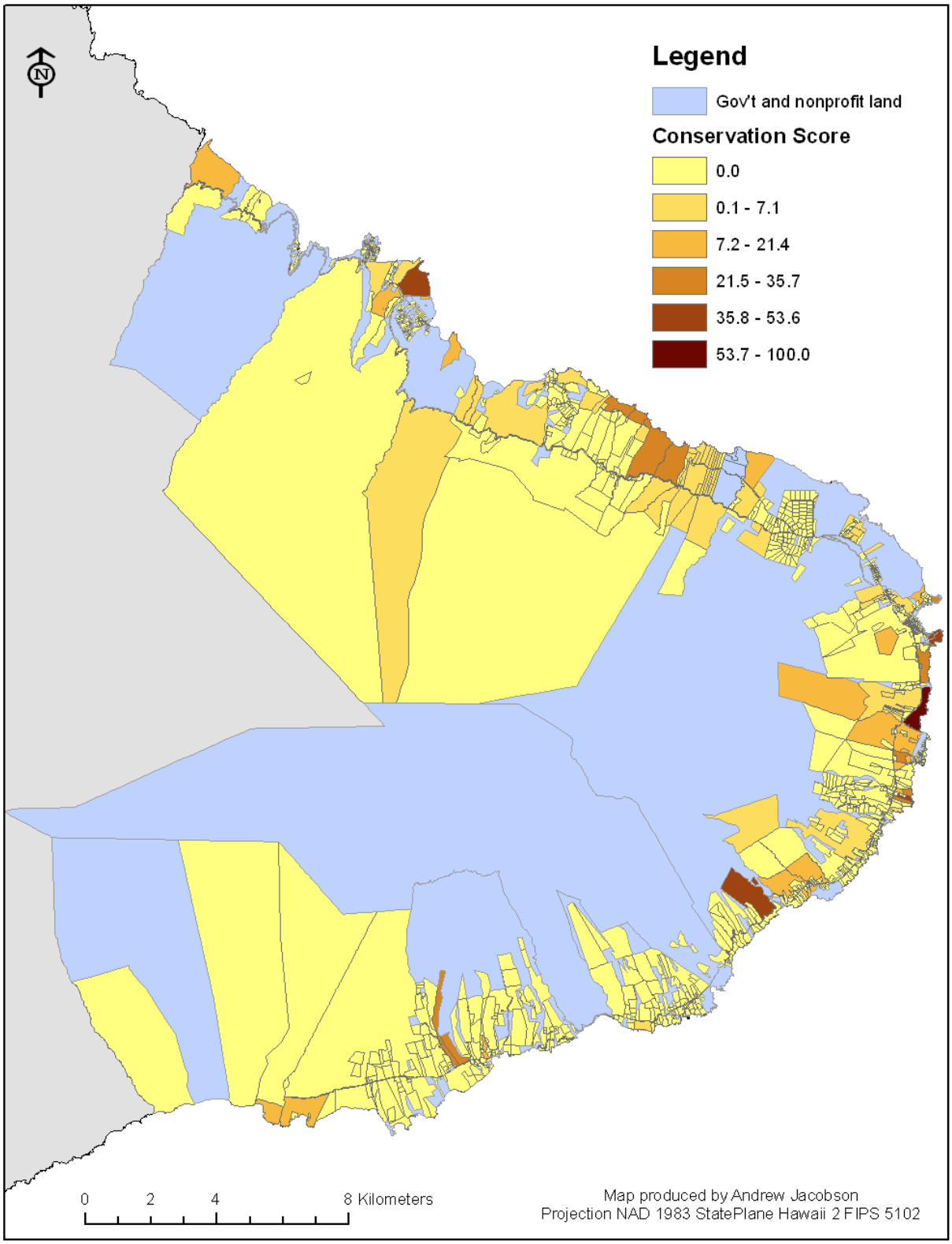

Figure 5. Results from scenario 3 in which the Historical resources category was weighted 100%.

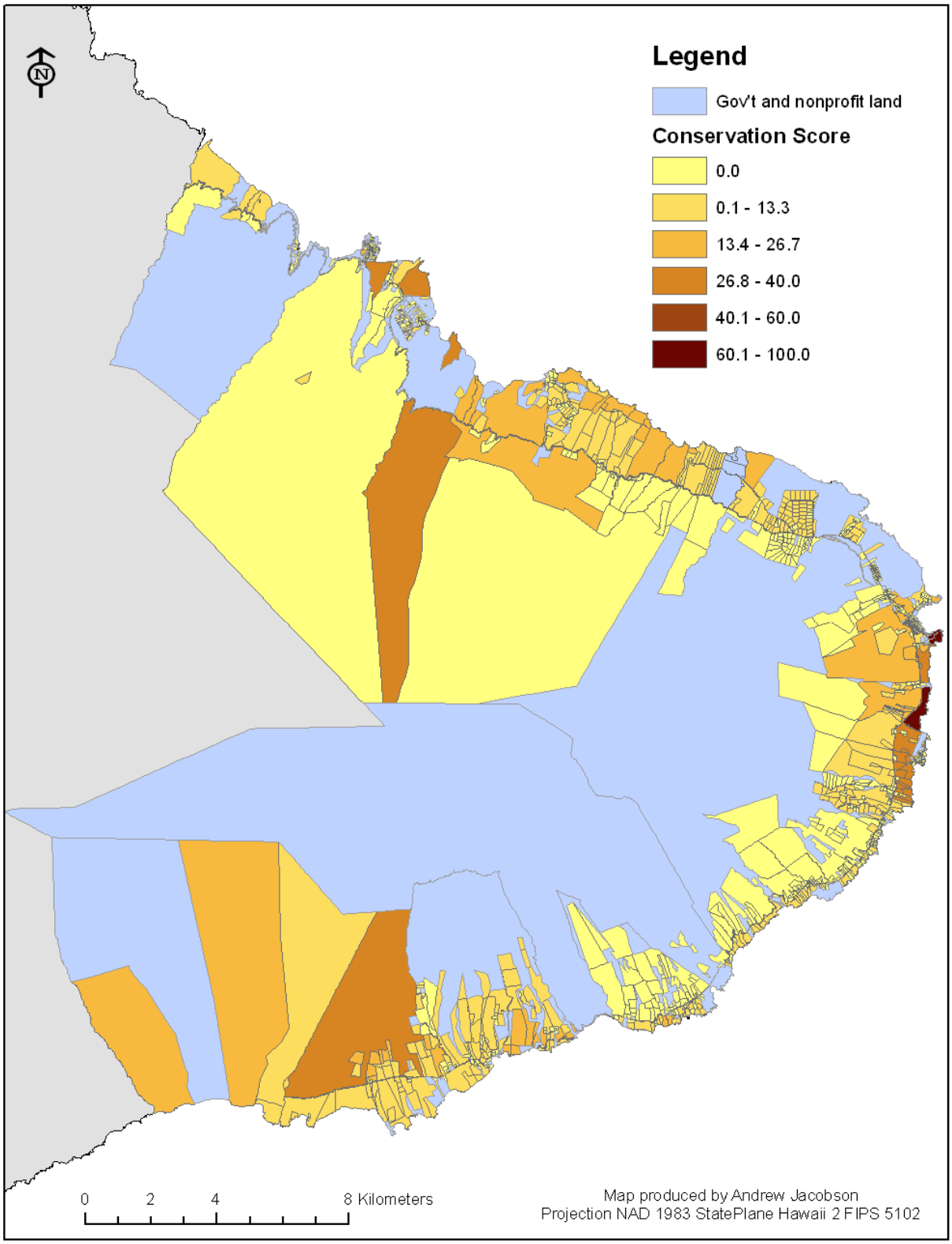

Figure 6. Results from scenario 4 in which the Recreational resources category was weighted 100%.

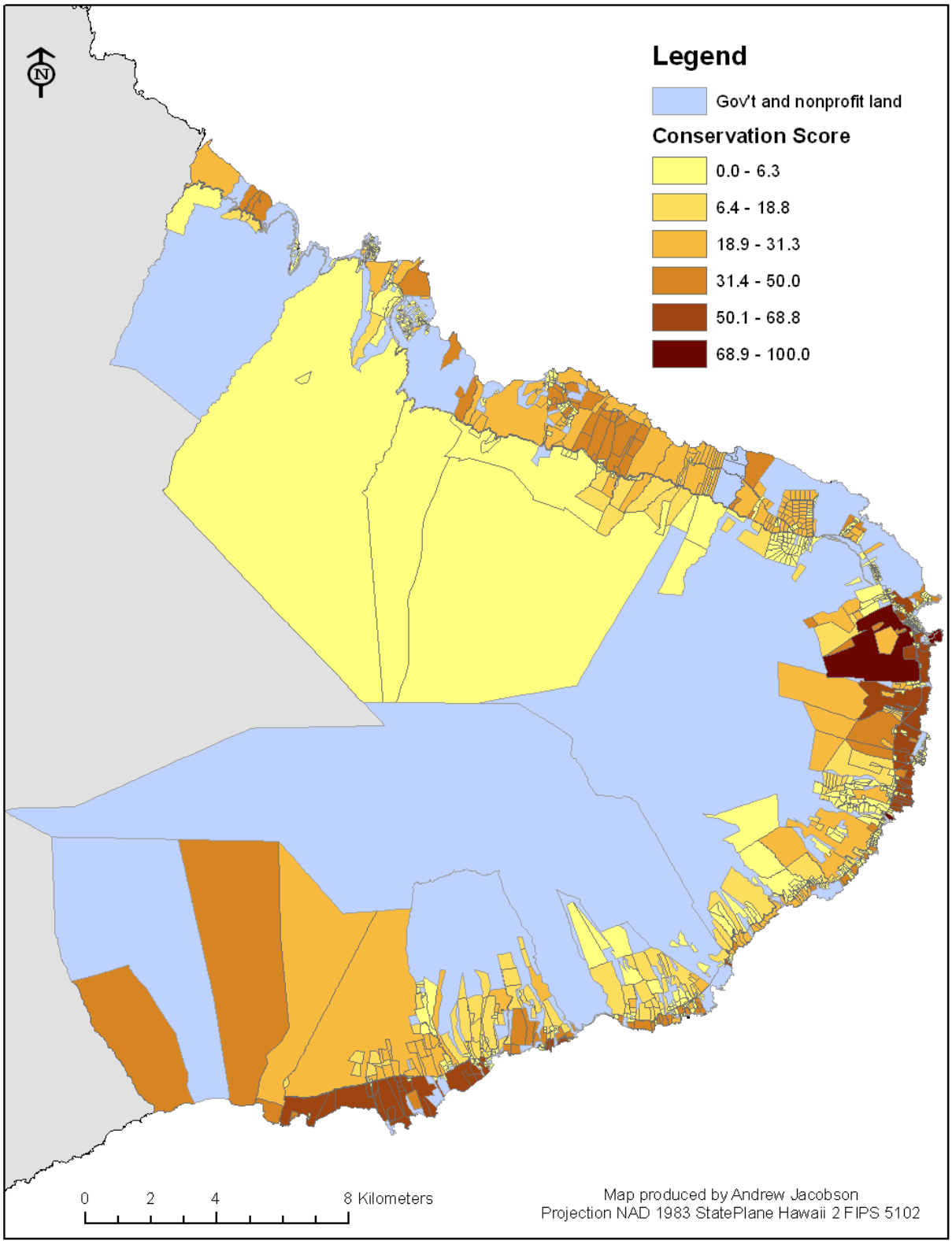

Figure 7. Results from scenario 5 in which the Other resources category was weighted 100%.

The final three simulations were run with the weights distributed among the five different categories. The scenario in which each category was given an even weight produced important parcels spread throughout the study area. There is a concentration of important parcels around Hāna but important parcels are spread along both the north and south coast (Figure 10). The two final scenarios that were tailored to the land trust had very similar outputs to each other (Figures 11 and 12). Many of the important parcels were important in both simulations. In addition, all three of the mixed runs (simulations six through eight) highlighted the same areas repeatedly, indicating robust results. Assuming that the land trust values each of the five categories of resources and gives some weight to all five categories, then their simulations will not produce wildly different results. In other words, swapping weights around between all five of the categories will not produce drastically different outputs. This robustness indicates that many of the parcels with high scores in one category have reasonably high scores in other categories. If this were not true, there would be more variability between the last three simulations.

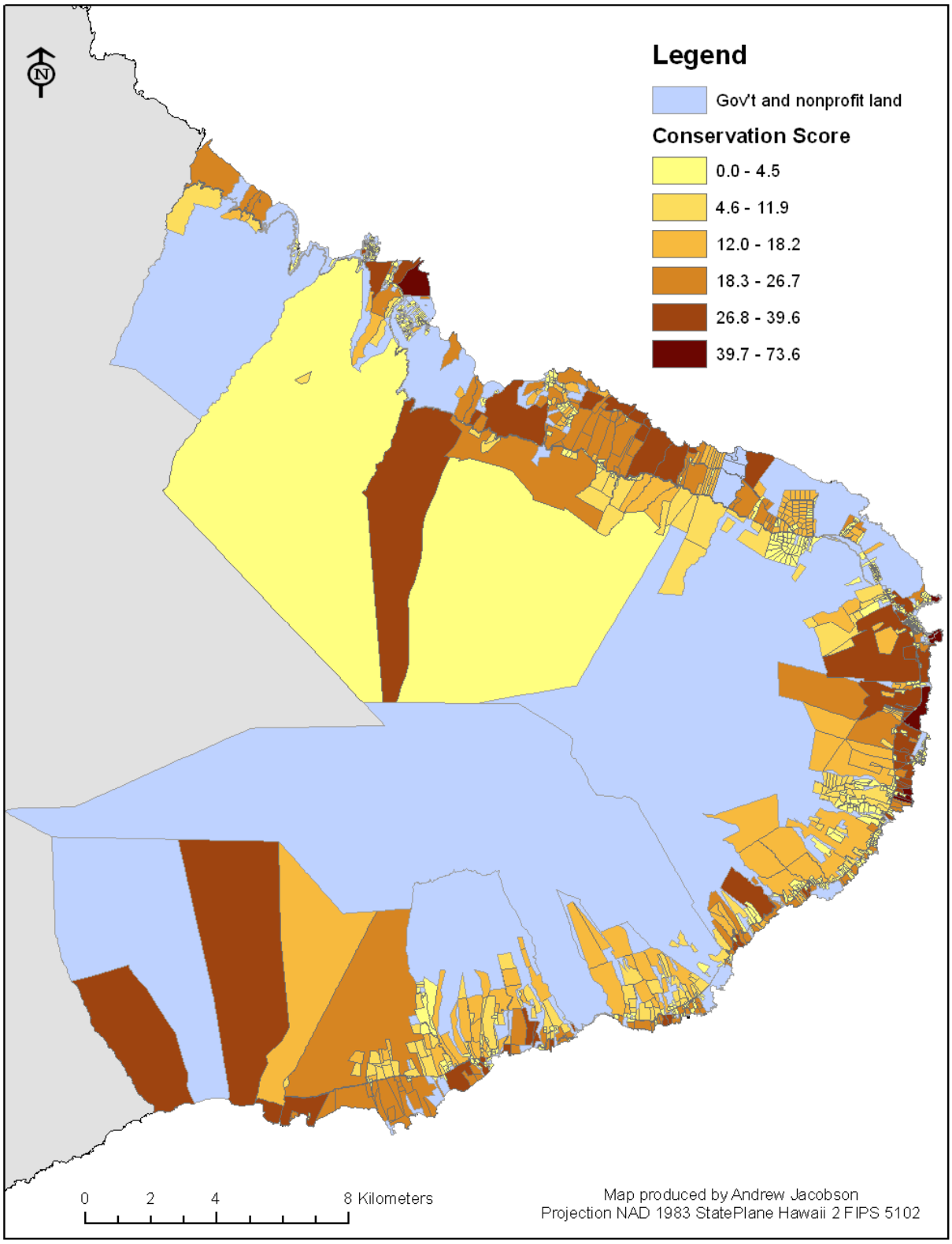

Figure 8. Results from scenario 6 in which all 5 categories were weighted evenly at 20%.

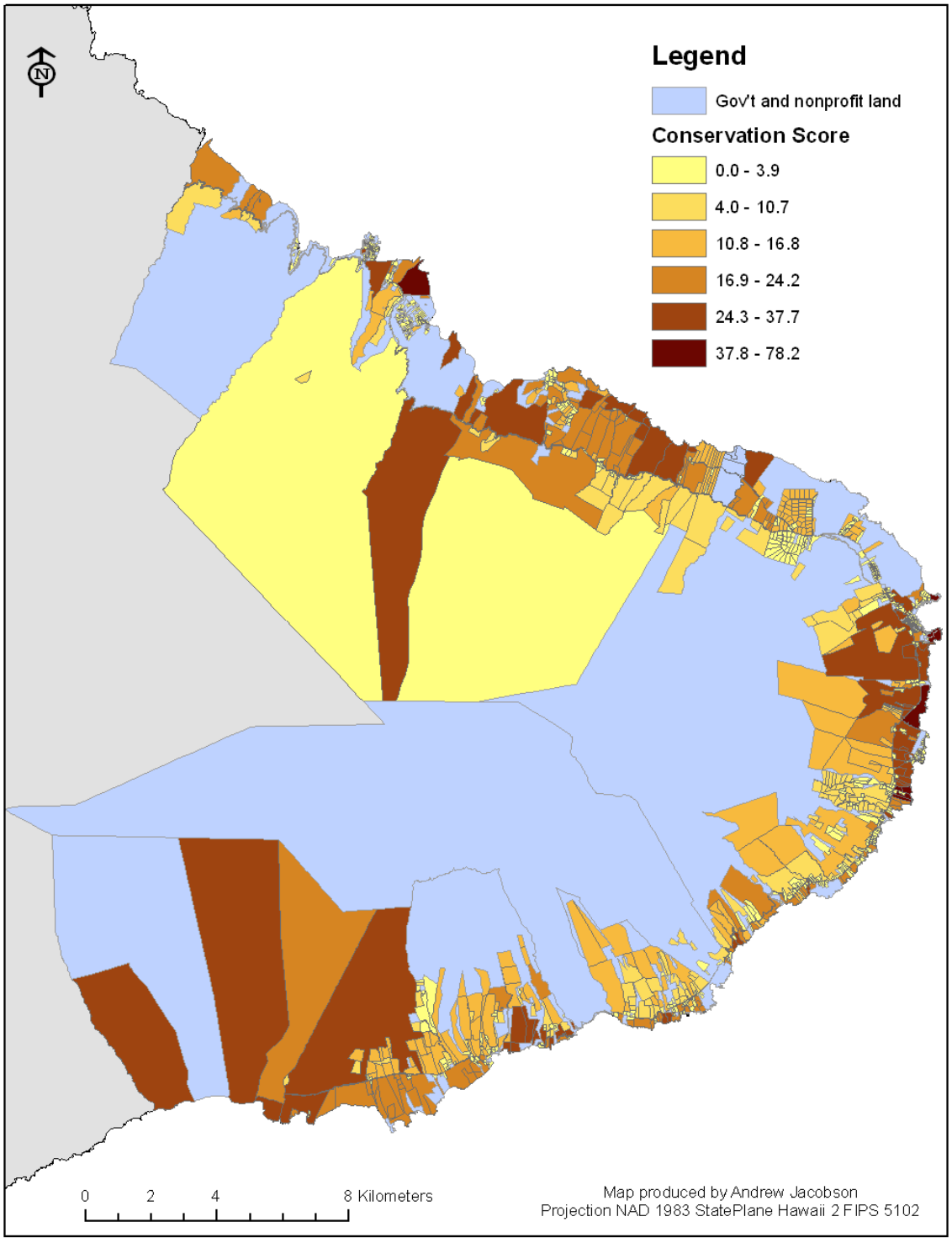

Figure 9. Results from scenario 7 in which the weights were determined by identifying the types of resources MCLT mentioned as qualifying criteria for lands they seek to protect. I tallied each category of resource every time it was mentioned in their checklist (Maui Coastal Land Trust, 2007). Dividing each category through by the total led to a specific weighting for each category. The weighting scheme is detailed in Table 4.

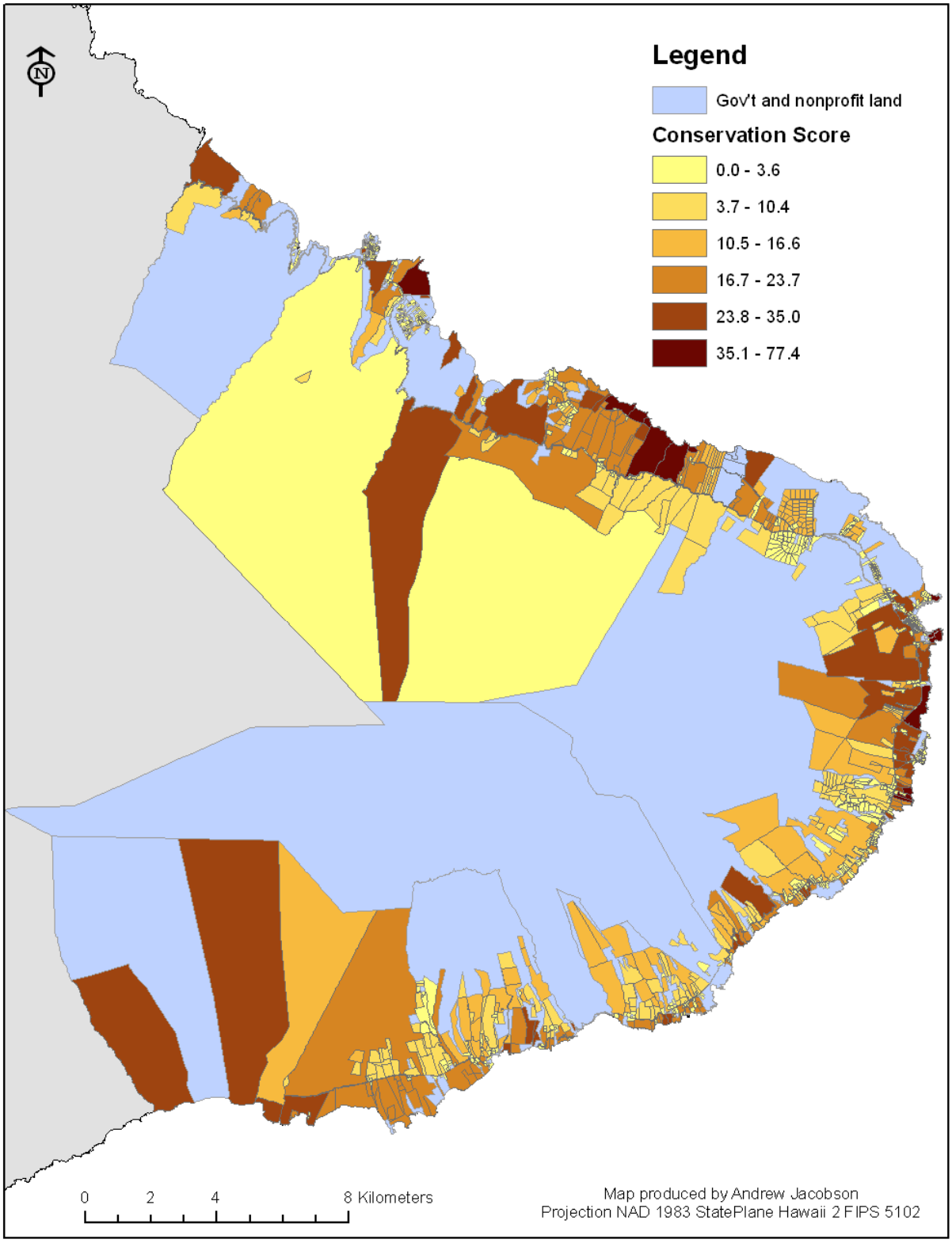

Figure 10. Results from scenario 8 in which the weighting scheme was determined subjectively by how I thought MCLT may assign weights based on personal interactions with staff. The weighting scheme is detailed in Table 4.

Top parcels

The top 20 parcels were chosen from each scenario for comparisons. Twenty parcels were used because it is a manageable number and represents approximately one percent of all the parcels in the study area. These initial 20 parcels were compared with government ownership. Several of the resource categories have nearly 50% of their top parcels owned by the government while other categories are less protected (Table 5). The categories with the most protection are biological and recreational resources, followed by cultural resources. Six of the top seven parcels for biological resources are owned by the government and four of the top five for cultural resources. All of the last three simulations with mixed weighting schemes have relatively high government ownership. However, the historical resource category only has three parcels owned by the government and the "other" resource category has none.

Table 5. The number of the top 20 parcels from each simulation that are owned by the government.

	Scenario 1 (Biological resources)	Scenario 2 (Cultural resources)	Scenario 3 (Historical resources)	Scenario 4 (Rec. resources)	Scenario 5 (Other resources)	Scenario 6 (All even)	Scenario 7	Scenario 8
Top parcels in gov't ownership (percent)	9 (45%)	8 (40%)	3 (15%)	9 (45%)	0 (0%)	9 (45%)	8 (40%)	7 (35%)

The government-owned parcels were removed from the list and the top 20 privately-owned parcels were selected from each scenario and compared. A total of 65 parcels were chosen once all the top parcels from each scenario were combined. One parcel was included as a top parcel in all eight scenarios and two were top parcels in seven of the simulations. In addition, 17 parcels were selected in four or more of the runs. These 17 parcels are highlighted as the most important parcels (Figure 13). The cutoff at four runs was arbitrary but the number of top parcels would have increased quickly if the threshold was lowered. In addition, 17 represented around one percent of the study area. These parcels range in size from six to over 310 acres. The top parcels are clustered around the town of Hāna as well

as in two other locations along the northern coast. No top parcels were from Kīpahulu or Kaupō. Only one of the top parcels was mauka of the road, all the rest of the parcels were makai of the highway.

While unable to account for development pressures in the analysis, county-designated growth boundaries were compared after-the-fact with the top parcels. The growth boundaries were designated by the Department of Planning in October, 2009. In East Maui, growth boundaries only exist around the town of Hāna. None of the growth boundaries overlap with any of the top parcels (Figure 14). However, parts of the growth boundaries are contiguous with some of the top parcels.

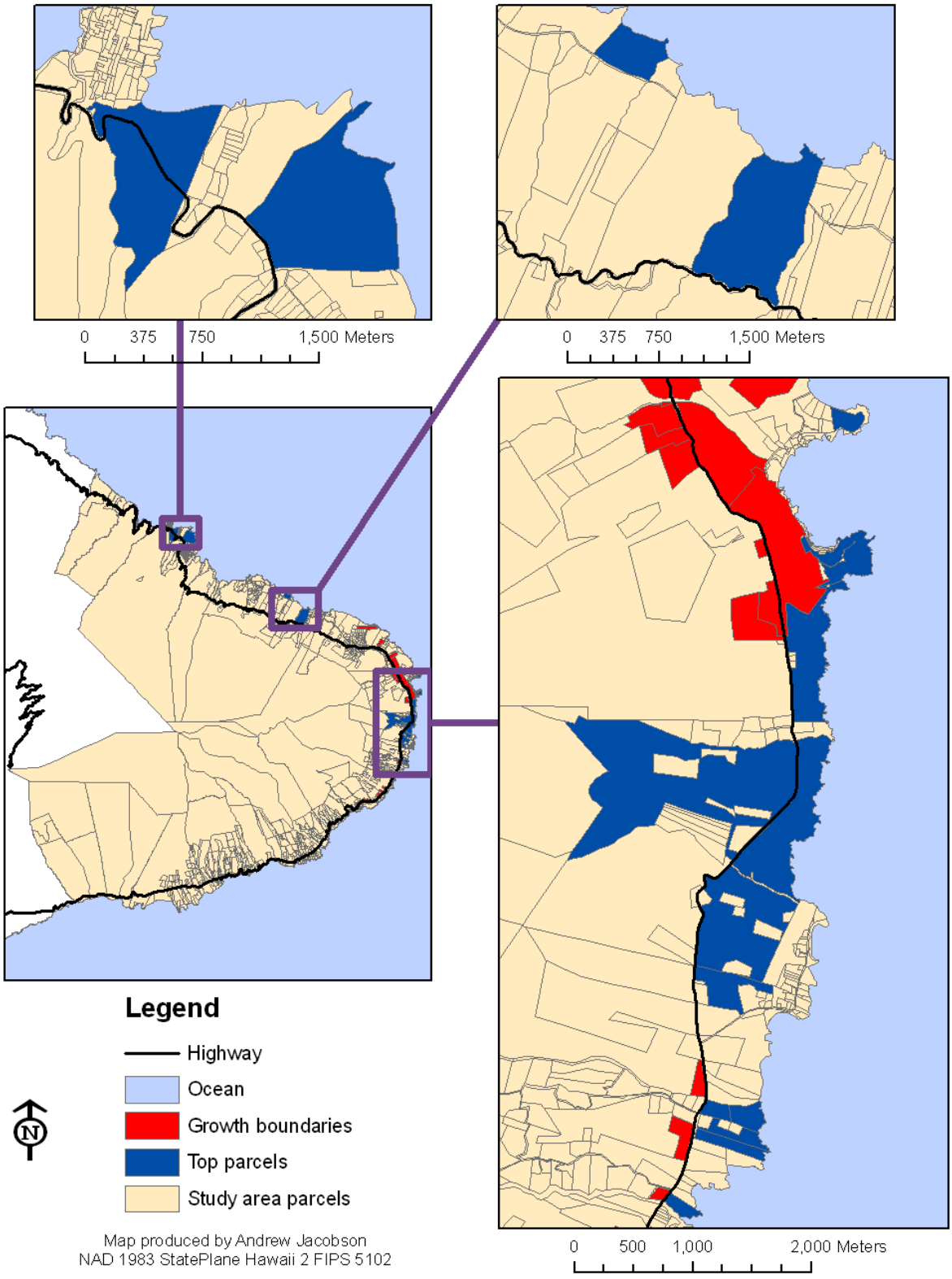

Figure 11. Map of the 17 most important TMKs; each was selected four or more times among the eight scenarios. This is roughly the best 1% of all parcels in the study area. Many of the top parcels are close to county-designated growth areas.

Discussion

Decision support system

MCLT may want to explore using MCDA in the future before making important land conservation decisions. In some instances the land trust will be proactive and may be able to use this prioritization study to guide their actions. In other cases, proposals to protect parcel "x" will come to the land trust and MCLT will have to react to the situation. In these scenarios, using an established MCDA and an objectives hierarchy will provide a solid foundation from which to make an informed and defensible decision.

If a land conservation decision is based in East Maui, then MCDA and an objectives hierarchy in conjunction with this analysis should be used. This report has detailed and mapped the top 17 parcels and if one of these parcels were to become available for conservation the land trust should strongly consider it. However, in many cases, a decision about a parcel not listed among the top parcels must be made. The data and tool provided with this report can help guide the land trust in their decision-making process. The land trust could examine the resources spreadsheet to find the parcel and see what resources are located on it and who or what the source was. Looking at the parcels' percentage scores for each of the five categories would be a quick indication of how relatively important that parcel is for each category of resource. The land trust could also use the GIS tool to run different scenarios to see how important that parcel is relative to all the others based on a user-defined weighting scheme. Therefore, MCLT has many options to explore the relative and absolute importance of a parcel and by looking at the spreadsheet can identify what the resources are and where to look for more information.

Caveats

This study has several important caveats and idiosyncrasies. Some are related to data collection whereas others have to do with the method of assigning values to the parcels.

The structure of the prioritization study is unusual in that it used interviews as the primary data source and it tried to capture a wide range of resource types. An overarching problem was my lack of time on the island in which to conduct interviews and gather data. This affected how and who I was able to contact for interviews. For instance, I was unable to interview some important community members. In addition, I was unable to gain trust from some segments of the population and therefore substantive and relevant information was not conveyed during interviews. Furthermore, my interviews were not evenly spread geographically throughout the study area. This is related to the fact that much of the population resides around Hāna; however, with more time I may have been able to make inroads into some of the smaller communities and interview more people from these under-represented areas. This is problematic because people primarily mention resources in their area. Since interview data was heavily weighted, this geographic-imbalance in interviews may have skewed the results. Another issue related to interviews is from the method of assembling contacts, snowball sampling. Because I relied on my contacts to provide me with further contacts, the initial contacts may have led to interviews of people who think in similar terms or who know similar information. This could lead to overlooking some resources while others were overly emphasized.

The method of assigning values to different resources based on the source and type of referral was also idiosyncratic. Many prioritization studies create different input layers that are then assigned different weights through a decision analysis process. On the contrary, this study connected the resources directly to the parcels within five general categories. The user can then manipulate the weights of these categories but cannot easily remove or add resource types or change emphases within these categories. For instance, trying to emphasize native Hawaiian historical landmarks over post-1900 landmarks would be difficult. Additionally, the choice of how to weight the different sources of information was subjective but based on the idea that what people said in interviews was what is most important to the community today, and therefore should be emphasized in the analysis. Unfortunately,

changing these weights around would require much manual input. Furthermore, I chose to add the values from each category together (when running anything but pure scenarios) but other methods besides additive weighting exist. For instance, the values from the different categories could have been averaged together instead. Or a minimum threshold could have been set such that a parcel that had a value below some threshold in any of the categories would be ignored in the output. These alternative methods would be analytically correct but emphasize different aspects of the data.

The values given to parcels based on their resources could also have been problematic. Resources could have been correlated with each other, such as some of the biological resources. For instance, an area could be counted both for having a wetland and for the endangered species that use the wetland. Another problem could be an artifact from the method of translating the data into parcel-specific resources. For instance, there was some subjectivity in categorizing how interviewees responded to questions. For instance, does fishing constitute a biological, recreational or cultural resource? This judgment was subjective and depended on the context of the conversation and in some instances the same resource was counted in more than one category.

Human error should also be considered a limitation of this study. In some cases, resources could not be assigned with confidence to specific parcels, and therefore, were left out of the analysis. Data entry errors are also possible. With 1881 parcels, 371 total resource types and some resources spread over several hundred parcels, ample opportunity existed to make entry errors. However, errors should be minor and would have been random.

This study does not take into account development pressures within the analysis. While conducting interviews, I asked specifically about development projects or areas that were imperiled by development. Only a few responses were given; these were directly relayed to the land trust and not included in the report. This was no other spatial assessment of threats. Therefore, some important areas

could be at risk for development and it would be unknown or not identified here. However, this is unlikely. Alternatively, the county identified growth areas around the town of Hāna and these boundaries are compared with the top parcels in the results of this study.

How to define success

This analysis is but one step towards preserving the biological and cultural communities of East Maui. Indeed, it is highly unlikely that the land trust, acting alone, can expect to preserve all elements of a biologically and culturally intact community. Partnerships with local groups are necessary, and as a first step, the land trust should define its goals in the region. This analysis can help influence decision-making, but other factors beyond conservation targets should be considered. The land trust must face realities associated with economics, ownership of the land, and community dynamics regarding conservation deals.

East Maui has unique situations which may make conservation deals more or less difficult. East Maui has a concentration of hui lands that are owned by a group of people. This type of land ownership makes it difficult to conduct conservation transactions, especially as group size increases. Community dynamics also have the potential to complicate or improve conservation deals. Many Hawaiians are inherently suspicious of land trusts (The Trust for Public Land, 1997) and community pressure may influence conservation transactions. The land trust should cultivate trust before moving forward. There is also a lack of awareness and understanding of how conservation easements work (The Trust for Public Land, 1997). Easements can be a great tool in the right situation but can also be misused. Easements can meet some community desires such as placing restrictions on development while concurrently maintaining community access. Conservation agreements must meet the desires of the landowner but should also be analyzed at the community level. Ultimately it is when the landowner, land trust and community act in coordination that lasting, successful results are produced. This study also does not

address economics. Land in Maui is scarce and therefore highly valued. Undoubtedly, finances will play an important role in what conservation deals are accomplished. Therefore social and financial realities must also be attended before a successful conservation agreement is reached.

Select recommendations from TPL's Community Assessment Project are also relevant. They note that resources are part of a larger network or system that cannot function if only partially protected; "entire ahupua'a should be considered as units for acquisition and management" (The Trust for Public Land, 1997). While the acquisition of entire ahupua'a is unlikely, it can be considered a goal, and management considerations could be made at the ahupua'a level. In addition, the report remarks that there is a need for long-term stewardship and management of resources along with the money to support these efforts, but that these efforts should be community-based and local (The Trust for Public Land, 1997). This presents a significant challenge but it is exactly what land trusts throughout the United States are attempting to accomplish. MCLT should strive to lead by example.

Top parcels

A comparison of this study's initial top parcels to government-owned land can indicate which resource types are already protected and to what degree. While government ownership does not necessarily imply protection, it is less likely that the parcel will be subdivided or developed than if it is privately owned. Of the top parcels from the Biological, Recreational and Cultural resource categories, each had approximately 40% government ownership. On the contrary, the Historical resources category only had 15% protection and the Other resource category had zero protection. The lack of protection for the Other category is not overly worrisome because it is a blend of resources. However, the relative lack of protection for historical resources may be a cause for concern. The land trust may want to investigate this situation and possibly focus on preserving historical resources in the future.

When comparing the top 20 privately-owned parcels among the eight scenarios, 160 total parcels could have been selected if each simulation had produced a different top one percent. Yet, only 65 top parcels were selected. This compaction into a smaller number of parcels indicates that many of the top parcels were important in more than one resource category. This suggests that resources are relatively concentrated in a limited number of parcels. This is beneficial for the land trust and other conservation organizations who can focus efforts on a limited number of parcels yet protect a significant proportion of resources. These top privately-owned parcels should function as priority areas for conservation organizations.

None of the top 17 parcels overlap with the county-designated growth areas although some are contiguous with the growth boundaries. The proximity of many top parcels to expected development is alarming. However, at least one of the top parcels adjacent to the growth boundary is unlikely to ever be developed due to its unique topography. One explanation for the proximity of so many top parcels to Hāna town is that it could be an artifact of data gathering. Resources close to population centers are better known and used. With relatively more interviewees from Hāna and interviews weighted most heavily in the analysis, it is likely that that area was biased. On the other hand, protecting resources closer to population centers may have a relatively larger impact for the community than conserving areas farther away. Overall, the preponderance of top parcels in proximity to growth areas signifies that many will be threatened with development in the near future. Thus, this finding should serve to invigorate the conservation community to protect these resources before development is proposed.

Conclusion

Strong protection and aggressive management programs are needed to maintain Hawaii's native ecosystems and species (Ricketts, 1999). The critical issues that biota are facing, such as invasive species and habitat modification, require active management programs. This suggests that a conservation-minded owner who uses adaptive management techniques may be best from a biological perspective. Yet, buying property can also secure historical or recreational resources from degradation and even preserve cultural traditions. Conservation easements that include provisions on biodiversity conservation or management programs may also be an appropriate solution to safeguarding resources. Thus land trusts, through both conservation easements and fee simple purchases, can be an effective and important player in protecting land and resources.

Eastern Maui is a unique location with a rich blend of history, culture and biological resources. While population growth cannot be halted altogether it can be directed to areas better equipped to handle it or to areas less valued by the community. The County and Planning Department are working to direct growth in this manner; however, it is unlikely that any entity working alone can preserve East Maui's resources. Multiple partners and organizations are needed and community voices will play a crucial role. Non-profits are important players in protecting resources throughout Hawai'i yet must remember the community context. This study acts as a step towards protecting the assemblage of East Maui resources by identifying a limited number of parcels that contain a concentration of resources. An added impetus for conservation is the proximity of current and future development to many of these areas. Therefore, this study serves as a call to action for the land trust and others in order to protect these priority areas.

Works cited

Beletsky, L. 2000. *Hawaii: The Ecotravellers Wildlife Guide.* London: Academic Press.

Belton, V. and T.J. Stewart. 2002. *Multi-criteria decision analysis: an integrated approach.* Massachusetts: Kluwer Academic Publishers.

Blackford, M. G. 2001. *Fragile Paradise: The Impact of Tourism on Maui 1959 - 2000.* Lawrence, KS: University Press of Kansas.

Borthwick, D.F., J Robins, W.H. Folk and H.H. Hammatt. 1992. Archaeological inventory survey and subsurface testing for the proposed Hana Ranch Country Club, Hana, Maui, Hawaii (TMK: 1-4-07:4, 6; 1-4-02:8, 9, 10 and 1-4-03:9). Cultural Surveys Hawaii.

Clark, J. R. K., 1989. *The Beaches of Maui County: Maui, Molokai, Lanai, Kaho'olawe 2nd edition*. University of Hawaii Press: Honolulu, HI.

County of Maui. 2009. *County of Maui 2030 General Plan: The Countywide Policy Plan.*

County of Maui. 1997. *Kalo Kanu o Ka'āina: A Cultural Landscape Study of Ke'anae and Wailuanui: Island of Maui.* Cultural Surveys Hawai'i.

County of Maui. 1994. *Hana Community Plan 1994.*

Department of Land and Natural Resources. 1989. *Hanawi Natural Area Reserve Management Plan.* Honolulu.

Eldredge, L. G. and N.L. Evenhuis. 2003. Hawaii's biodiversity: a detailed assessment of the numbers of species in the Hawaiian Islands. Bishop Museum Occasional Papers 76: 1-28.

Goodman, L. 1961. Snowball sampling. Annals of Mathematical Science: 148-170.

Haleakala National Park. Haleakala Resources: Park History. Retrieved February 28, 2010, from Haleakala National Park: http://www.nps.gov/archive/hale/pages/tier_two/park_history.htm.

Hawai'i CZM Program. 2006. *A Participant's Guide to the Special Management Area Permit Process in the State of Hawaii.* Office of Planning, State of Hawaii.

Hawai'i revised statutes: Chapter 195-1. Natural Areas Reserve System.

Hawai'i revised statutes: Chapter 205A. Coastal Zone Management.

Heckathorn, D.D. 1997. Respondent-driven sampling: a new approach to the study of hidden populations. Social Problems 44: 174-199.

Kent, N.J. 1983. *Hawai'i: Islands under the Influence.* New York: Monthly Review Press.

Long Range Planning, County of Maui. 2009. *Maui Island Plan: General Plan 2030 Draft.* Wailuku, HI.

Loope, L. 1999. Hawai'i and the Pacific Islands. In USGS, *Status and Trends of the Nation's Biological Resources.* Washington D.C.

Maui Coastal Land Trust. 2007. *Lands we seek to protect*. Retrieved March 1, 2010, from Maui Coastal Land Trust: http://www.mauicoastallandtrust.org/qualifying-criteria.php.

National Oceanic and Atmospheric Administration. 2005. *Evaluation Findings for the Hawaii Coastal Zone Management Program from November 2001 through August 2004.*

NOAA Coastal Services Center. Land Cover Analysis: Maui County Land Cover. Retrieved February 28, 2010, from NOAA Coastal Services Center: http://www.csc.noaa.gov/ccap/pacific/maui/index.html.

Noss, R. F. and R.L. Peters. 1995. *A status report on America's vanishing habitat and wildlife.* Washington D.C.: World Wildlife Fund.

Office of Economic Development, County of Maui. 2009. *Maui County Data Book 2008.*

Ricketts, T. H. 1999. *Terrestrial Ecoregions of North America: A Conservation Assessment.* Washington D.C.: Island Press.

Speakman Jr., C. E. 1978. *Mowee: An Informal History of the Hawaiian Island.* San Rafael, CA: Pueo Press.

State Historic Preservation Division. June, 2009. Hawai'i and national register of historic places. Retrieved March 1, 2010, from State Historic Preservation Division: http://hawaii.gov/dlnr/hpd/hpregistr.htm. Version Maui, 06/09.

State of Hawaii. 2010. Hawaii Statewide GIS Program. Retrieved August, 2009, from State of Hawaii: http://hawaii.gov/dbedt/gis/.

Strager, M.P. and R.S. Rosenberger. 2007. Aggregating high-priority landscape areas to the parcel level: an easement implementation tool. Journal of Environmental Management 82: 290-298.

The Nature Conservancy. 2006. *Hawaiian High Islands: Ecoregional Asssessment of Biodiversity Conservation.*

The Trust for Public Land. 1998. *East Maui Resource Inventory.* Honolulu: Bay Pacific Consulting.

The Trust for Public Land. 1997. *Hawai'i Community Assessment Project*. Honolulu: Bay Pacific Consulting.

U.S. Fish and Wildlife Service. 2005. *Endangered and threatened wildlife and plants.* Washington D.C.: 50 CFR 17.11 and 17.12.

Appendix A. Copy of interview questions

Needs and Prioritization Survey of the Hana District for Maui Coastal Land Trust

MCLT Mission: To preserve and protect coastal lands of Maui Nui for the benefit of the natural environment and of current and future generations.

Goals:

1. To identify issues and needs of the Hana District in regards to land conservation and community development and to how the land trust can play a role in meeting those needs
2. To identify high priority lands for conservation purposes and their conservation values
    a. Definition of high priority: good fit with MCLT mission, vulnerable to development, exceptional or other unique features and community-supported
3. To identify areas of high cultural or recreational importance
4. To identify land owners of high priority lands; suggested method of contact and openness to conservation/willingness to talk

Interview Questions:

1. What places do you feel should be protected that are in danger of being developed? i.e. If your area were to be developed, what areas should be protected or conversely what area if lost would bother you the most?
2. What areas are most important to the community that are not already protected? Such as areas used recreationally, culturally, for historic purposes etc. In addition, what areas are well-used for trails or for hunting?
3. What areas are viewed as crucial to preserving the community, its traditions, or culture?
4. Areas important to teaching cultural activities?
5. What areas have unique or well-preserved ecological conditions? Eg. Native species, gathering spots, protected species, geologic features etc.
6. Areas important for agriculture or as open space/for scenic views?
7. Areas critical to access otherwise difficult-to-access coastal features?
8. What areas should be preserved for community-only access?
9. Areas critical for buffering of streams, wetlands? Areas that play an important role hydrologically both on land and for marine resources?
10. Aware of possible liabilities from identified properties or other negatives?
11. Aware of impending or possible plans for development or subdivision in identified areas?
12. Do you know the land owners and/or suggest a method of contacting them/approaching them.