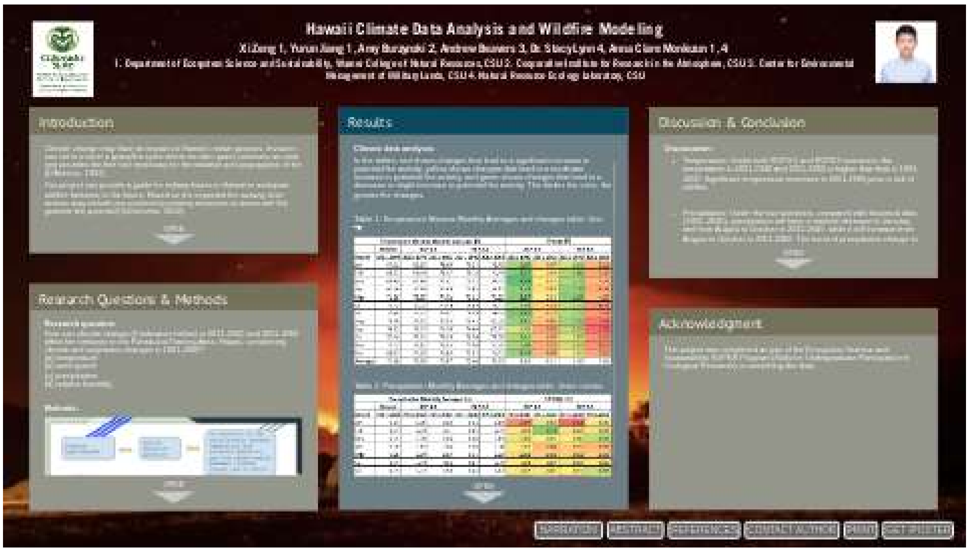
Hawaii Climate Data Analysis and Wildfire Modeling



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INTRODUCTION

Climate change may have an impact on Hawaii's native grasses. Invasion can set in motion a grass/fire cycle where an alien grass colonizes an area and provides the fine fuel necessary for the initiation and propagation of fire (D'Antonio, 1992).

Our project can provide a guide for military bases in Hawaii to anticipate wildfire behavior in the future. Based on the expected fire activity, their actions may include pre-positioning existing resources to areas with the greatest fire potential (Schlobohm, 2002).

We studied the effects of climate change on native grasses and wildfire patterns. Fire is not in the life cycle of Hawaii's native ecosystems, and wildfire is a major threat to threatened and endangered species in Hawaii, destroying native species and native ecosystems (Paul J. Conry, 2010).

We conducted wildland fire climate assessments for several Army properties in Hawaii. This project was designed to explore the potential impact of climate change on wildfires in the Pohakuloa Training Area in Hawaii.

We used climate data analysis and fire behavior modeling to estimate the potential impacts of climate change on fire spread and intensity, fire size, fire season, and changes in the ability to use a given fire.

In Hawaii, a single grass-fueled fire can kill most native trees and shrubs (D'Antonio, 1992), and more knowledge may help to avoid this scenario.

Figure 1: Pohakuloa Training Area map.

RESEARCH QUESTIONS & METHODS

Research question:
How can climate change (4 indicators below) in 2031-2040 and 2051-2060 affect fire behavior in the Pohakuloa Training Area, Hawaii, considering climate and vegetation changes in 1991-2000?
(a) temperature
(b) wind speed
(c) precipitation
(d) relative humidity

Methods:

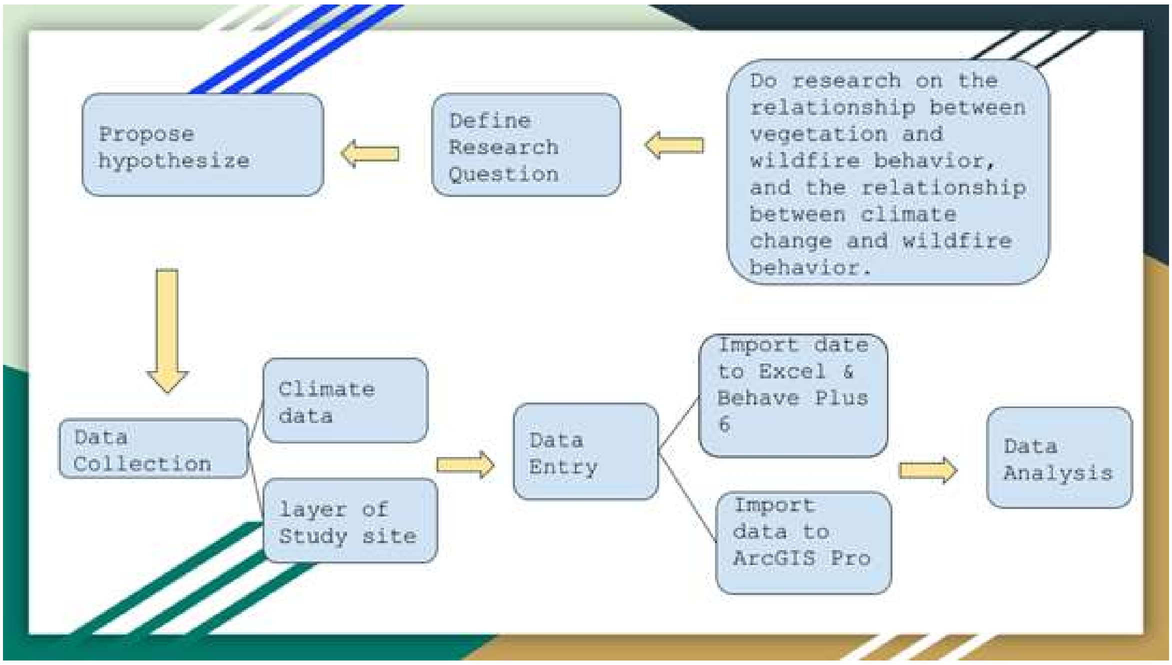

Figure 2: Methods outline.

- Analyzed the climate data according to the relationship between vegetation coverage and the frequency of wildfire.
- Used ArcGIS Pro to analyze the vegetation coverage in the study site, and export the study area map.
- Used Excel and Behave Puls to analyze climate data, taking into account the four variables of temperature, wind speed, precipitation, and relative humidity.

RESULTS

Climate data analysis:

In the tables, red shows changes that lead to a significant increase in potential fire activity, yellow shows changes that lead to a moderate increase in potential fire activity, and green shows changes that lead to a decrease or slight increase in potential fire activity. The darker the color, the greater the changes.

Table 1: Temperature Maxima Monthly Averages and changes table. Unit: °F.

Temperature Maxima Monthly Averages (F)						Change (F)			
	Historic	RCP 4.5		RCP 8.5		RCP 4.5		RCP 8.5	
Month	1991-2000	2031-2040	2051-2060	2031-2040	2051-2060	2031-2040	2051-2060	2031-2040	2051-2060
Jan	67.61	69.60	71.68	70.23	72.73	2.00	4.07	2.62	5.12
Feb	68.12	69.64	71.57	70.18	73.44	1.52	3.46	2.06	5.32
Mar	68.88	69.88	72.31	71.03	73.67	1.00	3.42	2.15	4.79
Apr	69.76	71.46	73.59	71.55	75.12	1.70	3.83	1.79	5.36
May	71.28	72.85	74.62	72.92	76.23	1.56	3.33	1.63	4.95
Jun	72.32	74.52	76.70	74.69	78.47	2.20	4.38	2.37	6.14
Jul	73.84	75.27	78.07	76.09	79.62	1.43	4.23	2.25	5.78
Aug	74.50	76.31	79.15	76.42	81.53	1.81	4.65	1.92	7.03
Sep	74.22	76.97	79.74	76.44	81.61	2.76	5.53	2.23	7.39
Oct	73.49	75.61	78.15	76.36	79.59	2.12	4.67	2.87	6.10
Nov	71.03	73.11	76.25	73.56	77.20	2.08	5.22	2.53	6.17
Dec	68.87	70.65	73.84	72.03	74.41	1.79	4.98	3.16	5.55
Average	71.16	72.99	75.47	73.46	76.97	1.83	4.31	2.30	5.81

Table 2: Precipitation Monthly Averages and changes table. Units: inches.

Precipitation Monthly Averages (in)						Change (in)			
	Historic	RCP 4.5		RCP 8.5		RCP 4.5		RCP 8.5	
Month	1991-2000	2031-2040	2051-2060	2031-2040	2051-2060	2031-2040	2051-2060	2031-2040	2051-2060
Jan	0.14	0.05	0.18	0.02	0.14	-0.09	0.04	-0.12	0.00
Feb	0.04	0.03	0.21	0.06	0.07	0.00	0.18	0.03	0.03
Mar	0.05	0.08	0.06	0.06	0.14	0.03	0.01	0.00	0.09
Apr	0.08	0.10	0.04	0.06	0.04	0.02	-0.04	-0.02	-0.05
May	0.05	0.04	0.03	0.03	0.03	-0.02	-0.02	-0.02	-0.03
Jun	0.04	0.04	0.06	0.07	0.04	0.00	0.02	0.03	0.00
Jul	0.04	0.07	0.03	0.05	0.13	0.02	-0.01	0.01	0.09
Aug	0.10	0.02	0.16	0.03	0.14	-0.08	0.06	-0.08	0.04
Sep	0.11	0.08	0.11	0.03	0.16	-0.03	0.01	-0.08	0.05
Oct	0.12	0.02	0.21	0.05	0.27	-0.10	0.08	-0.07	0.15
Nov	0.03	0.04	0.13	0.17	0.26	0.01	0.10	0.14	0.23
Dec	0.06	0.04	0.06	0.02	0.05	-0.01	0.01	-0.04	-0.01
Average	0.07	0.05	0.11	0.05	0.12	-0.02	0.04	-0.02	0.05

Table 3: Wind Speed Monthly Averages and change table. Units: mph.

Wind Speed Monthly Averages (mph)						Change (mph)			
	Historic	RCP 4.5		RCP 8.5		RCP 4.5		RCP 8.5	
Month	1991-2000	2031-2040	2051-2060	2031-2040	2051-2060	2031-2040	2051-2060	2031-2040	2051-2060
Jan	7.80	7.60	8.35	8.14	7.46	-0.21	0.55	0.34	-0.35
Feb	8.20	8.49	8.84	8.09	7.74	0.29	0.64	-0.11	-0.46
Mar	9.05	9.14	8.41	8.82	8.27	0.09	-0.65	-0.23	-0.78
Apr	9.48	9.12	8.97	8.46	9.35	-0.36	-0.51	-1.02	-0.13
May	8.65	8.49	9.02	9.17	8.63	-0.16	0.37	0.52	-0.02
Jun	9.74	9.67	9.01	9.23	9.30	-0.07	-0.73	-0.51	-0.44
Jul	9.19	9.59	9.57	9.97	9.26	0.40	0.38	0.78	0.07
Aug	9.35	9.20	9.13	9.59	8.42	-0.15	-0.22	0.25	-0.92
Sep	8.05	8.09	7.49	7.64	7.41	0.05	-0.55	-0.41	-0.64
Oct	8.38	8.45	7.44	8.31	7.81	0.08	-0.94	-0.07	-0.57
Nov	8.89	9.02	7.97	8.37	8.20	0.12	-0.92	-0.53	-0.70
Dec	8.94	8.45	8.22	7.60	8.83	-0.50	-0.73	-1.34	-0.12
Average	8.81	8.78	8.53	8.61	8.39	-0.03	-0.28	-0.20	-0.42

Table 4: Relative Humidity Monthly Averages and changes. Unit: %.

Relative Humidity Monthly Averages (%)						Change (%)			
	Historic	RCP 4.5		RCP 8.5		RCP 4.5		RCP 8.5	
Month	1991-2000	2031-2040	2051-2060	2031-2040	2051-2060	2031-2040	2051-2060	2031-2040	2051-2060
Jan	77.24	77.88	77.69	77.07	77.25	0.64	0.46	-0.17	0.01
Feb	75.46	76.35	77.36	76.37	75.77	0.89	1.90	0.91	0.31
Mar	76.07	77.60	76.09	76.46	75.42	1.52	0.01	0.39	-0.65
Apr	76.23	76.22	75.27	74.70	75.49	-0.01	-0.96	-1.54	-0.74
May	72.13	71.38	72.23	72.74	71.14	-0.75	0.10	0.60	-0.99
Jun	73.00	72.76	72.97	73.37	71.93	-0.24	-0.03	0.37	-1.07
Jul	73.41	74.56	73.85	74.76	74.47	1.15	0.44	1.35	1.06
Aug	74.01	73.58	74.80	74.41	73.56	-0.44	0.79	0.40	-0.45
Sep	72.77	73.00	73.20	73.08	72.44	0.23	0.44	0.32	-0.33
Oct	74.57	75.06	76.35	75.82	76.15	0.49	1.78	1.24	1.58
Nov	77.30	78.52	78.85	78.70	79.02	1.21	1.55	1.40	1.72
Dec	78.02	78.37	78.57	77.62	78.34	0.35	0.55	-0.40	0.32
Average	75.02	75.44	75.60	75.42	75.08	0.42	0.58	0.41	0.06

Fire behavior modeling:

When the Live Herb Moisture reaches 95% or above, the 10-m Wind Speed increment Flame Length hardly changes.

Table 3: Surface Fire Flame Length table from the Behave Plus 6 fire model. Units: feet. Table of Live Herbaceous Fuel Moisture and Surface Fire Flame Length under different 10-m Wind Speed conditions.

Head Fire

Surface Fire Flame Length (ft)

Live Herb Moisture %	10-m Wind Speed (upslope) mi/h 7	8	9	10
30	9.5	10.1	10.7	11.3
35	9.6	10.2	10.8	11.4
40	9.6	10.2	10.8	11.4
45	9.5	10.1	10.7	11.2
50	9.3	9.8	10.4	11.0
55	8.9	9.5	10.0	10.6
60	8.5	9.0	9.5	10.0
65	8.0	8.4	8.9	9.4
70	7.4	7.8	8.3	8.8
75	6.8	7.3	7.7	8.1
80	6.4	6.7	7.1	7.5
85	5.9	6.3	6.7	7.0
90	5.1	5.4	5.7	6.1
95	1.9	2.1	2.2	2.3
100	1.6	1.7	1.7	1.8

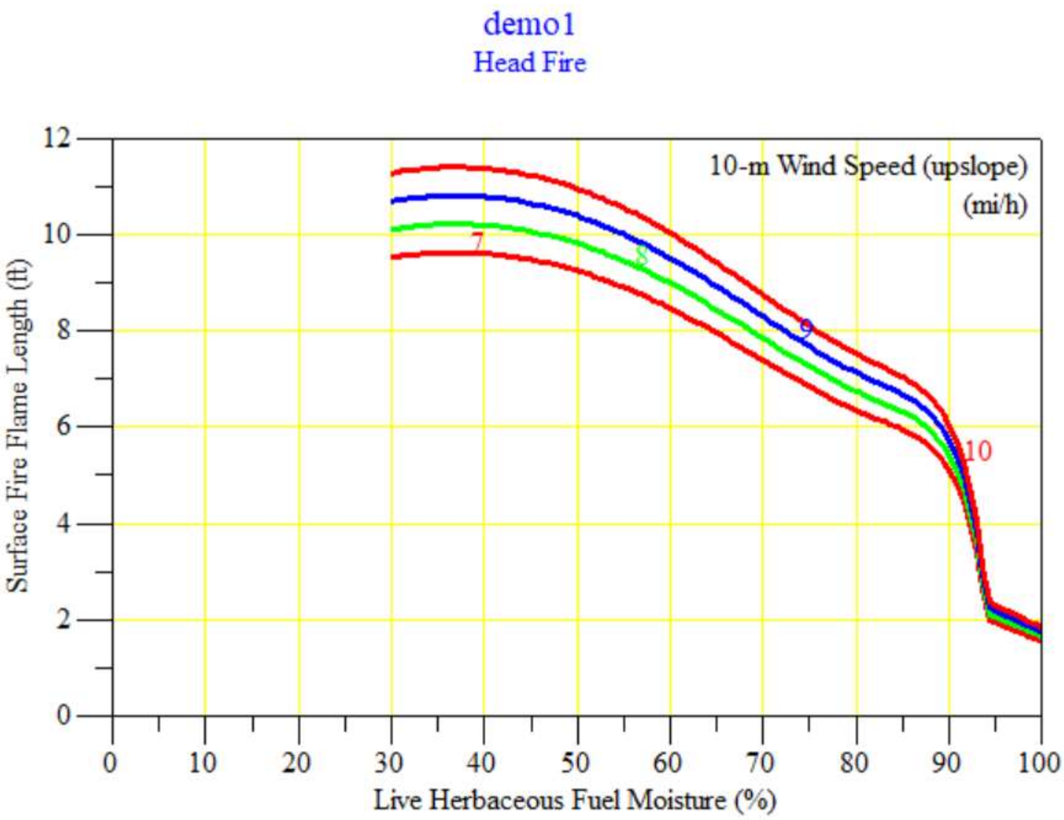

Figure 3: Chart of Live Herbaceous Fuel Moisture and Surface Fire Flame Length under different 10-m Wind Speed conditions.

Table 4: Table of Live Herbaceous Fuel Moisture and Surface Fire Rate of Spread under different 10-m Wind speeds.

Head Fire
Surface Fire Rate of Spread (ch/h)

Live Herb Moisture %	10-m Wind Speed (upslope) mi/h 7	8	9	10
30	42.5	48.5	54.8	61.5
35	42.2	48.0	54.3	60.9
40	41.0	46.7	52.7	59.2
45	39.1	44.5	50.3	56.5
50	36.7	41.7	47.2	53.0
55	33.8	38.5	43.5	48.8
60	30.6	34.9	39.4	44.2
65	27.3	31.1	35.2	39.5
70	24.1	27.4	31.0	34.8
75	21.1	24.1	27.2	30.5
80	18.6	21.2	24.0	26.9
85	16.6	18.9	21.3	24.0
90	13.5	15.3	17.3	19.4
95	4.5	5.1	5.8	6.5
100	3.4	3.8	4.3	4.9

demo1
Head Fire

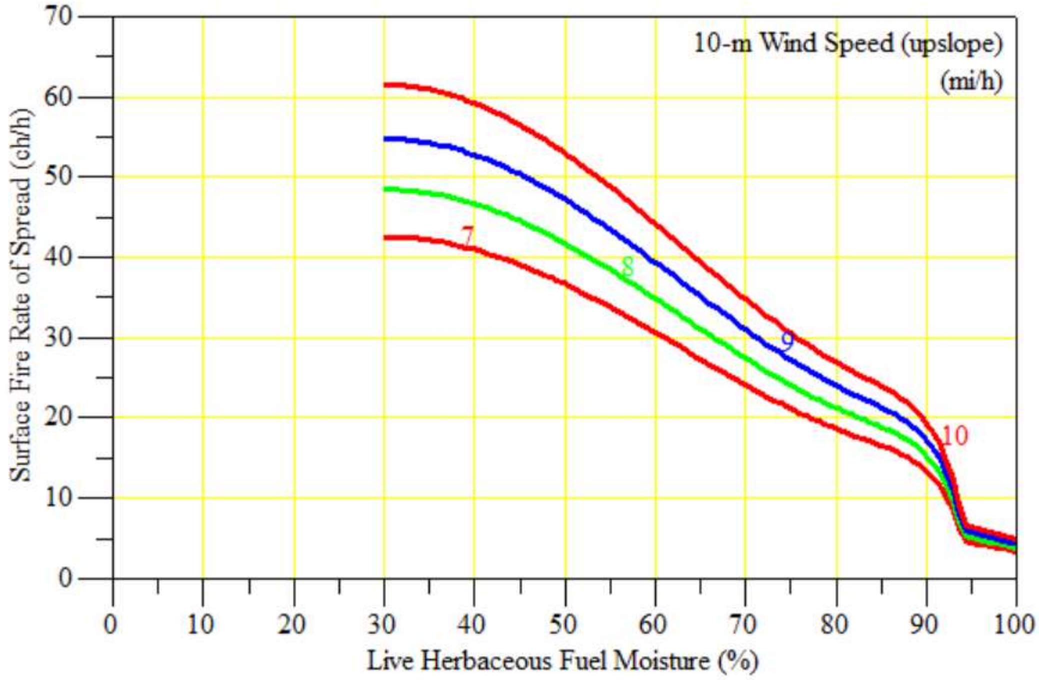

Figure 4: Chart of Live Herbaceous Fuel Moisture and Surface Fire Rate of Spread under different 10-m Wind speeds.

DISCUSSION & CONCLUSION

Discussion:

- Temperature: Under both RCP4.5 and RCP8.5 scenarios, the temperature in 2031-2040 and 2051-2060 is higher than that in 1991-2000. Significant temperature increases in 2051-2060 pose a risk of wildfire.

- Precipitation: Under the two scenarios, compared with historical data (1991–2000), precipitation will have a marked decrease in January and from August to October in 2031-2040, while it will increase from August to October in 2051-2060. The trend of precipitation change in 2051-2060 is steeper, while the trend in 2031-2040 is more stable. In the future, wildfires are more likely due to less precipitation at the end of summer.

- Wind speed: Compared with historical data (1991–2000), the average wind speed for all scenarios will increase significantly in July and decrease significantly in December. With the increase of wind speed, the flame length, and flame propagation speed increase, leading to expansion of fire area.

- Relative humidity: The average relative humidity for all scenarios will vary within a 1% range. When the live herbaceous fuel moisture reaches 95% and above, the fire behavior changes little with the wind speed. The surface fire flame length and spread rate decrease when the live herbaceous fuel moisture content increases.

Conclusion:

Based on our data analysis, climate change will have an impact on future wildfire behavior in Hawaii. Wildfires have caused a decline in native grasses in Hawaii. Native plants are not able to adapt to the rapid temperature changes, but invasive grasses can live with less water and can act as new vectors to fuel wildfires. This is the reason for the massive increase in the frequency and size of wildfires in recent times. Fires are more likely to occur in months with higher temperatures and lower precipitation. When the live herb moisture is below 95%, the surface fire flame length and the surface fire rate of spread change obviously with the wind speed. There will be a potential fire risk from April to May and from August to September in 2031-2040. There will be a potential fire risk and possible fire expansion in July in all scenarios. This project suggested that the Pohakuloa Training Area may experience more extreme fire behavior in the future in late summer and early fall.

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ABSTRACT

Climate change leads to changes in dominant forage species, which in turn may lead to changes in local fuel and the frequency of wildfires. Wildfires are a major threat to Hawaii's native species and native ecosystems. More than half a percent of Hawaii's total land area is burned each year. Here we conduct wildland fire climate assessments for the Pohakuloa Training Area in Hawaii. We use climate data and fire behavior modeling to estimate the potential effects of climate change on fire spread and intensity, fire size, fire season, and the changes in the ability to use prescribed fire. We found that rising temperatures will prevent native grasses from becoming dominant species. Warming temperatures dry out plants, which means more fuel, and dry plants are more likely to cause wildfires. Increases in temperature, wind speed, and relative humidity, as well as decreases in precipitation, will result in more intense wildfire behavior and larger wildfire area. Our data analysis may give a reference for Hawaii land managers and natural resources managers in their future practice of managing the Pohakuloa Training Area site.

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