Flammability of Native Versus Non-Native Grasses In Hawaii

Research Question

How do native (Pili Grass, Oahu Sedge, Mau'u'aki'aki) versus non-native (Natal Grass, Witch Grass, Feather-Fingered Grass) grasses compare in the set categories of flammability: ignition, sustainability and combustion.

Introduction

On August 8, 2023, the Maui Fire, with 3.2 billion dollars in property damage and 100 deaths (Hassan 2024), was a record-breaking disaster. An abnormally wet winter, followed by a drought summer created a tinderbox of dead, non-native grasses; this was a crucial contributor to the destruction on Maui. These non-native grasses were originally brought to Hawaii for cattle farming as the native grasses were insufficient in nutrients and resilience. Although an innovative idea in the past, non-native grasses have created an issue with the fires it has fueled. To establish flammability, it has been defined by three categories: ignitability, sustainability, and combustibility (Simpson et al. 2015). Ignitibility is the time between the application of heat and a flame appearing. Sustainability is the amount of time a fire burns, the total flame time the fuel of a plant can produce. Combustibility is the intensity of the burning process. These areas of flammability are used around the world to measure a plants' fire potential (Simpson et al. 2015). This experiment is centered around finding an alternative for non-native grasses as the State of Hawaii begins replanting efforts.

Independent Variable: All grasses burned throughout this experiment (Pili Grass, Oahu Sedge, Mau'u'aki'aki, Witch Grass, Natal Grass, Feather-Fingered Grass).

Dependent Variable: The flammability of such grasses, measured with ignition and sustainability (combustibility was not measured)

Definitions

Native Grasses: A grass that is a grass that is indigenous to a specific region, country, or continent.

Non-Native Grasses: Grass species that have not existed historically in one area but have been introduced due to human activities.

Flammability: A combination of the areas: ignition, sustainability, and combustibility.

- **Ignition**: "The ease of ignition" (Simpson et. al, 2015). In this context, the time (in seconds) between an object being exposed to heat and the appearance of a flame.
- **Sustainability**: "The maintenance of burning over time" (Simpson et. al 2015). This total time a flame is alive, the time of burning.
- **Combustibility**: "The intensity of combustion (burning)" (Simpson et al., 2015). Meaning the heat, speed, etc., all factors related to intensity of total flammability process. *NO DATA ON COMBUSTION

Methods

Safety Precautions: A readied fire extinguisher, a filled water bowl (to extinguish grass remains), the use of tongs (metal) and mitts to prevent burn, adult supervision always, closed-toed footwear, and long pants/shirt.

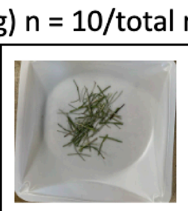
1. Prepare a hot plate (500° Celsius) with a metal pot.
2. Record constants: plate temperature and the outside humidity percentage.
3. Set a tripod with phone to record data sets.
4. Cut grass stems into two-centimeter pieces and plate 0.2 grams into labeled weigh boats. Prepare number of samples for the number of trials being done.
5. Show grass sample name/weigh boat to the camera
6. Gather all grass in weigh boat to a corner and place it in the pot, simultaneously press the stopwatch.
7. When flame appears (ignition) record the time, if the spark goes out prod using the tongs to keep the flame alive.
8. When the flame completely dies (sustainability), record the time and use the tongs to prod for one minute.
9. Take observations and times in notebook (sustainability = total time – 1 minutes – ignition time)(ignition time is self-explanatory).

Conduct ten dried test and five wet tests for each species.

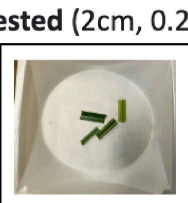
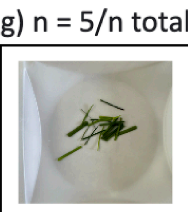
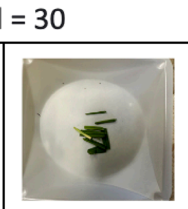
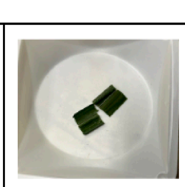
Materials: Oven mitts, hot plate, scale, high conductivity pot (metal), two-sided 12 in. ruler, testing trays, safety goggles, scissors, N95 mask, tripod (to hold phone), fire extinguisher, bowl of water, infrared thermometer, phone, stopwatch, notebook, humidity thermometer

Materials: Grasses

Dry Grasses Tested (2cm, 0.2g) n = 10/total n = 60

					
Pili grass	Oahu Sedge	Mau'u'aki'aki	Natal Grass	Witch Grass	Feather-Fingered Grass

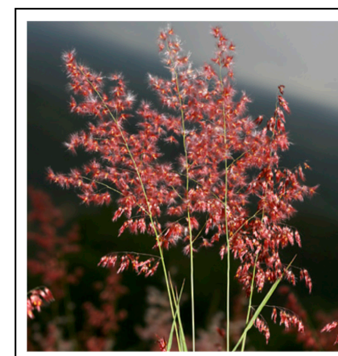
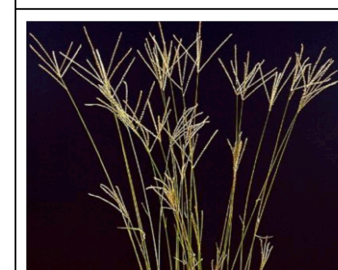
Wet Grasses Tested (2cm, 0.2g) n = 5/n total = 30

					
Pili Grass	Oahu Sedge	Mau'u'aki'aki	Natal Grass	Witch Grass	Feathered-Fingered Grass

Native / Perennial

	**Pili Grass** *Heteropogon contortus* Pili Grass is a native, perennial grass which has developed in clumps to the Hawaii climate. It contains barbs towards the tips of each stem, often tangling with other plants. Pili grass is xeric (developed to be drought tolerant and have water saving properties) which means it can last through dry periods without dying.
 https://4.bp.blogspot.com/-1PtBjs5v1HU/VXR4x4uPRDI/AAAAAAAADMs/5oPuhPS0qgs/s1600/Carex_wahuensis-5.jpg	**Oahu Sedge** *Carex wahuensis* Oahu Sedge is a plant endemic to Hawaii (does not live anywhere else) and shares the common perennial trait with many other native plants. It plays important roles in erosion control and ecosystems throughout Hawaii.
 https://hihort.blogspot.com/2012/02/mauu-akiaki-native-alternative-to-mondo.html	**Mau'u'aki'aki** *Fimbristylis cymosa* Mau'u'aki'aki is a native, perennial found in Hawaii, with sparsely growing stems and a collection of seeds found at the apex of each stem; they are not common in the wild. This grass grows in small, bush-like clusters, creating small patches of grass, scattered around a field.

Non-Native / Annual

 https://www.fireflyforest.com/flowers/1543/melinis-repens-rose-natal-grass/	**Natal Grass** *Melinis repens* Natal Grass is a non-native, annual grass that rapidly expands, taking over any nearby species. It has a long stem, with red/purple feathery, fluffy seeds towards the end. Natal grass has been seen to play a role in the number of fires in the area and is known as a flammable, fire sustaining problem that damages ecosystems.
 https://www.ebay.com/itm/123933817275	**Witch Grass** *Panicum capillare* Witchgrass is a huge (in size) non-native grass that is harmful to all plant species nearby. It is annual, meaning it dies yearly as a part of its life cycle, whether for a fire season or an imaginary winter, this creates a large biomass of fuel for potential fires to utilize. Witchgrass has small barbs on their leaves causing splinters and other suffering.
 https://pza.sanbi.org/digitaria-eriantha	**Feather-Fingered Grass** *Chloris Virgata* Feather-Fingered Grass is a thin, stringy non-native, annual grass that was brought to Hawaii for cattle grazing. They grow extremely densely and spread easily, making them nearly impossible to remove.

Results

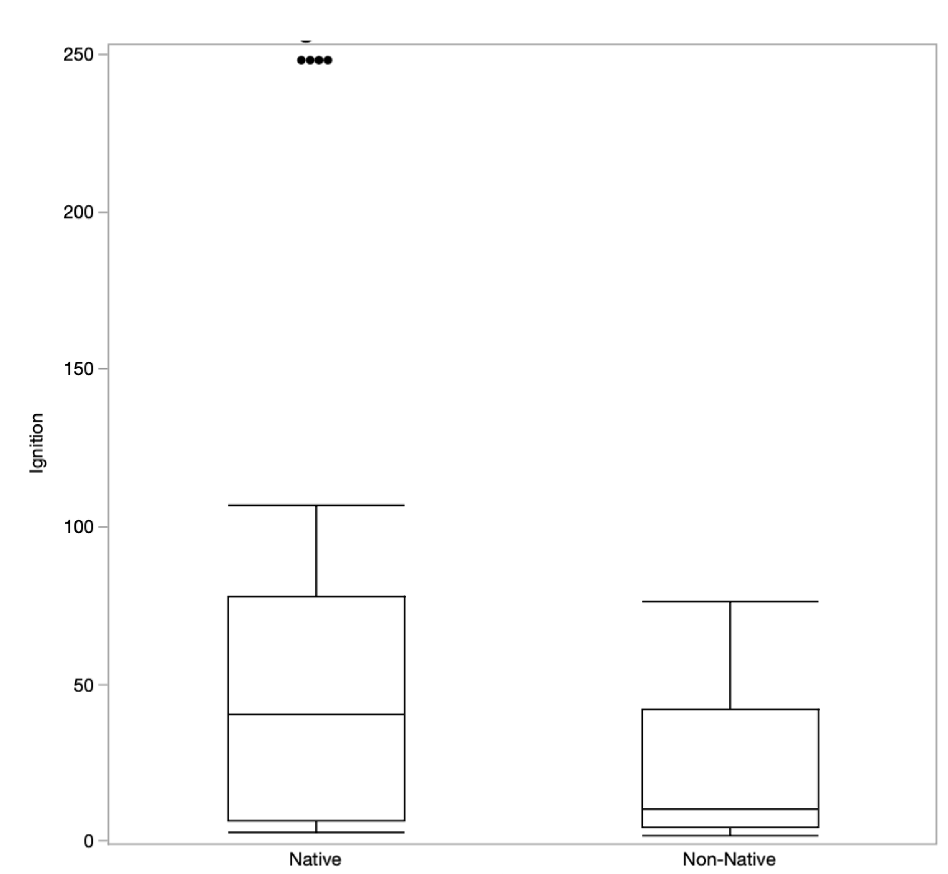
According to the data, in the dried grass category, native grasses were less flammable that non-native grasses.

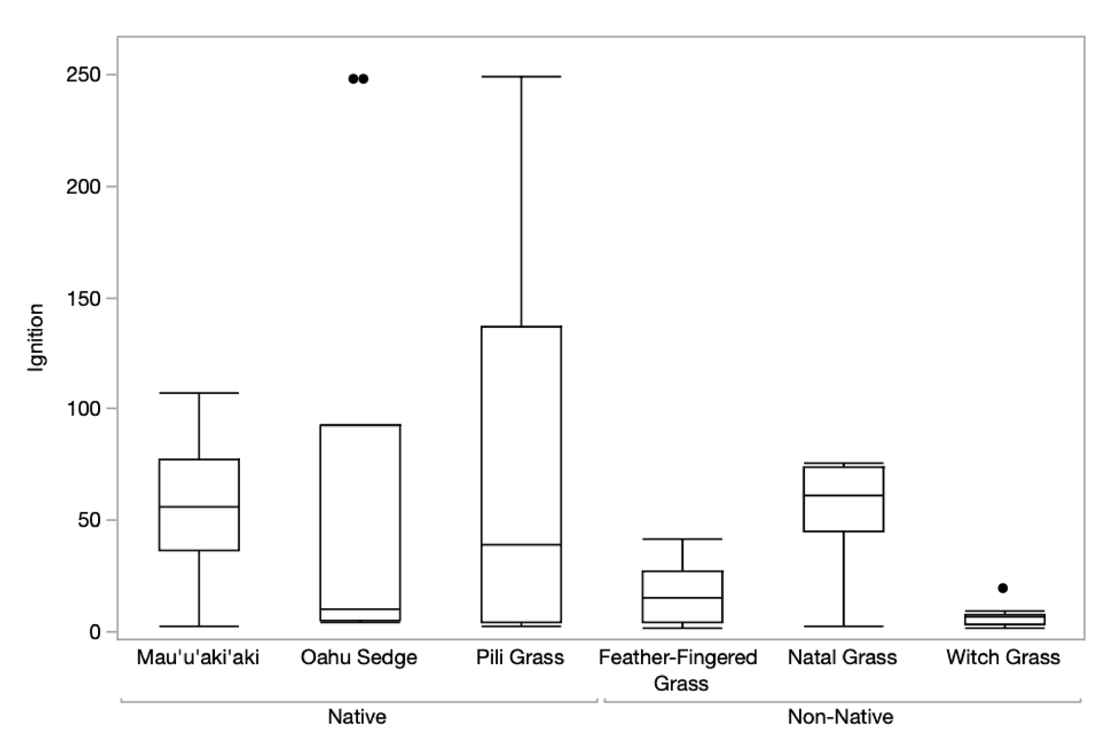
Ignition

A higher ignition time means that the grass is less flammable:
- The mean ignition for native grasses was 64.4 seconds.
- The mean ignition for the non-native grasses was **23.1 seconds.**
- The **difference** of the ignition means is **41.3 seconds**, with native grasses taking longer to ignite.

The wet/fresh grass testing was inconclusive, there were no significant differences in the data.

Ignition Time of Dried Native vs. Non-Native Grasses (t-Test, $p < 0.05$)



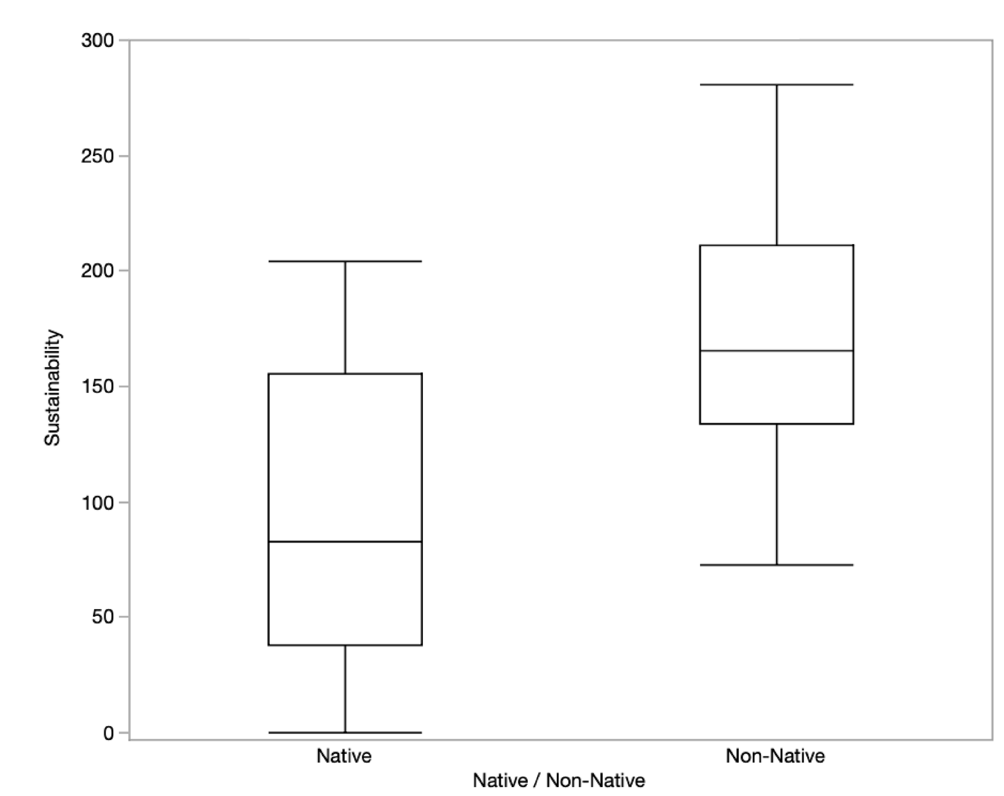


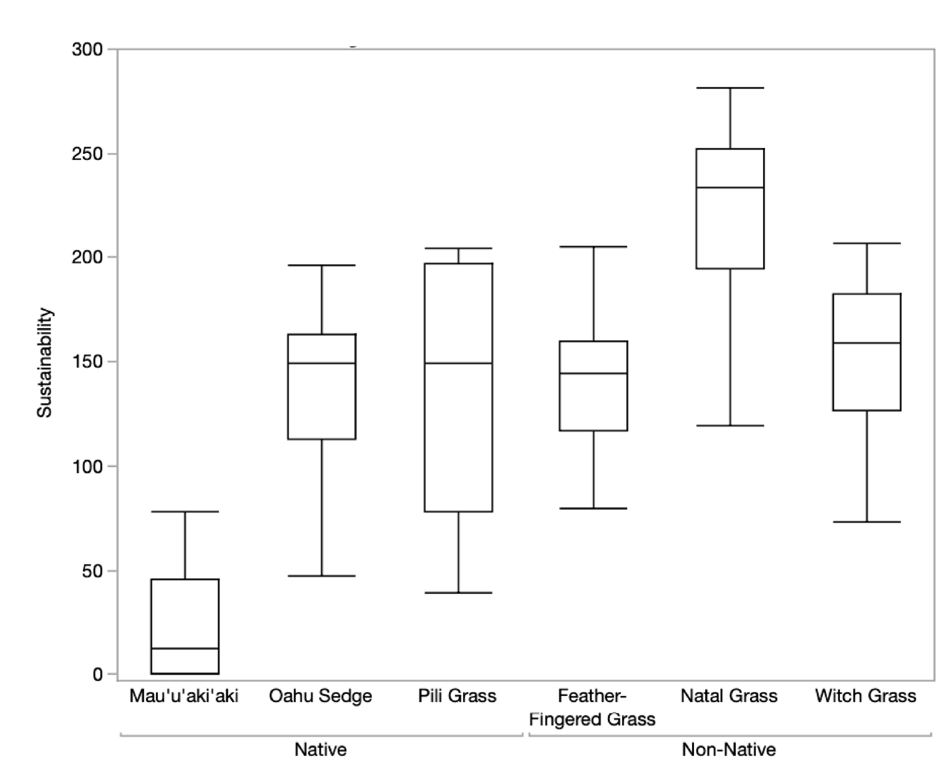
Sustainability

A lower sustainability time means that the grass is less flammable:
- The native grasses had a mean sustainability time of **98.2 seconds**
- The mean ignition time for the non-native grasses was **171.8 seconds**.
- This has a total difference of **73.1 seconds** in sustainability, with the native grasses having a shorter sustainability time.

The wet/fresh grass testing was inconclusive, there were no significant differences in the data.

Sustainability Time of Dried Native vs. Non-Native Grasses (t-Test, $p < 0.05$)





Discussion

There were three key discussion points that have come to my attention and must be addressed.

1. Outliers surrounding the dried native grass testing:

- The dried native grass ignition tests had two outliers for both **Pili Grass and Oahu Sedge**.
- These outliers weighed heavily towards the side of less flammable, giving the native grasses a major boost.
- Without these outliers, the native grasses would not have as convincing of a difference as previously.
- The dried native Pili Grass and Oahu Sedge ignition tests had a **standard deviation** of 96 and 99.

2. The use of makeshift testing equipment:

- Due to a lack of funds and scientific equipment, I utilized a hot plate and pot as an **epiradiator.**
- This creates problems in reliability.
- We were unable to completely replicate a real flame.
- Does not exactly mimic a wildfire.

3. Most of the grasses that I tested were not a part of the Maui Fire.

- Every grass except **Witch Grass** did not partake in the Maui Fire.
- Cannot directly draw conclusions about the Maui Fire from my research.
- The grasses in the Maui Fire were believed to be more flammable than the grasses tested.
- I utilized nearby grasses, because I believed the most "abundant" grasses must be in the areas of wildfires.
- There may be a connection to the lifecycles of these non-native grasses (may have died off by winter).

4. Perennial vs. Annual Grasses

- **Perennial Grasses** can live for multiple growth cycles and reproduce vegetatively and by seed.
- **Annual Grasses**, on the contrary, complete their growth cycle in a single growing season and reproduce only by seed (Life Cycles of Grass).
- All tested native grasses were perennial and all non-native grasses were annual.
- This could be a reason why the native grasses were less flammable than the non-native grasses
- It would be interesting to test the flammability of a non-native perennial grass and see whether that is the key factor in flammability

Conclusion

The results support that the dried native grasses are less flammable that the non-native grasses tested in this experiment

- This is because of a **41.3 second** difference in average **ignition time**, towards the native grasses.
- The mean **sustainability difference** was **73.1 seconds**, again on the side of native grasses

The impact that these numbers have:

- Multiplied across a field, these times may considerably slow down a spreading wildfire
- These numbers do not account for other factors (wind, etc.)
- May be the difference between firefighters or medical aid arriving.

Future Research

1. Testing other factors in native/non-native grasses:

- All of Hawaii's native grasses are perennial and most of Hawaii's non-native grasses are annual.
- How would these factors play a role in the flammability?

2. Doing a much larger scale test with native and non-native grasses:

- The use of a/multiple controlled burn(s) could test this on a more realistic field
- Would this still support my research that native grasses are less flammable that non-native grasses?
- How would the data change with the incorporation of other factors (wind, soil, moisture, etc.)

3. Testing garden/backyard plants:

- I could use the same procedure to test the flammability of garden/backyard plants.
- This could provide homeowners with data on what/not plants to buy.

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*All figures, graphs, and pictures, done by the author unless otherwise specified.