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.

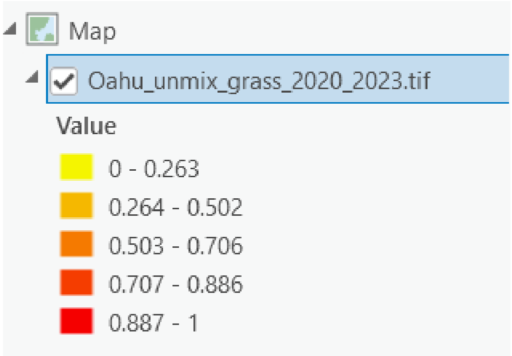
Contents

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)



Processing:

- Spectral unmixing of grass fraction (0–1)
- Threshold selected for fuel continuity: **≥50% herbaceous cover**
- Masked …

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.

Ovewrview

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.

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; $0 = \le 50\%$ 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**
WUI_Grass_Metrics_Final.shp	WUI polygons containing mean, median, and dominance percentage attributes.
WUI_Grass_Summary.csv	Per-WUI tabular summary of grass metrics for statistical analysis.

Data Quality Notes

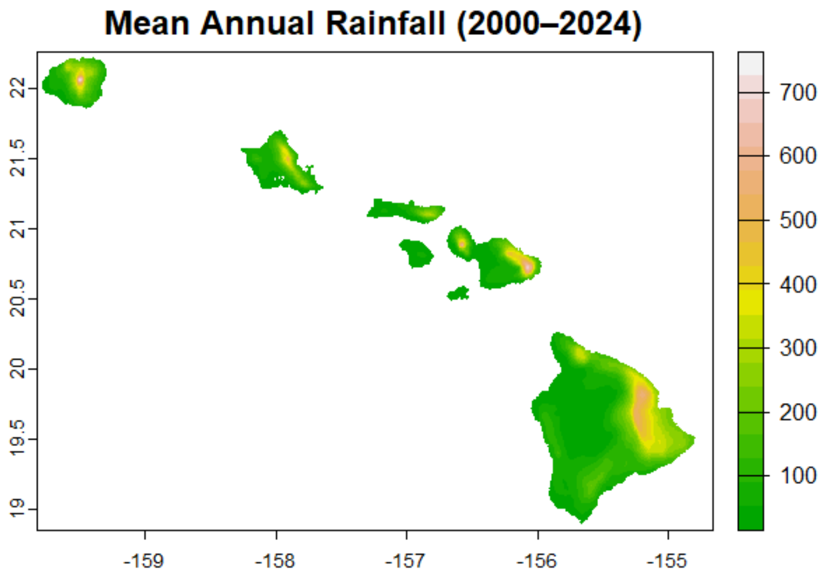
- **Spectral Unmixing:** Values represent sub-pixel fractions; a value of 0.50 means 50% of the 30m pixel is identified as herbaceous fuel.
- **Fuel Continuity:** The 50% threshold is a standard heuristic used to identify where fine fuels are likely continuous enough to support fire spread.
- **Data Vintage:** The raster represents a composite/average of conditions between 2020 and 2023.

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

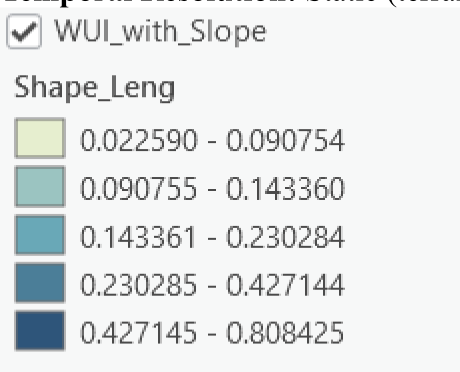
- Rainfall surfaces are interpolated estimates based on station data and kriging methods.
- Spatial uncertainty varies across islands; coastal and high-elevation areas may have higher error.
- Long-term averaging smooths interannual variability and extremes.

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
slope_hawaii_10m.tif	Slope (degrees) statewide at 10 m resolution
roughness_hawaii_10m.tif	Surface roughness statewide at 10 m resolution
WUI_with_Slope.shp	WUI polygons with mean slope added
WUI_with_Roughness.shp	WUI polygons with mean roughness added
WUI_Mean_Slope.csv	Per-WUI mean slope values

WUI_Mean_Roughness.csv	Per-WUI roughness values

Data Quality Notes

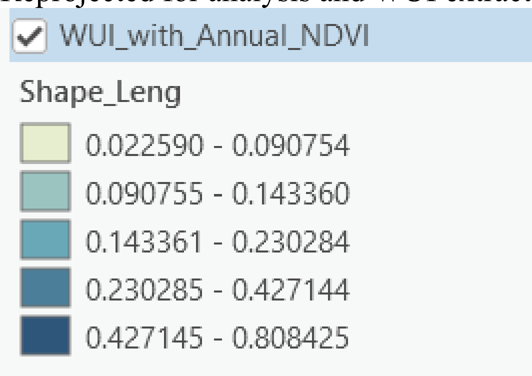
- DEM is high-quality but may contain localized errors (steep cliffs, cloud shadows in source LIDAR mosaics).
- Coastlines and small islets may include minor artifacts.
- Roughness depends on the 3×3 window; different kernel sizes produce different interpretation scales.
- Resampling the DEM to match 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., NDVI > 0.25 → 1, else 0), and a 3×3 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
NDVI_Monthly_Stack_YYYY_MM.tif	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)
NDVI_Adjacency_Index.tif	NDVI-based adjacency/continuity index raster
WUI_with_Annual_NDVI.shp	WUI polygons with mean annual NDVI attribute
WUI_with_Adjacency_Index.shp	WUI polygons with NDVI adjacency index attribute

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., NDVI > 0.25 for "vegetated") are analytical choices and should be interpreted in the context of Hawai'i's vegetation types and fuel models.

5. Fuel Continuity

Download Impervious data: https://coastalimagery.blob.core.windows.net/ccap-landcover/CCAP_bulk_download/High_Resolution_Land_Cover/Phase_1_Initial_Layers/Impervious/index.html

Dataset Title: Hawaiʻi Fuel Continuity (Herbaceous + Shrub) Raster Products
Time Period: 2020–2023 (mean composite)
Resolution: 30 m
Format: GeoTIFF
Geographic Coverage: Hawaiʻi Island, Maui, Oʻahu, Kauaʻi

CRS:

- Input spectral/unmixing products: EPSG 4326 (WGS84)
- Final analysis layers reprojected to match WUI/fire modeling: EPSG 26904 (NAD83 /

UTM Zone 4N)

Overview

This dataset represents fuel continuity for the Hawaiian Islands by integrating herbaceous cover (grass), shrub cover, and impervious surface removal to derive spatially explicit fire-spread potential. Fuel continuity reflects how connected fine fuels (primarily grasses and shrubs) are across the landscape. These values are critical for wildfire exposure modeling because Hawaiʻi's fire regimes are driven by fine, fast-burning, and continuously distributed fuels, especially invasive grasses.

The original herbaceous and woody vegetation fraction rasters were produced from spectral unmixing of multi-year (2020–2023) satellite imagery. These rasters were then processed to classify and mask out impervious areas and golf courses, producing cleaned and clipped fuel-continuity surfaces ready for wildfire modeling and WUI extraction.

Input Data Sources

1. Herbaceous and Shrub Fractions

- Derived from unmixing of multi-year (2020–2023) satellite observations
- Provided at 30 m resolution
- Layers used:
  - unmix_grass_2020_2023.tif
  - unmix_woody_2020_2023.tif

2. Impervious Surfaces

- High-resolution (1 m) CCAP impervious dataset (2021)
- Source: NOAA Office for Coastal Management (OCM)
- Separate files for each county:
  - Maui, Oʻahu, Hawaiʻi, Kauaʻi
- Upsampled to 30 m through aggregation and thresholding to preserve maximum impervious presence.

3. Golf Courses (OSM)

- Source: OpenStreetMap
- Extracted via osmdata package (feature = leisure=golf_course)
- Rasterized and used as an exclusion mask.

Processing Workflow Summary

Step 1 — Grass and Shrub Thresholding

- Defined thresholds based on continuity:
  - Grass continuity: > 50% herbaceous fraction

- Shrub continuity: < 80% woody fraction

- Binary classification for each layer (1 = fuel, 0 = no fuel).

Step 2 — Impervious Layer Resampling

Because resampling directly from 1 m → 30 m loses detail, a two-step process was used:

1. Aggregate to 30 m using mean()
2. Apply a very low threshold (>= 0.001) → If ANY impervious exists, classify pixel as impervious.

Result:
impbinary0_1.tif — A binary raster where 1 = impervious, 0 = non-impervious.

Step 3 — Masking Grass and Shrub Fuel Layers

- Impervious mask applied using:

maskedimp_grass <- mask(grass_crop, reproj_impbinary, maskvalue = 1)

- Golf mask applied using rasterized OSM polygons.

Output:

- *_Masked_Grass.tif
- *_Masked_Shrub.tif

Step 4 — Clipping to Zoning / WUI Boundaries

- Zoning layers used for island-specific clipping
- WUI polygons used for extraction
- CRS aligned using st_transform() and terra::project().

Step 5 — Extract Fuel Statistics per WUI

- Mean fuel continuity per zone extracted using:

extract(masked_imp_grass, vect(zones), fun=mean)

Output examples:

- Hawaii_Grass_by_Zone.csv
- maui_Grass_by_Zone.csv

Output Products

File Name	Description
*_Masked_Grass.tif	Grass fuel continuity raster with impervious & golf courses removed
*_Masked_Shrub.tif	Shrub fuel continuity raster, masked same as grass
Island_Grass_by_Zone.csv	Mean grass fuel continuity per zoning / WUI

Fuel_Continuity_Final.tif	Combined composite fuel surface (if merged)
Fuel_Continuity_perWUI.csv	Final fuel exposure summary at WUI level

Key Attributes

Attribute	Meaning
0	No herbaceous fuel present or removed (impervious/golf)
1	Herbaceous fuel present (grass continuity above threshold)
Shrub values	Continuous shrub cover up to 80%
NA	Outside the island mask or missing data

Data Quality Notes

- Impervious resampling from 1 m to 30 m can overestimate developed areas, but this is intentional to avoid false fuel signals near buildings.
- Golf courses are masked entirely because they function as low-fuel barriers.
- Thresholds (>50% grass, <80% shrub) are analytically justified but adjustable depending on fire-behavior calibration needs.
- Spectral unmixing may misclassify wet soils, rocks, or fallow lands as low vegetation in rare cases.
- Final rasters align with 30 m fuel modeling frameworks used in Hawai‘i wildfire analysis.

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.

Intended Use

Fire environment characterization and inclusion as a meteorological predictor in the Hawaiʻi Wildfire Risk Assessment Index (WRAI), GLMM modeling, and multivariate analyses.

Response Variables

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

- Burn Area (BP_prop) = burned area ÷ 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^2)

1. Burn Probability

(BP_prop = burned area ÷ WUI area)

- Dissolve (on fire perimeters)
- Intersect (fire polygons × WUI polygons)
- Calculate Geometry Attributes (get area m^2)
- 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
WUI_Area_m2	Total area of WUI polygon	m²	from projected geometry
SUM_BurnArea_m2	Total burned area *within* WUI	m²	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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