

# Metadata Descriptions

This is a part of University of Hawaii at Manoa NREM MS Plan A thesis data spatio-temporal data details. In this file you will find predictive and responsive variables for Wildfire Vulnerability Assessment Index for Hawaii (WRAI). Here the details of ecological data processing. [Click here](#) for access the master data excel file.

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## Predictive Variables

### 1. Grass Cover

**Source:** Pacific Fire Exchange (PFX) (Not sure, Koaclud, Ask Ally)

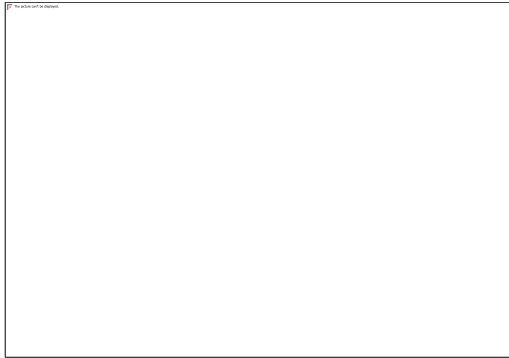
File name: unmix\_grass\_2020\_2023.tif

**Resolution:** 30m

**Format:** GeoTIFF

Variable Type: Continuous Ratio Variables

Data Type: Numeric (0–1)



### Overview

This dataset quantifies grass proportion, abundance and spatial dominance across Hawai‘i’s Wildland-Urban Interface (WUI). Using a spectral unmixed grass file, the analysis calculates the average fractional cover and the total land area where grass constitutes the dominant fuel type (defined as  $\geq 50\%$  cover per pixel).

### Attributes

- **grass\_mean** - Average fractional grass cover per WUI unit (0–1 scale).
- **grass\_median** - Median fractional grass cover per WUI unit (0–1 scale).
- **pct\_dom\_grass** - Percentage of WUI area where grass is dominant (pixels  $> 0.50$ ).

### Processing Summary / Workflow

1. Data Loading: Import statewide WUI polygons (214 units) and 30m fractional grass raster.
2. Alignment & Cropping: Project WUI polygons to match raster CRS and crop the raster to the WUI extent.
3. Intensity Extraction: Calculate mean and median pixel values (0–1) per WUI polygon to quantify grass density.
4. Thresholding: Reclassify pixels into a binary raster (1 =  $>50\%$  cover; 0 = less than 50% cover) to identify areas of fuel dominance.
5. Spatial Aggregation: Calculate the mean of the binary raster per polygon to determine the proportion of grass-dominated area.
6. Final Scaling: Convert proportions to percentages (0–100%) and export as .shp and .csv.

### Output Products

Output	Description
<b>WUI_Grass_Metrics_Final.shp</b>	WUI polygons containing mean, median, and dominance percentage attributes.
<b>WUI_Grass_Summary.csv</b>	Per-WUI tabular summary of grass metrics for statistical analysis.

### Data Quality Notes

1. **Spectral Unmixing:** Values represent sub-pixel fractions; a value of 0.50 means 50% of the 30m pixel is identified as herbaceous fuel.
2. **Fuel Continuity:** The 50% threshold is a standard heuristic used to identify where fine fuels are likely continuous enough to support fire spread.
3. **Data Vintage:** The raster represents a composite/average of conditions between 2020 and

2023.

## 2. Drought -USDM

### Drought Exposure (USDM → WUI) Metadata

**Download Link:** <https://droughtmonitor.unl.edu/DmData/GISData.aspx>

**Files Used:** USDM\_YYYYMMDD.shp (2000–2024)

**Source / Publisher:** National Drought Mitigation Center (NDMC), USDA, NOAA, University of Nebraska–Lincoln

**Format:** Shapefile

**Coverage:** Hawai‘i statewide

**Temporal Resolution:** Weekly

**Spatial Resolution:** Vector polygon

**CRS:** EPSG:4326 (WGS 84) for raw USDM

**Analysis CRS:** EPSG:4326 (WGS 84)

**Raster Grid:** ~0.005° (~500 m)

### Overview

This dataset contains weekly U.S. Drought Monitor (USDM) polygon classifications for Hawai‘i from 2000–2024. Weekly drought categories (D0–D4) were rasterized to a common grid, converted to drought indicators, summarized as annual drought-week counts, averaged across years, and extracted to Wildland–Urban Interface (WUI) polygons.

### Attributes

#### DM — Drought category code

0 = No drought

1 = D0 (Abnormally Dry)

2 = D1 (Moderate Drought)

3 = D2 (Severe Drought)

4 = D3 (Extreme Drought)

5 = D4 (Exceptional Drought)

### Processing Summary / Workflow

Download weekly USDM shapefiles (~4–5 per month).

Organize files by year.

Rasterize weekly polygons to a ~500 m grid using **max(DM)** per cell.

#### Overview

This dataset quantifies grass abundance and spatial dominance across Hawai‘i’s Wildland–Urban Interface (WUI). Using a spectral unmixed grass product, the analysis calculates the average fractional cover and the total land area where grass constitutes the dominant fuel type (defined as ≥50% cover per pixel). This serves as a proxy for fine fuel continuity in fire risk modeling.

Pixel Value	r_dm (Intensity)	r_any (Any?)	r_sev (Severe?)
No Drought	0	0 (No)	0 (No)
Moderate (D1)	2	1 (Yes)	0 (No)
Severe (D2)	3	1 (Yes)	1 (Yes)

## Output Products

### Data Quality Notes

USDM classes are expert-derived composites, not direct measurements.

Rasterization and long-term averaging introduce spatial/temporal smoothing.

Boundary alignment differences may occur between polygons and raster grids.

## 3. Rainfall -HCDP

**Download Source:** Hawaii Climate Data Portal (HCDP) – <https://www.hawaii.edu/climate-data-portal/data-portal/>

**Files used:** Monthly statewide rainfall rasters: rainfall\_YYYY\_MM.tif (2000–2025)

**Source Information / Publisher:** University of Hawai‘i at Mānoa – Department of Geography & Environment, Ecohydrology Lab, Water Resources Research Center (WRRC), Hawai‘i EPSCoR ‘Ike Wai Program

**Format:** GeoTIFF

**Coverage:** Hawai‘i statewide

**Temporal Resolution:** Monthly

**Spatial Resolution:** ~250 m gridded rainfall prediction

**CRS:** EPSG 4326 (WGS 84)

**Projected to:** EPSG 26904 (NAD83 / UTM Zone 4N) for extraction and WUI analysis



### Overview

This dataset represents long-term mean annual rainfall for Hawai‘i derived from high-resolution monthly rainfall rasters produced by the Hawai‘i Climate Data Portal. Monthly rainfall totals were summed to annual totals for each year (2000–2024), then averaged across all years to generate a statewide mean annual rainfall surface. The resulting raster was spatially summarized for each WUI polygon to support wildfire risk and vulnerability analysis.

### Processing Summary / Workflow

1. Load monthly rainfall GeoTIFFs for each year (12 months/year).

2. Sum monthly rasters → annual total rainfall per year.
3. Stack annual rasters (2000–2024).
4. Compute pixel-wise mean → long-term mean annual rainfall.
5. Extract mean rainfall values to WUI polygons.
6. Join extracted values to WUI attributes and export.

#### Output Products

Output	Description
Mean_Annual_Rainfall_2000_2024.tif	Long-term mean annual rainfall (mm), pixel-level
WUI_Rainfall_Results.shp	WUI polygons with mean annual rainfall
WUI_Rainfall_Summary.csv	Per-WUI rainfall summary table

#### Data Quality Notes

- Rainfall surfaces are interpolated estimates based on station data and kriging methods.
- Spatial uncertainty varies across islands; coastal and high-elevation areas may have higher error.
- Long-term averaging smooths interannual variability and extremes.

### 3. Slope and Roughness

**Download Source:** U.S. Geological Survey (USGS) 10-m Digital Elevation Model (DEM), accessed through PacIOOS ERDDAP

<https://data.usgs.gov/datacatalog/data/USGS:6809585bd4be0211235186c3>

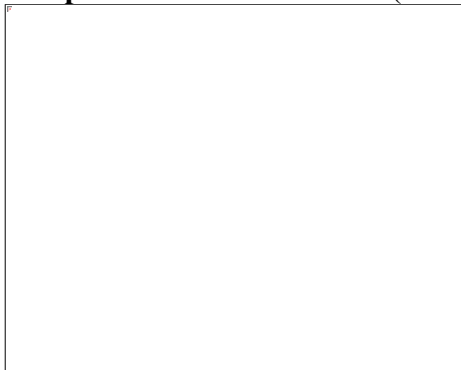
Dataset ID: **usgs\_dem\_10m**

**Format:** GeoTIFF / NetCDF (converted to GeoTIFF for analysis)

**Coverage:** Hawai‘i statewide (island mosaics including Hawai‘i, Maui Nui, O‘ahu, Kaua‘i)

**Spatial Resolution:** 10 meters (1/3 arc-second)

**Temporal Resolution:** Static (terrain does not vary over time)



#### CRS

- Original DEM CRS: **EPSG 4326 (WGS84)**
- Reprojected to analysis CRS:  
**EPSG 26904 — NAD83 / UTM Zone 4N**

## Overview

This dataset represents a high-resolution digital elevation model (DEM) developed by the U.S. Geological Survey and distributed via PacIOOS. The DEM provides a foundational terrain surface from which multiple physical landscape metrics can be derived. For wildfire and WUI exposure analysis, the DEM was used to compute **slope** and **surface roughness**, two key biophysical variables influencing fire spread, fireline intensity, suppression difficulty, and fuel continuity patterns in Hawai‘i.

## Attributes and Derivative Variables

### Slope

- Computed using: `terrain(dem, v="slope", unit="degrees")`
- Output unit: **degrees**
- Interpretation:  
Higher slope increases fire rate-of-spread (ROS), flame tilt, and difficulty for ground suppression crews.

### Roughness

- Computed using: `terrain(dem, v="roughness")`
- Output unit: dimensionless (variance of elevation within a 3×3 kernel)
- Interpretation:  
Higher roughness indicates heterogeneous terrain, cliffs, and ridges; lower values indicate smoother, flatter surfaces.

## Processing Workflow

1. Downloaded 10-m DEM tiles from PacIOOS ERDDAP.
2. Mosaicked DEM tiles into a single statewide DEM using `terra`.
3. Removed Ni‘ihau DEM tile errors and cleaned coastline water artifacts.
4. Projected DEM to UTM Zone 4N to align with fire-risk and WUI datasets.
5. Computed slope raster from DEM (degrees).
6. Computed roughness raster from DEM (local elevation variability).
7. Applied land/water mask to remove ocean and non-land pixels.
8. Clipped rasters to WUI polygons using `terra::extract()`.
9. Calculated mean slope and mean roughness per WUI and exported as shapefile + CSV.

## Output Products

File Name	Description
<code>slope_hawaii_10m.tif</code>	Slope (degrees) statewide at 10 m resolution
<code>roughness_hawaii_10m.tif</code>	Surface roughness statewide at 10 m resolution
<code>WUI_with_Slope.shp</code>	WUI polygons with mean slope added
<code>WUI_with_Roughness.shp</code>	WUI polygons with mean roughness added
<code>WUI_Mean_Slope.csv</code>	Per-WUI mean slope values
<code>WUI_Mean_Roughness.csv</code>	Per-WUI roughness values

## Data Quality Notes

- DEM is high-quality but may contain localized errors (steep cliffs, cloud shadows in source LIDAR mosaics).
- Coastlines and small islets may include minor artifacts.
- Roughness depends on the 3×3 window; different kernel sizes produce different interpretation scales.
- Resampling the DEM to match other raster datasets may slightly smooth the terrain.

## 4. NDVI & Moisture

**Download Source:** Hawai‘i Climate Data Portal (HCDP), MODIS NDVI product

<https://www.hawaii.edu/climate-data-portal/data-portal/>

**Example file:** ndvi\_modis\_day\_statewide\_data\_map\_2001\_01\_01.tif

**Format:** GeoTIFF

**Coverage:** Hawai‘i statewide

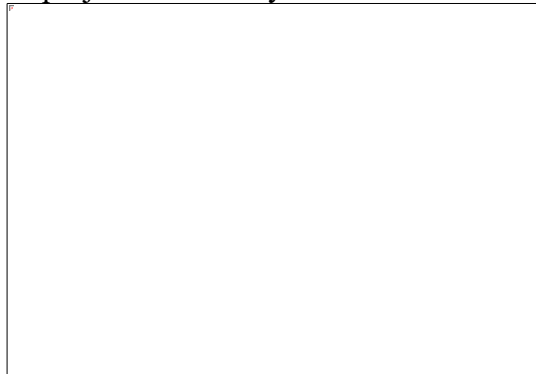
**Temporal Resolution:** Daily (native), aggregated to monthly and annual

**Spatial Resolution:** Native HCDP MODIS NDVI grid (~MODIS-scale, sub-km; see HCDP metadata)

**CRS:**

Original NDVI GeoTIFFs: **WGS 84 (EPSG:4326)**

Reprojected for analysis and WUI extraction to: **NAD83 / UTM Zone 4N (EPSG:26904)**



### Overview

This dataset contains daily MODIS-based NDVI (Normalized Difference Vegetation Index) rasters for the Hawaiian Islands, obtained from the Hawai‘i Climate Data Portal (HCDP) for the period 2000–2025. NDVI is a dimensionless index derived from red and near-infrared reflectance that ranges approximately from  $-1$  to  $+1$ , where higher values indicate denser and more photosynthetically active vegetation. The daily NDVI rasters were processed to produce monthly NDVI stacks, annual mean NDVI rasters, and a multi-year NDVI stack for use in wildfire exposure and WUI vulnerability analysis.

### Key Attribute

#### NDVI

Variable name in rasters: NDVI band (single-band GeoTIFF)

Units: unitless index (approximately -1 to +1)

Interpretation:

- < 0: water, clouds, non-vegetated noise
- 0–0.2: bare soil, sparse or senescent vegetation
- 0.2–0.5: grassland, shrubs, mixed cover
- 0.5: dense, healthy vegetation

## Processing Summary / Workflow

### 1. Daily NDVI acquisition:

Daily statewide NDVI rasters were downloaded from HCDP for each year (e.g., `ndvi_modis_day_statewide_data_map_YYYY_MM_DD.tif`).

### 2. Monthly NDVI stacks:

For each month, all valid daily NDVI rasters were loaded using `terra(rast())`, quality-checked, and stacked into a multi-layer raster (`NDVI_Monthly_Stack_YYYY_MM.tif`). Only existing and readable daily files were included.

### 3. Annual mean NDVI:

For each year, the 12 monthly stacks (or all available months) were loaded, merged into an annual stack, and the mean NDVI was computed across all monthly layers using `app(..., mean, na.rm = TRUE)`.

Output: `NDVI_Annual_Mean_YYYY.tif`.

### 4. Multi-year annual NDVI stack (time series):

All annual mean rasters from 2001–2025 were combined into a multi-band raster (`NDVI_Annual_Stack_2001_2025.tif`) to support time-series analysis and long-term vegetation trends.

### 5. NDVI-based adjacency / continuity index:

Annual NDVI was further thresholded to identify “vegetated” pixels (e.g.,  $\text{NDVI} > 0.25 \rightarrow 1$ , else 0), and a  $3 \times 3$  focal window was used to calculate a local adjacency index (number of vegetated neighbors per cell). This produced a continuous **NDVI adjacency index** raster indicating local fuel continuity.

### 6. WUI extraction:

Wildland–Urban Interface (WUI) polygons were reprojected to match the NDVI raster CRS. Mean annual NDVI and the NDVI adjacency index were extracted per WUI polygon using `terra::extract(..., fun = mean, na.rm = TRUE)`, and appended back to the WUI shapefile as new attributes.

## Output Products

File Name	Description
<code>NDVI_Monthly_Stack_YYYY_MM.tif</code>	Daily NDVI stacked for each month (multi-layer)



NDVI_Annual_Mean_YYYY.tif	Mean annual NDVI raster per year
NDVI_Annual_Stack_2001_2025.tif	Multi-band stack of annual mean NDVI (time series)

### Data Quality Notes

- NDVI values are derived from MODIS satellite observations processed by HCDP and are subject to cloud cover, atmospheric effects, and sensor noise.
- Daily data gaps (e.g., persistent cloud cover) and missing daily files may reduce the number of valid observations in some months; averaging is done with `na.rm = TRUE` to minimize bias.
- Aggregation from daily > monthly > annual smooths short-term variability and emphasizes long-term vegetation condition.
- Thresholds (e.g.,  $\text{NDVI} > 0.25$  for “vegetated”) are analytical choices and should be interpreted in the context of Hawai‘i’s vegetation types and fuel models.

## 6. Wind Speed

**Source:** Global Wind Atlas v3 (World Bank Group; DTU Wind Energy)

**Access:** <https://globalwindatlas.info/api/gis/country/USA/wind-speed/10>

### Input Data:

- Raster: USA\_wind-speed\_10m.tif
- Height: 10 m above ground
- Units: meters per second (m/s)
- Spatial resolution: ~250 m
- Temporal representation: Long-term climatological mean

### Spatial Units:

- WUI polygons (WUI\_Polys.shp),  $n = 214$  statewide WUI units

### Coordinate Reference System:

- Raster CRS: WGS 84 (EPSG:4326)
- WUI polygons were reprojected to match the raster CRS prior to analysis.

### Processing Summary

The national 10 m wind speed raster was cropped to the Hawaiian Islands using the bounding extent of the statewide WUI polygons to improve processing efficiency. The cropped raster was then masked to the WUI boundaries to retain wind values only within WUI areas. Mean wind speed was extracted for each WUI polygon using zonal statistics, excluding NoData values. Extracted values were joined back to the WUI attribute table and exported as both a shapefile and CSV. Wind speed was retained in meters per second and additionally converted to miles per hour for interpretability.

### Output Products

- **Statewide\_WUI\_Wind\_Final.shp** - WUI polygons with mean wind speed attributes

- **Statewide\_WUI\_Wind\_Final.csv** - Tabular WUI-level wind speed dataset

#### Key Attributes:

- Wind\_ms - Mean 10 m wind speed (m/s)
- Wind\_mph - Mean 10 m wind speed (mph)

#### Data Quality Notes

Wind speed values represent long-term average conditions rather than event-scale winds. The dataset does not capture short-term gusts or extreme wind events but is appropriate for relative wildfire risk assessment and WUI-scale comparative analysis.

#### 7.Social Drivers

ACS > WUI Area-Weighted

**Source:** U.S. Census Bureau, **American Community Survey (ACS) 5-year Estimates, 2023 release (2019–2023)**

**Access:** Downloaded programmatically using the **tidycensus** R package and official Census API.

#### Input Data:

- Polygon layer: Census **tract geometries** (ACS 5-year, Hawai‘i)
- Social variables derived from ACS tables:
  - Population: total population
  - Income: median household income
  - Poverty: percent below poverty line
  - Employment: percent unemployed
  - Education: percent < high school; percent bachelor’s+
  - Disability: percent with disability
  - Housing: percent renter-occupied
  - Transportation: percent households without vehicle
  - Connectivity: percent households without internet
  - Age structure: percent under age 5; percent age 65+

#### Spatial Units:

- **Input:** Census tracts (ACS geography)
- **Output:** **WUI polygons** (*WUI\_Polys.shp*), **n = 214 statewide WUI units**

#### Coordinate Reference System:

ACS tracts (raw): NAD83 geographic

Analysis CRS: **NAD83 / UTM Zone 4N (EPSG:26904)**

All layers reprojected to EPSG:26904 prior to intersection and weighting.

#### Processing Summary

ACS tract-level social variables were first downloaded and cleaned using reproducible R scripts. To align social data with wildfire-relevant spatial units, **area-weighted spatial interpolation** was applied:

1. Census tracts and WUI polygons were projected to **UTM Zone 4N**.
2. **Geometric intersection** was performed to create tract–WUI fragments.

3. **Area weights** were computed as:  

$$\text{intersection area} \div \text{total WUI polygon area}.$$
4. **Area-weighted means** of all social variables were calculated for each WUI.
5. Weighted values were **joined back to WUI polygons**.
6. Final datasets were exported as **shapefile and CSV**.

## Output Products

**WUI\_ACS\_Social\_AreaWeighted.shp** — WUI polygons with area-weighted social indicators

**WUI\_ACS\_Social\_AreaWeighted.csv** — Tabular WUI-level social dataset

### Key Attributes:

- **total\_pop** — Area-weighted population estimate
- **med\_hh\_income** — Median household income
- **pct\_poverty** — Percent below poverty line
- **pct\_unemployed** — Percent unemployed
- **pct\_less\_hs** — Percent without high school diploma
- **pct\_bachelors\_plus** — Percent bachelor's degree or higher
- **pct\_disability** - Percent population with disability
- **pct\_renter** - Percent renter-occupied housing
- **pct\_no\_vehicle** - Percent households without vehicle
- **pct\_no\_internet** - Percent households without internet
- **pct\_under5** - Percent population under age 5
- **pct\_65plus** - Percent population age 65+

## Data Quality Notes

- ACS values are **survey-based estimates** with sampling uncertainty.
- Census tracts and WUI boundaries **do not spatially align**, requiring interpolation.
- Area-weighted interpolation **assumes uniform distribution of population within tracts**, which may introduce bias in heterogeneous landscapes.
- Weighted WUI population totals may differ from statewide ACS totals due to:
  - Partial tract overlap with WUI boundaries
  - Coastal/ocean clipping
  - Spatial interpolation effects

## Response Variables

Purpose: Create a response variable table per WUI, including:

- **Burn Area (BP\_prop)** = burned area  $\div$  WUI area
- **Fire Frequency (Freq\_perYr)** = fires per year
- **Fire Return Interval (FRI\_years)** = years per fire  
 All expressed *per WUI polygon*, ensuring spatial integrity.

Inputs:

- WUI\_Polys (Field: WUI\_Riskar (unique ID for each WUI))
- fires\_1999\_2022
- Study window: 1999–2022 (24 years)
- Projection: EPSG:6933 – Cylindrical Equal Area (areas are in m<sup>2</sup>)

### 1. Burn Probability

(BP\_prop = burned area ÷ WUI area)

- Dissolve (on fire perimeters)
- Intersect (fire polygons × WUI polygons)
- Calculate Geometry Attributes (get area m<sup>2</sup>)
- Summary Statistics (Sum BurnArea\_m2 by WUI\_Riskar)
- Add Field + Calculate Field (on WUI layer)

Equation (Calculate Field): !SUM\_BurnArea\_m2! / !WUI\_Area\_m2!

Output field: BP\_area

### 2. Fire Frequency

(Freq\_perYr = fires ÷ years)

- Summary Statistics on fire intersections (Count FIRE\_UID by WUI\_Riskar)
- Add Field + Calculate Field

Equation (Calculate Field): !COUNT\_FIRE\_UID! / 24

(24 number of study years)

Output field: Freq\_perYr

### 3. Fire Return Interval

(FRI\_years = years ÷ fires)

- Use the same summary table from Fire Frequency
- Add Field + Calculate Field

Equation (in Calculate Field): 24 / !COUNT\_FIRE\_UID!

Output field: FRI\_years

(Set FRI\_years = <Null> where COUNT\_FIRE\_UID = 0)

### Result:

Each WUI polygon has:

BP\_prop, Freq\_perYr, and FRI\_years calculated manually — using Add Field → Calculate Field in the attribute table.

### Units & Data Integrity

Variable	Definition	Units	Notes
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WUI_Area_m2	Total area of WUI polygon	m <sup>2</sup>	from projected geometry
SUM_BurnArea_m2	Total burned area <i>within</i> WUI	m <sup>2</sup>	from intersection
BP_prop	Burned / WUI area	unitless (0–1)	proportional
COUNT_FIRE_UID	Number of distinct fires	count	0 means no fire
Freq_perYr	Fires per year	count/year	= COUNT / total_years
FRI_years	Years per fire	years/fire	= total_years / COUNT; NA if COUNT=0

### Contact

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