Invasive Vegetation Management: An Overview of Two Key Fire Risk Plant Species in Hawaiʻi Volcanoes National Park

Capstone Project

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Abstract

Morella faya tree (*Morella faya*) and fountain grass (*Pennisetum setaceum*) have both been continuously managed throughout Hawaiʻi due to their invasiveness and contribution to fire risk. Hawaiʻi Volcanoes National Park (HAVO) has identified these specifically as fire-promoting invasive species. The islands have been experiencing an increase in wildfire occurrences over several years. Widespread fires have caused significant damage to native ecosystems and threatened the safety of local communities. Treatment patterns regarding these two plants over time may provide insight into how invasive species management impacts wildfire behavior allowing land managers to create solutions to try to prevent future fires. This study's purpose was to identify literature gaps concerning invasive species management in Hawaiʻi and work with an organized dataset of fire-related invasive species control in HAVO for potential future analysis. Having a dataset with several years of treatment data can provide land managers with an idea of the impact of current treatments now and in the future. The literature review focused on the management of faya and fountain grass as fire-promoting invasive species. Information for my research solely concerned management areas within HAVO. A dataset obtained from the park containing treatment dates, herbicide details, and worker efforts per management unit over 20 years was provided to interpret trends. Microsoft Excel was used to organize and extract the variables needed to track work efforts. Looking at only faya and fountain grass data, the variables chosen for building the table were individual plants treated, hours of effort workers worked on sweeps, and the amount of herbicide used each time. The outputs of my study were the dataset containing only the extracted variables created as a product to be utilized by park staff for management decisions and the literature review. There was a significant number of studies concerning the use of chemical management treatments on invasive species. However, not much is currently known about how an ecosystem is affected in the long term after these treatments. Further studies need to be conducted to determine the effectiveness of long-term management plans.

Keywords: non-native species, invasive grass, woody species, land management, fire impact, ecosystem composition

Motivation

Wildfire risk has been a growing issue in several places across the globe including Hawaiʻi and the Pacific (Weise et al., 2010). Invasive grasses in Australia have increased fuel loads and severity of fires, and in South Africa and Brazil, multiple invasive grasses, such as molasses grass (*Melinis minutiflora*), have also been linked to larger fires (Fusco et al., 2021). Moreover, invasive grasses have been discovered to alter fire behavior patterns in many other parts of the US, including deserts, forests, and even Hawaiʻi (Fusco et al., 2021). Hawaiʻi Volcanoes National Park (HAVO) carries out invasive species management techniques on several species within the park to support native ecosystem conservation. Two species, faya tree (*Morella faya*) and fountain grass (*Pennisetum setaceum*), have been identified as high-risk species that contribute to fire occurrence (LaRosa et al., 2008).

Hawaiʻi's native ecosystems are incredibly important to the islands and their people. About 20 percent of the land is still composed of intact native plant communities (Anderson-Fung and Maly, 2009). The islands' rich native biodiversity provides a spiritual connection between Hawaiʻi and its indigenous people (2009). In Hawaiʻi Volcanoes National Park specifically, many native plant species call this area home within its unique landscape. The park's volcanoes, forests, and flora carry significant cultural significance in Native Hawaiian history (USGS, n.d.). Presently, the State of Hawaiʻi is home to around 1,400 vascular plant taxa, encompassing species, subspecies, and varieties, with nearly 90 percent of them being unique to the islands and not found elsewhere in the world (DLNR, n.d.). With both invasive species and fire posing threats to these ecosystems, it is crucial to ensure the survival of these native species for future generations. Developing more effective management strategies for invasive species provides a better picture of how we can preserve Hawaiian culture and its resources.

Background

Hawaiʻi has one of the largest numbers of invasive species in the United States today (Kraus & Duffy, 2010). According to the Hawaiʻi Invasive Species Council, Hawaiʻi currently lacks a regulatory list of "invasive species," though scientists estimate that the number of such species is in the thousands (Hawaiʻi Invasive Species Council, n.d.). Invasive plants, crucial in fueling wildfires, are becoming more prevalent amidst the escalating frequency and severity of global wildfires (Faccenda and Daehler, 2022). The escalating frequency and severity of wildfires in Hawaiʻi have caught the attention of land managers, prompting a shift in focus toward understanding the environmental factors influencing these fires. There has been a steady and exponential increase in the burned area in Hawaiʻi over the past few decades (Trauernicht et al., 2015). Most recently, the 2023 Maui Wildfire further highlights this trend, with Hawaiian fires becoming more severe and frequent (Trauernicht et al., 2015).

Invasive species quickly alter fuel properties, actively changing fire regimes, especially with multiple invaders in an area (Brooks et al., 2004). Typically, these invasions modify various fuel and fire properties simultaneously, which increase frequency by altering fuel characteristics while also altering fire intensity and soil heating patterns (Brooks et al., 2004). Often, climate change is highlighted for its role in altering fire patterns, invasive grasses also make up a significant part (Fusco et al., 2019). *Pennisetum setaceum* (fountain grass) is considered an invasive species across the Hawaiian Islands, including Kauai, Lanai, Oahu, Kahoolawe, Maui, and Hawaiʻi Island. In the continental United States, it grows in states like Oregon, California, Arizona, New Mexico, and Colorado, as well as in Louisiana, Florida, and Tennessee (USDA-NRDC, 2018). While not extensively introduced globally, *Morella faya* (faya) is notably found in the Hawaiian Islands, Florida, Australia, and New Zealand. In the Hawaiian Islands, faya has established itself as a significant environmental weed (Whiteaker et al., 1992).

Species of Fire Risk Concern at HAVO

a. Morella faya

Morella faya was likely brought to Hawaiʻi in the late 1800s by Portuguese immigrants from the Azores or Madeira for decorative and medicinal purposes. Today, Hawaiʻi Island hosts over 80% of species cover (Pasiecznik, 2022). While it is considered a major weed species, it was also introduced to Florida, USA, during the same period, and to Queensland, Australia, and New Zealand, however, only in Hawaiʻi is it considered one of the main noxious weeds (Pasiecznik, 2022). This tree produces an abundance of seeds which are spread by birds causing rapid spread (R. K. Loh & Daehler, 2008).

b. Pennisetum setaceum

Fountain grass is an invasive grass species originally from Africa. It is a perennial ornamental grass with stems about two feet high. Fountain grass is spreading to new areas in the Southwestern United States and is identified as an invasive species in California, Nevada, and

Arizona (USDA, 2017). In Hawai`i, it is found on O`ahu, Kaua`i, Lana`i, and Hawai‘i Island (Fact Sheet: Fountain Grass, 2005). Fountain grass spreads rapidly due to its high seeding rate. It can be found in areas at various elevations with a median annual rainfall of less than 1250mm (Da Re et al., 2020).

c. Invasive Management in HAVO

Helicopter sweeps meticulously searched for individuals and separated plant clusters, across minimal vegetated areas including lava flows. Faya was commonly identified as young seedlings, which were easy to remove from the soil (Loh et al., 2014). With increased fire risks and the invasion of lava flows, fountain grass has become a serious concern for management efforts within HAVO. Over time, biannual surveys aimed at tackling the grass in the southwest region and along park roadsides (Benitez et al., 2012). The main strategy for controlling fountain grass is manually removing individual plants, while larger plants and extensive infestations are treated with herbicide diluted in water to cover the leaves (Benitez et al., 2012).

Objectives

The main objective of this study was to gather literature and organize data on treatment actions concerning faya (*Morella faya*) and fountain grass (*Pennisetum setaceum*) in Hawai‘i Volcanoes National Park to facilitate future analysis. Literature was gathered to better understand the need to continue invasive species treatments in the interest of reducing fire risk. Available treatment data was highly disorganized due to an old database design. Therefore, it was necessary to extract the information and link treatment actions to specific SEAS, providing a smaller, streamlined dataset that would enable land management staff to track treatments over time.

Approach

A literature review was conducted containing several topics including the grass-fire cycle, the contribution of woody invaders to fire risk, and details on faya and fountain grass. The collection of articles included information about invasive species management in Hawai‘i, faya, and fountain grass behavior, and the potential impacts these plants have concerning fire occurrence. Sources were obtained by searching across ScienceDirect, Google Scholar, and JSTOR.

A large dataset obtained from Hawaiʻi Volcanoes National Park (HAVO) contained details of herbicide treatments per each event of treatment. The park's objective in collecting the dataset was to monitor and record treatment dates as part of subsequent monitoring projects for faya and fountain grass. Data was recorded from the years 2000 to 2021. Additional data leads back to the 80's, however, it does not have a digital form. All the invasive plants targeted by the invasive management were contained in the file. Both the SEA and Localized data had over one thousand entries of data while the Special Projects had around eight hundred entries. This information included the taxon of the species, herbicide used, worker hours, and management unit names. For each SEA, the number of days workers spent in the field treating invasive plants, the number of plants treated, and the amount of herbicide used were documented for each treatment cycle (Loh et al., 2014).

The database's role was to provide a detailed description of the management treatment efforts in the past years. Park staff needed an easily accessible form of data organization to track treatments over time. The information contained three different management projects including SEA, Localized, and Special Projects.

I received the data directly from the park in a downloadable database form. Data was listed using an "Event ID" which was a unique number to identify each management action done. For this task, I focused on the years from 2000-2021. Several attempts were made to align the data with the corresponding "Event ID" indicating when the action took place. I identified a key table that linked the Event ID to another key table listing the management units.

Worker hours were the number of total hours worked by workers performing the treatments. The number of workers was available as well but was not used in the table due to hours providing a more compatible unit for work efforts. The total amount of herbicide used was the amount of chemicals used on the plants. The number of individuals treated was the number of plants located in the sweeps and actively treated. All the information regarding these variables was recorded in the field in a notebook which was later transferred to spreadsheets on the computer.

Eventually, I would generate yearly summaries by the management unit, leading to the creation of an organized data table with only extracted data. This table offers an annual overview of each variable per management unit, facilitating linkage to GIS layers through the variables to attribute tables. Ultimately, the data will be stored in a shapefile format, connecting management histories over time to individual management units to be utilized for analysis and visualization.

Limitations

The lengthy process of organizing and breaking down the data brought up a few issues. In the beginning stages of sorting through the data, the variables were not linked to any of the management units. Data was listed all together in separate columns making it difficult to distinguish connectiveness. As mentioned before, the data contained several duplicates with the same IDs. Several of the years had missing data with no record indicating there were no treatments performed at all. This problem was addressed by filling in the entries with zeros to indicate no data. With several dates missing, the data cannot be analyzed linearly, but other findings can be established from the available numbers. Another piece of information to consider is that we were not sure how much faya was present in the management units before the recorded treatment dates. With each of the management units having different acreage, it is not fair to assume the efficacy of the treatments is all the same. Depending on the ecological conditions, different units received different treatment cycles. The length of these cycles and the time between influences factors such as worker hours and plant numbers treated. The number of individual plants treated is not equal to the number of invasives present in the unit altogether. Different numbers of plants were treated due to time restraints and fluctuating available workers. Another issue to consider is the condensed way the data needed to be organized for various purposes. Pieces of information were combined to organize the data for future analysis. Information about the types of workers performing treatments was included in the data as well. However, these categories' values were all combined to look at hours per year. Despite having these problems, the data was able to be transformed into a manageable dataset.

Results

Literature

a. **Effects of Grassy and Woody Invasion on changing regimes**

A key component of increasing fire risk in Hawaiʻi is the widespread distribution of invasive grasses which contributes to a process known as the grass-fire cycle. This cycle describes the process by which grass allows fires to easily ignite and carry rapidly into wooded or forested areas while the grass provides quick fuel for the fire (Fusco et al., 2021). Research conducted in non-native forests and invasive grasslands on the island of Oahu, Hawaiʻi, shows that grass-invaded habitats reveal a significantly higher predicted fire behavior in comparison to open grasslands (Ellsworth et al., 2014). This is despite a similar fuel moisture and load (2014). A recent study covering various ecoregions in the US revealed that invasive grasses can elevate fire incidence by up to 230% and fire frequency by up to 150% (Fusco et al., 2019). Grass invasion changes fire patterns due to alterations in landscape fuel structure, causing increased fine fuel biomass and heightened flammability (Kerns et al., 2020). When invasive grasses experience quick recovery after a fire, this often leads to increased fuel loads and shorter fire return intervals. Fast recovery fosters a cycle that escalates fire spread, severity, and frequency. Possibly transforming ecosystems from woodlands to grasslands (Kerns et al., 2020).

One aspect of invasive species and fire that the grass-fire cycle does not capture is the potential effects of woody invasive species on increasing fire risk. A study by D’Antonio and Vitousek (1992) showcases the concept of invasion-fire cycles and demonstrates how non-native invasive plants like woody invaders can increase fire intensity by changing fuel properties. Tree and shrub growth contribute to increasing the risk of spot fires (Donovan et al., 2023). Woody vegetation typically causes severe fire behavior, causing flames to reach over 14 meters, making it harder to control and put out fires that spread through the trees. (Donovan et al., 2023). Furthermore, Mack and D’Antonio (1998) and Simberloff (2011) provide key examples that show the broader ecological impacts of woody invaders on fire regimes, changes in community compositions, structures, and ecosystem functions (Mack et al. 1998). Woody species invading grasslands which are higher in moisture leads to suppression of fuel buildup in the understory. In Australian floodplains invaded by *Mimosa pigra* shrubs, fires die out as soon as they reach thickets of this shrub, here understory biomass is lower compared to native shrubs. Similarly, the invasion of *Schinus terebinthifolius*, or pepper tree, of fire-maintained prairies and abandoned farmland in Florida causes dense groups that suppress understory grasses, thus, reducing fire intensity and spread. The residence time of a fire may increase with the presence of woody fuels. This includes the burning of branches or woody debris from trees and shrubs (Shaw et al., 2022).

Crown fires are typically large-scale, and fast-moving, making them difficult to control directly, with a deep flame front (George Neary et al., 2020). While rapid passage through tree crowns may result in minimal soil heating, if there is ample fuel from the forest floor to the crowns, the fire can consume all fuel, leading to substantial soil heating, commonly occurring in forest canopies and dense shrublands (George Neary et al., 2020).

Ecological Impacts and Control of Morella Faya

In Hawaiʻi, Morella faya is taking over native ecosystems without a native nitrogen-fixing plant, which significantly alters the nitrogen balance. Faya invades sites going through primary succession, which were previously dominated by native species. Additionally, faya is a nitrogen-fixing tree that can occupy volcanic soils with fewer nutrients. Faya impacts the nutrient balance in the soils which encourages invasions from alien plants (Vitousek et al., 1987).

Regarding controlling faya, some methods have produced varied results. Then, in September 1997, the Septoria hodgesii fungus was approved to be distributed after being separated from another plant in North Carolina. Leaf damage and stunted growth in the weed are produced by this biocontrol, but its effectiveness in controlling M. faya remains uncertain (Culliney et al., n.d.). Another method to remove Morella faya includes direct uprooting of seedlings and saplings, cutting and spraying the stems with herbicide mixture, and cutting the outer bark (Gardner, n.d.). Currently, HAVO staff are controlling faya trees by cutting and treating larger trees and uprooting seedlings.

Morella faya poses a significant fire risk due to its highly flammable foliage and rapid growth rate, forming dense thickets that serve as fuel for wildfires (Loh et al., 2008). Many nonnative trees can survive fire and increase the number of woody debris, or coarse fuels, which can increase the intensity of the flame which can have greater impacts on ecosystems (Brown, 2003). For instance, the Eurasian Salt cedar is an invasive tree in the United States that drops its branches, accumulating fuel loads that pile up and intensify fires. (Mandle et al, 2011). Control and eradication efforts are often necessary to mitigate the spread and impact of this invasive species in affected regions.

Ecological Impacts and control of Fountain grass

Fountain grass is especially problematic in the National Park as it can spread onto bare lava flows while outcompeting native species (Tunison, n.d.). Seeds can avoid the impact of fires due to their ability to germinate without sunlight. Therefore, the plant returns fairly quickly in contrast to native species (Rowe et al., 2022). These seeds are easily spread across roads and rivers and dispersed by wind, water, animals, and vehicles (Rahlo et al., 2010). Fountain grass seeds found at the surface of the soil are easily damaged by fire, but those buried a few centimeters deep tend to germinate more successfully. Lava flows contain crevices that seeds can fall into, avoiding flames and increasing their chance to regenerate (Adkins et al., 2011).

In a study done in Hawaiʻi by Litton, Sandquist, and Cordell, invasive grasses in a tropical dry forest increased the overall level of carbon in soils (Litton et al., 2008). Carbon availability directly increases the chances of fire, as carbon storage and fire threats are closely correlated (2008). Reducing fires, as suggested by Girod and Frolking et al. (2007), leads to increased carbon storage through the accumulation of woody vegetation and debris. This ultimately fuels fires through a negative feedback loop, causing carbon to accumulate in regions that were previously at low risk for fires (2007).

Fountain grass alters ecosystems by forming dense surface cover that increases fuel loads, contributing to more intense and frequent wildfires. Its invasive nature displaces native vegetation, reducing biodiversity and altering ecosystem structure and function. Changes in fire regimes and ecosystem composition heighten fire risk in affected areas, necessitating effective management strategies to mitigate the spread of fountain grass and restore ecosystem health.

Data Table

A data table (Table 1) consists of the total number of each variable across all the management units over 20 years. The table represents data from the years 2000 to 2021. This includes the chosen variables worker hours, individual plants treated, and herbicide used. Total area was also considered in the study but remained unchanged. Sorting the data this way allows for a transferrable format into a geospatial shapefile of the management units.

The final data table (Table 2) contains the management units with enough faya and fountain grass data to utilize for analysis. Data was separated into individual management units and the efforts of each. The duration of a treatment cycle ranged from 1 day to two years, depending on the size of the area and workforce availability.

Figure 3. The table below shows the management unit Hilina Pali's total working hours. These are the total hours of work put into this unit specifically. Hours are listed per year, per unit.

Site Name&Block Category	SEA Morfray Information	Total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Year Last Treated
HILINAPALI	Total Individuals Treated and uprooted	2141	0	0	722	0	207	0	0	1133	420	0	0	0	0	2856	652	463	7424	122	120	313	1855	4681	2021
	Total Herbicide Use	210	0	0	4400	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0.75	0	0.63	19.805	26.65	
	Total Worker Hours	73.625	0	0	61.5	0	44	0	0	49.3515	46.7812	0	0	0	0	87.3974	16.1875	96	160	48	3	208	594	1078	
	Total Area in Acres	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	
	Area (Acres) per hour	15.668612			18.757749		26.218218			23.375208	24.659512					13.199495	71.264962	12.016683	7.2100099	24.033366	384.53386	5.5461614	1.9420902	1.0701313	
	Stems Per Hour	29.080			11.740		4.705			22.958	8.978					32.678	40.278	4.823	46.400	2.542	40.000	1.505	3.123	4.342	
	Herbicide Per Hour	2.852			71.545		0.000			0.000	0.000					0.034	0.124	0.000	0.000	0.016	0.000	0.003	0.033	0.025	

Figure 4. Hilina Pali's unit stems per hour are highlighted below. These values were calculated from the original recorded variables to use for future analysis. Stems treated are only listed under the years containing nonzero data.

Site Name&Block Category	SEA Morfray Information	Total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Year Last Treated
HILINAPALI	Total Individuals Treated and uprooted	2141	0	0	722	0	207	0	0	1133	420	0	0	0	0	2856	652	463	7424	122	120	313	1855	4681	2021
	Total Herbicide Use	210	0	0	4400	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0.75	0	0.63	19.805	26.65	
	Total Worker Hours	73.625	0	0	61.5	0	44	0	0	49.3515	46.7812	0	0	0	0	87.3974	16.1875	96	160	48	3	208	594	1078	
	Total Area in Acres	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	1153.6016	
	Area (Acres) per hour	15.668612			18.757749		26.218218			23.375208	24.659512					13.199495	71.264962	12.016683	7.2100099	24.033366	384.53386	5.5461614	1.9420902	1.0701313	
	Stems Per Hour	29.080			11.740		4.705			22.958	8.978					32.678	40.278	4.823	46.400	2.542	40.000	1.505	3.123	4.342	
	Herbicide Per Hour	2.852			71.545		0.000			0.000	0.000					0.034	0.124	0.000	0.000	0.016	0.000	0.003	0.033	0.025	

These results will provide a better understanding of the impact of the overall treatments. By obtaining these values, land managers can make better decisions on how to plan the next steps for invasive management practices in the park. Trends point to the alien plants being in the park indefinitely. This is why it is important to learn which techniques work most efficiently while maintaining the ecosystems.

Discussion

Faya and fountain grass have significant impacts on native ecosystems when looking at potential fire risk. Several studies provide evidence of both fountain grass and Morella faya contributing to fire behavior. While there is limited available evidence of faya increasing fire intensity, some studies indicate that higher levels of both native and nonnative woody biomass/cover in ecosystems can elevate fire intensity, exacerbating fire impacts and posing greater risks for firefighters. With conditions such as rapid regeneration and nutrient alterations, both plants have tendencies to become fire-promoting invaders. Grasses like fountain grass allow for quick ignition of flames to spread into woodlands where faya are present. The outputs from this study seek to provide support to park managers to make decisions regarding their future management plans.

Data organization and collection are a big part of scientific monitoring. Table 2 can be used for various statistical analyses. Park staff will be able to look at trends across the 20 years and draw conclusions on the efforts worked. Linking these key variables together can provide an idea of the effectiveness of the treatments. Trend lines can be drawn to piece together a treatment history which can be applied to the current conditions of plant dispersion, as seen in Figure 3. The national park is currently using an updated geospatially linked data collection system in ArcGIS Online to track invasive management. The data table will support past years' efforts to guide managers. One thing to note is that there are different ecological regions among the management units. Among the management units, they are located in the rainforest, dry ʻŌhiʻa woodland, and dry-mesic ʻŌhiʻa woodland. Each has its characteristics which affect the treatments they receive. When looking at options for analysis, varying total areas and ecosystem characteristics play a key role.

While several sources detail the ecological effects of fountain grass and faya, there is limited information on the effects on fire risk long term. Knowing these impacts over time can aid in the management of invasives. The more we know about these alien grasses and tree patterns, we can find ways to create ideal environments. Encouraging the growth of native species will create an ecosystem that can build resilience to natural disasters, such as fire. Supporting invasive species monitoring at HAVO and how it can help with cases in similar situations. Further studies need to be done concerning the management of both faya and fountain grass.

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Appendix

Table 1. Total values for each variable per year in all management units.

	Total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total Individuals Treated and uprooted	307819	740	19097	11508	15718	10249	25421	16591	13468	6817	20308	6708	30212	7736	11067	28430	10373	32266	2008	485	18799	11958	7860
Total Herbicide Used	394852.04	734	183311.8	173037	26232	9010.8	5.3	719	0	0	0	130.25	0	0	526.3	421.09	70.85	8.53	87.777	104.98	359.91	50.418	43.075
Total Worker Hours	19853.53	51	434.5	565.4	498.4	484.55	923.68	433.52	476.45	364.34	389.59	292.2	435.62	404.44	547.9	1315.3	1482.7	2497.5	466	206	2672.5	2707.5	2204.5
Total Area in Acres	18875.975	18876	18875.98	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876	18876

Table 2. Final table containing variables by management unit data per year.

Site Name&Block Category	SEA Morfray Information	Total	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Year Last Treated
AINAHOUNORTH	Total Individuals Treated and uprooted	2141	312	0	200	0	412	0	547	0	0	670	0	0	0	0	0	0	0	0	0	0	0	0	2009
	Total Herbicide Use	210	100	0	110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	73.625	13	0	14.5	0	16	0	15	0	0	15.125	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Area in Acres	46.996876	46.997	46.99688	46.9969	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	46.997	
	Area (Acres) per hour	0.6383277	3.6151		3.24116		2.9373		3.1331			3.1072													
	Stems Per Hour	29.080	24.000		13.793		25.750		36.467			44.298													
	Herbicide Per Hour	2.852	7.692		7.586		0.000		0.000			0.000													
HILINAPALIEXPNEW	Total Individuals Treated and uprooted	1591	0	0	0	0	199	0	0	0	0	0	244	0	339	809	0	0	0	0	0	0	0	0	2013
	Total Herbicide Use	5.8	0	0	0	0	5.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	169.5125	0	0	0	0	14	0	0	0	0	0	17.125	0	38.288	100.1	0	0	0	0	0	0	0	0	
	Total Area in Acres	2054.114	2054.1	2054.114	2054.11	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	2054.1	
	Area (Acres) per hour	12.117773					146.72						119.95		53.65	20.521									
	Stems Per Hour	9.386					14.214						14.248		8.854	8.082									
	Herbicide Per Hour	0.034					0.414						0.000		0.000	0.000									
HILINAPALINORTHEXP	Total Individuals Treated and uprooted	4186	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1690	538	1448	0	0	0	0	510	2021
	Total Herbicide Use	6.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	6.2	
	Total Worker Hours	1018.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	368.5	155	290	0	0	0	0	205	
	Total Area in Acres	2279.865	2279.9	2279.865	2279.87	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	2279.9	
	Area (Acres) per hour	2.2384536															6.1869	14.709	7.8616					11.121	
	Stems Per Hour	4.110															4.586	3.471	4.993					2.488	
	Herbicide Per Hour	0.006															0.000	0.000	0.000					0.030	

HILINAPALISOUTHEXP	Total Individuals Treated and uprooted	5023	0	523	340	277	57	0	0	287	443	0	819	0	0	246	1685	229	0	117	0	0	0	0	2017
	Total Herbicide Use	1107.725	0	0	1000	106.5	0	0	0		0	0	0	0	0	0	0	0	0	1.225	0	0	0	0	
	Total Worker Hours	745.3408	0	55	22	59.5	13.836	0	0	14	41.75	0	32.555	0	0	12.5	263	107.2	3	110	11	0	0	0	
	Total Area in Acres	493.34814	493.35	493.3481	493.348	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	493.35	
	Area (Acres) per hour	0.6619095		8.969966	22.4249	8.2916	35.657			35.239	11.817		15.154			39.468	1.8758	4.6021	164.45	4.485	44.85				
	Stems Per Hour	6.739		9.509	15.455	4.655	4.120			20.500	10.611		25.158			19.680	6.407	2.136	0.000	1.064	0.000				
	Herbicide Per Hour	1.486		0.000	45.455	1.790	0.000			0.000	0.000		0.000			0.000	0.000	0.000	0.000	0.011	0.000				
HILINAPALI	Total Individuals Treated and uprooted	20968	0	0	722	0	207	0	0	1133	420	0	0	0	0	2856	652	463	7424	122	120	313	1855	4681	2021
	Total Herbicide Use	4452.835	0	0	4400	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0.75	0	0.63	19.805	26.65	
	Total Worker Hours	2492.2176	0	0	61.5	0	44	0	0	49.352	46.781	0	0	0	0	87.397	16.188	96	160	48	3	208	594	1078	
	Total Area in Acres	1153.6016	1153.6	1153.602	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	1153.6	
	Area (Acres) per hour	0.4628816			18.7577		26.218			23.375	24.66					13.199	71.265	12.017	7.21	24.033	384.53	5.5462	1.9421	1.0701	
	Stems Per Hour	8.413			11.740		4.705			22.958	8.978					32.678	40.278	4.823	46.400	2.542	40.000	1.505	3.123	4.342	
	Herbicide Per Hour	1.787			71.545		0.000			0.000	0.000					0.034	0.124	0.000	0.000	0.016	0.000	0.003	0.033	0.025	
KahaliiNorth	Treated and uprooted	5576	0	1374	473	0	0	682	0	0	537	0	0	348	0	0	0	0	2162	0	0	0	0	0	2016
	Total Herbicide Use	5308.5	0	1300	4000	0	0	0	0	0	0	0	0	0	0	0	0	0	8.5	0	0	0	0	0	
	Total Worker Hours	250.625	0	10	14	0	0	34.25	0	0	31.875	0	0	27.5	0	0	0	0	133	0	0	0	0	0	
	Total Area in Acres	228.97925	228.98	228.9793	228.979	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	228.98	
	Area (Acres) per hour	0.9136329		22.89793	16.3557			6.6855			7.1837			8.3265					1.7216						
	Stems Per Hour	22.248		137.400	33.786			19.912			16.847			12.655					16.256						
	Herbicide Per Hour	21.181		130.000	285.714			0.000			0.000			0.000					0.064						

KahaliiSouth	Total Individuals Treated and uprooted	11990	0	8250	591	0	0	397	0	0	146	0	0	0	159	0	0	0	2447	0	0	0	0	0	2016
	Total Herbicide Use	4090	0	4000	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	338.9374	0	22	29	0	0	37.375	0	0	19.5	0	0	0	27.062	0	0	0	204	0	0	0	0	0	
	Total Area in Acres	244.37405	244.37	244.374	244.374	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	244.37	
	Area (Acres) per hour	0.7210005		11.10791	8.42669			6.5384			12.532				9.03				1.1979						
	Stems Per Hour	35.375		375.000	20.379			10.622			7.487				5.875				11.995						
	Herbicide Per Hour	12.067		181.818	3.103			0.000			0.000				0.000				0.000						
KAHALIINORTHEXP	Total Individuals Treated and uprooted	6831	0	0	3262	0	0	0	0	0	0	0	0	3569	0	0	0	0	0	0	0	0	0	0	2011
	Total Herbicide Use	4020.75	0	0	4020.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	121.375	0	0	58.5	0	0	0	0	0	0	0	0	62.875	0	0	0	0	0	0	0	0	0	0	
	Total Area in Acres	41.899305	41.899	41.89931	41.8993	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	41.899	
	Area (Acres) per hour	0.3452054			0.71623									0.6664											
	Stems Per Hour	56.280			55.761									56.763											
	Herbicide Per Hour	33.127			68.731									0.000											
KAHALIISOUTHEXP	Total Individuals Treated and uprooted	128	0	0	0	0	0	0	21	0	107	0	0	0	0	0	0	0	0	0	0	0	0	0	2008
	Total Herbicide Use	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	27.25	0	0	0	0	0	0	10	0	17.25	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Area in Acres	289.69039	289.69	289.6904	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	289.69	
	Area (Acres) per hour	10.63084							28.969		16.794														
	Stems Per Hour	4.697							2.100		6.203														
	Herbicide Per Hour	0.000							0.000		0.000														

KAHUESOUTH	Total Individuals Treated and uprooted	7851	0	0	0	233	2235	1687	342	1440	745	1153	0	16	0	0	0	0	0	0	0	0	0	0	2011
	Total Herbicide Use	7005.3	0	0	0	0	7000	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	516.3124	0	0	0	12	170.3	153.45	26.438	68.125	52.063	33.375	0	0.5625	0	0	0	0	0	0	0	0	0	0	
	Total Area in Acres	288.22229	288.22	288.2223	288.222	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	288.22	
	Area (Acres) per hour	0.5582324				24.019	1.6925	1.8782	10.902	4.2308	5.5361	8.6359		512.4											
	Stems Per Hour	15.206				19.417	13.124	10.994	12.936	21.138	14.310	34.547		28.444											
	Herbicide Per Hour	13.568				0.000	41.105	0.035	0.000	0.000	0.000	0.000		0.000											
KEAMOKU4A	Total Individuals Treated and uprooted	16111	0	228	42	29	0	43	0	520	0	0	0	1028	81	414	4958	4271	1451	1457	0	1589	0	0	2019
	Total Herbicide Use	2710.57	0	2571	100	25	0	0	0	0	0	0	0	0	0	2.5	5.1	0	0	5.5	0	1.47	0	0	
	Total Worker Hours	1149.2216	0	28.5	7	7.125	0	42.625	0	20.5	0	0	0	28.125	16.413	40.475	166.96	294	137.5	210	0	150	0	0	
	Total Area in Acres	2510.6286	2510.6	2510.629	2510.63	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	2510.6	
	Area (Acres) per hour	2.184634		88.09223	358.661	352.37		58.9		122.47				89.267	152.97	62.029	15.037	8.5396	18.259	11.955		16.738			
	Stems Per Hour	14.019		8.000	6.000	4.070		1.009		25.366				36.551	4.935	10.229	29.696	14.527	10.553	6.938		10.593			
	Herbicide Per Hour	2.359		90.211	14.286	3.509		0.000		0.000				0.000	0.000	0.062	0.031	0.000	0.000	0.026		0.010			
KEAMOKU4B	Total Individuals Treated and uprooted	16405	55	107	0	54	0	0	0	0	0	209	0	280	485	0	6635	0	8580	0	0	0	0	0	2016
	Total Herbicide Use	217.74	100	70	0	41	0	0	0	0	0	0	0	0	0	0	6.74	0	0	0	0	0	0	0	
	Total Worker Hours	1172.7733	0	10	0	13.125	0	0	0	0	0	11.25	0	18.875	34.023	0	155.75	0	929.75	0	0	0	0	0	
	Total Area in Acres	2959.6125	2959.6	2959.613	2959.61	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	2959.6	
	Area (Acres) per hour	2.5236016		295.9613		225.49						263.08		156.8	86.988		19.002		3.1832						
	Stems Per Hour	13.988		10.700		4.114						18.578		14.834	14.255		42.600		9.228						
	Herbicide Per Hour	0.186		7.000		3.124						0.000		0.000	0.000		0.043		0.000						

KEAMOKU4C	Total Individuals Treated and uprooted	7599	2	0	0	8	0	0	0	0	0	0	0	415	922	0	2532	0	3720	0	0	0	0	0	2016
	Total Herbicide Use	9.925	4	0	0	1	0	0	0	0	0	0	0	0	0	0	4.925	0	0	0	0	0	0	0	
	Total Worker Hours	364.2653	2	0	0	4	0	0	0	0	0	0	0	13.25	33.125	0	55.391	0	256.5	0	0	0	0	0	
	Total Area in Acres	3354.6118	3354.6	3354.612	3354.61	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	3354.6	
	Area (Acres) per hour	9.2092542	1677.3			838.65								253.18	101.27		60.563		13.078						
	Stems Per Hour	20.861	1.000			2.000								31.321	27.834		45.712		14.503						
	Herbicide Per Hour	0.027	2.000			0.250								0.000	0.000		0.089		0.000						
KEANAKAKOIEAST	Total Individuals Treated and uprooted	50456	0	0	0	2410	0	14821	934	5718	1262	11526	3615	7655	1631	0	0	884	0	0	0	0	0	0	2015
	Total Herbicide Use	1804	0	0	0	1800	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	
	Total Worker Hours	515.7187	0	0	0	8	0	101.7	10.125	25.25	6.75	99.75	67.519	26.813	9.8125	0	0	160	0	0	0	0	0	0	
	Total Area in Acres	162.65584	162.66	162.6558	162.656	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	162.66	
	Area (Acres) per hour	0.3153964				20.332		1.5994	16.065	6.4418	24.097	1.6306	2.409	6.0664	16.576			1.0166							
	Stems Per Hour	97.836				301.250		145.733	92.247	226.455	186.963	115.549	53.541	285.501	166.217			5.525							
	Herbicide Per Hour	3.498				225.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			0.025							
MAUNAULU2	Total Individuals Treated and uprooted	16570	0	0	0	0	0	0	0	0	0	0	345	15015	0	0	0	894	316	0	0	0	0	0	2016
	Total Herbicide Use	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	
	Total Worker Hours	247.75	0	0	0	0	0	0	0	0	0	0	8.625	125.13	0	0	0	42	72	0	0	0	0	0	
	Total Area in Acres	173.82143	173.82	173.8214	173.821	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	173.82	
	Area (Acres) per hour	0.7016001											20.153	1.3892				4.1386	2.4142						
	Stems Per Hour	66.882											40.000	120.000				21.286	4.389						
	Herbicide Per Hour	0.012											0.000	0.000				0.071	0.000						

PUAULUBUFFER1	Total Individuals Treated and uprooted	5349	0	576	472	72	0	596	40	680	992	21	127	510	436	257	179	0	391	0	0	0	0	0	2016
	Total Herbicide Use	4931.5	0	100	4800	30	0	0	0	0	0	0	0	0	0	1.4	0.1	0	0	0	0	0	0	0	
	Total Worker Hours	351.5668	0	25	19	5.125	0	31.375	20.25	28.813	30.195	15.5	22.116	21.375	22.359	8.8337	21.625	0	80	0	0	0	0	0	
	Total Area in Acres	176.26602	176.27	176.266	176.266	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	176.27	
	Area (Acres) per hour	0.5013728		7.050641	9.27716	34.393		5.6181	8.7045	6.1177	5.8376	11.372	7.97	8.2464	7.8833	19.954	8.151		2.2033						
	Stems Per Hour	15.215		23.040	24.842	14.049		18.996	1.975	23.601	32.853	1.355	5.742	23.860	19.500	29.093	8.277		4.888						
	Herbicide Per Hour	14.027		4.000	252.632	5.854		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.158	0.005		0.000						
PUAULUBUFFER10	Total Individuals Treated and uprooted	4293	122	146	228	76	0	411	0	462	0	388	123	50	153	279	248	0	26	0	0	1581	0	0	2019
	Total Herbicide Use	8661.565	325	230	8000	100	0	0	0	0	0	0	0	0	0	0	0.21	0	0	0	0	6.355	0	0	
	Total Worker Hours	663.492	12	9	58	4.5	0	34.813	0	54.563	0	15.875	11.5	3.4687	13.961	27.875	18.437	0	60	0	0	339.5	0	0	
	Total Area in Acres	212.18908	212.19	212.1891	212.189	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	212.19	
	hour	0.3198065	17.682	23.57656	3.65843	47.153		6.0952		3.8889		13.366	18.451	61.173	15.199	7.6122	11.509		3.5365			0.625			
	Stems Per Hour	6.470	10.167	16.222	3.931	16.889		11.806		8.467		24.441	10.696	14.415	10.959	10.009	13.451		0.433			4.657			
	Herbicide Per Hour	13.055	27.083	25.556	137.931	22.222		0.000		0.000		0.000	0.000	0.000	0.000	0.000	0.011		0.000			0.019			
PUAULUBUFFER2	Total Individuals Treated and uprooted	1114	0	0	0	0	0	108	0	119	0	0	50	55	0	128	494	0	114	0	0	46	0	0	2019
	Total Herbicide Use	0.535	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.45	0	0.03	0	0	0.055	0	0	
	Total Worker Hours	143.4749	0	0	0	0	0	2.175	0	9.125	0	0	6.4874	0	0	12.375	10.313	0	48	0	0	55	0	0	
	Total Area in Acres	43.927381	43.927	43.92738	43.9274	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	43.927	
	Area (Acres) per hour	0.3061677						20.196		4.814			6.7712			3.5497	4.2596		0.9152			0.7987			
	Stems Per Hour	7.764						49.655		13.041			7.707			10.343	47.903		2.375			0.836			
	Herbicide Per Hour	0.004						0.000		0.000			0.000			0.000	0.044		0.001			0.001			

PUAULUBUFFER3	Total Individuals Treated and uprooted	4701	126	0	56	51	278	225	0	203	0	925	0	57	123	0	248	0	0	0	0	2409	0	0	2019
	Total Herbicide Use	27188.57	130	0	27000	50	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	8.07	0	0	
	Total Worker Hours	879.2149	12	0	27	5	28	51.75	0	33.438	0	44.313	0	22.813	27.25	0	21.652	0	0	0	0	606	0	0	
	Total Area in Acres	354.39066	354.39	354.3907	354.391	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	354.39	
	Area (Acres) per hour	0.4030763	29.533		13.1256	70.878	12.657	6.8481		10.599		7.9975		15.535	13.005		16.367					0.5848			
	Stems Per Hour	5.347	10.500		2.074	10.200	9.929	4.348		6.071		20.874		2.499	4.514		11.454					3.975			
	Herbicide Per Hour	30.924	10.833		1000.000	10.000	0.000	0.000		0.000		0.000		0.000	0.000		0.023					0.013			
PUAULUBUFFER4	Total Individuals Treated and uprooted	2290	0	25	35	36	0	143	0	48	16	80	34	76	1643	18	59	0	37	0	0	40	0	0	2019
	Total Herbicide Use	50.07	0	30	0	20	0	0	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0.01	0	0	
	Total Worker Hours	270.7003	0	5	9	4.5	0	22.364	0	8.125	8.25	4.8125	13.055	9.5	69.719	11.125	11.25	0	30	0	0	64	0	0	
	Total Area in Acres	100.89665	100.9	100.8966	100.897	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	100.9	
	hour	0.3727246		20.17933	11.2107	22.421		4.5115		12.418	12.23	20.966	7.7286	10.621	1.4472	9.0694	8.9686		3.3632			1.5765			
	Stems Per Hour	8.460		5.000	3.889	8.000		6.394		5.908	1.939	16.623	2.604	8.000	23.566	1.618	5.244		1.233			0.625			
	Herbicide Per Hour	0.185		6.000	0.000	4.444		0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005		0.000			0.000			
PUAULUBUFFER5A	Total Individuals Treated and uprooted	19828	0	87	0	1075	0	897	0	889	143	698	763	42	253	3557	0	0	0	0	0	11424	0	0	2019
	Total Herbicide Use	489.66	0	30	0	420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39.66	0	0	
	Total Worker Hours	1204.3608	0	15	0	81.4	0	29.188	0	22.5	3.3515	10.688	29.375	6.7187	14.266	30.875	0	0	0	0	0	961	0	0	
	Total Area in Acres	228.61885	228.62	228.6189	228.619	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	228.62	
	Area (Acres) per hour	0.1898259		15.24126		2.8086		7.8328		10.161	68.214	21.391	7.7828	34.027	16.026	7.4047						0.2379			
	Stems Per Hour	16.464		5.800		13.206		30.732		39.511	42.667	65.310	25.974	6.251	17.735	115.206						11.888			
	Herbicide Per Hour	0.407		2.000		5.160		0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000						0.041			

PUAULUBUFFER5B	Total Individuals Treated and uprooted	18309	0	663	308	1210	0	1110	578	802	796	583	0	167	256	0	7511	0	2448	0	0	1077	0	800	2019
	Total Herbicide Use	7520.805	0	230	120	6865	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	302.81	0	2.75	
	Total Worker Hours	548.2857	0	15	8	31.125	0	30.063	20.125	21.969	8.125	24.125	0	4.6875	18.523	0	27.844	0	25.7	0	0	173	0	140	
	Total Area in Acres	117.24498	117.24	117.245	117.245	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	117.24	
	Area (Acres) per hour	0.2138392		7.816332	14.6556	3.7669		3.9	5.8258	5.3369	14.43	4.8599		25.012	6.3296		4.2108		4.5621			0.6777		0.8375	
	Stems Per Hour	33.393		44.200	38.500	38.876		36.923	28.720	36.507	97.969	24.166		35.627	13.820		269.756		95.253			6.225		5.714	
	Herbicide Per Hour	13.717		15.333	15.000	220.562		0.000	0.000	0.000	0.000	0.000		0.000	0.000		0.009		0.000			1.750		0.020	
PUAULUBUFFER6	Total Individuals Treated and uprooted	4566	0	200	0	0	0	550	892	235	0	753	173	0	553	653	237	0	0	0	0	320	0	0	2019
	Total Herbicide Use	920.08	0	200	0	0	0	0	719	0	0	0	0	0	0	0	0.23	0	0	0	0	0.85	0	0	
	Total Worker Hours	439.3498	0	15	0	0	0	40.291	20.672	5.0625	0	45.75	40.37	0	9.0468	38.845	108.31	0	0	0	0	116	0	0	
	Total Area in Acres	58.423747	58.424	58.42375	58.4237	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	58.424	
	Area (Acres) per hour	0.1329777		3.894916				1.45	2.8263	11.54		1.277	1.4472		6.4579	1.504	0.5394					0.5037			
	Stems Per Hour	10.393		13.333				13.651	43.151	46.420		16.459	4.285		61.127	16.810	2.188					2.759			
	Herbicide Per Hour	2.094		13.333				0.000	34.782	0.000		0.000	0.000		0.000	0.000	0.002					0.007			
PUAULUBUFFER7	Treated and uprooted	3824	123	733	0	213	0	830	0	123	3	0	0	123	0	0	497	292	887	0	0	0	0	0	2016
	Total Herbicide Use	365.06	75	250	0	40	0	0	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0	0	
	Total Worker Hours	227.2639	12	9.5	0	21.5	0	28.359	0	5.625	3.0296	0	0	9.625	0	0	5.625	100	32	0	0	0	0	0	
	Total Area in Acres	300.84309	300.84	300.8431	300.843	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	300.84	
	Area (Acres) per hour	1.323761	25.07	31.66769		13.993		10.608		53.483	99.301			31.256			53.483	3.0084	9.4013						
	Stems Per Hour	16.826	10.250	77.158		9.907		29.267		21.867	0.990			12.779			88.356	2.920	27.719						
	Herbicide Per Hour	1.606	6.250	26.316		1.860		0.000		0.000	0.000			0.000			0.011	0.000	0.000						

PUAULUBUFFER9	Total Individuals Treated and uprooted	2249	0	0	0	0	0	0	132	0	5	0	379	154	180	287	297	0	815	0	0	0	0	0	2016
	Total Herbicide Use	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	
	Total Worker Hours	83.2741	0	0	0	0	0	0	5	0	0.1715	0	11.22	0	5.1953	4.0625	21.625	0	36	0	0	0	0	0	
	Total Area in Acres	20.4347	20.435	20.4347	20.4347	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	20.435	
	Area (Acres) per hour	0.2453908							4.0869		119.15		1.8213		3.9333	5.0301	0.945		0.5676						
	Stems Per Hour	27.007							26.400		29.155		33.780		34.647	70.646	13.734		22.639						
	Herbicide Per Hour	0.001							0.000		0.000		0.000		0.000	0.000	0.005		0.000						
PUAULUBUFFERK4	Treated and uprooted	2959	0	0	873	0	0	0	420	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1664	2021
	Total Herbicide Use	11632.475	0	0	11625	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.475	
	Total Worker Hours	783.5625	0	0	48	0	0	0	32.875	0	0	0	0	0	0	17.188	0	0	0	0	0	0	0	685.5	
	Total Area in Acres	386.38993	386.39	386.3899	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	386.39	
	Area (Acres) per hour	0.4931195			8.04979				11.753							22.481								0.5637	
	Stems Per Hour	3.776			18.188				12.776							0.116								2.427	
	Herbicide Per Hour	14.846			242.188				0.000							0.000								0.011	
PUAULU	Total Individuals Treated and uprooted	10308	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10103	205	2021
	Total Herbicide Use	30.6125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30.613	0	
	Total Worker Hours	2209.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2113.5	96	
	Total Area in Acres	230.78112	230.78	230.7811	230.781	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	230.78	
	Area (Acres) per hour	0.1044495																					0.1092	2.404	
	Stems Per Hour	4.665																					4.780	2.135	
	Herbicide Per Hour	0.014																					0.014	0.000	

THURSTON1	Total Individuals Treated and uprooted	590	0	0	74	0	0	132	0	0	65	0	0	0	0	319	0	0	0	0	0	0	0	0	2013
	Total Herbicide Use	823	0	0	823	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	60.0625	0	0	6	0	0	34	0	0	14.125	0	0	0	0	5.9375	0	0	0	0	0	0	0	0	
	Total Area in Acres	19.989217	19.989	19.98922	19.9892	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	19.989	
	Area (Acres) per hour	0.332807			3.33154			0.5879			1.4152					3.3666									
	Stems Per Hour	9.823			12.333			3.882			4.602					53.726									
	Herbicide Per Hour	13.702			137.167			0.000			0.000					0.000									
THURSTON10	Total Individuals Treated and uprooted	1429	0	0	512	0	0	370	0	0	19	95	0	0	0	433	0	0	0	0	0	0	0	0	2013
	Total Herbicide Use	140.72	0	0	140.72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	67.7125	0	0	15.9	0	0	15.125	0	0	7	11.25	0	0	0	18.438	0	0	0	0	0	0	0	0	
	Total Area in Acres	12.775485	12.775	12.77549	12.7755	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	12.775	
	Area (Acres) per hour	0.1886725			0.80349			0.8447			1.8251	1.1356				0.6929									
	Stems Per Hour	21.104			32.201			24.463			2.714	8.444				23.485									
	Herbicide Per Hour	2.078			8.850			0.000			0.000	0.000				0.000									
THURSTON15	Total Individuals Treated and uprooted	582	0	0	104	0	0	0	0	413	0	0	36	0	0	29	0	0	0	0	0	0	0	0	2013
	Total Herbicide Use	20125.75	0	0	19995.5	0	0	0	0	0	0	0	130.25	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	197	0	0	31.5	0	0	0	0	89.5	0	0	32.25	0	0	43.75	0	0	0	0	0	0	0	0	
	Total Area in Acres	14.718227	14.718	14.71823	14.7182	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	14.718	
	Area (Acres) per hour	0.0747118			0.46725					0.1644			0.4564			0.3364									
	Stems Per Hour	2.954			3.302					4.615			1.116			0.663									
	Herbicide Per Hour	102.161			634.778					0.000			4.039			0.000									

THURSTON16	Total Individuals Treated and uprooted	13360	0	0	0	2709	4504	1077	0	396	67	1569	0	10	226	0	0	2802	0	0	0	0	0	0	2015
	Total Herbicide Use	7868.85	0	0	0	5800	2005	0	0	0	0	0	0	0	0	0	0	63.85	0	0	0	0	0	0	
	Total Worker Hours	763.8765	0	0	0	50	68.625	29.338	0	20.5	3.5625	36.094	0	11.563	15.695	0	0	528.5	0	0	0	0	0	0	
	Total Area in Acres	43.035248	43.035	43.03525	43.0352	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	43.035	
	Area (Acres) per hour	0.056338				0.8607	0.6271	1.4669		2.0993	12.08	1.1923		3.722	2.7419			0.0814							
	Stems Per Hour	17.490				54.180	65.632	36.711		19.317	18.807	43.470		0.865	14.399			5.302							
	Herbicide Per Hour	10.301				116.000	29.217	0.000		0.000	0.000	0.000		0.000	0.000			0.121							
THURSTON18	Total Individuals Treated and uprooted	7105	0	370	226	433	2357	460	1747	0	0	0	0	642	270	0	0	0	0	245	355	0	0	0	2018
	Total Herbicide Use	248539.18	0	174300	67308	6800	0	0	0	0	0	0	0	0	0	0	0	0	0	50.2	80.975	0	0	0	
	Total Worker Hours	804.9686	0	120.5	70	17	129.8	37.75	121.13	0	0	0	0	42.75	35.047	0	0	0	0	81	150	0	0	0	
	Total Area in Acres	74.499237	74.499	74.49924	74.4992	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	74.499	
	Area (Acres) per hour	0.0925492		0.618251	1.06427	4.3823	0.574	1.9735	0.6151					1.7427	2.1257					0.9197	0.4967				
	Stems Per Hour	8.826		3.071	3.229	25.471	18.159	12.185	14.423					15.018	7.704					3.025	2.367				
	Herbicide Per Hour	308.756		1446.473	961.543	400.000	0.000	0.000	0.000					0.000	0.000					0.620	0.540				
THURSTON19	Total Individuals Treated and uprooted	26979	0	5815	1967	6832	0	0	10794	0	0	1571	0	0	0	0	0	0	0	0	0	0	0	0	2009
	Total Herbicide Use	20133.75	0	0.75	16000	4133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	412.9375	0	95	30	170	0	0	112.88	0	0	5.0625	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Area in Acres	72.755518	72.756	72.75552	72.7555	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	72.756	
	Area (Acres) per hour	0.1761901		0.765848	2.42518	0.428			0.6446			14.371													
	Stems Per Hour	65.334		61.211	65.567	40.188			95.628			310.321													
	Herbicide Per Hour	48.757		0.008	533.333	24.312			0.000			0.000													

THURSTON2	Total Individuals Treated and uprooted	710	0	0	124	0	0	113	0	0	195	3	0	0	0	275	0	0	0	0	0	0	0	0	2013
	Total Herbicide Use	25.6	0	0	25.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	65.2812	0	0	6	0	0	15.125	0	0	26.5	0	0	0	0	17.656	0	0	0	0	0	0	0	0	
	Total Area in Acres	7.2707486	7.2707	7.270749	7.27075	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	7.2707	
	Area (Acres) per hour	0.1113758			1.21179			0.4807			0.2744					0.4118									
	Stems Per Hour	10.876			20.667			7.471			7.358					15.575									
	Herbicide Per Hour	0.392			4.267			0.000			0.000					0.000									
THURSTON20	Total Individuals Treated and uprooted	765	0	0	0	0	0	261	144	0	0	0	0	0	0	360	0	0	0	0	0	0	0	0	2013
	Total Herbicide Use	497.8	0	0	0	0	0	0	0	0	0	0	0	0	0	497.8	0	0	0	0	0	0	0	0	
	Total Worker Hours	212.3918	0	0	0	4.5	0	108.94	39.031	0	0	0	0	0	0	59.923	0	0	0	0	0	0	0	0	
	Total Area in Acres	24.686182	24.686	24.68618	24.6862	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	24.686	
	Area (Acres) per hour	0.1162295				5.4858		0.2266	0.6325							0.412									
	Stems Per Hour	3.602				0.000		2.396	3.689							6.008									
	Herbicide Per Hour	2.344				0.000		0.000	0.000							8.307									
THURSTON3	Total Individuals Treated and uprooted	908	0	0	172	0	0	197	0	0	418	0	0	0	0	121	0	0	0	0	0	0	0	0	2013
	Total Herbicide Use	2559	0	0	2537.4	0	0	0	0	0	0	0	0	0	0	21.6	0	0	0	0	0	0	0	0	
	Total Worker Hours	51.2975	0	0	8.5	0	0	14.25	0	0	22.063	0	0	0	0	6.485	0	0	0	0	0	0	0	0	
	Total Area in Acres	24.554847	24.555	24.55485	24.5548	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	24.555	
	Area (Acres) per hour	0.4786753			2.88881			1.7231			1.113					3.7864									
	Stems Per Hour	17.701			20.235			13.825			18.946					18.658									
	Herbicide Per Hour	49.885			298.518			0.000			0.000					3.331									

THURSTON6	Total Individuals Treated and uprooted	805	0	0	470	0	0	65	0	0	215	55	0	0	0	0	0	0	0	0	0	0	0	0	2009
	Total Herbicide Use	915	0	0	915	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	59.625	0	0	15	0	0	14.25	0	0	14	16.375	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Area in Acres	17.62975	17.63	17.62975	17.6298	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	17.63	
	Area (Acres) per hour	0.2956772			1.17532			1.2372			1.2593	1.0766													
	Stems Per Hour	13.501			31.333			4.561			15.357	3.359													
	Herbicide Per Hour	15.346			61.000			0.000			0.000	0.000													
THURSTON9	Total Individuals Treated and uprooted	735	0	0	257	0	0	246	0	0	223	9	0	0	0	0	0	0	0	0	0	0	0	0	2009
	Total Herbicide Use	25.56	0	0	25.56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Worker Hours	30.375	0	0	7	0	0	15.125	0	0	8	0.25	0	0	0	0	0	0	0	0	0	0	0	0	
	Total Area in Acres	11.090285	11.09	11.09029	11.0903	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	11.09	
	Area (Acres) per hour	0.3651123			1.58433			0.7332			1.3863	44.361													
	Stems Per Hour	24.198			36.714			16.264			27.875	36.000													
	Herbicide Per Hour	0.841			3.651			0.000			0.000	0.000													
THURSTONPIPELINE	Total Individuals Treated and uprooted	635	0	0	0	0	0	0	0	0	0	0	0	0	26	24	508	0	0	67	10	0	0	0	2018
	Total Herbicide Use	454.462	0	0	0	0	0	0	0	0	0	0	0	0	0	0	400.36	0	0	30.102	24	0	0	0	
	Total Worker Hours	120.5311	0	0	0	0	0	0	0	0	0	0	0	0	14.656	4.0625	42.812	0	0	17	42	0	0	0	
	Total Area in Acres	40.143419	40.143	40.14342	40.1434	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	40.143	
	Area (Acres) Per hour	0.3330544													2.739	9.8815	0.9377			2.3614	0.9558				
	Stems Per Hour	5.268													1.774	5.908	11.866			3.941	0.238				
	Herbicide Per Hour	3.770													0.000	0.000	9.351			1.771	0.571				

Figure 3. Line graph illustrating Keamoku4A Management Unit totals per year of each variable