

Kona's Soil and Water

*Resource Concerns, Kuleana, and Actions
Overcoming Challenges & Keeping Kona Green*



Kona Soil and Water Conservation District

This book grew out of a belief that if people knew of our soil and water resources, how they came to be, and the threats they face, they would better appreciate and care for them.

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would like to thank the following individuals and organizations
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ranchers, and private forest landowners
for doing the hard work of stewarding their land
so that we have clean drinking water
as well as soil on the island and not on the reefs around it.*

Mahalo!

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I. Introduction. Kona, Hawaii: A Fragile Environment

“I mua!”— “Forward!”



A 1950s lava flow that crossed Mamalahoa Hwy. in S. Kona. The 'ōhia tree and some ferns in the foreground are the pioneer species on this flow.

The District of Kona, like many other areas in Hawaii, is one of the most enticing and beautiful areas of the world to live in and visit. For residents and visitors alike, Kona offers unique and beautiful weather and scenery. Part of the uniqueness of Kona is that it is one of the newest and youngest landscapes in the world. The entire district, like the rest of Hawaii Island, was formed on top of countless lava flows with the most recent in 1954 when three separate flows crossed Mamalahoa Highway in South Kona. Only the Ka'u and Puna districts south and southeast of Kona have more recent flows and very young landscapes.

The nature of Kona's landscape is one of many highly fractured layers of rock and soil with very fragile topsoil. The topsoils of Kona do not have the capability to store high quantities of nutrients and chemicals and are highly susceptible to contaminants leaching into ground water and ocean surface waters. In addition, topsoils are highly susceptible to soil erosion and degradation. Deforestation of native vegetation over the last 200 years is widespread. This land use change has drastically altered the environment in Kona. Invasive species thrive in the year-round growing season and if not controlled will quickly take over the land. In addition, invasive species encroach on many of the remaining stands of native trees.

Over the last 50 years the population of Hawaii Island has grown from 63,000 to over 190,000, with the largest growth

occurring on the west side of Hawaii, primarily Kona. Resorts, homes, businesses, golf courses, etc. have all been recently constructed on lands sensitive to environmental degradation. Chemical herbicides to control weeds are widely used on new and old lands used for residential and commercial properties. There are over 800 farmers in Kona growing coffee, macadamia nuts, and a wide variety of fruits and other agricultural products. Tons of fertilizer are used to feed these crops and it is common for farmers to spray chemicals to control weeds. County and State road crews use extensive amounts of chemical herbicides to control weeds along roadsides and public right-of-ways. If applied correctly fertilizers and herbicides are not considered harmful; it is widespread misuse that has the potential to harm the environment and people of Kona.

The purpose of this paper is to inform the public of the primary resource concerns and practices that land users need to employ to protect our land for future generations. New residents and many lifelong residents are not generally aware of Kona's fragile environment and may be unintentionally harming our land with poor management practices.

The Kona Soil and Water Conservation District (SWCD) is committed to educating the public on the need to be good stewards of the land. The SWCD provides technical assistance to residents, farmers, and ranchers, and works hand-in-hand with the USDA's Natural Resources Conservation Service, "Helping people help the land."



Both of the above photos were taken at an award-winning native forest restoration project in S. Kona. The mosses in these photos are native mosses.



The photo on the left was taken in 2007 on a farm that was going to start regular mulching. The photo on the right is the same farm 10 years later. After consistent annual applications of mulch, there are two inches of soil!
Mulching builds soil!

Above: Private land that used to be acres of Christmas berry. Now it is the beginnings of a forest, a beautiful one at that!

Right: Improving soil by adding organic matter. The addition of mulch to this orchard will improve the soil's ability to maintain a microbial population, and hold moisture, minerals, and nutrients for use by the crop trees. This producer will lay out 3-6" of mulch throughout this field for 3-5 years. This will provide a soil to grow grass in. Once grass is established, grass clippings become the organic matter to feed the soil.



II. Loss of Native Forest and Native Forest Fragmentation

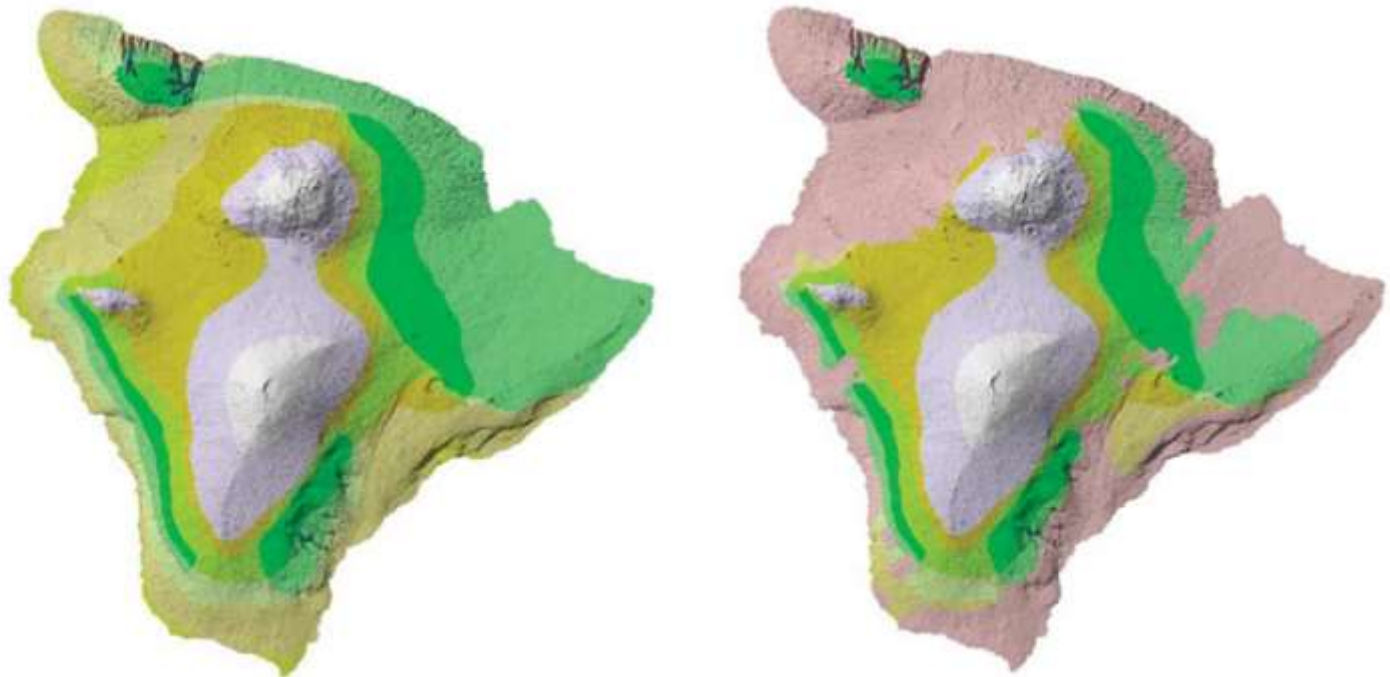
“‘Upu mai ana ke aloha i ka uka nahele...”

“Loving memory returns of the forest uplands...”

— Hawaiian poetical saying

Native forests are a critical element of our natural resource landscape. Native forests are essential for maintaining water quality and availability, they help prevent the erosion of West Hawaii’s young volcanic soils, they serve as an effective way to reduce greenhouse gases, and they provide important habitat for West Hawaii’s unique biodiversity. West Hawaii’s native forests, if sustainably managed, can also serve as an important economic resource, providing jobs for foresters, wood carvers, furniture and cabinetry makers, and other woods-related employment.

A significant resource concern for West Hawaii is the loss of native forest cover and the extensive fragmentation of the native forests that remain. Approximately 95% of Kona’s dryland forest and 50% of the upland forest in Kona have been destroyed or severely degraded. As the maps below demonstrate, West Hawaii has lost most of its lowland dry and mesic forests and the upland forests have become fragmented and degraded. This is the result of activities that have converted these forest lands to non-forest uses as well as the invasion of non-native species. Forest loss has resulted in the extinction of dozens of bird species and many others are on the endangered species list. The loss of forest extent and connectivity significantly impairs the ecological and economic function of the remaining forest land and further incentivizes conversion to other uses.



Key to types of vegetation

	Alpine desert
	Coastal dry shrubland and grassland
	Dry cliff
	Lowland dry forest and shrubland
	Lowland dry shrubland and grassland
	Lowland mesic forest and shrubland
	Lowland wet forest and shrubland
	Montane dry forest and shrubland
	Montane mesic forest and shrubland
	Montane wet forest and shrubland
	Subalpine dry shrubland and grassland
	Wet cliff
	Wetland
	Non-native vegetation

The image on the left was the vegetative cover before humans arrived on Hawaii Island and the image on the right is the vegetative cover today. As you can see, much of the island’s vegetation today is non-native.

*Please note, some of the areas and descriptions listed in the legend to the left may not be found on Hawaii Island, such as “Dry Cliff” or “Wet Cliff.”

Source: *Hawaii Ecosystems and Culture*, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa 2002; 2009

Restoring native forests in West Hawaii is an important resource priority of the Kona Soil and Water Conservation District. Hawaii's Soil and Water Conservation Districts have entered into a memorandum of understanding with the State of Hawaii, the Forest Service, and the Natural Resources Conservation Service to cooperate and coordinate efforts to assist private landowners in their work to restore native forests.

The memorandum of understanding provides for landowners to utilize the State Forest Stewardship Program to receive cost sharing for creating a professionally-developed forest stewardship plan. That plan can identify various restoration activities (called practices), create a timeline for implementation, and establish a budget. The approved forest stewardship plan can then be used to access cost-sharing resources from a variety of programs, such as the State Forest Stewardship Program, NRCS's Environmental Quality Incentives Program (EQIP), and FSA's Conservation Reserve Enhancement Program (CREP), as appropriate. Landowners can receive technical assistance throughout their restoration work and are supported by educational programs provided through the University of Hawaii and other resources.

Below are photos from several forest restoration projects in North and South Kona. The photo at lower left was taken at the West Hawaii Veterans Cemetery; others were taken on private land.



A forestry project on Hualalai.



A forestry project on Mauna Loa.



This dryland forest has traditional crops like lilikoi, coffee, & papaya. They also produce native seeds, like pili grass seed. The lower right of the photo shows pili grass which is a bunch grass & was used for roof thatching by ancient Hawaiians.



A trail through a restored dryland forest.



A very old rock wall cuts through a restored native forest. One of the remaining challenges for this native forest is the continuing control of strawberry guava.

III. Soil Degradation

“*Ua mau ke ea o ka `āina i ka pono.*”

“The life of the land is preserved in righteousness.”

— Motto of the State of Hawaii

Soil degradation is a serious resource concern in Kona. According to the USDA’s Natural Resources Conservation Service (NRCS) soil survey, 75%-80% of Kona’s soils were formed from the decomposition of organic matter. These organic soils differ from mainland organic soils in that they are extremely susceptible to volatilization if the ground cover of trees, grasses, and legumes is removed from the surface of the soil. The year-round growing season combined with heat from the surface of the rocky subsoil will quickly degrade the topsoil, leaving bare rock if ground cover is destroyed. The organic soils of Kona require continual additions of organic matter to maintain their quality. In addition, unprotected soil is susceptible to high rates of soil erosion during storms and rain showers. This is true whether the land is cropland, residential lots, businesses, public parks, or roadsides. Leaving soil uncovered or bare will result in the loss of its topsoil in a relatively short

time. With the loss of organic matter, the microbes and soil life within the topsoil quickly die, further degrading the soil quality and health.

This is easy to see at the low elevations in North Kona where bare rocks from older lava flows are visible from Kailua-Kona north to Waikoloa. To the visitor and many residents, these old flows give the appearance of fresh flows of lava. However, most of these lands were once covered with ancient dryland forests that are no longer present. The loss of the dryland forest also leads to the destruction and volatilization of the organic topsoil, and so the soils that had formed under these ancient forests, in many cases, is gone or severely depleted. The dryland forest of Kona added tons of organic matter to the soil each year and with its loss the topsoil quickly degraded. Degraded soils are generally very easy to identify throughout North and South Kona. Whether the land is in coffee or other crop production, golf courses, business lots, roadways, and residential lands, if the surface of the land is rocky and is not covered by vegetation, the soil is probably degraded. Approximately 20-25% of the 800 farms in Kona have little to no topsoil or vegetation on the ground surface. The same is true for hundreds of residential and business lots, public parks, and public roadways within Kona district. Lack of ground cover combined with decades of herbicide spraying has degraded topsoils, leaving a rocky surface. This combined loss of organic matter and soil microbes has diminished the soil health and quality in many areas of North and South Kona.

It is important to understand that at one time, Kona was covered with forests, and topsoil covered the rocky substrate. This is the case on all lands except very new lava flows. How long it takes vegetation to cover land with new lava flows is variable, depending on elevation and rainfall, but the three 1950 flows in South Kona do have ‘ōhia trees that are beginning to colonize the flows, with some invasive species.



Above: A coffee orchard growing out of a field of rocks. The coffee’s root system gets very hot during the day with the trees wilting by 9am! Because there is virtually no soil there is no moisture-holding capacity, necessitating more frequent watering with the irrigation system. This farm needs organic matter (mulch/cover crop) to rebuild its soil.



Rocky soil, typical for Kona. A permanent ground cover will improve this soil tremendously. Start with mulch; it will cover the rocks. Let it break down for some time: three months would be good, then broadcast cover crop seed for a temporary vegetative cover, or a perennial grass seed, like Bermuda or carpetgrass seed for a permanent cover. With regular mowing or weed whacking your rocks will get covered up. Organic matter builds soil. Contact the Kona SWCD for more information.

In summary, the soils of Kona are very fragile. In most cases, a rocky soil surface is an indication of a degraded soil. Keeping vegetation growing on the soil surface is critical to protect the soil and add needed organic matter to feed soil microbes that build and maintain a healthy soil.



Left: A South Kona farm with conservation cover over most of the acres. The leaf litter seen in the photo is organic matter and its breakdown will improve the soil. The grass cover provides the soil with organic matter every time it is mowed.



To the right, a ten-acre forestry project. Like the forests Mother Nature gives us, this forest is producing an abundance of leaf litter, which will improve the soil and cover up all the rocks we can see in this photo.



Above left: A coffee farm located on the steep slopes common in Kona. This producer chose to overcome that challenge with terraces and mulch, making walking through the orchard easier and protecting the soil. The photo on the right is of a coffee farm with perennial peanut being used as a ground cover. Perennial peanut is a nitrogen fixer, taking nitrogen from the air and changing it to a form that plants can use.

IV. Invasive Species

“I ka nānā no a `ike.”

“By observing, one learns.”

— Hawaiian saying



A field of invasive fountain grass. Fountain grass grows quickly and is “fire adapted,” meaning it survives brush fires where many native plant species do not. It is also an excellent fuel for brush fires, and it can change the vegetative structure of the land. The “sticks” you see in the photo used to be some type of shrub but they are not getting the water they need because of the fountain grass and therefore do not survive.



Two pigs exploring a bird of paradise farm. Feral pigs here killed bird of paradise plants, caused soil erosion, attacked pets, and enjoyed eating some of the fruit grown on this farm, including papaya, mango, and avocado. The only way to really control them and protect your land and crops is with a fence.

For many hundreds of millennia the flora and fauna of Hawaii evolved with no human contact. Hawaii’s extreme isolation also prevented many plants, animals, and birds present in other parts of the Pacific and the world from reaching the island. As a result, Hawaii’s plant and animal kingdom evolved into one of the world’s most unique ecosystems, with most of its species only found in Hawaii.

The arrival of man brought thousands of new species into Kona and Hawaii. The mild climate of Kona allowed new species to thrive and often out-compete native species. These new species have contributed to the decline of our native forests and have made pest control the burden it is today. Invasive or introduced plant species now cover approximately 90% of land below 1200’ and approximately 50% of land above 1500’. The spectrum of new species brought to Hawaii includes trees, shrubs, grasses, legumes, flowers, insects, birds, hooved animals, weed species, and others. Invasive species can be any of these categories. Some species become invasive quickly and spread over large areas of ranch and farmland if left unchecked.

The type of invasive species often varies with elevation from North to South Kona. Fountain grass covers a large swath of land in the low elevations of North Kona. The spread of fountain grass across North Kona occurred quickly. Fountain grass is considered invasive but does serve as a ground cover that protects and builds a degraded soil. Tropical grasses such as elephant and guinea grass cover a large swath of land in the low and mid-range elevations of South Kona and part of North Kona. Other tropical grasses such as kikuyu grass thrive at mid-range and higher elevations.

Tropical grasses were planted throughout North and South Kona and pasture land has replaced much of the forest at the

lower and higher elevations. Tropical grasses can be invasive, and many farmers, home owners, and other property holders struggle to control these grasses. However, tropical grasses have played a positive role in improving soil health. The soil health in well-managed ranchland or grass management areas is generally high because of the ground cover, annual addition of organic matter, and the natural fertilizer added to the soil through animal manure.

While some invasive plants provide soil health benefits, many invasive species are difficult to control and provide no benefit to the environment in Kona. Invasive species encroach into native forests, ranches, and croplands, and can destroy restoration and conservation efforts. Invasive species such as cat’s claw, koster’s curse, running bamboo, and a wide variety of vines are extremely persistent and difficult to control. There are also many tree and shrub species in Kona that are very invasive and can overtake land within a couple of years. Species such as Christmas berry, African tulip tree, lantana, and strawberry guava grow throughout North and South Kona and spread rapidly. The African tulip tree can grow ten feet per year and the small seed



Miconia, a very aggressive invasive plant originally from the tropical regions of North and South America. It can grow up to 50' tall and produce 10-20 million seeds each year. The seeds can remain viable for up to 12 years. Because of its quick growth, how close together the species can grow, and the size of the leaves, they are very good at shading out all other forest species.



Above is koster's curse, a woody invasive shrub that loves the sun and is highly tolerant of shade. Originally from tropical America (Mexico to Paraguay), the texture of the leaf looks like seersucker fabric. The seeds are spread by birds and pigs

Photo credit: *Weeds of Hawai'i's Pastures and Natural Areas; An Identification and Management Guide* by P. Motooka et al. ©2003, College of Tropical Agriculture and Human Resources, University of Hawai'i at Mānoa.

sprouts are also aggressive and spread quickly.

Feral goats, pigs, and sheep also live at different elevations and are invasive and destructive. Feral goats are generally found at low elevations, feral pigs at mid-range elevations, and feral sheep at higher elevations. All these animals cause environmental and economic damage to agricultural lands, native forests, habitat restoration projects, and landscaped areas. These feral animals thrive in the wild and have proven nearly impossible to eradicate. The wild goats in Kona eat native plants and new seedlings, feral pigs destroy farmers' conservation projects and lawns, and sheep invade native forests, resulting in invasive plant species' encroachment.

Other introduced mammals like rats cause economic damage to macadamia nut production by eating the nut and also contribute to the spread of rat lung worm disease. The failed attempt to control rats by introducing the mongoose resulted in an infestation of both species. The population of feral cats is high in scattered areas throughout North and South Kona, and introduced birds brought avian malaria, resulting in the loss of native birds in most midrange and lowland areas of Kona.

There are new varieties of insects that cause serious economic damage to the coffee industry. The twig borer and coffee berry borer require yearly treatment to prevent catastrophic loss of coffee. Introduced mosquitoes carry tropical diseases. The little red fire ants' appearance brings potential disaster to farmers if the fire ant gets a strong foothold in Kona. Rat lung worm disease is caused by a parasite carried by introduced slugs. The coqui frog has spread through vast areas of Kona over the last ten years, disrupting the quiet nights of Kona with its high-pitched call.

The list of invasive species in Kona is extensive and can affect nearly every landowner. Whether an insect, plant, tree, or mammal, invasive species are scattered throughout North and South Kona. Invasive and introduced species are so prevalent in Kona that visitors and residents may rarely see or recognize a native plant or tree.

Invasive and troublesome pests are likely here to stay. The

question is, "How will we manage or treat the problem?" Too often, home and property owners turn to herbicides as a first option for controlling troublesome plant species. The SWCD is encouraging land-users throughout Kona to take an integrated approach to pest management utilizing multiple practices to control unwanted pests. Chemical herbicide should not be used as the primary treatment solution. Restoring degraded soils with organic matter and planting ground cover or trees can counter invasive plant species. Planting roadsides and lawns with low-growing grasses allows for good weed control simply by mowing. If planting is not feasible, convert to mowing weeds instead of spraying. Diligent mowing will in some cases allow an area to vegetate naturally. The same practices that are needed to address all of Kona's resource concerns can also address the invasive species concerns. The long-term solution to controlling unwanted plant growth is to replace the species with living plants and trees. However, even with a good ground cover of grass, mulch, and trees, invasive species in Kona require constant maintenance to stop re-growth. The spread of some invasive species like insects and frogs can only be controlled with a community-wide effort.

V. Water Resources of Kona

Water Quality, Water Quantity, and Flooding

“Mōhala i ka wai ka maka o ka pua.”

“Unfolded by the water are the faces of the flowers.”

— Hawaiian poetical saying



Heavy rains produce storm water runoff. These water courses come together at a sediment basin, something built by the land owner to contain flood water.

Perhaps the most important and vital resource of Kona is its underground supply of fresh, clean ground water and the surface water surrounding the island. Water from the wells at higher elevations provides some of the purest drinking water in the world. The ocean waters surrounding Hawaii Island remain relatively clean and are widely used by tourists and residents alike.

However, the loss of native forests and degradation of Kona soils has affected the quality of water entering the ocean and percolating into ground water supplies. Forest loss in Kona increases water runoff from the upper and midrange watersheds, creating serious flooding issues. The degradation of Kona soils and increased use of chemical herbicides, pesticides, and fertilizers increases the potential of contaminants entering ground water and the ocean.

Understanding the resource concerns affecting Kona’s water quality, quantity, and flooding issues will help landowners manage their property to protect Kona’s water resources.

An old Hawaiian proverb states, “Rains always follow the forest.” As the forest retreats, rainfall diminishes, and the land eventually becomes a desert. Annual rainfall in Kona two centuries ago is not known. However, it is widely believed that rainfall patterns have indeed significantly decreased with the loss of forest cover in Kona. Annual rainfall records have been tracked by some of Kona’s ranchers since the late 1920s. These records indicate that rainfall patterns have decreased by as much as 50% in some areas of Kona since those records were started.

The reduction in rainfall also decreases the amount of water available to percolate into the ground water. The loss of forest cover has increased water runoff, further decreasing water percolation. According to the US Geological Service, ground water recharge is 10-50% of rainfall, depending on land use, slope, and soil type. Undoubtedly the highest recharge areas in Kona are under the heavy vegetative cover of native forests and the least are impermeable surfaces such as roads and roofs.

The landscape of Kona is one of the world’s youngest, and the floodways (intermittent stream channels) are unable to handle large rain events. The change in land use and loss of native forest has greatly increased the potential for catastrophic flooding. Land development projects involving earth moving at elevations above 1500’ can change storm water runoff patterns, resulting in flood waters changing course. There are over 20 intermittent streams or floodways in Kona and many of these floodways sit empty for years. Most of the floodways in Kona are shallow and narrow and cannot handle 50-, 100-, or 500-year storm events. Property owners with floodways are often unaware of the potential danger of flooding and floodways are not maintained. It is not uncommon for Kona floodways to go over 20 years without enough rain in the watershed to cause runoff to flow in the streambed. As a result, landowners often neglect to maintain stream channels and water flows out of their already inadequate banks. When a large storm event occurs, flash flooding quickly fills floodways with water which leaves the channel, causing severe damage to adjacent properties and roadways. Floodways obstructed by heavy brush, garbage, and tall grasses will force water out of the banks even during small runoff events. Flood waters then carry sediment and other pollutants into ocean waters. Keeping these floodways clear of brush and garbage is vital to prevent catastrophic flooding.

The County of Hawaii, working with the Federal Emergency Management Agency (FEMA), recently completed the re-mapping of Kona floodways. The FEMA floodway maps provide accurate mapping for the Kona

district that has been lacking in the past. The ground water supplies in Kona appear abundant and produce a high-quality drinking water. However, there is less water percolating into the soil profile than there was 100



Above is the Ki'ilae Stream. If you have ever driven past the S. Kona Fruit Stand you have driven past this stream bed. It starts in a swampy wetland area at about 2,800' elevation and flows continuously at that elevation. The elevation at the highway is about 900'. The Ki'ilae Stream is intermittent (only runs with rainfall) at that elevation. The mouth of the stream is at the Pu'u honua O Hōnaunau. On many occasions this stream has carried sediment down to the ocean.

years ago, and manmade pollutants are highly susceptible to percolation into Kona's ground water supplies. To understand Kona's unique underground water supply, refer to Hawaii County's Department of Water Supply publication, "Ground Water in Hawaii," <http://hi.water.usgs.gov>

The Environmental Protection Agency (EPA) is responsible for ensuring public water supplies within the US are safe through a law passed by Congress in 1974. The Safe Drinking Water Act provides guidelines to States on tolerable levels of pollutants in drinking water. The EPA determines what levels of contaminants are allowed in water supplies and are still considered safe to drink. To comply with federal law, the Hawaii Department of Water Supply conducts periodic water testing and provides water quality reports to water users in North and South Kona. The reports indicate that Kona water supplies

are indeed susceptible to contamination. According to the 2016 water quality report, the most common manmade contaminate in our Kona wells is nitrate from runoff, percolation from fertilizer use, and septic tanks. Many naturally occurring pollutants are also being detected in some wells. However, all levels of contamination are well below the guidelines set forth by the EPA. To access this report on-line refer to; <http://www.hawaiidws.org/7%20water/ccr/2016/CRNKona2016lo.pdf> or Hawaii Department of Water Supply.

In 2013-2014 a statewide pesticide sampling pilot program was conducted by the Hawaii Department of Health and Department of Agriculture. Surface water samples were collected from 24 sites statewide testing for 136 different pesticides. The study found that at least one pesticide was detected at each location although only one (pesticide for termites) exceeded state and federal levels. Five other pesticide compounds were detected at levels exceeding the EPA's aquatic life benchmark. All other detected levels were lower than the most stringent standards for aquatic and human health. There were seven sites tested for the presence of glyphosate and all tested positive.

Although only one sample was taken in Kona, this report is important because it demonstrates the susceptibility of Kona's water supply to pesticide contamination. Nearly all the surface water samples in this study were taken in areas where soils are better formed and more capable of holding manmade contaminants than in Kona. This raises the concern that contaminants in Kona are percolating into the soil profile and are or eventually will enter ground and/or ocean waters.

An additional report that raises concerns in Kona is the "2004 List of Impaired Waters in Hawaii," which shows Kailua Bay, Kealakekua Bay, and Magic Sands Beach on the list of impaired waters. Prior to 2004, Kealakekua Bay was on the list of "Pristine US Waters." To read the report refer to; <http://www.state.hi.us/health/environmental/envplanning/wqm/303pcfinal.pdf>

In summary, drinking water and ocean surface waters in Kona remain clean and detected pollutants are well within the guidelines set forth by the EPA. However, land use change has affected Kona rainfall patterns and less water is percolating into our ground water supplies. The risk of damaging floods has increased with the loss of forest and land development projects. The potential for chemical herbicides, pesticides, and fertilizers leaching into fresh and ocean waters is high. The wide-scale use of chemical herbicides such as glyphosate provides an unknown risk. Glyphosate has a short residence time in water and is known to bind tightly to soils and sediments. However, Kona's degraded organic soils may not have the soil particles that bind glyphosate and it is likely that concentrations of glyphosate are working their way into ocean waters and potentially into ground water supplies. To prevent long-term damage to our water supplies, action should be taken to under-

stand the extent of pollutant-leaching throughout Kona. Taking soil samples at varying depths in areas known for long histories of manmade chemical application may be an important first step. Together we can take important measures that will ensure Kona's high-quality water supply.



For residents who do not have access to the county's water supply, the photo on the left shows the Ho'okena Spigot.



To the left and below: Infrastructure related to our public water supply. Facilities like this are located throughout N. & S. Kona.



In the mauka lands above Kainaliu Town are a number of flood control structures all built in the late 1960s and early 1970s. The three photos above are all from one structure. Water collects in the grass swale in the photo on the left. That water feeds into a concrete channel that is almost 800 feet long and is shown in the center photo. The concrete channel empties into a lava tube, the one shown in the photo on the right. There are five flood control structures in the mauka ranch lands that work together to protect the homes and businesses in Kainaliu. These photos were taken on 10/24/2017 when 7-plus inches of rain fell in the area. All of the structures above Kainaliu were in operation on that day. Below, you can see what these look like when it is dry.



The photo on the far left is of the grass swale that feeds storm water into a concrete channel. The center photo is of the concrete channel on a dry day, and the photo on the right is the lava tube the concrete channel flows into. You can see part of the channel's concrete wall in the lower-right corner of the photo. This flood control structure was constructed in the early 1970s.

The five flood control structures above Kainaliu Town all have similar designs. Water flows along a grassed swale into a concrete channel, and then into a lava tube. These were constructed in the late 1960s and early 1970s using federal dollars and could not be built today. Today the federal government will not allow using lava tubes in this fashion because you cannot determine the capacity of a lava tube.



The two photos above and the two below are of another flood control structure above Kainaliu. The above photos show the grassed swale, on the left operating as designed on 10/24/2017, on the right during a tour of the structure.

Below are photos of the concrete channel the swale above directs water into. On the left is a photo taken on 10/24/2017 and on the right during a tour of the structure. At the end of the channel is a lava tube the water is flowing into.



The bottom five photos are all from the flood control structure on Nap'opo'o Rd. This structure protects the Sunset Coffee Mill.

P1: Mauka area the water comes from.

P2: North side of the overpass.

P3: Note the discoloration on the wall, This is from sediment that was deposited here during a 2007 rain/flood event. It was 2-3' deep.

P4: South side of the overpass

P5: Diversion for flood waters.

VI. Chemical Herbicides

“*Lele ka hoaka.*”

“The spirit has flown away.”

— Hawaiian poetical saying



A typical result of a plant exposed to the herbicide glyphosate, the active ingredient in Round-up. This photo shows an example of “witches broom.”

(Photo credit: CTAHR *Glyphosate Injury to Coffee*, Scott Nelson, November 2008)

The use of chemical herbicides in the USA began in earnest in the 1950s with the advent of 2-4D. The development of chemical herbicides after that period revolutionized American agriculture and helped make the American farmer the most productive in the world. Chemical herbicide usage continues to be an integral part of agriculture in the USA, including among Kona farmers. The most common form of chemical herbicide in Kona has an ingredient named glyphosate.

Unfortunately, the use of chemical herbicides for weed control spread beyond just farmers and is now commonly used on roadsides, residential areas, businesses, and government properties throughout Kona. There is often what seems to be a casual attitude towards the use of chemical herbicides in Kona. It is not unusual to see people spraying chemical herbicides in slippers and light clothes, and the Kona SWCD has observed the misuse of chemical herbicides in Kona on many occasions. Many Kona land users rely 100% on herbicides to control weeds. It is important to remember that chemical herbicides are a type of poison designed to kill a specific pest. Every chemical herbicide sold has very specific and important labeling requirements on the proper use of the herbicide.

When herbicides are misused they can create potential hazards for humans, animals, and ground and surface waters. In addition, the fragile soils within Kona raise the question of whether there should be stricter labeling requirements for chemical herbicide application on Kona soil. Kona soils act more like a sieve than a sponge. Many soils elsewhere do indeed act like a sponge and can absorb many pollutants; however, Kona soils cannot provide that filtering action.

Spraying herbicides on roadways near the ocean greatly in-

creases the potential for herbicides such as glyphosate to enter ocean waters.

Anyone who is struggling to control weeds on their property understands the benefit of chemical herbicides. The physical labor involved in farming and landscaping in Kona is demanding. The cost and labor involved in weed control by hand can be significantly higher than spraying a chemical herbicide. Also, the rough and rocky landscape makes herbicide weed control easier to use than mechanical control. However, these are not reasons for not *safely* applying chemical herbicides.

Land users need to be aware of the potential dangers of chemical herbicides and handle herbicides with respect and safety. The most important safety tips for handling chemical herbicides include:

Read the instructions and follow the labeling requirements.

Do not mix more concentrate than specified.

Check wind conditions to avoid chemical drift from blowing on neighboring properties.

Most herbicides have a minimal drying time of four hours or more prior to re-entering the treated area. Ensure no person enters the treated area after spraying for the designated time.

Wear protective clothing by covering all exposed skin and wear a respirator or appropriate face mask to prevent breathing fumes.

Do not overspray herbicides. If you are spraying a one-inch sidewalk crack with a four-inch band of spray, you are over-spraying.

First and foremost, read the directions. If you are spraying areas where people and animals frequently walk, the spraying should cease and/or the landowner should post a warning sign. The warning sign should remain in the treated area until the recommended re-enter time. Road crews need to ensure treated areas will not be walked into during the period identified on the label. Failure to do so exposes people to poisons they are unaware of but that do exist.

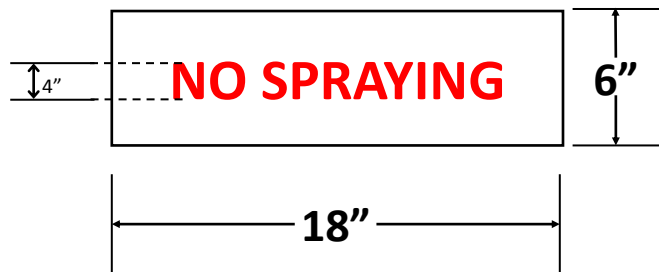
In summary, chemical herbicides are widely used throughout Kona. Chemical herbicides are contributing to widespread soil degradation by destroying organic matter that would otherwise be added to the soil. The loss of soil organic matter is destroying habitat for soil microbes, insects, and worms, which further degrades soils. In many cases innocent bystanders are being exposed to chemical herbicides by improper use of the herbicide. The Kona SWCD strongly encourages homeowners, business owners, and government offices to reduce or eliminate the reliance on chemical herbicides for weed control. Farmers reliant on chemical herbicides are encouraged to establish grass or ground cover to offset the amount of chemical herbicides needed for weed control. If you use chemical herbicides for weed control, read the instructions. Ensure other people have no way of becoming exposed to the poison.



This photo depicts a method for planting coffee: herbicide the row you want to plant so the farm workers can very quickly “punch a hole and plant a tree.” The benefit is the grass stays in place and therefore, so does the soil.



In the above photo you can see the dead vegetation along both sides of the roadway. The county sprays herbicide to maintain the site lines to ensure safe driving.



If you do not want the County to spray your land with herbicide you can let them know that. There is a form that needs to be completed. It can be obtained through the county’s Department of Public Works. You also need to create two signs that follow the dimensions noted above. Place one on the left side of your property and one on the right side of your property. Per the form, the county will not spray herbicide on the land between the two signs. As the property owner you will be held responsible for maintaining the edge of your property so that the vegetation does not cause a hazard for drivers, walkers or bicyclists.

VII. *The Role of Forests and Soils in Climate Change*

Another Critical Reason to Protect the Forests and Soils of Kona

“He pili wehena `ole.”

“An unseverable relationship.”

— Hawaiian saying

Soil, like the world’s oceans, forests, and grasslands, can play a huge role in addressing and solving climate change. Hawaii farmers, residents, and units of government all can contribute to reducing the high amounts of carbon in the atmosphere by keeping soils covered and planting trees, particularly hardwood or native trees. Leaving soil exposed and uncovered contributes to climate change, because carbon stored in the soil is quickly released into the atmosphere when the vegetation is removed and the soil is left exposed. Not all areas can be planted in trees, but grasses and legumes protecting the soil also allow the soil to capture or sequester atmospheric carbon.

To begin to understand climate change, it is important to understand the carbon cycle, which is taught in most elementary and high schools throughout the United States. The carbon cycle teaches us that as carbon is released into the atmosphere by human activity or natural occurrences, the released carbon is recaptured or sequestered by forests, plants, organic matter, ocean waters, and soils. Carbon is considered a greenhouse gas, which means it cannot escape Earth’s atmosphere and unless recaptured, will contribute to warming the surface of the planet. One analogy commonly used to describe this is that atmospheric carbon is like a huge blanket covering the planet.



‘Ōhia Forest Farm, home to an award-winning six-acre restored ‘ōhia forest. The carbon cycle is hard at work here in this forest.

Since the existence of humankind, humans have been releasing carbon into the atmosphere through the burning of wood for cooking and comfort, and grasslands for wildlife management. However, the role the carbon cycle plays in climate change is rarely discussed, with nearly all the media focus being directed towards the fossil fuel industry and the high amounts of carbon being released using fossil fuels. There is no denying the role that the burning of fossil fuels plays in climate change, especially with the tremendous increase in automobiles in China, India, and many third world countries.

More alarming is that the Earth’s ability to reabsorb atmospheric carbon has been severely damaged over the last 50 years. The World Wildlife Federation estimates that over the last half-century nearly 75% of the world’s tropical forests have been destroyed or severely damaged. Harvesting wood for lumber, cooking, and warmth has greatly contributed to the demise of our tropical forests. Population growth and the need to grow food to feed this population is also driving this deforestation. The land cleared of trees is used to produce needed crops and animals for the growing world’s population. Unfortunately, the farming methods used in many countries (and in Kona) causes soil degradation over a short period of time. Many of the world’s soils cleared of forests to grow crops are left bare, causing any carbon stored in the soil to be released into the atmosphere. Soils store atmospheric carbon if covered with live or dead plant residues, and release carbon if

bare.

With the loss of forests and the degradation of soil, two of the three world's carbon banks or sinks are being severely degraded. Thus, the ocean is forced to absorb more atmospheric carbon, resulting in increased ocean acidity, and the increase of ocean acidity threatens the entire oceanic food chain.

Hawaii farmers and residents can play a role in addressing climate change by keeping our soils covered with vegetation and organic matter. This can be accomplished by changing farming techniques from widespread spraying of herbicides to establishment of low-growing grasses. Many farmers in Kona do indeed use grasses or ground cover; however, widespread herbicide use in residential areas and by units of government needs to be addressed.



Our best soils have a lot of organic matter. Uncovered soil, as in this photo, is breaking down. The organic matter is decomposing and that process releases carbon into the atmosphere and becomes part of the climate change problem. Keeping soil covered is part of the climate change solution.



A local coffee farm with conservation cover virtually throughout the orchards. Soil is staying put, it is being fed organic matter every time mowing takes place, the soil temperature does not fluctuate greatly, and the soil's moisture is not lost as rapidly during a drought. As an added bonus, this producer is locking up carbon in these orchards and is part of the climate change solution.



There are thousands of acres of forest and grassland on Mauna Loa and Hualalai. Forests and grasslands are very good at storing carbon.



Ranchland is good at storing carbon.

VIII. *Healing the Land: Best Management Practices*

“*Hahai no ka ua i ka ululā`au.*”

“Rains always follow the forest.”

—Hawaiian proverb

As discussed in this paper, the environment in Kona is indeed fragile and has suffered from poor land management in the past. In many cases residents and other property owners are unaware of the sensitivity of Kona’s soils and the amount of deforestation that has occurred over the last 200 years. Most visitors and many residents are probably unaware that a high percentage of vegetation visible from roadways is not native to Hawaii and is, in many cases, an invasive or undesirable species. The use of chemical herbicides is widely used and is contributing to soil degradation and potential ground and surface water contamination.

All these resource concerns within Kona can be addressed and further degradation prevented by utilizing best management practices geared toward specific resource concerns. Not only can residents of Kona address our resource concerns, we can also play a significant role in addressing climate change by protecting our soils and forests that sequester carbon.

Below is a breakdown of critical conservation practices, or best management practices, needed to address each individual resource concern.

Conservation Cover-Protecting the soil by covering the surface of the land with vegetation or mulch is a critical first step in stopping soil degradation in Kona. A wide variety of low growing grasses grow well on farm lands, and residential, business, and government properties. Establishing native plants and trees can serve as ground cover when combined with other ground-covering vegetation. Establishing ground cover provides an almost immediate benefit to the soil by providing organic matter that will regenerate soil life. A recent publication by the USDA’s Natural Resources Conservation Service states, “If you want a healthy soil, you shouldn’t see it very often.”

Mulching-Adding organic matter to our soils replicates nature and will quickly improve soil quality by restoring habitat and food to soil insects and microbes. Ground covers such as grasses add organic matter throughout the year; however, soils that are seriously degraded may also require mulch to build the surface organic matter content. Putting mulch and compost around trees conserves water and over time will provide plant food for the tree. Instead of spraying weeds, cut the weeds with mowers or weed whackers and leave the vegetation on the soil surface to add organic matter.

Tree Planting-Tree planting is a very important practice in Kona. Landowners should consider native species whenever possible although there are other tropical woods that provide benefits to the Kona environment. Tree planting is one of the best practices landowners can do to address climate change and keep our watershed healthy.

Fencing-In many cases, an animal fence needs to be installed to protect conservation measures from feral ungulates, including goats, pigs, sheep, and cattle. Feral ungulates are very destructive and can destroy newly installed conservation measures quickly. For instance, mulch and ground cover improves insect life in the soil, and pigs will tear up sod looking for food. Goats love newly planted trees and will quickly devour them. Feral ungulates threaten our remaining native forests by destroying ground cover, allowing invasive species to encroach on exposed soil.

Pest Management-Controlling invasive species is a challenge for nearly all landowners in Kona and is the primary reason for the high herbicide usage occurring throughout the district. Unwanted pests, including weeds, insects, and animals, should be controlled in an environmentally friendly and sustainable manner. Conservation practices, including establishing grasses, legumes, and mulch will decrease the amount of invasive species. Use herbicides as one tool to control weeds, but not the only tool. Complete reliance on chemical herbicide to control weeds will quickly degrade our soil.

Nutrient Management-Prior to any application of commercial and organic fertilizer, a soil analysis should be taken to determine the available nutrients within the soil. A soil analysis will help the land user determine how much nitrogen, phosphorus, and potassium should be applied. Over-application of fertilizer will result in leaching and potential ground water contamination.

Reducing Chemical Herbicides-The indiscriminate use of chemical herbicides needs to be offset by environmentally friendly methods for controlling weeds. Use of chemical herbicides on roadways, parks, businesses, and homes near the ocean should be limited or ended. If necessary, use herbicides only on hard-to-control weeds and plant low-growing grasses and legumes to control most other weeds.

Water Harvesting Catchment-Water harvesting catchment from roof runoff to store in a tank has a long history in Kona and many tropical areas of the world. Having a tank full of water next to a home or building provides an emergency source of water in times of water shortages.

In summary, the environmental problems within Kona can be solved if residents understand the fragility of Kona’s land and make necessary management changes that address the concern. A community-wide effort needs to occur that involves units of government, businesses, private organizations, and home owners. Landowners who have degraded soil should make efforts to rebuild their land. Bringing life back to the soil starts almost immediately with the introduction of organic matter. Planting ground cover and/or trees and adding mulch, combined with the reduction of chemical herbicides, causes an almost immediate improvement on any land in Kona. Landowners are encouraged to work with the County of Hawaii by agreeing to control weeds on right-of-ways adjacent to their property. Break out the weed whacker. Brown vegetation killed by herbicides on public and private lands is unsightly and is potentially harmful to the environment, people, and pets.

If left alone the land in Kona will quickly re-vegetate itself in most cases with invasive or unwanted species. Landowners can spray chemical herbicides to try to kill these species 4-6 times/year, but the regrowth will continue unabated until landowners control weeds with ground cover or desirable species.

The Kona Soil and Water Conservation District hopes this paper will serve as a catalyst to bring about positive change, and a greener Kona..



Both of these show the practice called **cover cropping**. On the left is sunn and buckwheat mix and the photo on the right is just buckwheat. The vegetation will be weed whacked and simply left on the ground to act as mulch. This practice provides organic matter above and below the surface. The root system is organic matter, too, and helps to prevent erosion, and provide weed control and nutrient value for crops. Sunn hemp is a nitrogen fixer, buckwheat helps release phosphorous bound to soil, and all the nutrients in the plants will cycle back into the soil after the plant is mowed

The above photo depicts the conservation practice of **mulching**. Mulch will break down into soil and it will moderate soil temperatures (some roots do not like it too hot). Mulch also helps minimize soil moisture loss so that watering or irrigating can be done less frequently.



The photo on the far left shows a barbed wire fence used in ranching. The middle photo is a catchment pond on ranch land and in the far right photo tree/shrub establishment with conservation cover and mulching.

IX. Hawaii and the World: Lessons of a Lone Lama Tree

*“ E lauhoe mai na wa’a,
I ke kā, i ka hoe; i ka hoe, i ke kā;
Pae aku i ka ‘āina.”*

“Everybody paddle the canoes together,
Bail and paddle; paddle and bail;
And the shore is reached.”

— Hawaiian saying

“To see a World in a Grain of Sand...”

— William Blake, “Auguries of Innocence”



A centuries-old lama tree alone in a sea of fountain grass,
where once there was a great forest.

Hawaii is the “Grain of Sand” in which to see the world, for the history of Hawaii—natural and human—is part of, parallel to, and reflects the history of the world. And Kona is the grain of sand in which to see Hawaii. The five great phases of Kona’s history (Formation of the Land, Coming of Life, Coming of Man, Coming of the “Other,” and Continuing Change) can be applied anywhere in the world, and Kona’s resource concerns are similar — and often the same — as in communities all over the planet. We all must “paddle the canoes together.”

At the new UH Center at Pālanui mauka of the airport, students are making the Pālanui Nature Trail to connect (and save) the remnant native trees in the surrounding fountain-grass sea. The first beautiful old lama tree is just south of the Administration Building; the second is a quarter-mile walk through the sea of invasive grass. This second lama tree, larger and with a beckoning island of shade, sits in a lava depression, only its top visible until you come upon it. Leaning back against its trunk, you see it there alone, another quarter-mile to the next tree, in what was once the *Wao Lama*, the “Realm of the Lama,” with lama the predominant species in this belt of the lowland forest that once stretched from Kohala to Ka’u, an ecosystem as rich in native species as the wetter upland forests.

What happened? Human-introduced changes caused the almost-complete destruction of this mighty forest: cattle, goats, cutting, burning, unsustainable practices, and invasive plant species. And trees are the defenders of air, water, soil, wildlife, and us. Now this lone lama sits in Hawaii’s (and the world’s) most endangered ecosystem, the lowland dry forest that once covered huge areas of Kona, and vast expanses around the world. Awareness-*Kuleana*-Action: the lesson of the lama tree is clear: we have to take care of the world, and that world starts with the world around us. “Everybody paddle the canoes together”; together we reach the shore.



Everyone working together. The West Hawaii Veterans Cemetery in North Kona encompasses a forest restoration project. A few times a year a call is put out for volunteer planters. This is a way for us to all paddle together and reach the shore. See the next page for some of the results.



Grab a paddle! In this case your paddle is a plant.



To the "canoe" (forest) for planting.



"Paddlers" come in all shapes and sizes.



The two photos above and the two below demonstrate the progress we can make as a community when everyone helps out. Before this project started this was a sea of fountain grass. Over the years, and with the help of hundreds of people putting in thousands of plants, the West Hawaii Veterans Cemetery Reforestation Project has, by virtually all measures, been a huge success. Military members, farmers, artists, business professionals, politicians, educators, students, veterans, and more have helped plant a native forest and what a world of difference it makes when hundreds grab a paddle or a plant; the work that can be done is amazing. Every one of the native plants you see in these four photos was established in the past 10 years so it is a young forest. It is protected by fencing to keep goats, sheep, and pigs at bay and with that protection this dryland forest should last forever.



X. The Road to Action: Reforestation and Restoration Projects in Kona

“Kēlā nahele heahea, walowalo i ke kanaka, wahine, keiki.”

“That calling forest, summoning men, women, children.”

— Adapted from an ancient Hawaiian saying

“One who walks in nature always receives more than he seeks.”

— John Muir

I. Awareness-*Kuleana*-Action

The road to action begins with awareness, and this awareness emerges on several levels:

- We have in Kona serious resource concerns and harmful practices, some so dire they harm the present and threaten the future.
- Human activity, especially over the past two centuries, has greatly harmed the Earth and its life-support systems, and this includes Kona.
- We are part of the Earth, part of Kona, and part of the problem.

From awareness comes *kuleana*—responsibility—and *kuleana* leads to action. We are part of the problem, and we can be part of the cure. Many individuals and organizations in Kona have followed the path of Awareness—*Kuleana*—Action, directly addressing the resource and practice issues raised here. The new recruit to the worldwide Green Revolution will find plenty of opportunities to serve the cause in Kona, planting native trees and engaging in other conservation activities, and restoring ancient trails, fishponds, and field systems. For those wanting to get involved, below is a partial list. Mostly unsung here must remain those many “unknown” individuals whose *aloha* for the ‘āina makes them natural stewards of the Earth in their daily practices. *Mahalo nui* to them, and to the people and organizations below:

Kona Soil and Water Conservation District (KSWCD) and the USDA’s Natural Resources Conservation Service (NRCS). A good first-stop for information and guidance into the Kona natural resources scene. “Helping people help the land,” NRCS and its partner KSWCD provide technical and financial assistance to Kona residents, farmers, and ranchers. Call them at 808-339-9042, or visit <http://www.kswcd.org/stewardship.html>.

University of Hawaii Center-Pālanui. Students from Kona’s branch of the UH system plant or give away thousands of native trees every year, and restore and clean ancient trails and sites. At the Veterans Cemetery they plant lowland dry forest plants; in the Kaloko uplands they plant primarily koa. Non-student volunteers are welcome. Call Dr. Richard Stevens, 808-323-3860. The Veterans Cemetery is at <http://www.arlingtonofthepacific.org>.

Aloha Kuamo’o ‘Āina: A new non-profit focused on healing the Battlefield of Kuamo’o, where the *Kapu* system ended in 1819 in the death of 300 Hawaiians. (The land has also been severely impacted by cattle, goats, and pigs.) Planting of native species and Polynesian introductions has begun in a goat-proof enclosure, with plans to eventually fence and reforest the project’s 47 acres along the Kona shoreline. Cleaning of trails and sites is also underway, with volunteers making it happen. Call Project Director Monika Frazier at 808-640-2797, or visit <http://www.kuamoo.org>.

Ka'ūpūlehu Dryland Forest Preserve. The “godfather” of Kona’s dryland forest preserves, seeds from here have helped other projects get started. Some of Kona’s oldest and most beautiful trees are here, and it is probably here that most Kona school children are first introduced to the wonders of the dryland forest. The dedicated staff welcomes volunteers. Visit <https://www.hawaiiforestinstitute.org>.

Nāpu`u Conservation Project. For years the land on and around majestic Pu`u Wa`awa`a was battered by a variety of human-induced causes. Now a massive restoration project works to repair the damage. Volunteers have been very important, planting thousands of trees, and augmenting the labors of the project’s staff. To see (and learn from) restoration over a large Kona landscape, get to know Pu`u Wa`awa`a. To learn more about volunteer opportunities check out their Facebook page at <https://www.facebook.com/Puuwaawaa/>

Kaloko-Honokōhau National Historical Park. “Nature and culture were one in ancient Hawaii.” This important concept in words by a Pālamanui teacher can be seen in the two ancient fishponds along the shore of the Park, where volunteers help control invasive waterweeds, and which are today crucial habitats for endangered Hawaiian birds. The Park’s mission is to preserve and restore nature and culture, and that is the destination many Kona residents have reached, as they have moved along their own roads of Awareness-*Kuleana*-Action. Visit <https://www.nps.gov/kaho/index.htm>.

Queen Lili`uokalani Trust. QLT in Kona is promoting native plants on their projects in a big way. They have a new greenhouse, and they welcome volunteers’ help. Their Interpretive Center is state-of-the-art, and is surrounded by native plants and archaeological sites. <https://www.onipaa.org>.

Kamehameha Schools. KS is planting thousands of koa trees on Hawaii Island, restoring King Kamehameha’s great field system at Maluaka in Kona, and encouraging its farm tenants to plant natives and practice agroforestry. As with all the above, volunteering with KS is a learning (as well as a very satisfying) experience. Visit: <http://www.ksbe.edu/land/about-us/>.

II. The Future of Reforestation and Restoration in Kona

The above is, as stated, a partial list, and the future, with our *kōkua*, can reverse negative trends. Students in Kona come to UH-Pālamanui college classes already *akamai* about the need to *mālama* the Earth, and knowing that love and care for the *kai* and the *‘āina* is part of the heritage of our *kūpuna*. “Take care of the land, and it will take care of you” is part of the common knowledge, consciousness about resource issues is growing, and individuals and organizations are rising. We can *all* have a role in the saving of our soil, the restoration of our forests, and the protection of our air and water. Our life expands as we act, and the world of our grandchildren looks brighter. Kona—this many-blessed part of Earth—needs and deserves our love and care. Walking in nature brings unexpected benefits. *Working* in nature, working *with* nature, means we are saving Kona, and we are saving ourselves.

In addition to the “mahalos” on the inside front cover, the Kona Soil and Water Conservation District would especially like to thank, for research, writing, and photographs, and for their love of Kona `āina:

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(Quotes in Hawaiian, and their translations, are from `Ōlelo No`eau: Hawaiian Proverbs and Poetical Sayings, and the Hawaiian Dictionary.)

Dedicated to all who love the land.



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