Current Challenges with Activity Data Collection and Emissions Estimation Methods for Wildland Fires

EPA EMISSIONS INVENTORY CONFERENCE: TRAINING

SEPTEMBER 15, 2025

Outline

- Goals for EPA fire inventories
- Define fire types
- Activity challenges
- Emissions challenges
- Interactive parts include poll questions, interactive exercises and Q&A

Poll Question 1:

What is your Affiliation?

Goals for EPA fire emissions inventories

- Acquire available fire activity data (satellite, state-local-tribal (SLT) and federal agencies)
- Daily emissions are needed for EPA Emissions Modeling Platforms to capture the temporal and spatial variability of fire emissions to assist with better air quality modeling performance
- Reconcile all fire activity to generate daily acres burned for wildland fire types at specific locations
  - Daily temporal scale has many challenges; some to be covered today
  - Specific locations allow for better spatial allocation of emissions and plume rise estimation for air quality modeling
- Estimate daily emissions for each daily fire/burn at specific location
- For the EPA National Emissions Inventory (NEI), EPA sums the daily emissions to the county and monthly time scale
  - The daily and specific location information is no longer available in the NEI

Benefits of understanding the challenges of developing fire emissions inventories

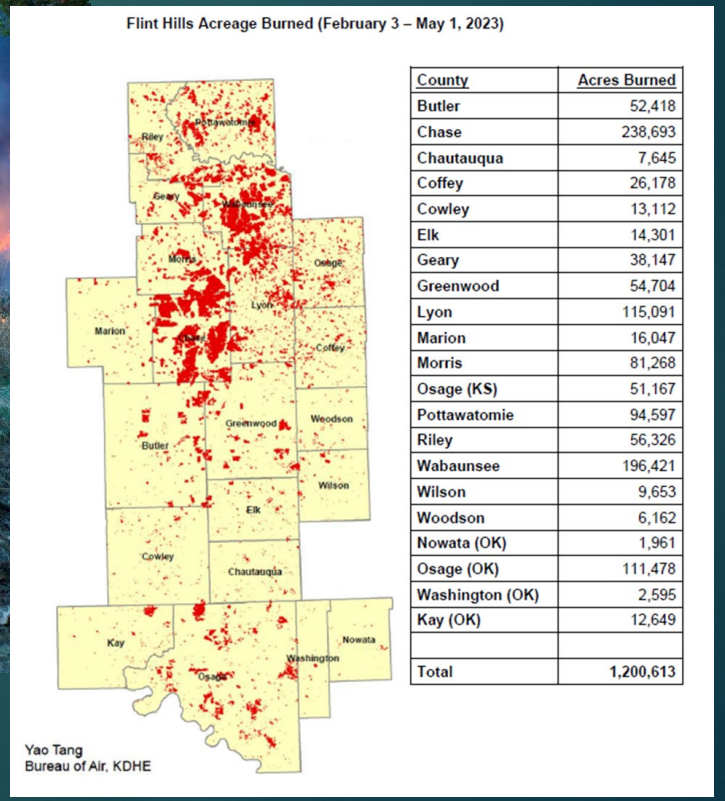
- State, Local, Tribal and other federal agencies can better understand why the activity data and the quality of the data is important
- Agencies and others can learn about some of the tools they can use to quality assure activity
  - Understand sources of uncertainty and possibly provide information to reduce it
- Users of the fire emissions inventories can better understand the types of fire information provided by EPA during inventory generation process and the data limitations

Fire Types in National Emissions Inventory

- Wildland fire: Areas of land that are undeveloped and consist primarily of natural vegetation. These areas can include forests, grasslands, and shrublands, and are often subject to natural or human-induced fires.
- Wildfires: Uncontrolled fires that occur in wildland areas. They can be caused by natural events, such as lightning, or human activities, such as unattended campfires, or a downed powerline.
- Prescribed burns: controlled burns, these are intentionally set fires used as a vegetation/land management tool. They are designed to reduce the risk of larger wildfires, manage ecosystems, and promote the growth of certain plant species. Careful planning and execution is required to minimize risk.

Prescribed burn technique: Broadcast

- Broadcast burn: A type of prescribed burn where fire is applied across a large area to manage vegetation and reduce fuel loads.
- Flint Hills grasslands is a special case where annual broadcast burns are used to manage tallgrass prairie ecosystems in Kansas and Oklahoma.



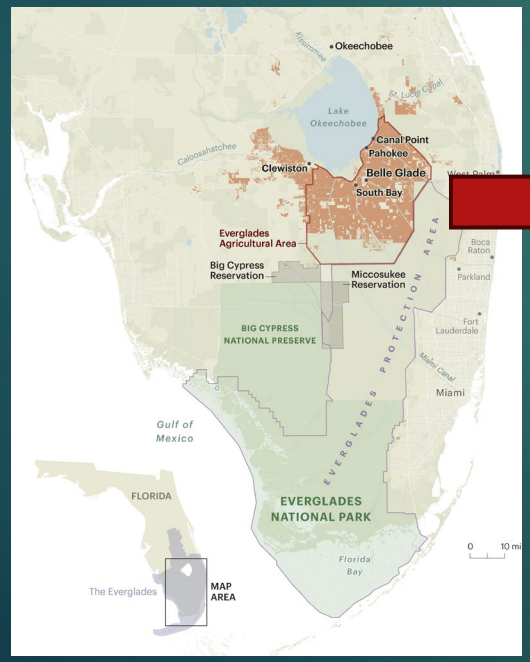
County	Acres Burned
Butler	52,418
Chase	238,693
Chautauqua	7,645
Coffey	26,178
Cowley	13,112
Elk	14,301
Geary	38,147
Greenwood	54,704
Lyon	115,091
Marion	16,047
Morris	81,268
Osage (KS)	51,167
Pottawatomie	94,597
Riley	56,326
Wabaunsee	196,421
Wilson	9,653
Woodson	6,162
Nowata (OK)	1,961
Osage (OK)	111,478
Washington (OK)	2,595
Kay (OK)	12,649
Total	1,200,613

Prescribed burn technique: Pile burns

- A prescribed burn technique where collected vegetation debris, such as branches and logs, are burned in piles. This method is often used for managing debris after land clearing or logging.
- Pile burning is often favored over broadcast burning in the West for several reasons:
  - **More flexible conditions**: can be conducted under a broader range of weather conditions than broadcast burns and can be more easily controlled.
  - **Targeted fuel reduction**: Pile burning is particularly effective in forests where dense undergrowth or logging debris creates a high fire hazard.
  - **Wildland-urban interface**: Pile burning is often used in the wildland-urban interface (WUI), where human development meets wildlands, to reduce fuel loads and create a buffer against wildfires.
- Pile burn methodology just added for the 2023NEI.

Agricultural/crop residue burns

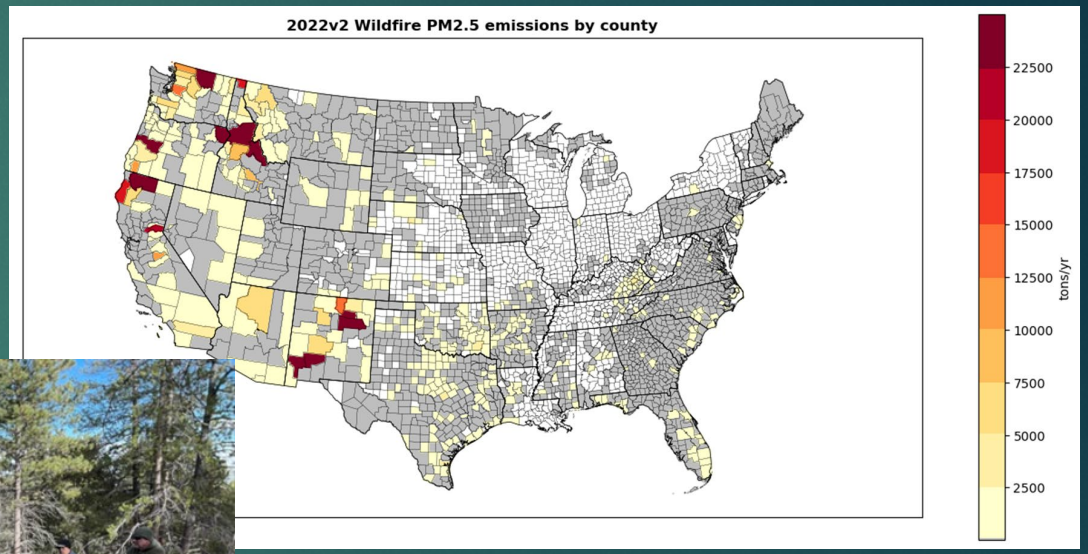
- The practice of burning leftover plant material after harvest to clear fields and prepare for the next planting season. It is also used to control pests and diseases.
- Can include fields or irrigation ditches.
- This can include burning sugarcane pre-harvest (southern FL) to remove leaves and make harvesting easier.
- Agricultural pile burn not currently estimated in NEI.



Other burns

- **These type of burns have separate methodologies for emissions estimation in the NEI**
  - **Emissions are estimated at county and annual level**
- **Land Clearing**: The process of removing trees, shrubs, and other vegetation from an area to prepare it for agricultural use, construction, or other development. Burning is sometimes used to dispose of the cleared vegetation.
- **Open burning**: The burning of materials in an open environment. This can include burning household waste, yard debris, or other materials.
- **These burns can be detected by satellites too!**

Poll Question 2: Which Type of Fire do you think is most common in your region?

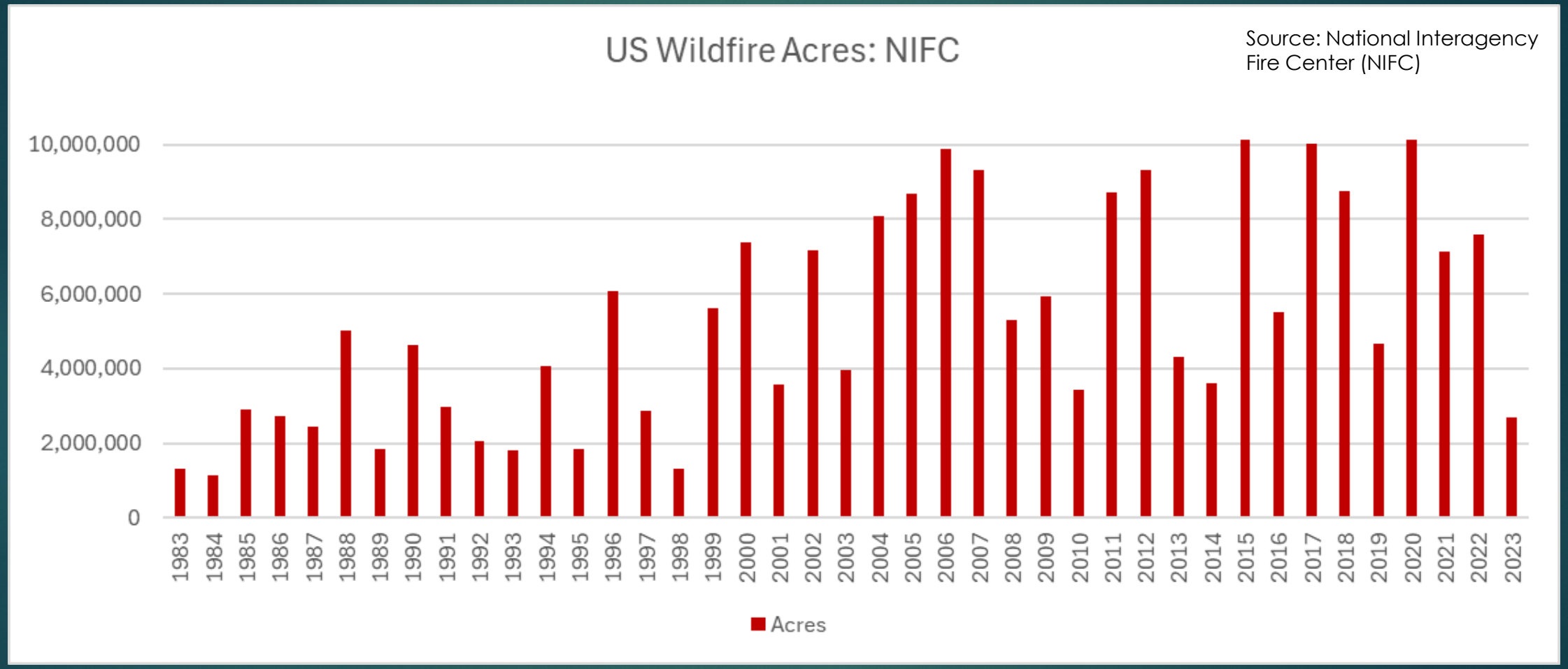


Terminology/Acronyms

- WF = Wildfires
- RX = Prescribed burns
  - PB = Pile burns
- AG = Agricultural burns
- pySF2 = modified python SmartFire2
- BSP = BlueSky Pipeline framework
- EF = Emissions Factor
- FH = Flint Hills grasslands (eastern Kansas and Oklahoma)

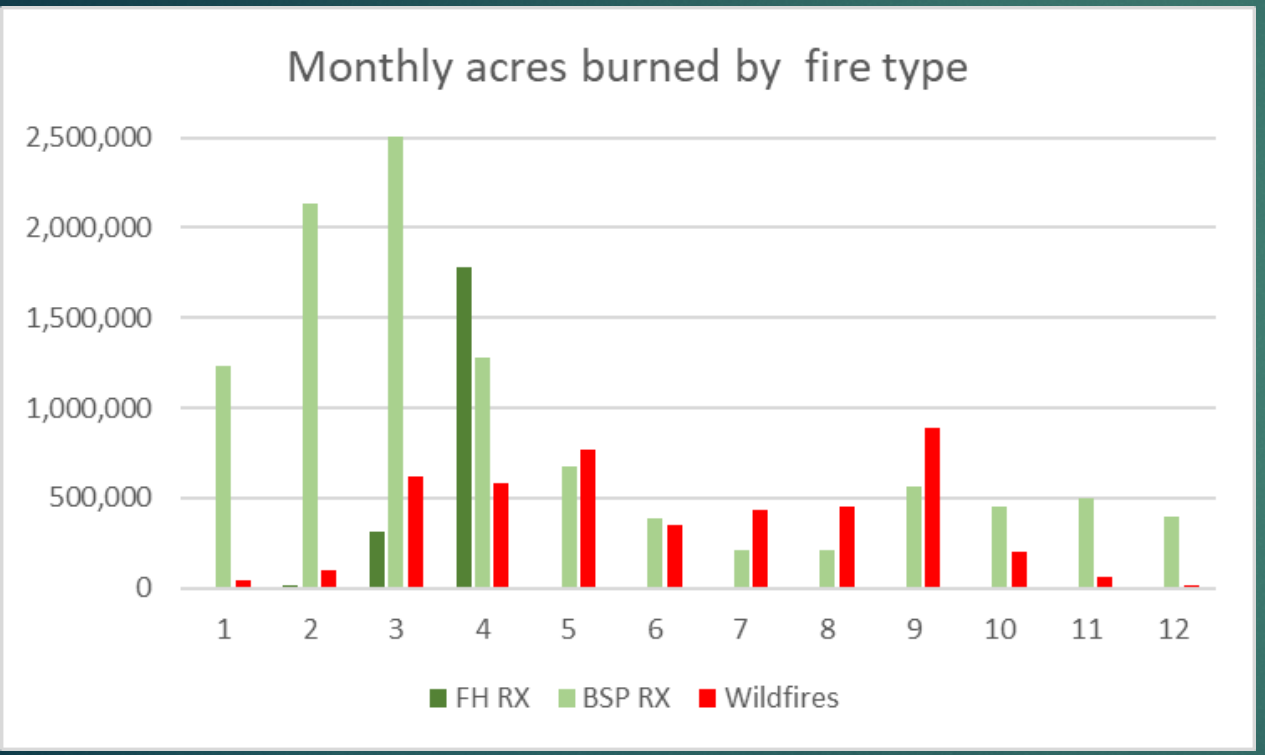
Fire Activity Data Available and Challenges Using the Data

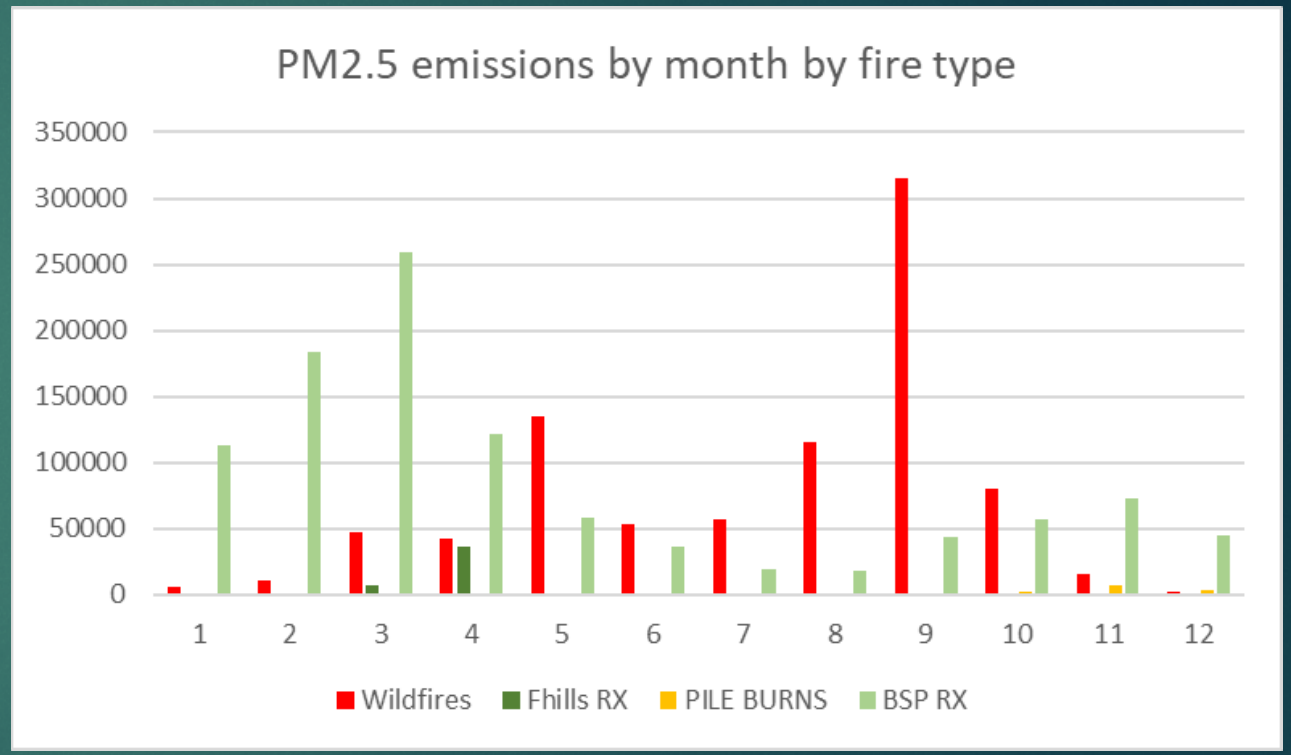
Wildfire season variability



USA total acres burned for 2023 was about 2.7M; quietest season since 1998

Monthly fire type analysis for CONUS Year 2022 examples





Activity data used: Federal agencies

- **NOAA HMS (Hazard Mapping System)** satellite detection
  - https://www.ospo.noaa.gov/Products/land/hms.html
- Incident Status Summary reports (**ICS-209**) daily incident report data
  - https://www.wildfire.gov/application/famweb-data-warehouse
  - Mainly wildfires
- Wildland Fire Interagency Geospatial Services (**WFIGS**) Group Fire Perimeter data
  - Shapefiles acquired from: https://data-nifc.opendata.arcgis.com/datasets/nifc::wfigs-interagency-fire-perimeters/about
  - Mainly wildfires
- US Forest Service Activity Tracking System (**FACTS**)
  - Hazardous Fuel Treatment Activity data for 2023
  - Wildfires and Prescribed burns
- Department of Interior (DOI) fire activity data from National Fire Plan Operations and Reporting System (**NFPORS**)
  - Obtained via DOI's RESTful GIS service: https://usgs.nfpors.gov/arcgis/rest/services
  - Prescribed burns only on DOI lands

Hazard Mapping System fire detects

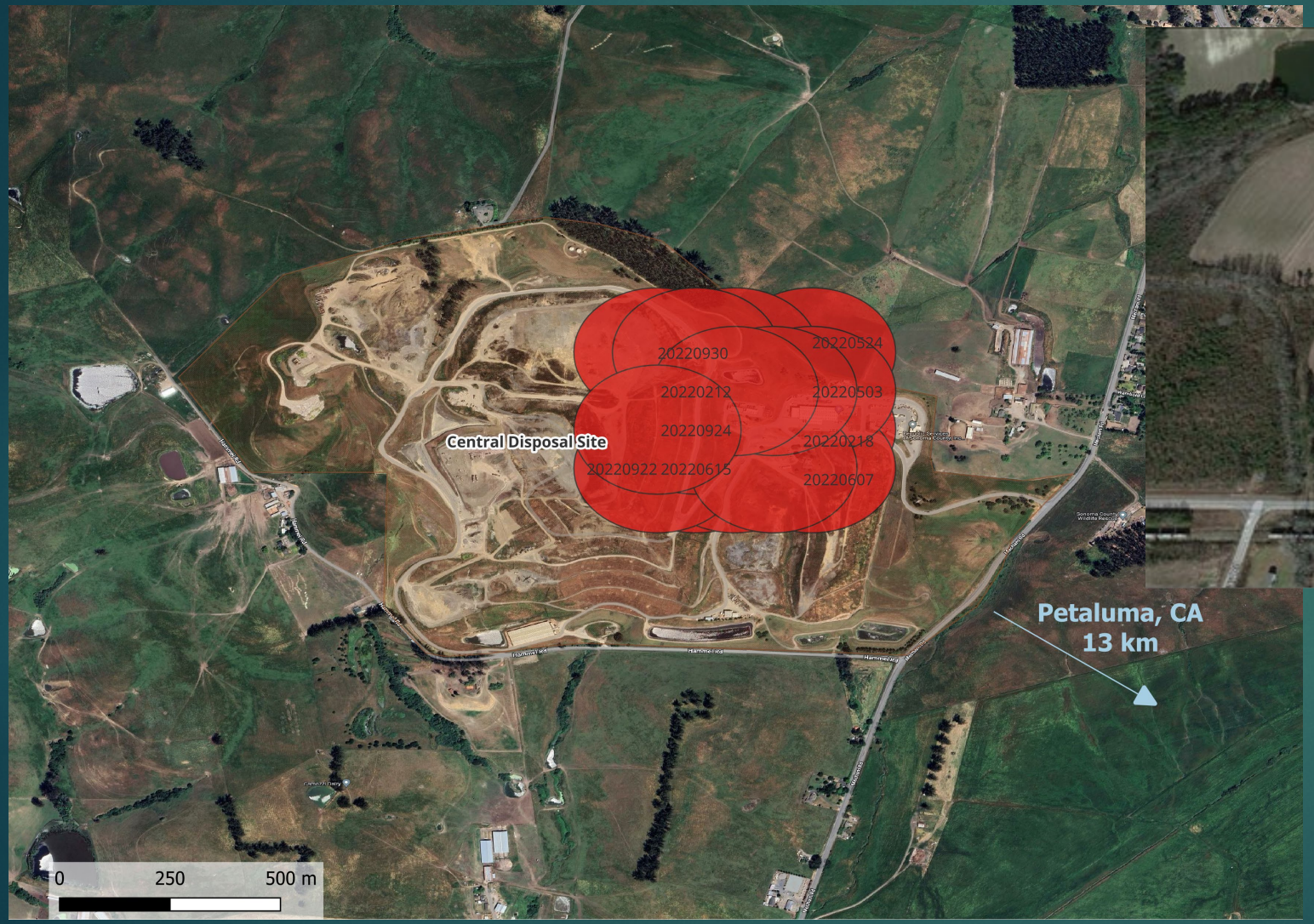
- NOAA/NESDIS's Hazard Mapping System (HMS) was first implemented in 2003 in response to high demand for active fire and smoke information over North America.
- The system combines near real-time polar and geostationary satellite observations into a common framework in which analysts perform quality control of automated fire products and digitization of smoke plumes.
- Historically, the system has used data from multiple satellite instruments as they enter operations and are later replaced with follow-up missions
- Currently, the HMS uses the 2km resolution Advanced Baseline Imager (ABI) data from GOES-19 (East) and GOES-18 (West) geostationary satellites, along with 375m resolution VIIRS data from S-NPP and NOAA-20 polar satellites, and 1km resolution MODIS data from the Terra polar satellite.
- Instrumentation and resolution changes since 2020 have meant adjusting NEI methodology!

The number of HMS fire detects annually have tripled since 2020!!

HMS false detects

- False detections in HMS are possible due to the complexities of remote sensing and environmental factors. Human analysts and ongoing algorithmic improvements help with accuracy, but higher resolution has tripled the number of satellite fire detects since 2020.
  - Examples: Solar glint off snow/water, heat from anthropogenic source.
- EPA filters out detects that occur at or near known solar farms, landfills, and oil and gas operations (e.g., flaring).
  - The list of known solar farms, landfills, mines, and oil and gas operations is far from complete.
  - EPA adds new filters when located.
  - EPA uses Google Maps and other GIS tools to investigate sources that do not reconcile with federal or SLT activity data.

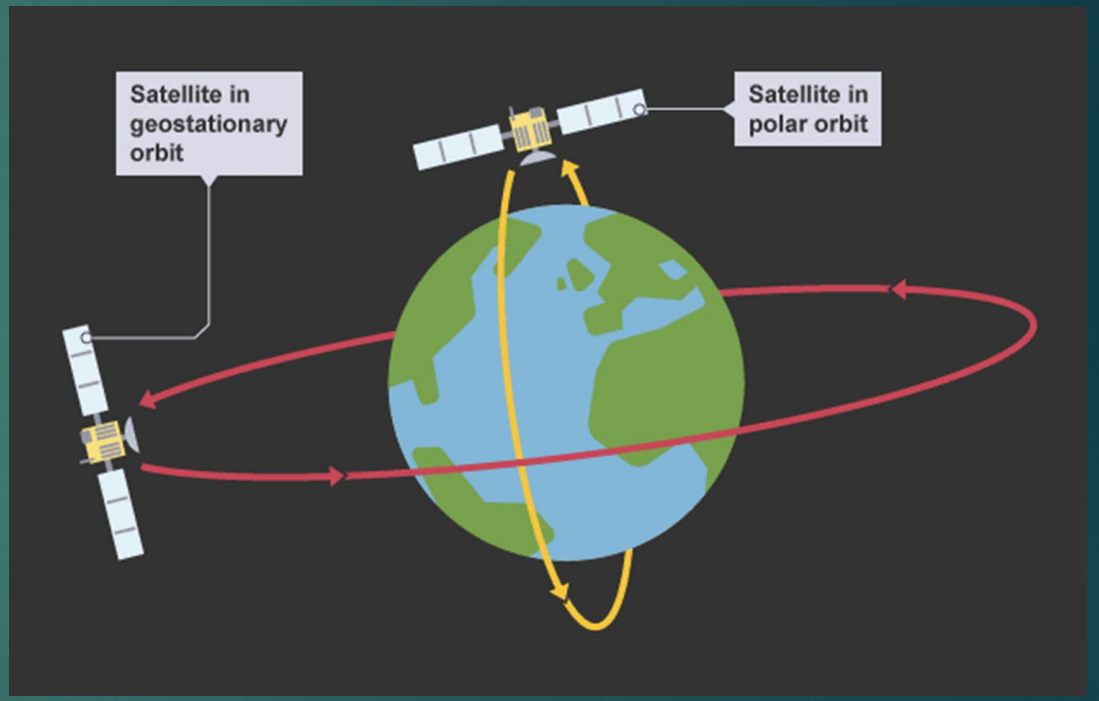
Possible false detect locations



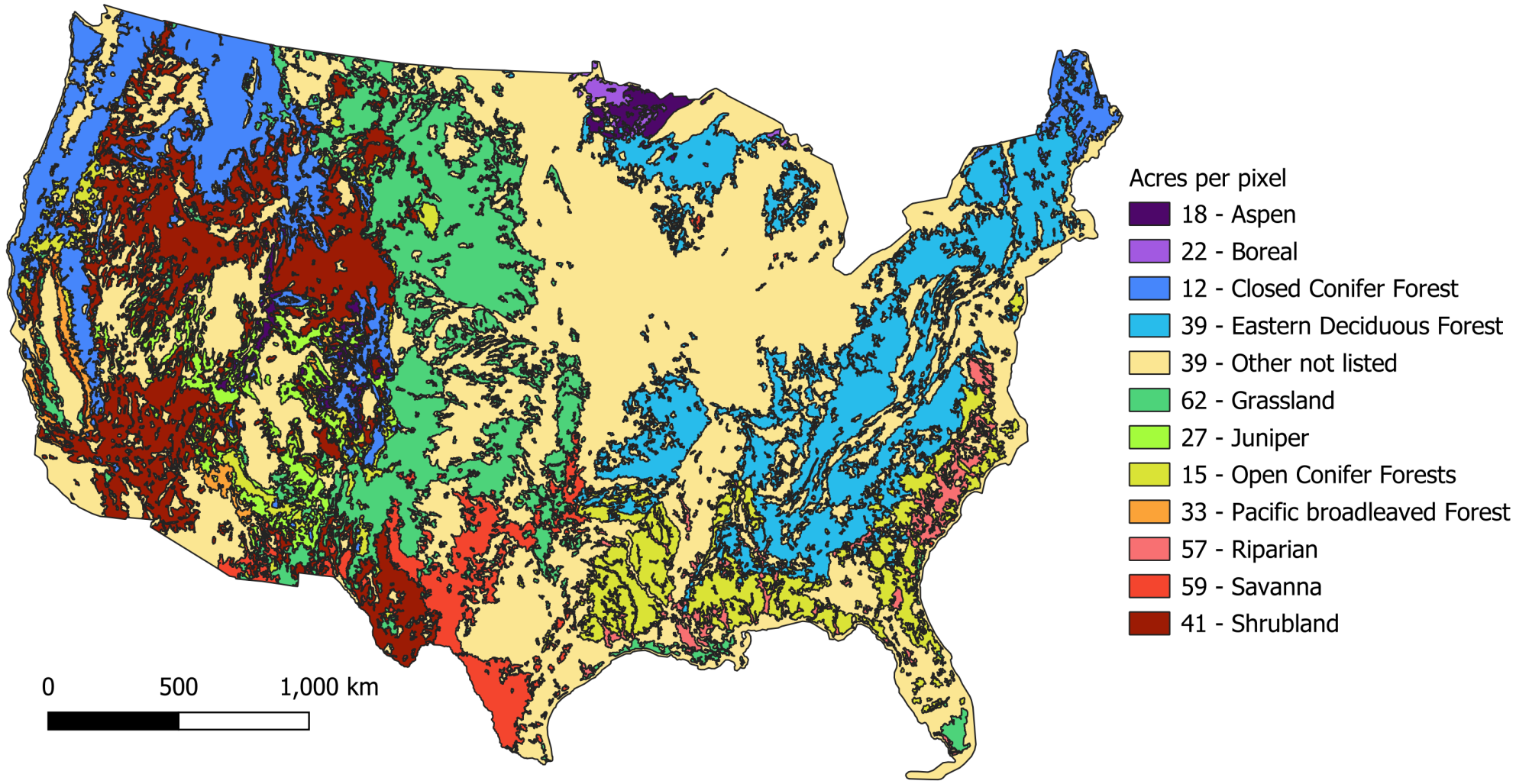
Poll Question 3: What challenges do you think arise from false detects of a satellite sensor?

HMS does miss fires too!

- HMS can miss smaller fires
- Errors of omission commonly include limited passes over area and cloud cover
- Another reason why SLT fire activity is important!



Default acres per HMS pixel/detect

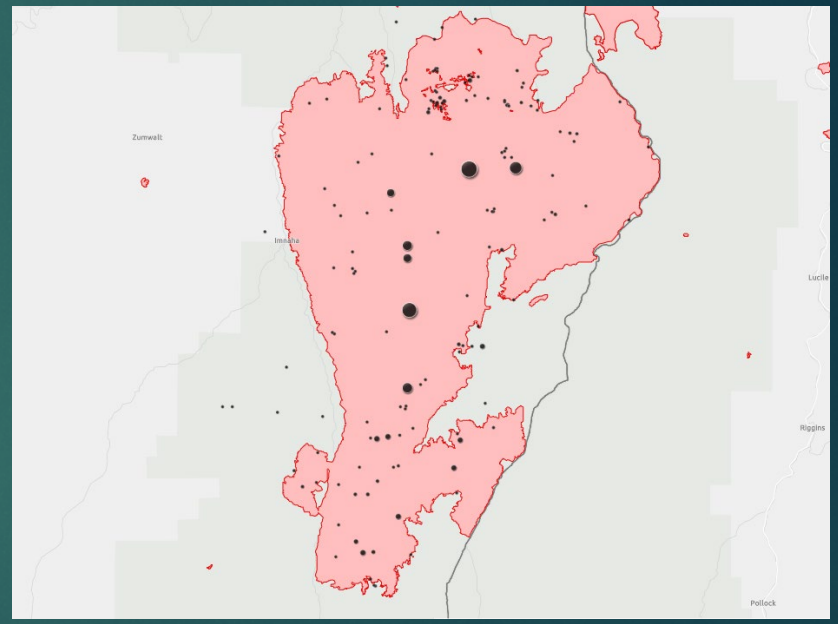


Used when we don't have actual documented fire activity and must rely solely on HMS detect

Based on the average area per detection over a fire perimeter

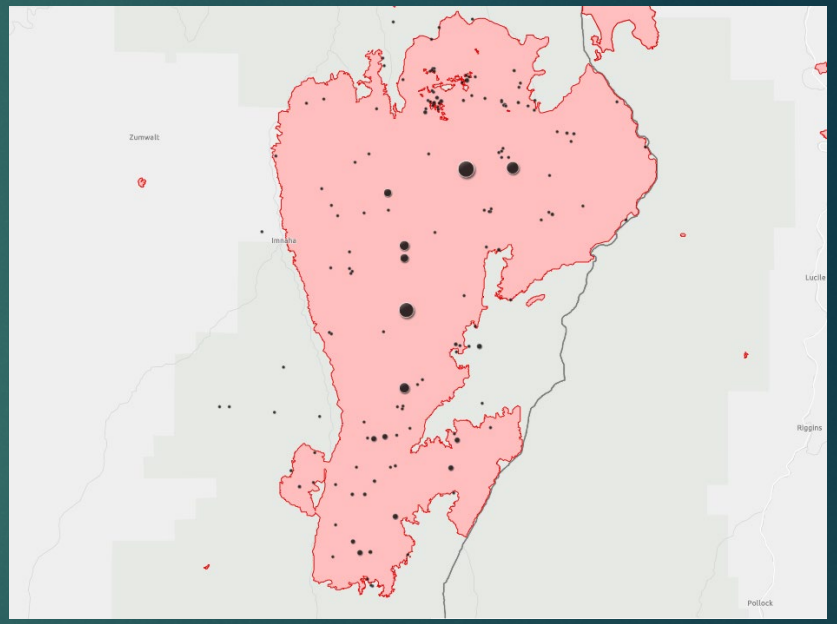
Needed activity data information

- Fire type
  - Prescribed burn (RX), wildfire (WF), agricultural burn (AG)
    - Pile burn (PB)
- Date(s) of burn/fire (start and ending dates)
- Size (acres burned)
- Location
  - Latitude-longitude or shapefile



Activity data information: challenges!

- Fire Type
  - Usually specified in activity data sources
- Date(s) of burn/fire (start and ending dates)
  - Some provide discovery, containment, and other dates
  - Dates are often incorrect
- Size (acres burned)
  - Different activity datasets have different sizes for same fire
- Location
  - Latitude-longitude is incorrect
  - Shapefile has multiple burn sizes and time periods in metadata

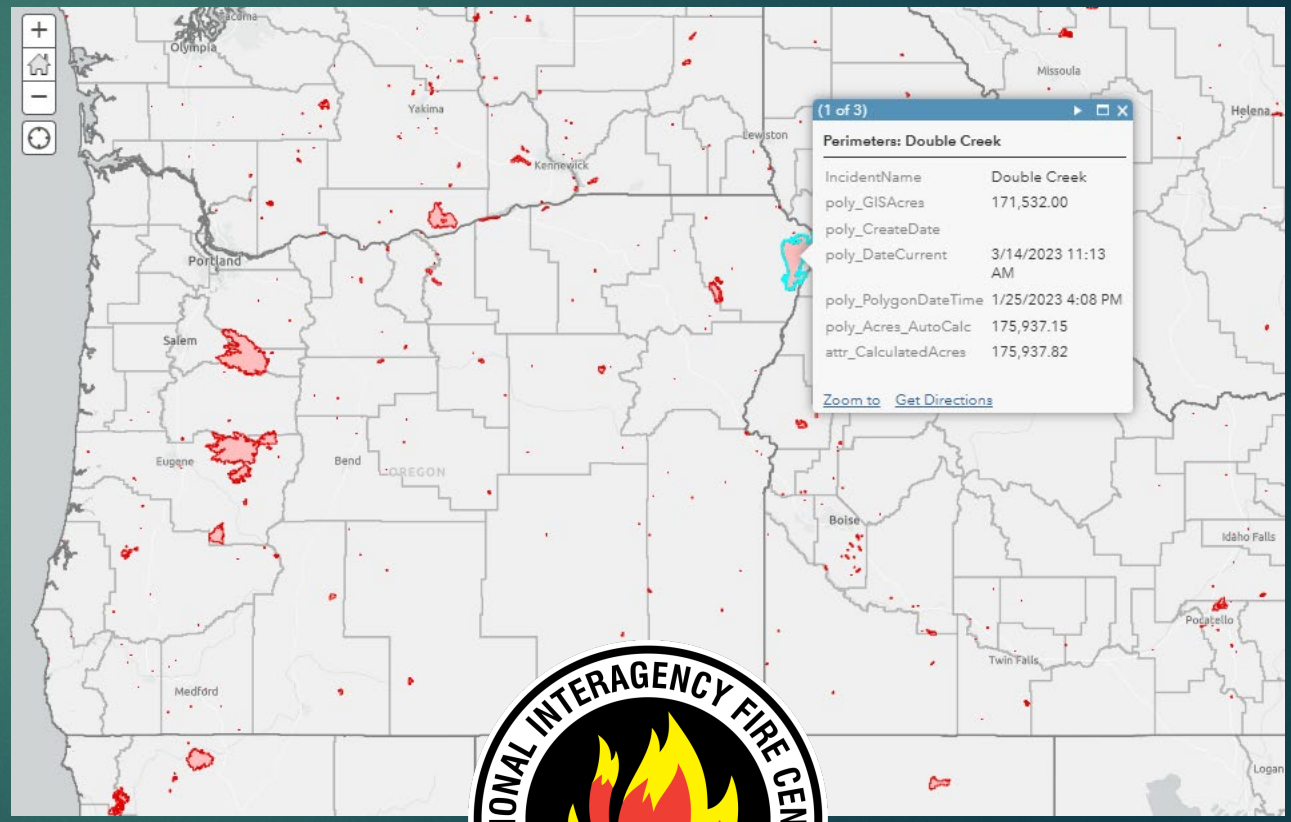


Poll Question 4: Which ONE characteristic of fire activity in your opinion is MOST prone to error?

BRIEF Q&A

Wildland Fire Interagency Geospatial Services (WFIGS) Fire Perimeter

- Available on National Interagency Fire Center website
- Best available perimeters for all recorded wildland fires in the United States
  - NIFC updates these perimeters often
  - May use different methods to estimate size of fire
- Can contain incorrect information
  - Start and end date
  - Inconsistent sizes
- Missing some small wildfires



Incident Status Summary (ICS-209)

- Mainly wildfires
- Not shapefiles; one latitude-longitude for each fire event
- Can contain incorrect information
  - Duplications
  - Dates
  - Location
  - Different size than WFIGS shapefiles

The ICS-209 blocks highlighted in yellow (below) meet the minimum national requirements for incidents managed under Monitor, Confine, and Point Zone Protection strategies.

Incident Status Summary (ICS-209)

1: Date	2: Time	3: Initial | Update | Final	4: Incident Number	5: Incident Name

6: Incident Kind/Strategy	7: Start Date Time	8: Cause	9: Incident Commander	10: Incident Command Organization	11: State-Unit

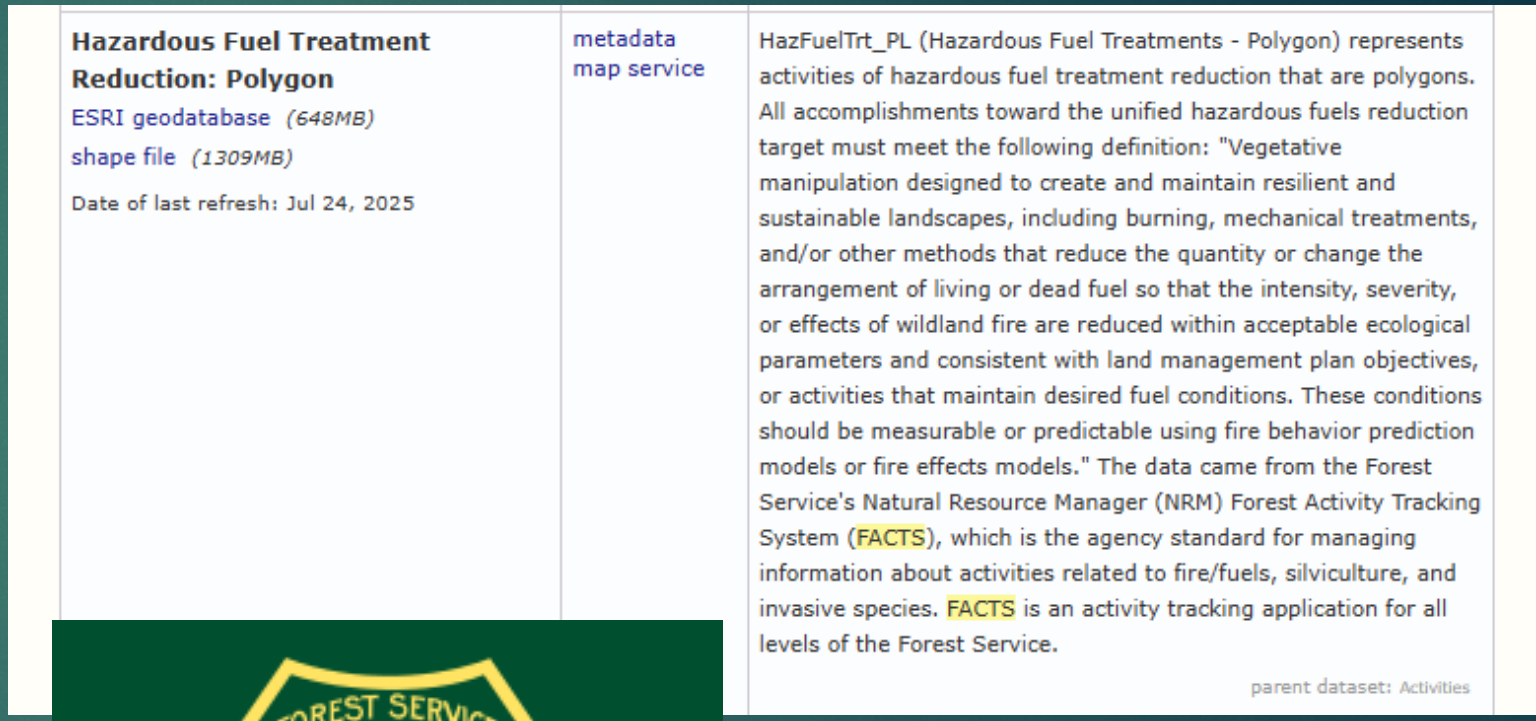
12: County	13: Latitude and Longitude Lat: Long: Ownership at Origin:	14: Short Location Description (in reference to nearest town):

15: Size/Area Involved	16: % Contained or MMA	17: Expected Containment Date:	18: Line to Build	19: Estimated Costs to Date	20: Declared Controlled Date: Time:

21: Injuries this	22: Injuries	23: Fatalities	24: Structure Information

US Forest Service Activity Tracking System (FACTS)

- Prescribed burns and wildfires on USFS lands
- Shapefiles
- Can contain incorrect information
  - Dates
  - Location/shape size
- Some burns are not recorded or are otherwise missing



Hazardous Fuel Treatment Reduction: Polygon ESRI geodatabase *(648MB)* shape file *(1309MB)* Date of last refresh: Jul 24, 2025	metadata map service	HazFuelTrt_PL (Hazardous Fuel Treatments - Polygon) represents activities of hazardous fuel treatment reduction that are polygons. All accomplishments toward the unified hazardous fuels reduction target must meet the following definition: "Vegetative manipulation designed to create and maintain resilient and sustainable landscapes, including burning, mechanical treatments, and/or other methods that reduce the quantity or change the arrangement of living or dead fuel so that the intensity, severity, or effects of wildland fire are reduced within acceptable ecological parameters and consistent with land management plan objectives, or activities that maintain desired fuel conditions. These conditions should be measurable or predictable using fire behavior prediction models or fire effects models." The data came from the Forest Service's Natural Resource Manager (NRM) Forest Activity Tracking System (FACTS), which is the agency standard for managing information about activities related to fire/fuels, silviculture, and invasive species. FACTS is an activity tracking application for all levels of the Forest Service. parent dataset: Activities

National Fire Plan Operations and Reporting System (NFPORS)

- An inter-departmental, inter-agency data management and reporting system developed, operated, and maintained by the Department of the Interior (DOI) collaboratively with the Department of Agriculture (USDA).
- Record for accomplishments in fuels, restoration & rehabilitation, and community assistance. Supports reporting at field, regional, and national levels.
- Prescribed burns on federal lands.
- Bureau Land Management, US Fish and Wildlife Service, Bureau of Indian Affairs, and National Park Service.
- Shapefiles.
- Can contain incorrect information.
  - Dates
  - Location/Shape size
- Some burns not recorded.

Activity data used: State agencies

- 2023 NEI includes complete or partial activity from 37 different states
  - 35 states submitted complete or partial prescribed burn activity
    - 17 states submitted complete or partial pile burn activity
  - 20 states submitted complete or partial wildfire activity
  - 10 states submitted complete or partial agricultural burn activity
  - KS, OK is the Flint Hills activity only
- States assumed to have complete prescribed burn activity
  - **AL, MS, FL, GA, NC, SC, OR, WA, and CA**

State/Local/Tribal fire activity data in 2023NEI

State	RX	WF	AG	PB
Alabama	Yes	No	Yes	Yes
Alaska	Yes	Yes	No	No
Arizona	Yes	No	No	Yes
Arkansas	Yes	Yes	Yes	Yes
California	Yes	Yes	No	Yes
Colorado	Yes	No	No	Yes
Connecticut	Yes	Yes	No	No
Delaware	Yes	No	Yes	No
Florida	Yes	Yes	Yes	Yes
Georgia	Yes	Yes	Yes	Yes
Hawaii	No	Yes	No	No
Idaho	Yes	No	Yes	Yes
Iowa	Yes	Yes	No	No
Kansas	Yes	No	No	No
Kentucky	Yes	No	No	No
Maine	No	Yes	No	No
Maryland	Yes	Yes	No	No
Minnesota	Yes	No	No	No
Mississippi	Yes	No	Yes	No
Nebraska	Yes	Yes	No	No
Montana	Yes	No	No	Yes
Nevada	Yes	Yes	No	Yes
New Jersey	Yes	Yes	Unable to	No
New Mexico	Yes	Yes	No	Yes
Nez Perce Tribe	Yes	No	Yes	Yes
North Carolina	Yes	Yes	Yes	No
North Dakota	Yes	No	No	Yes
Oklahoma	Yes	No	No	No
Oregon	Yes	No	No	Yes
Pennsylvania	Yes	Yes	No	No
South Carolina	Yes	Yes	Yes	No
TN Shelby County	Yes	No	No	No
Texas	Yes	Yes	No	No
Utah	Yes	No	No	Yes
Virginia	Yes	Yes	No	No
Washington	Yes	No	No	Yes
West Virginia	No	Yes	No	No
Wyoming	Yes	Yes	No	Yes

Activity data challenges: State agencies

- Determining level of completeness
- Can contain incorrect or missing information
  - Dates
  - Size
  - Location: degrees to a minimum of 3 decimal places
- Sometimes includes FACTS, NFPORS or ICS209 activity
  - But different sizes, locations and dates (possibly from permitting database)
- Department of Defense (DOD) prescribed burns
  - Most states do not have DOD burn information

Determining level of completeness

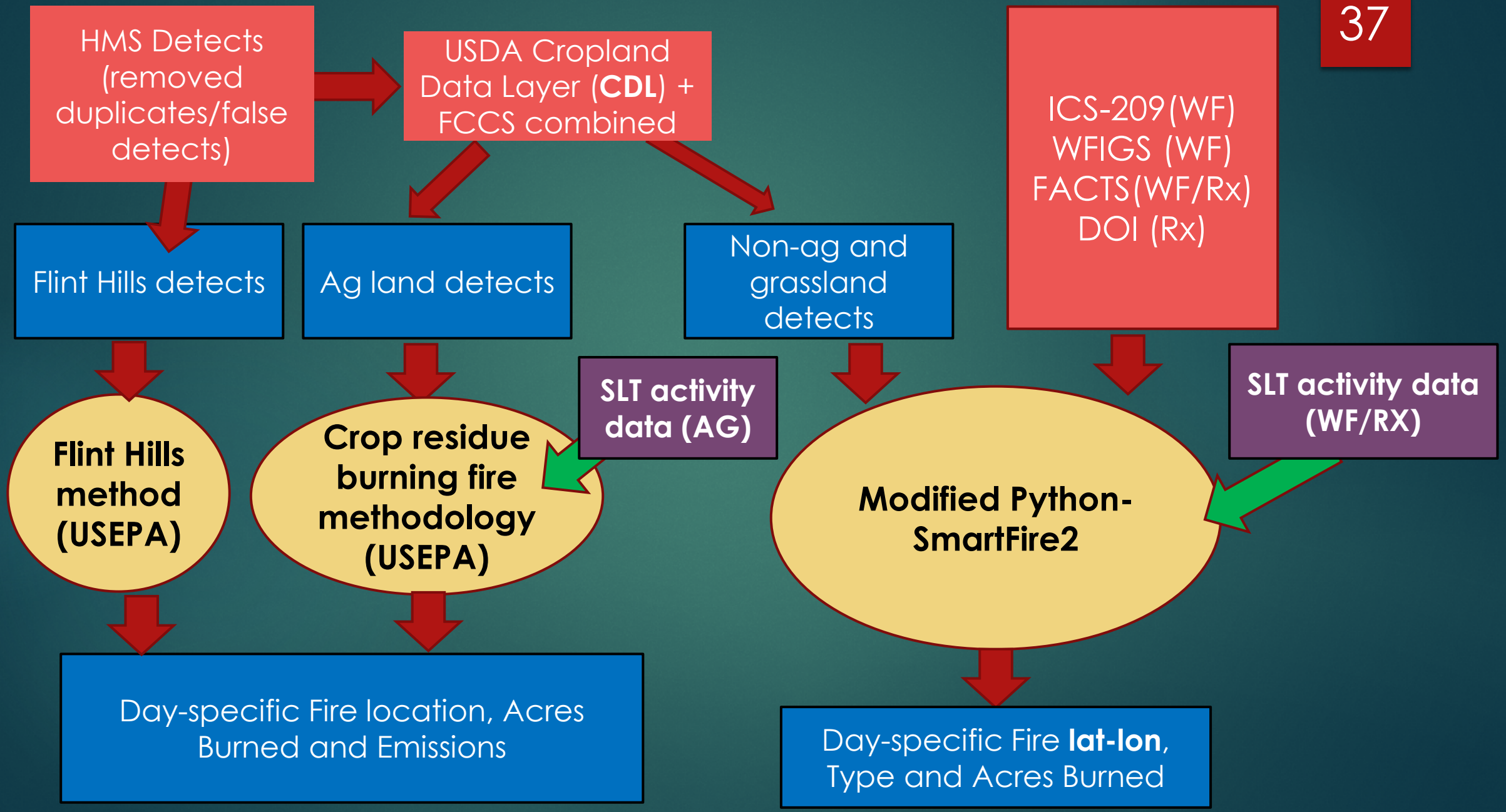
- For state agencies that submit activity, we typically see the following:
  - State agency has all type of fire type activity (WF, RX, AG)
    - NC a good example of providing all 3 consistently
    - FL and GA provide all 3 as well; very detailed prescribed fire activity in their state
  - State agency has one or two fire type activity
- Historical analysis of satellite activity are used to gauge level of completeness
  - What would the acres burn be without the state agency's data?
- Communication with state agency over time
  - Learn about burn practices and what to expect and why

Fire inventory tool used for reconciling activity

- Modified python-based SmartFire version 2 (pySF2)
  - Uses HMS satellite detects, federal and State-Local-Tribal (SLT) fire activity information
    - Activity input as either shapefiles or csv files containing location, fire type, acres burned and start and end time of burn/fire
  - Uses weighting factors and other parameters to reconcile fire activity with HMS satellite detects
  - Assigns fire type, latitude-longitude and daily acres burned
  - Provides reference information (e.g., source of activity used)
  - If no federal or SLT activity data available for a HMS detect to reconcile with, EPA assigns a fire type and acres burned estimate

Changes in the processing of activity data

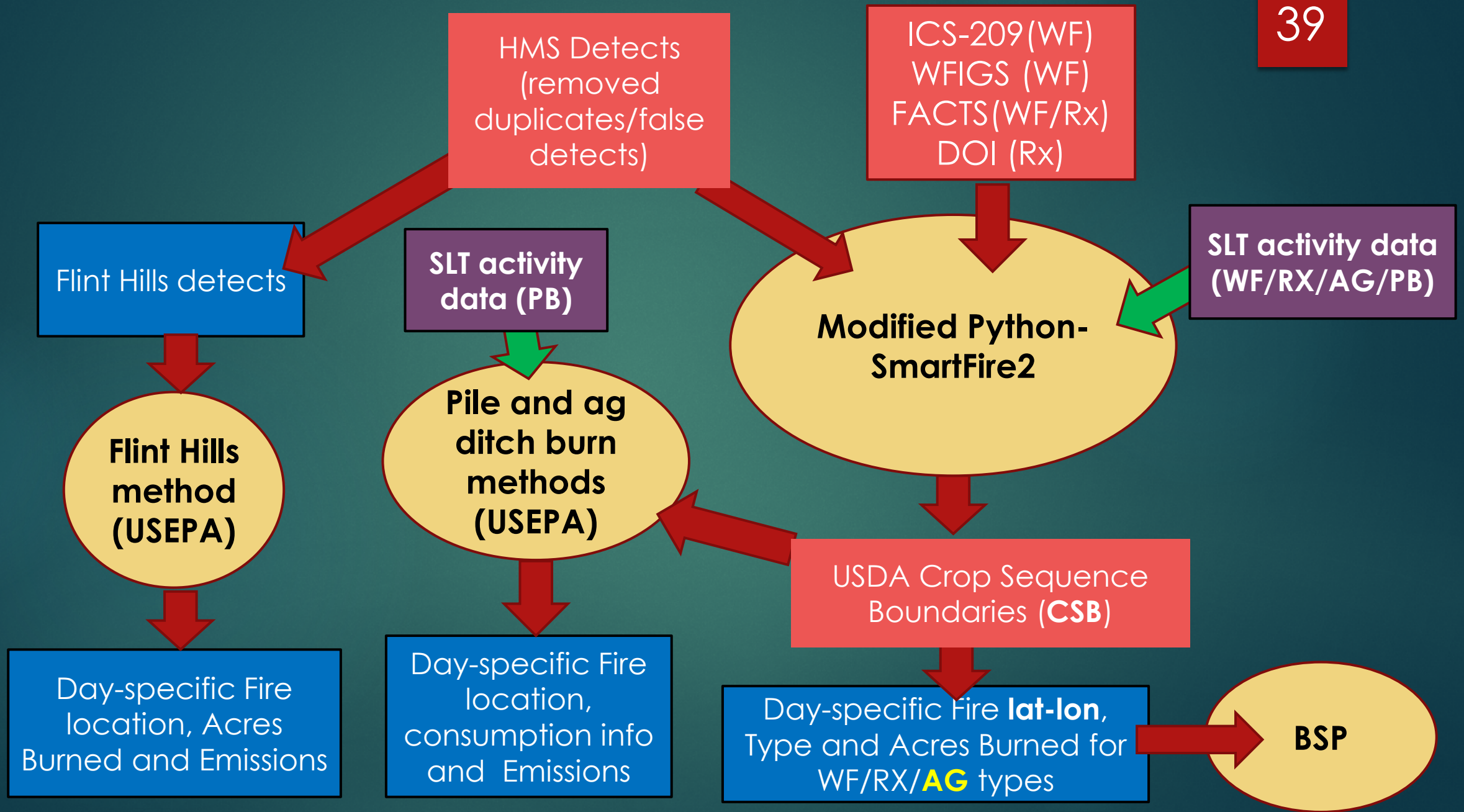
Python-SMARTFIRE2 + other burns processing for 2020 NEI



2023 NEI change: Application of cropland shapefile in fires processing

- Used to identify agricultural burns when SLT data not available or incomplete
- Done before python-SmartFire2 since 2011 NEI
  - Results in double counting situations
    - Wildfires over agricultural lands
    - Prescribed burns near agricultural lands
- Applying cropland shapefile after python-SmartFire2 in 2023 NEI
  - Should reduce double counting
  - Allow for better characterization (more HMS detects) to allocate fire emissions spatially and temporally

Python-SMARTFIRE2 + other burns processing for 2023 NEI



PySF2: Weighing/ranking activity

Rank	Location Weight	Size Weight	Shape Weight	Growth Weight	Name Weight	Fire Type Weight
1	SLT Supplemental Data	SLT Supplemental Data	NIFS	HMS	SLT Supplemental Data	SLT Supplemental Data
2	NIFS	NIFS	FACTS	NIFS	NIFS	NIFS
3	HMS	FACTS	HMS	STL Supplemental Data	ICS-209	FACTS
4	FACTS	ICS-209	ICS-209	DOI	FACTS	ICS-209
5	ICS-209	DOI	SLT Supplemental Data	PFIRS	DOI	DOI
6	DOI	PFIRS	DOI	USFWS	PFIRS	PFIRS
7	PFIRS	USFWS	PFIRS	ICS-209	USFWS	USFWS
8	USFWS	HMS	USFWS	FACTS	HMS	HMS

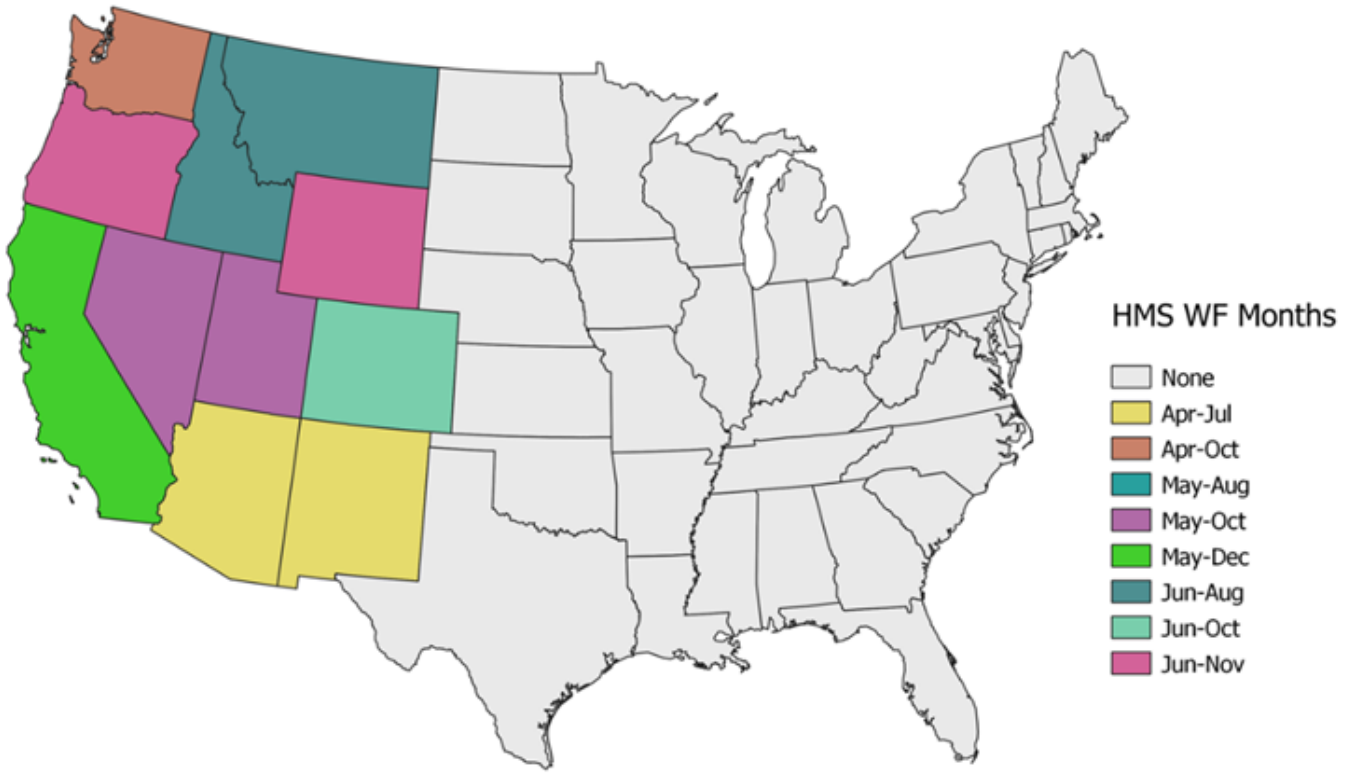
- 2020NEI example
- NIFS = WFIGS shapefiles
- PFIRS = Prescribed Fire Incident Reporting System for California
- Weights are applied based on:
  - Location
  - Size
  - Shape
  - Growth
  - Naming
  - Fire Type

Situations where all we have for activity is HMS satellite information for year 2022

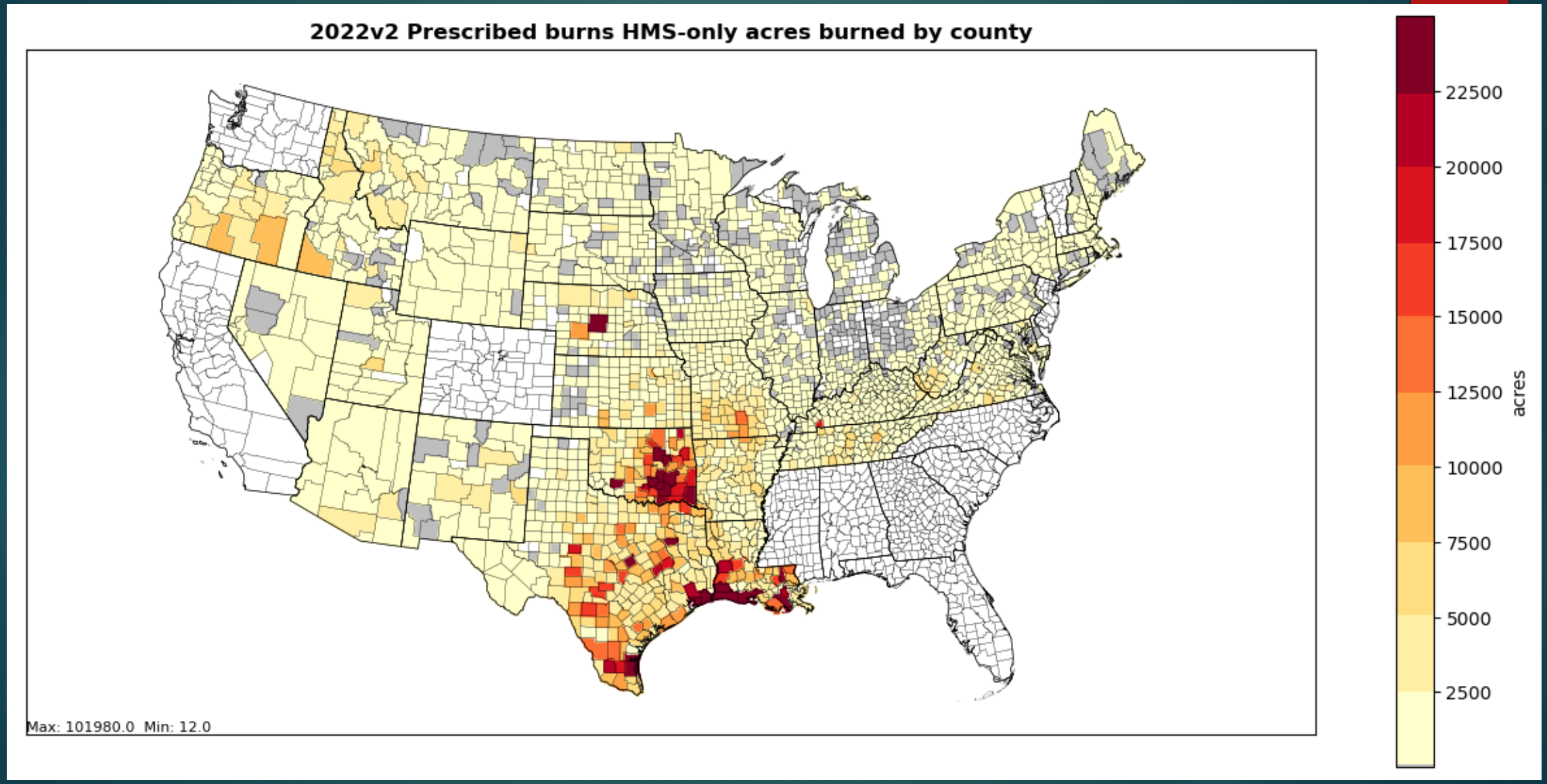
Fire Type	Total Acres Burned	HMS satellite detected only	Reconciled with activity data	%not reconciled with activity in v2	%not reconciled with activity in v1
Prescribed burns	12,733,214	4,512,461	8,220,753	35.4%	42.0%
Wildfires	4,503,624	70,921	4,432,703	1.6%	1.8%

These 10 states sum up to about 3.7M HMS detect only acres burned

State	HMS detect only acres burned v1	%not reconciled with activity v1	HMS detect only acres burned v2	Total prescribed acres burned v2	%not reconciled with activity v2
Texas	1,393,982	92.0%	1,319,872	1,573,079	83.9%
Oklahoma	788,583	72.5%	785,991	1,083,633	72.5%
Alabama	729,468	89.2%	0	789,385	0.0%
Louisiana	583,453	86.8%	581,731	670,178	86.8%
Mississippi	314,904	72.8%	0	517,298	0.0%
Missouri	295,620	91.4%	293,904	321,821	91.3%
Arkansas	228,294	30.6%	226,956	745,607	30.4%
Kansas	181,330	7.6%	181,174	2,058,176	8.8%
Tennessee	164,871	94.4%	164,364	173,751	94.6%
Nebraska	115,039	96.6%	114,286	116,291	98.3%

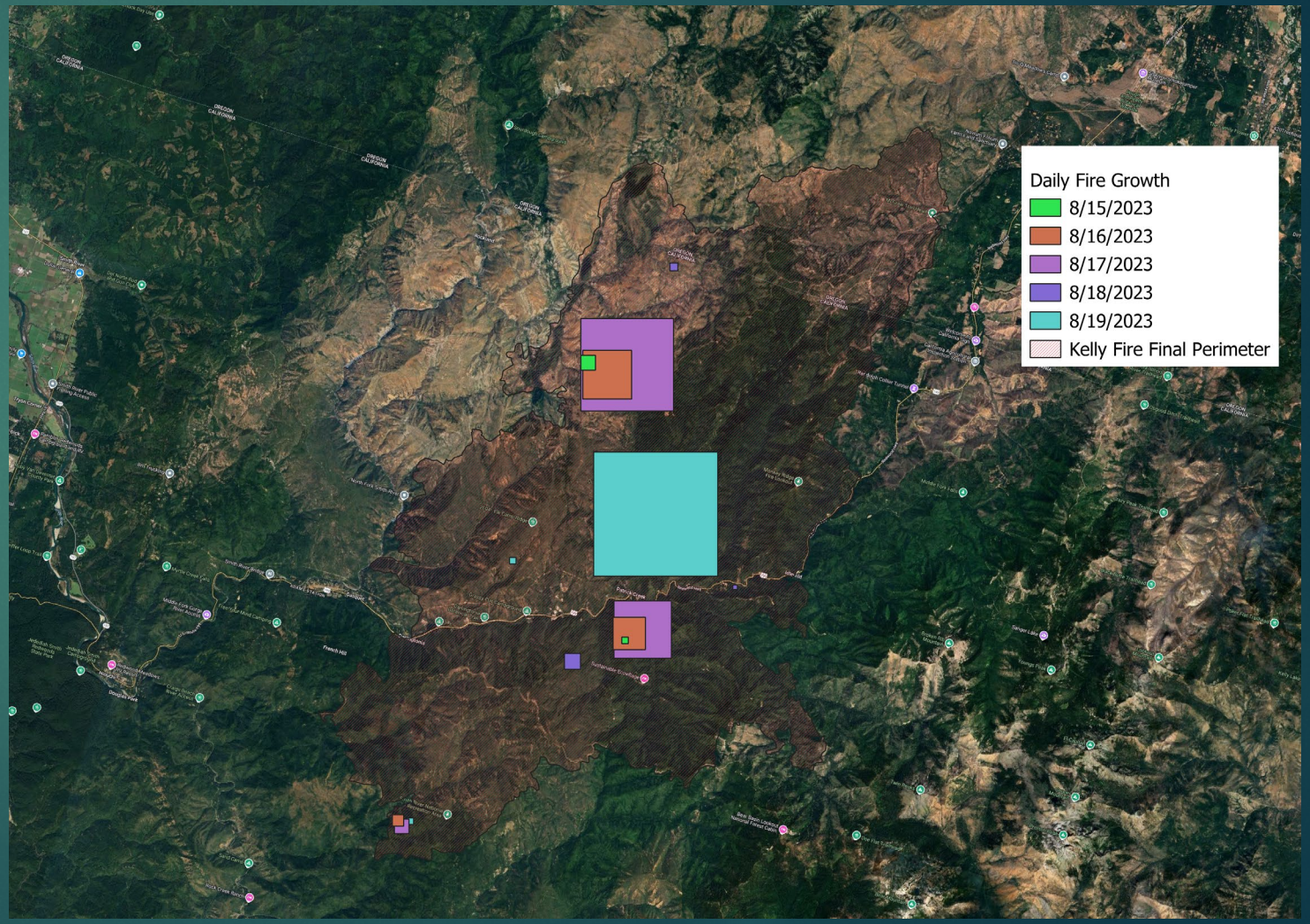


- HMS-only detects will be assign wildfire type during these WF months
- Otherwise, HMS-only detects will be assigned prescribed burn type
- Most of these assignments end up being prescribed burns


2022v2 Prescribed burns HMS-only acres burned by county
Max: 101980.0 Min: 12.0
22500
20000
17500
15000
12500
10000
7500
5000
2500
acres

Example of events that are aided by HMS detects: Kelly wildfire in 2023

- Started in northern California in mid-August
- HMS detects helped with the timing and growth of the wildfire
- The WFIGS shapefile from NIFC helps with capturing the entire burned area
- Eventually spread to parts of Oregon
- Most of the activity occurred in August but some activity in September, first 5 days shown

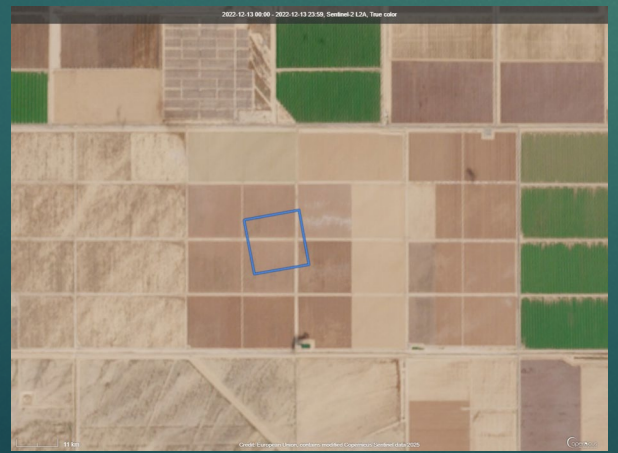


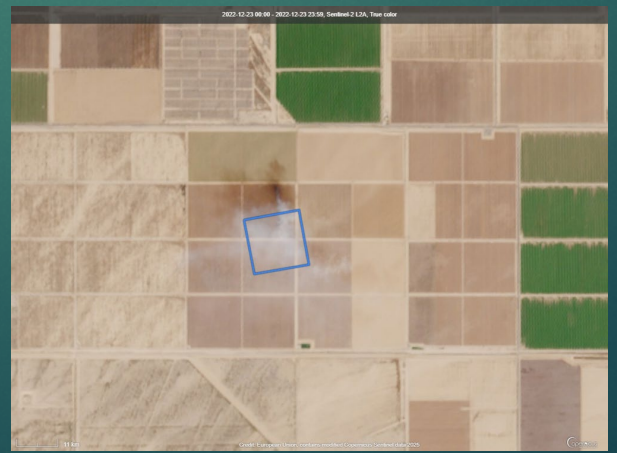
BREAK TIME

QUALITY ASSURANCE AND CASE STUDIES

ESA Sentinel imagery: Investigation Tool for fires!

- The Multispectral Imager (MSI) aboard the ESA (European Space Agency) Sentinel-2 series of satellites is a wide-swath, high-resolution, multi-spectral imaging sensor supporting Copernicus Land Monitoring studies. Its combination of spectral bands enables a wide range of uses, including the monitoring of vegetation, soil, and water cover and observing inland waterways and coastal areas.
  - Key usage for fires is the land cover change monitoring and at times smoke detected
  - Limitations: limited passes over areas and cloud cover

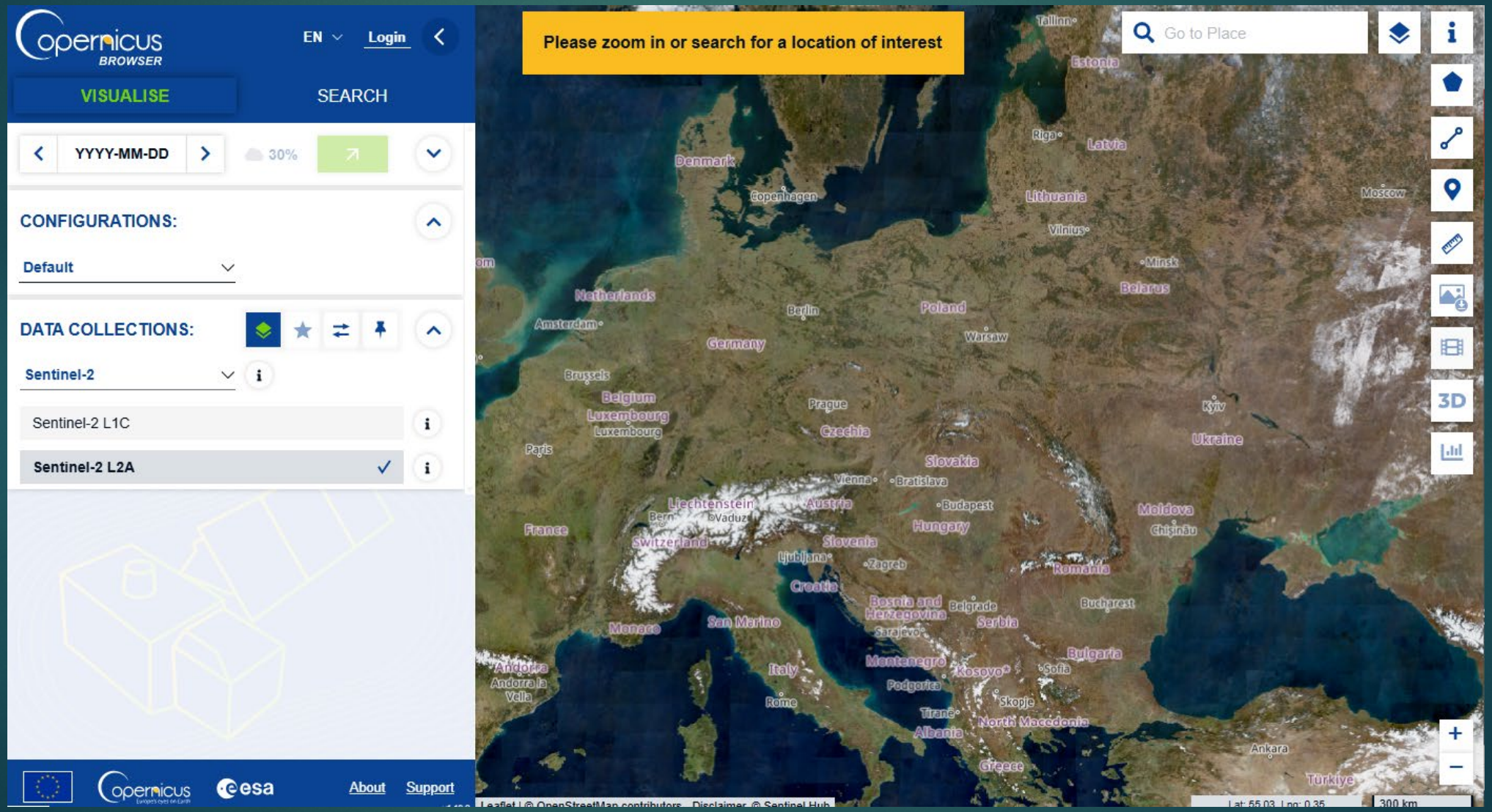




Interactive session with European Space Agency (ESA) Sentinel imagery

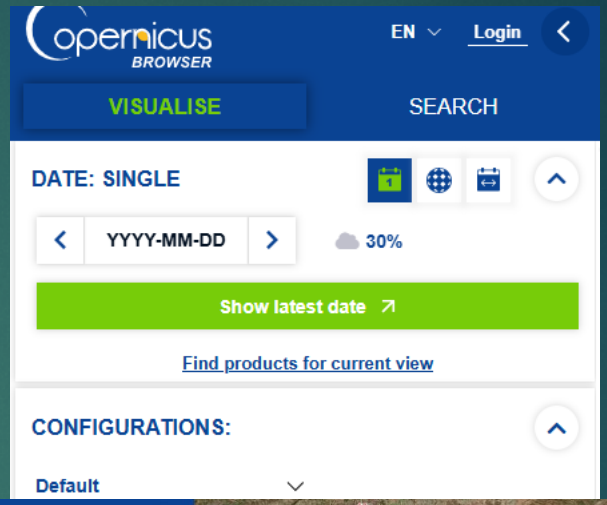
ESA Sentinel imagery: Investigation Tool online

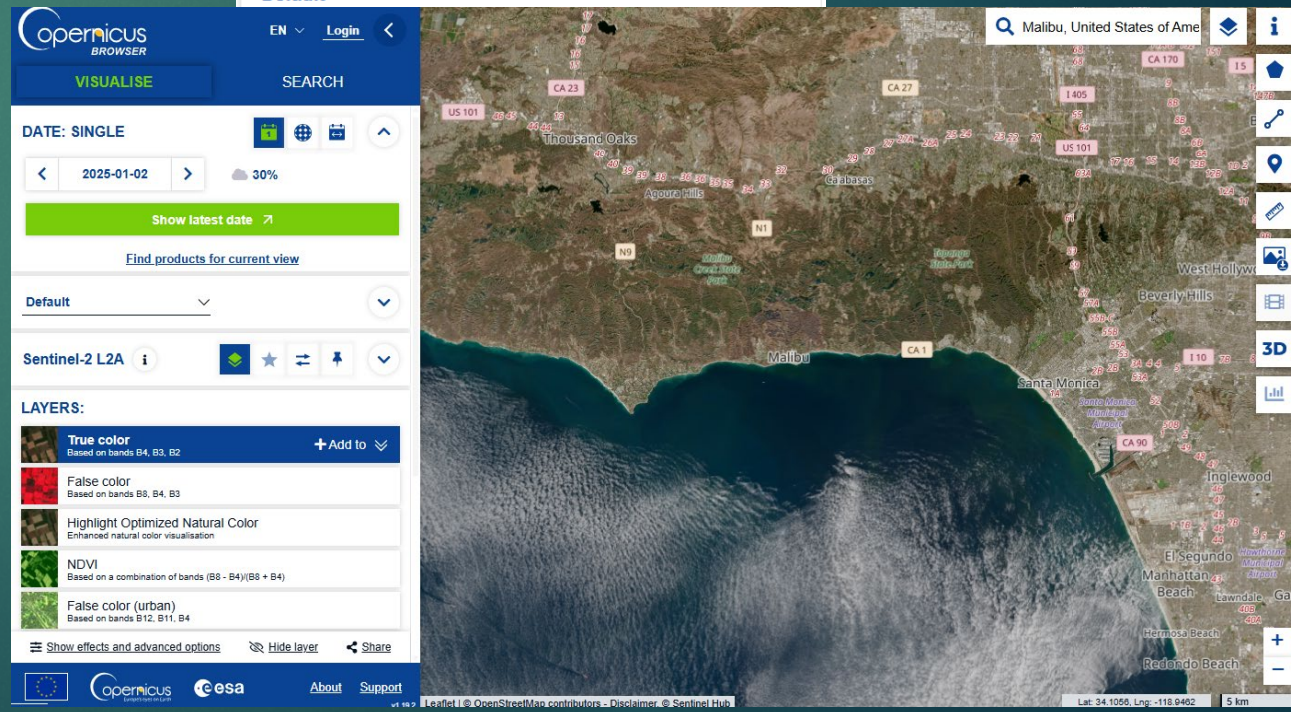
- https://browser.dataspace.copernicus.eu/



ESA Sentinel imagery: Investigation Tool for fires!

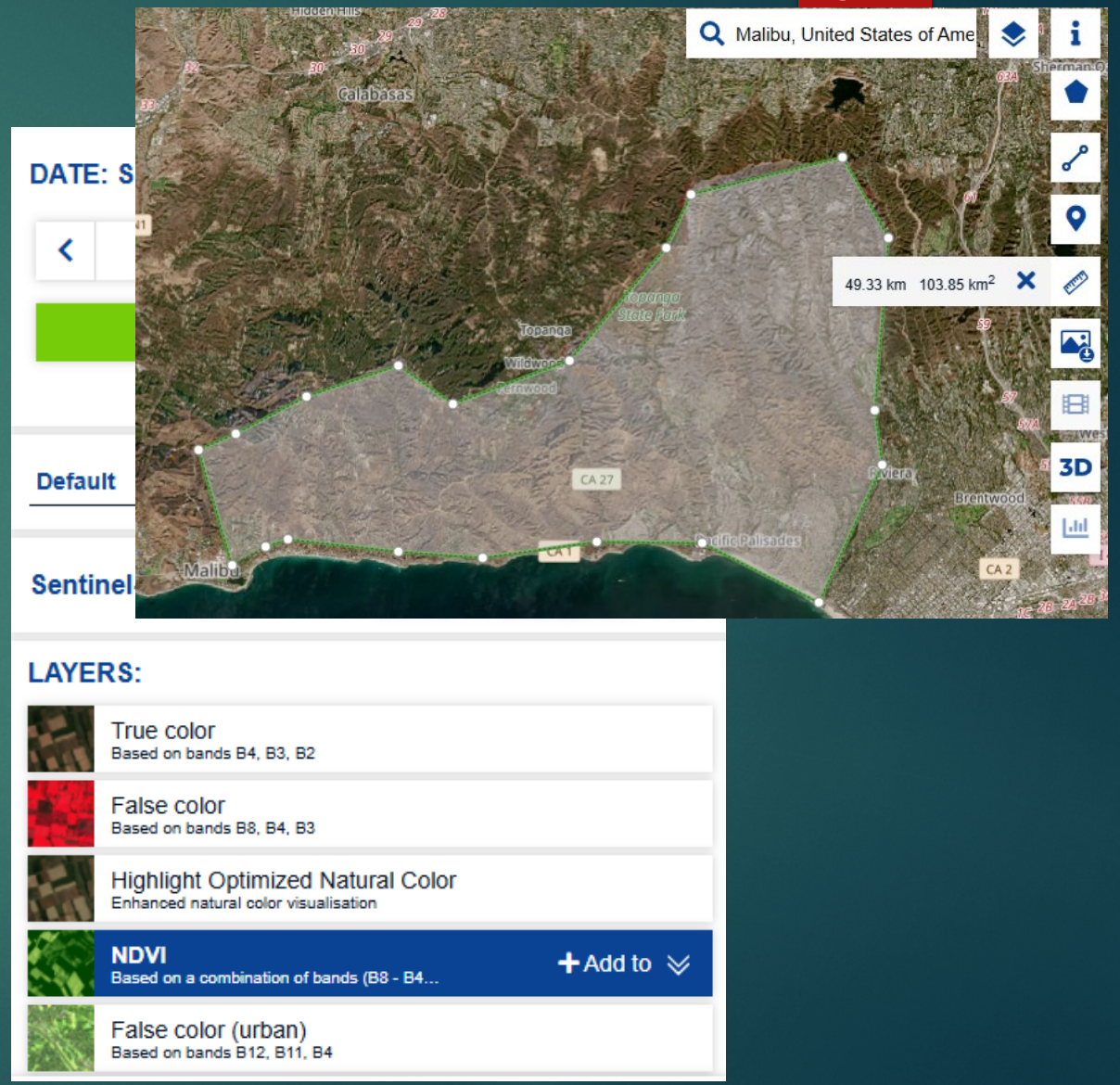
- Type in “Malibu” in upper right search box
- Choose “Malibu, United States of America”
- In the Date: SINGLE, click on YYYY-MM-DD
- Choose January 2, 2025
- Note the area around Malibu
- Zoom into the area using “+” in bottom right
- Click on the “>” next to “2025-01-02”
- This will give you next available day with image
- Look at 2025-01-12 image vs. 2025-01-02





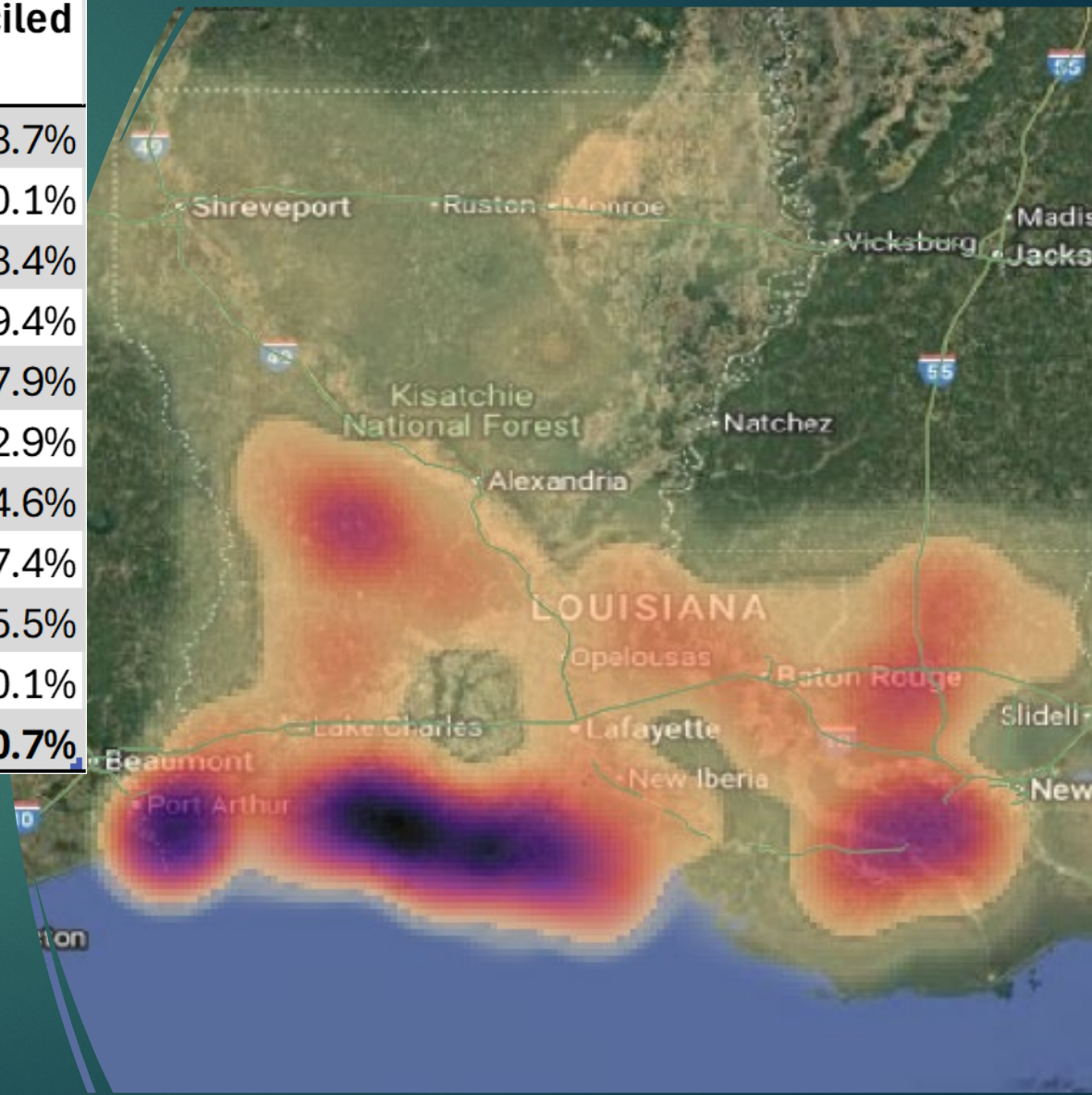
ESA Sentinel imagery: Investigation Tool for fires!

- Zoom in further and toggle back and forth on dates using < and > besides date right below "DATE:SINGLE"
- Also, try looking at the different "LAYERS" in bottom left
- Click on ruler symbol on right
- Click on any point on map and you can begin to make a shape; draw a crude outline of LA wildfire to get estimate of size based on January 12 imagery
  - Double click when finished defining shape to get area estimate

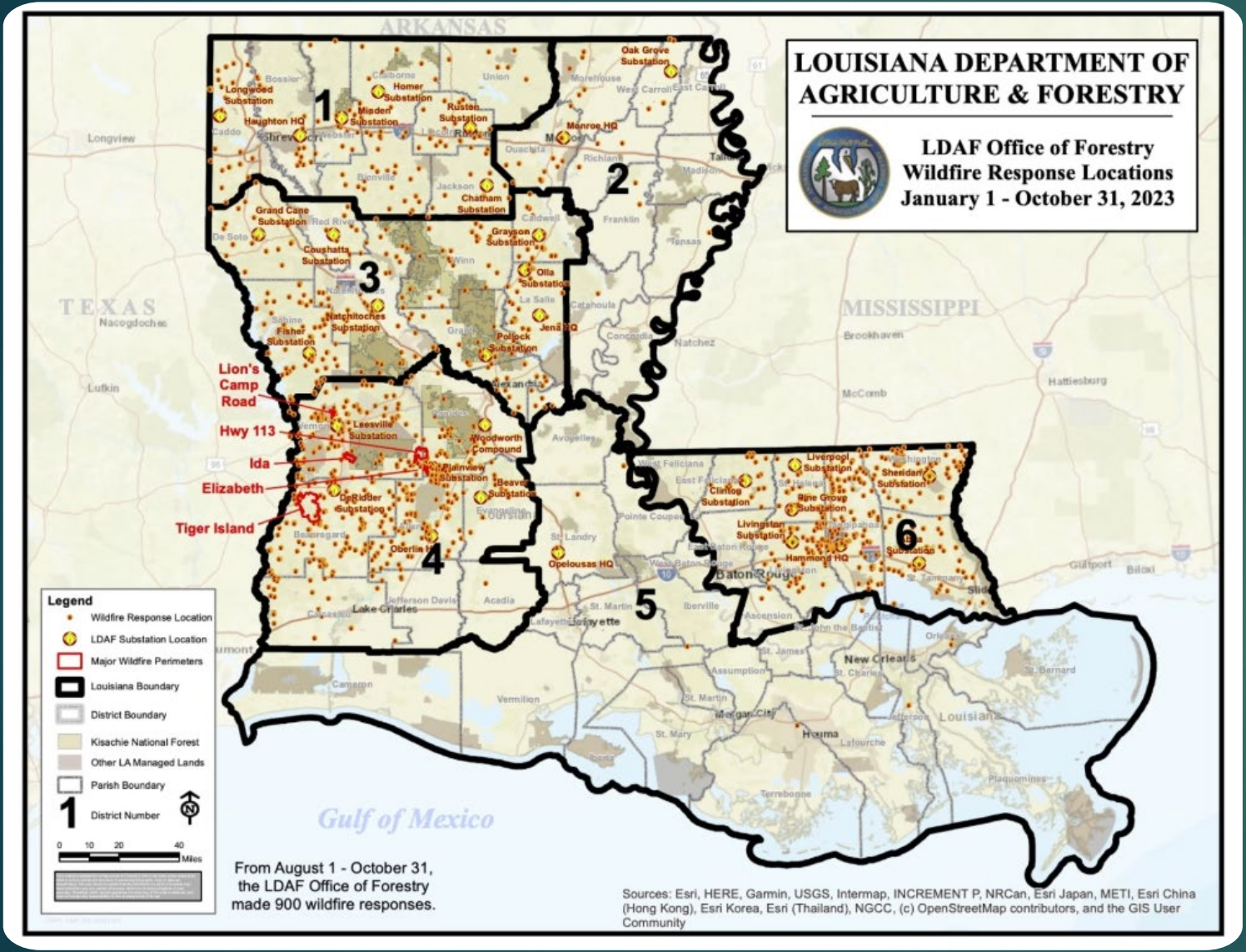


BRIEF SUMMARIES OF ACTIVITY CHALLENGES

State	HMS detect only acres burned	Total prescribed acres burned	% not reconciled with activity
Texas	1,461,453	1,647,099	88.7%
Louisiana	727,379	907,641	80.1%
Oklahoma	671,152	759,581	88.4%
Missouri	620,100	693,623	89.4%
Kansas	415,477	1,488,957	27.9%
Arkansas	250,372	583,223	42.9%
Tennessee	227,511	268,918	84.6%
Iowa	188,047	215,154	87.4%
Nebraska	178,847	187,300	95.5%
Illinois	167,466	185,836	90.1%
SUBTOTAL	**4,907,803**	**6,937,332**	**70.7%**



- Acres-burned heat map shows the highest intensity of HMS-only activity is along the western Gulf Coast
- ~47% of the Unknowns occurred Oct-Dec



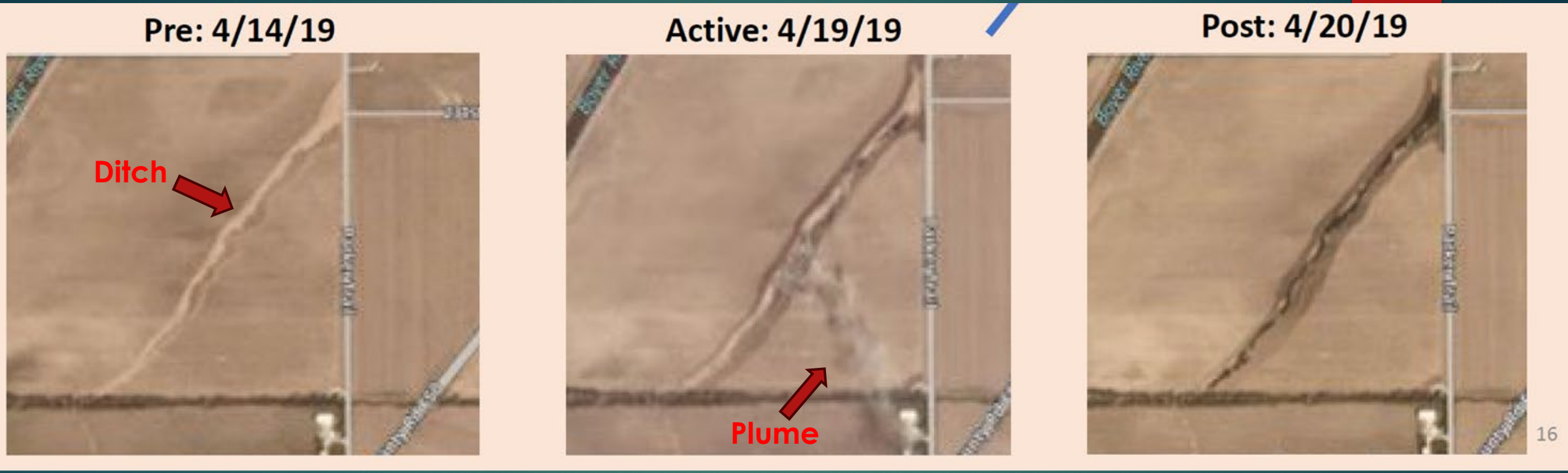
- 2023 had a significant WF season
- Aug – Oct had over 60k acres burned by WFs driven by drought
- Burn ban starting in August
- Few fires shown along hot spots of Gulf Coast

Sabine Pass

- Highest concentration of HMS-only fires
- Periodic fires from Aug-Sep
- Private land ownership by multiple owners
  - Burns extend across parcels
- No indication of RX burning in this area in previous years

- Burns visible during burn ban period
- Reclassify to WF based on timing and location

Agricultural ditch burns: Example



- Midwest region conducts ditch burns on or near corn and soybean fields
- New SCC 2801540000 used in 2023NEI for these type of agricultural land ditch burns
- Was using a prescribed burn SCC in 2020 NEI

Aransas National Wildlife Refuge prescribed burn

1/11/2022

1/16/2022

- Aransas County, TX just north of Corpus Christi of about 1150 acres
- HMS indicates burn occurred on Jan 13th
- No activity data from DOI available in NFPORS for this grassland burn!
- Sentinel imagery used to confirm and get DOI involvement
- DOI confirmed there was a prescribed burn at this site in this time period and the size was close to our HMS default acres burned value
- No change in acres but slight change in coordinates used

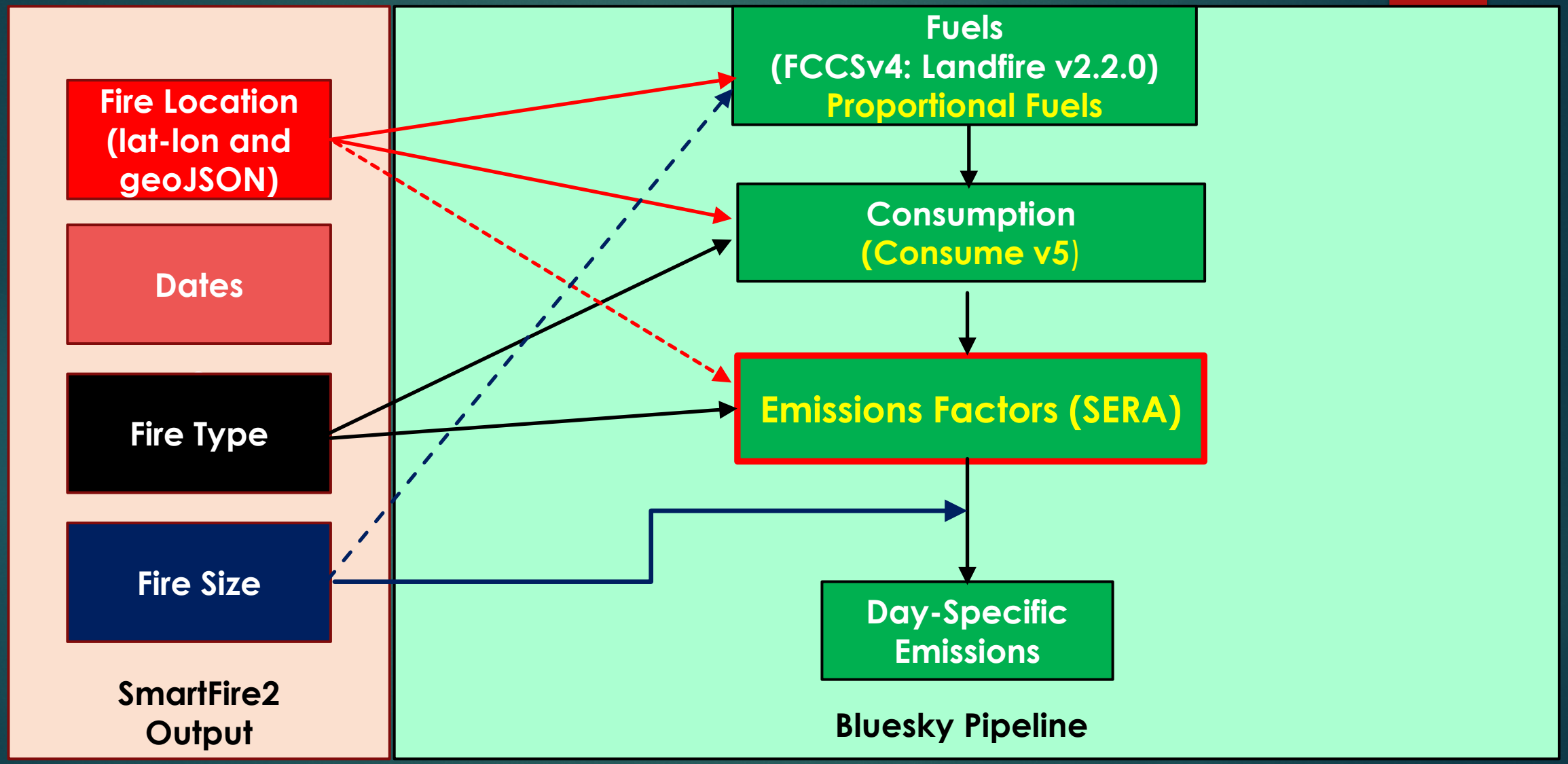
BRIEF Q&A: ACTIVITY WRAP-UP

Emissions Estimation Challenges

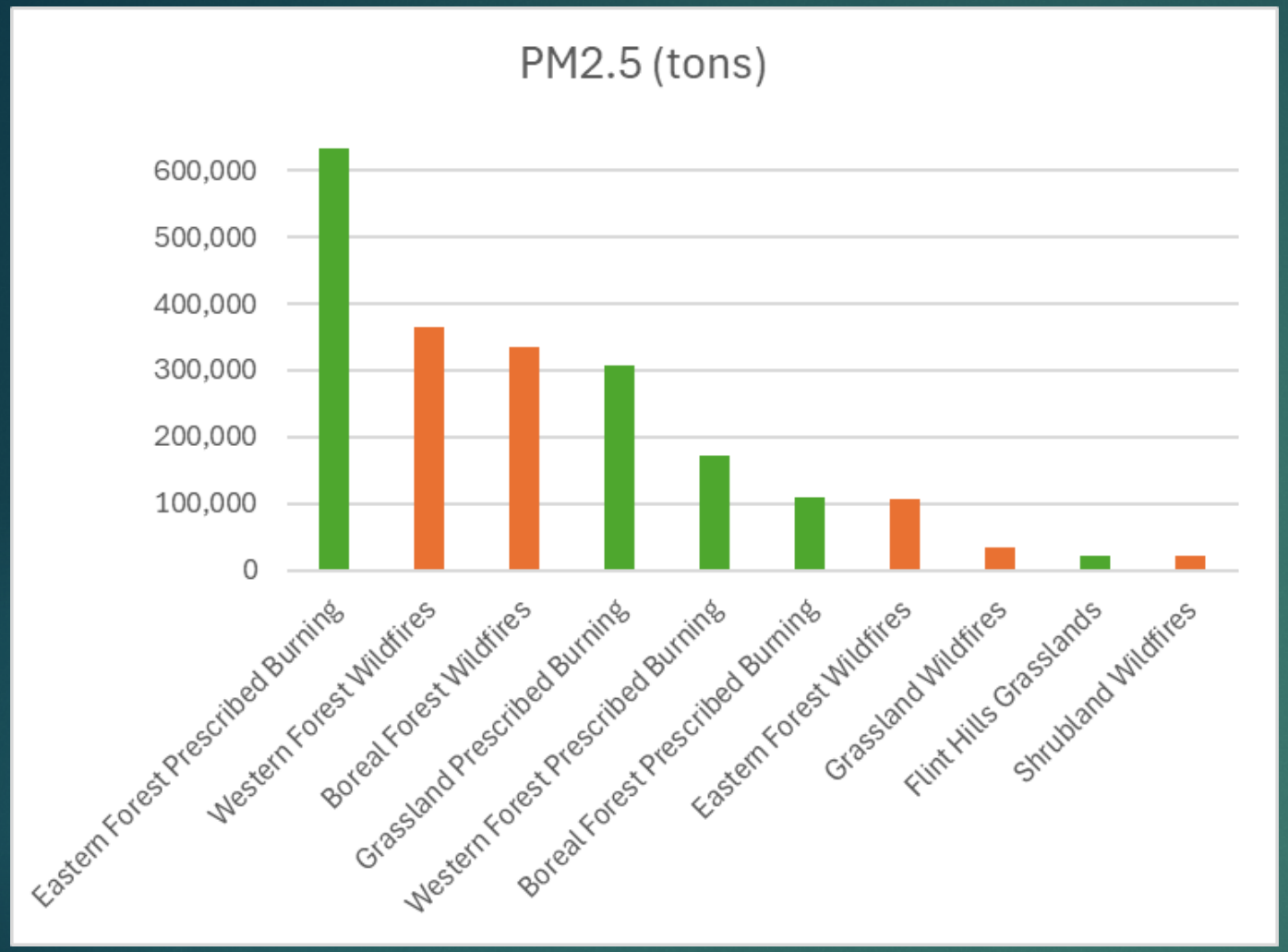
Fire inventory tools used

- BlueSky Pipeline (BSP) framework system
  - Take the pySF2 output (daily acres burned)
  - Assigns fuels burned
  - Estimates consumption and emissions

2023 NEI Bluesky Pipeline modules



FCCS = Fuel Characteristic Classification System SERA=Smoke Emissions Reference Application

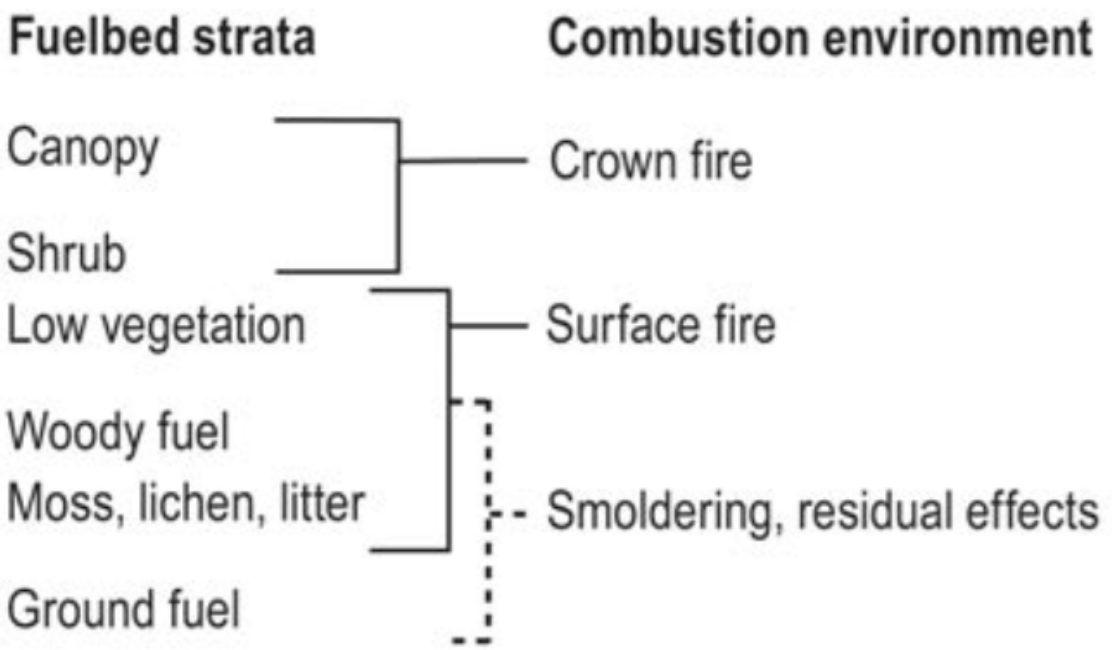


PM2.5 example for one year

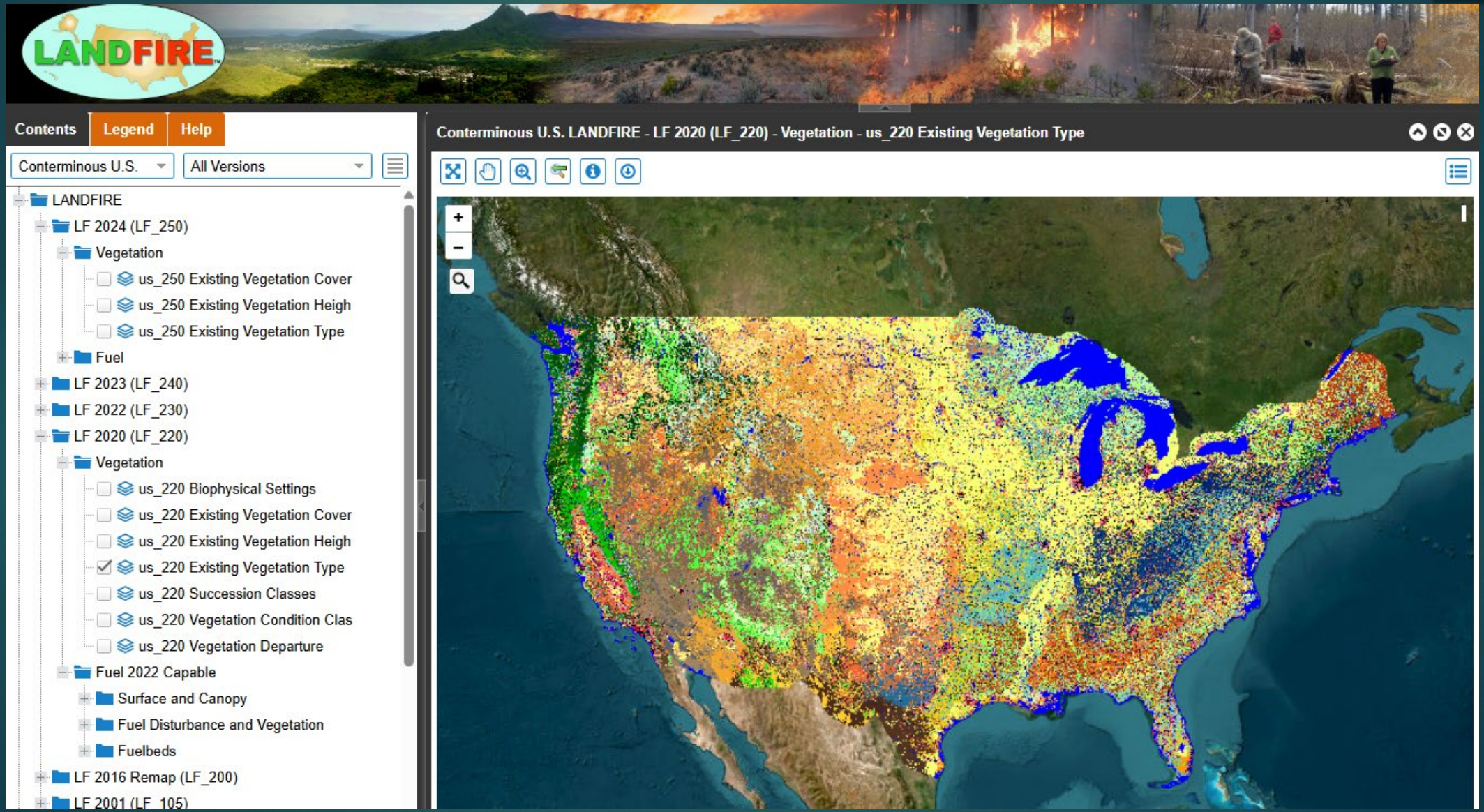
- Fuels consumed
- Consumption
- Emissions factors
- All important and will vary every year

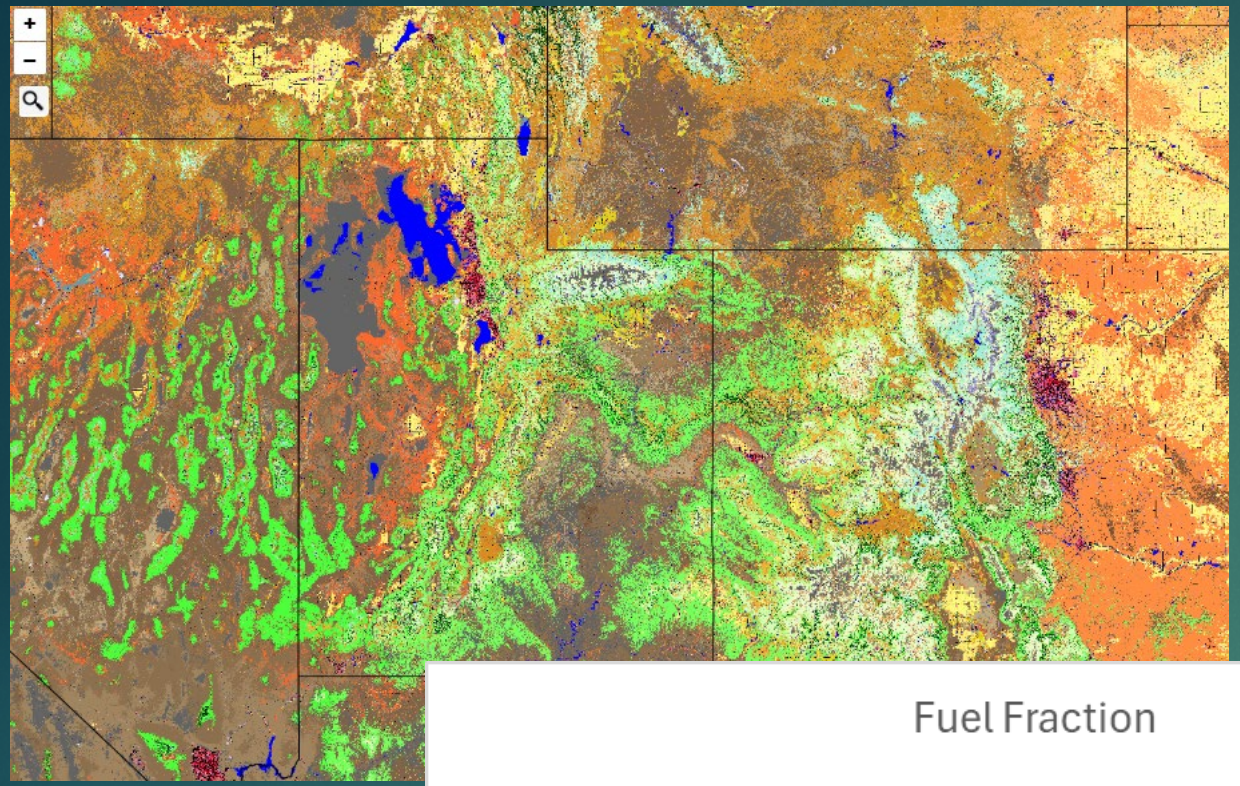
Fuel Characteristic Classification System (FCCS)

- One of the spatial datasets contained in the LANDFIRE data and applications.
  - U.S. Department of the Interior, Geological Survey, and U.S. Department of Agriculture.
- About 400 vegetation types used in Bluesky Pipeline-FCCS.
- FCCS defines a fuel bed as the inherent physical characteristics of fuel that contribute to fire behavior and effects.
- In FCCS, fuel beds represent the structure and composition of wildland fuels and can accommodate a wide range of fuel characteristics in multiple horizontal fuel layers called **strata** .
- FCCS reference fuel beds represent fuels throughout much of North America and were compiled from published literature, fuels photo series, other fuels data sets and expert opinion.
- The fundamental component of the FCCS, the fuel bed, is the mapping unit in the FCCS. The LF FCCS is delivered with attributes summarized from the FCCS calculator for each fuel bed, including name and fuel loading information in tons per acre.

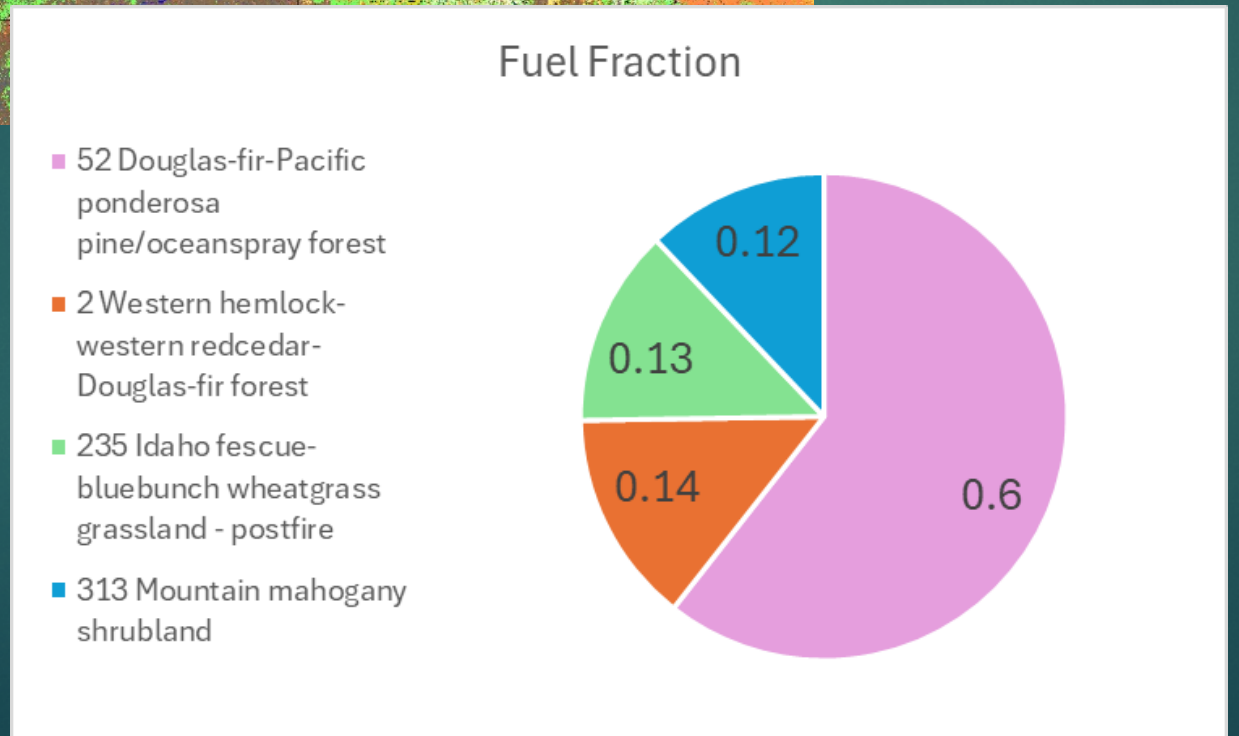

Fuelbed strata
Combustion environment
Canopy
Shrub
Crown fire
Low vegetation
Surface fire
Woody fuel
Moss, lichen, litter
Smoldering, residual effects
Ground fuel

https://landfire.gov/viewer/





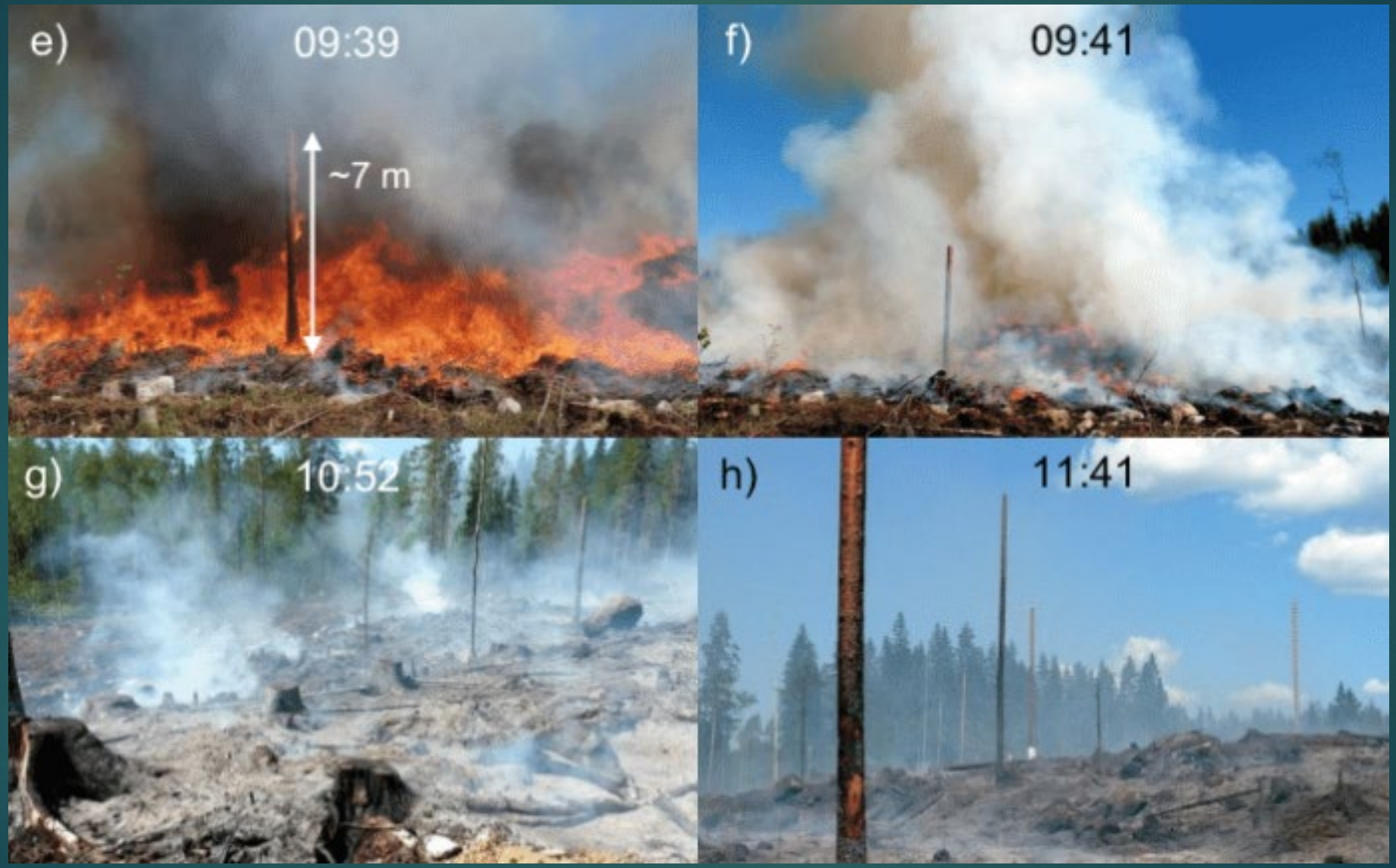
- Bluesky Pipeline FCCS module takes samples of the fuel beds to get fuel fractions for an event (based on latitude and longitude of activity)
- Fuel fractions add up to 1



- One sample event for one day at one location
- Four different fuels involved
- Different fractions for each
- Information is used in CONSUME

Combustion Phases

Flaming and concurrent smoldering phases



Residual smoldering phase

Flaming phase

- This is the active, high-intensity stage of a wildfire where flames are visible and rapidly spreading.
- It involves the combustion of gases released from the heated fuel.
- Characterized by high temperatures and rapid fire spread.
- While intense, the duration at any given spot is usually relatively short.

- Smoldering phase
  - A slow, low-temperature, and flameless form of combustion.
  - Occurs after or alongside the flaming phase, consuming solid fuels directly on their surface.
  - Driven by the reaction of oxygen with the char layer that remains after the flaming phase.
  - Can also initiate independently under certain conditions, as it has a lower ignition temperature than flaming combustion.
  - Can consume a significant portion of the burned biomass, sometimes more than 50%.

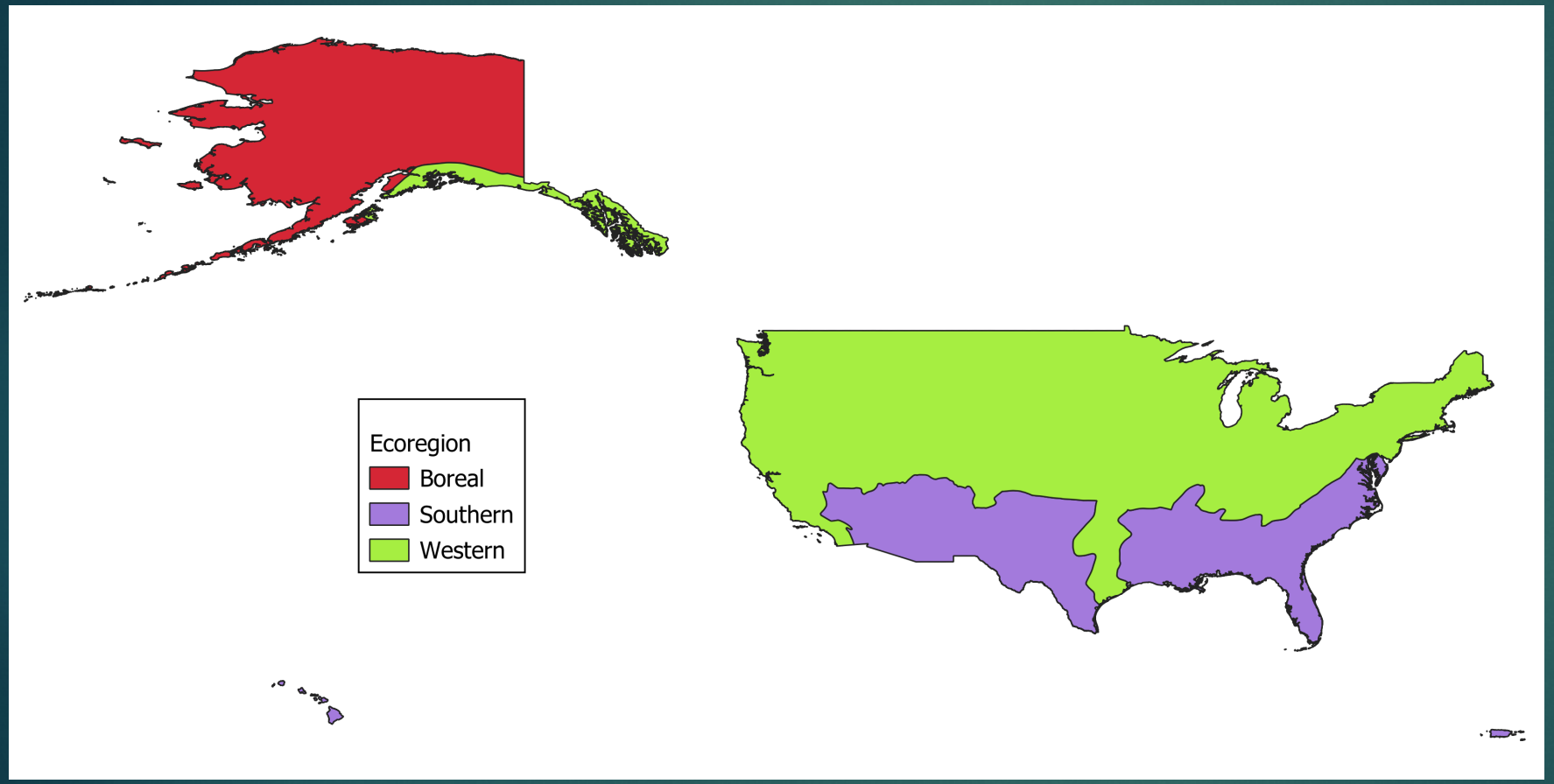
Residual Smoldering Combustion Phase

- This refers to the long-duration process of smoldering and/or intermittent flaming that can continue for hours or days after the main flaming front has passed.
- Significant source of atmospheric pollutants like trace gases and particulate matter, potentially affecting local communities and firefighters.
- Often involves the burning of thicker fuels like stumps, logs, duff layers, and organic soils.
- Can cause substantial heating to the soil and result in significant damage to trees and other vegetation.

Consume version 5 in BSP

- Consume estimates total fuel consumption by ecoregion, and heat release for fuel beds and burn units based on input fuel loadings, fuel moisture, and other environmental factors.
- Based on equations from empirical data and physical processes, varying by ecoregion.
- Uses the fuels identified in FCCS for a given fire event.
- Heat release is estimated for use in plume rise calculations.
- Fuel moisture assumption currently being used is based on climatological estimates for prescribed and wildfires.

Consume: Ecoregions in BlueSky Pipeline



- Wildland fires may consume different amounts of biomass across different ecoregions due to factors like climate, vegetation, and ignition sources
- Map highlights ecoregion assignments used to determine consumption equations

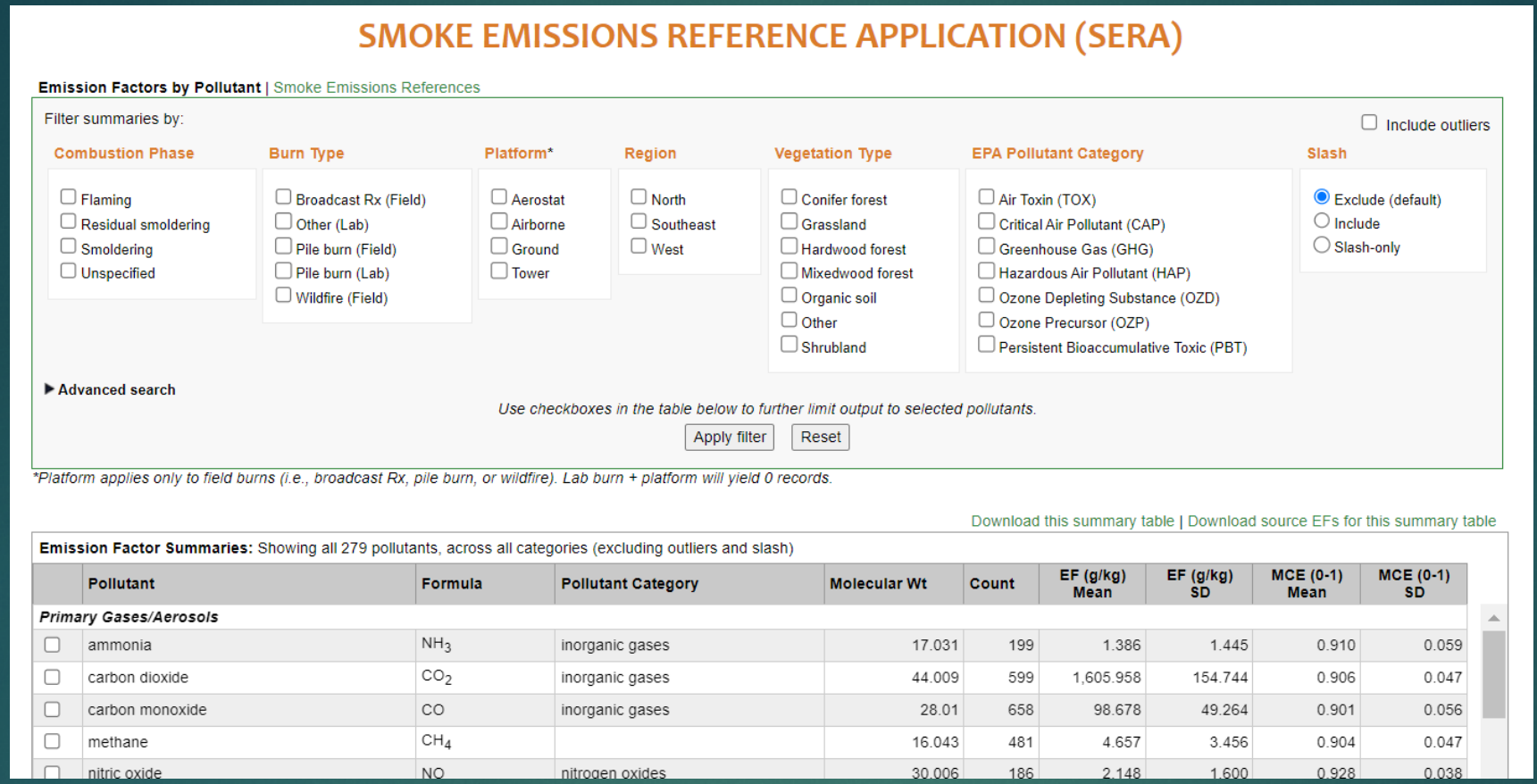
Recent changes to Emissions Factors used in fire inventory development

Smoke Emissions Reference Application (SERA)

- SERA is a searchable online database coordinated by the US Forest Service and University of Washington
  - https://depts.washington.edu/nwfire/sera/index.php
- Consists of existing peer-reviewed emission factors (EFs) of 276 known air pollutants
- Database enables the analysis and summaries of existing EFs, and creation of average EFs to be used in decision support tools for smoke management, including BSP
- EPA has applied wildland fire EIs using SERA-derived emissions factors in modeling applications from 2016 to 2023
- Other EFs: Non-Methane Organic Compound (NMOC) and HAP EFs are coming from the reference values in Urbanski 2014

Interactive session: SERA

https://depts.washington.edu/nwfire/sera/index.php



SMOKE EMISSIONS REFERENCE APPLICATION (SERA)

Emission Factors by Pollutant | Smoke Emissions References

Filter summaries by:

Include outliers

Combustion Phase
- Flaming
- Residual smoldering
- Smoldering
- Unspecified

Burn Type
- Broadcast Rx (Field)
- Other (Lab)
- Pile burn (Field)
- Pile burn (Lab)
- Wildfire (Field)

Platform*
- Aerostat
- Airborne
- Ground
- Tower

Region
- North
- Southeast
- West

Vegetation Type
- Conifer forest
- Grassland
- Hardwood forest
- Mixedwood forest
- Organic soil
- Other
- Shrubland

EPA Pollutant Category
- Air Toxin (TOX)
- Critical Air Pollutant (CAP)
- Greenhouse Gas (GHG)
- Hazardous Air Pollutant (HAP)
- Ozone Depleting Substance (OZD)
- Ozone Precursor (OZP)
- Persistent Bioaccumulative Toxic (PBT)

Slash
- Exclude (default)
- Include
- Slash-only

▶ Advanced search

Use checkboxes in the table below to further limit output to selected pollutants.

Apply filter | Reset

*Platform applies only to field burns (i.e., broadcast Rx, pile burn, or wildfire). Lab burn + platform will yield 0 records.

Download this summary table | Download source EFs for this summary table

Emission Factor Summaries: Showing all 279 pollutants, across all categories (excluding outliers and slash)

	Pollutant	Formula	Pollutant Category	Molecular Wt	Count	EF (g/kg) Mean	EF (g/kg) SD	MCE (0-1) Mean	MCE (0-1) SD
Primary Gases/Aerosols									
☐	ammonia	NH_3	inorganic gases	17.031	199	1.386	1.445	0.910	0.059
☐	carbon dioxide	CO_2	inorganic gases	44.009	599	1,605.958	154.744	0.906	0.047
☐	carbon monoxide	CO	inorganic gases	28.01	658	98.678	49.264	0.901	0.056
☐	methane	CH_4		16.043	481	4.657	3.456	0.904	0.047
☐	nitric oxide	NO	nitrogen oxides	30.006	186	2.148	1.600	0.928	0.038

- Go to website above and experiment with the different filtering options for a few minutes (e.g., click on Region of interest and Apply filter)
- Note the changes in the "EF (g/kg) Mean" (average emissions factor) column when changing filtering options

New wildfire SCCs for 2023 NEI

SCC	scc level three	scc level four
2810070001	Boreal Forest Wildfires	Smoldering + Flaming
2810070002	Boreal Forest Wildfires	CWD Residual Smoldering
2810070003	Boreal Forest Wildfires	Duff Residual Smoldering
2810071001	Eastern Forest Wildfires	Smoldering + Flaming
2810071002	Eastern Forest Wildfires	CWD Residual Smoldering
2810071003	Eastern Forest Wildfires	Duff Residual Smoldering
2810072001	Grassland Wildfires	Smoldering + Flaming
2810073001	Shrubland Wildfires	Smoldering + Flaming
2810073002	Shrubland Wildfires	CWD Residual Smoldering
2810073003	Shrubland Wildfires	Duff Residual Smoldering
2810074001	Western Forest Wildfires	Smoldering + Flaming
2810074002	Western Forest Wildfires	CWD Residual Smoldering
2810074003	Western Forest Wildfires	Duff Residual Smoldering

Duff is a layer of dead plant material on the forest floor that can burn in wildfires. It's made up of partially decayed organic matter like leaves, twigs, needles, bark, and roots.

CWD: Coarse woody debris

New SCCs will possibly allow for fire-type and fuel bed specific speciation in future inventories

New prescribed burn SCCs for 2023 NEI

SCC	scc level three	scc level four
2810080001	Boreal Forest Prescribed Burning	Smoldering + Flaming
2810080002	Boreal Forest Prescribed Burning	CWD Residual Smoldering
2810080003	Boreal Forest Prescribed Burning	Duff Residual Smoldering
2810081001	Eastern Forest Prescribed Burning	Smoldering + Flaming
2810081002	Eastern Forest Prescribed Burning	CWD Residual Smoldering
2810081003	Eastern Forest Prescribed Burning	Duff Residual Smoldering
2810082001	Grassland Prescribed Burning	Smoldering + Flaming
2810083001	Shrubland Prescribed Burning	Smoldering + Flaming
2810083002	Shrubland Prescribed Burning	CWD Residual Smoldering
2810083003	Shrubland Prescribed Burning	Duff Residual Smoldering
2810084001	Western Forest Prescribed Burning	Smoldering + Flaming
2810084002	Western Forest Prescribed Burning	CWD Residual Smoldering
2810084003	Western Forest Prescribed Burning	Duff Residual Smoldering

Duff is a layer of dead plant material on the forest floor that can burn in wildfires. It's made up of partially decayed organic matter like leaves, twigs, needles, bark, and root

CWD: Coarse woody debris

New SCCs will allow for fire-type and fuel bed specific speciation

Fire Information for Quality Assurance: FIRELOC files!

Fireloc file: compiled for each state/region

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	date	id	event_id	event_name	latitude	longitude	type	area	fips	state	county	scc	consumpt	consumpt	consumpt	heat	fccs_numl	fuelbed_fr
2943	20230216	SF11C0088328	SF11E00528915	Leoni Meadows Forest Restoration Pro	38.63498	-120.513	RX	33.19	6017	California	El Dorado Co	2810084003	0	0	5.266955	84271278	214	214 1.0
2944	20230216	SF11C0088328	SF11E00528915	Leoni Meadows Forest Restoration Pro	38.63498	-120.513	RX	33.19	6017	California	El Dorado Co	2810084002	0	0	169.8165	2.72E+09	214	214 1.0
2945	20230216	SF11C0088328	SF11E00528915	Leoni Meadows Forest Restoration Pro	38.63498	-120.513	RX	33.19	6017	California	El Dorado Co	2810084001	232.1749	183.7431	0	6.65E+09	214	214 1.0
2946	20230216	SF11C0088321	SF11E00528925	_5550	36.82995	-121.708	RX	0.1175	6053	California	Monterey Co	2810083003	0	0	0.02228	356484.3	401	36 0.75; 40
2947	20230216	SF11C0088321	SF11E00528925	_5550	36.82995	-121.708	RX	0.1175	6053	California	Monterey Co	2810083002	0	0	0.269806	4316890	401	36 0.75; 40
2948	20230216	SF11C0088321	SF11E00528925	_5550	36.82995	-121.708	RX	0.1175	6053	California	Monterey Co	2810083001	1.028377	0.353344	0	22107531	401	36 0.75; 40
2949	20230216	SF11C0088321	SF11E00528925	_5550	36.82995	-121.708	RX	0.3525	6053	California	Monterey Co	2810082001	1.390777	0.324623	0.182419	30365106	36	36 0.75; 40
2950	20230216	SF11C0088314	SF11E00528942	Espp 02_5593	37.90937	-122.216	RX	10.99	6013	California	Contra Costa Cc	2810082001	37.61753	8.156982	4.265497	8.01E+08	36	36 0.75; 53
2951	20230216	SF11C0088313	SF11E00528939	Onion Valley_5588	36.80305	-118.204	RX	4	6027	California	Inyo Co	2810083001	4.258307	0.454325	0	75402109	311	311 1.0
2952	20230216	SF11C0088313	SF11E00528937	Oak And Pine Mixed_5583	35.97254	-121.259	RX	2	6053	California	Monterey Co	2810082001	5.800612	1.127043	0.5175	1.19E+08	36	36 0.5; 65 (
2953	20230216	SF11C0088313	SF11E00528935	Block 1_5579	38.52646	-122.691	RX	14.99	6097	California	Sonoma Co	2810084003	0	0	66.93702	1.07E+09	47	48 0.75; 47
2954	20230216	SF11C0088313	SF11E00528935	Block 1_5579	38.52646	-122.691	RX	14.99	6097	California	Sonoma Co	2810084002	0	0	66.6074	1.07E+09	47	48 0.75; 47
2955	20230216	SF11C0088313	SF11E00528935	Block 1_5579	38.52646	-122.691	RX	14.99	6097	California	Sonoma Co	2810084001	165.3318	215.7258	0	6.1E+09	47	48 0.75; 47
2956	20230216	SF11C0088312	SF11E00528930	Crown G Smp 21-63 Broadcast_5564	39.01913	-123.063	RX	0.666667	6045	California	Mendocino Co	2810082001	1.236763	0.137418	0	21986891	533	16 0.33; 44
2957	20230216	SF11C0088312	SF11E00528930	Crown G Smp 21-63 Broadcast_5564	39.01913	-123.063	RX	0.666667	6045	California	Mendocino Co	2810083001	5.676584	0.615708	0	1.01E+08	44	16 0.33; 44
2958	20230216	SF11C0088312	SF11E00528930	Crown G Smp 21-63 Broadcast_5564	39.01913	-123.063	RX	0.666667	6045	California	Mendocino Co	2810084003	0	0	0.030088	481415.3	16	16 0.33; 44
2959	20230216	SF11C0088312	SF11E00528930	Crown G Smp 21-63 Broadcast_5564	39.01913	-123.063	RX	0.666667	6045	California	Mendocino Co	2810084002	0	0	0.94165	15066408	16	16 0.33; 44
2960	20230216	SF11C0088312	SF11E00528930	Crown G Smp 21-63 Broadcast_5564	39.01913	-123.063	RX	0.666667	6045	California	Mendocino Co	2810084001	3.953118	1.231759	0	82958035	16	16 0.33; 44
2961	20230216	SF11C0088311	SF11E00528916	Carbonator_5537	37.74467	-122.103	RX	2.663333	6001	California	Alameda Co	2810083001	22.67795	2.459754	0	4.02E+08	44	36 0.33; 42

Contains location, size, day, SCC, fuels, sources(s) of activity, consumption and emissions information

Interactive session: Fireloc files

Fireloc file exercise

- Must have access to a spreadsheet tool (e.g., Excel)
- Download a sample fireloc from the 2023NEI for a desired state here:
  - https://gaftp.epa.gov/Air/nei/2023/doc/supporting_data/events/v1/
- Also download the README to help explain each column in fireloc file
  - https://gaftp.epa.gov/Air/nei/2023/doc/supporting_data/events/v1/FIRELOC_README.xlsx
- Load above files into desired spreadsheet tool
- Familiarize yourself with the fireloc file by examining largest wildfires and prescribed burns in the state
  - Use filtering capability or other favorite spreadsheet functions you like to use on data

Poll Question 5: What do you find most challenging about using the FIRELOC file?

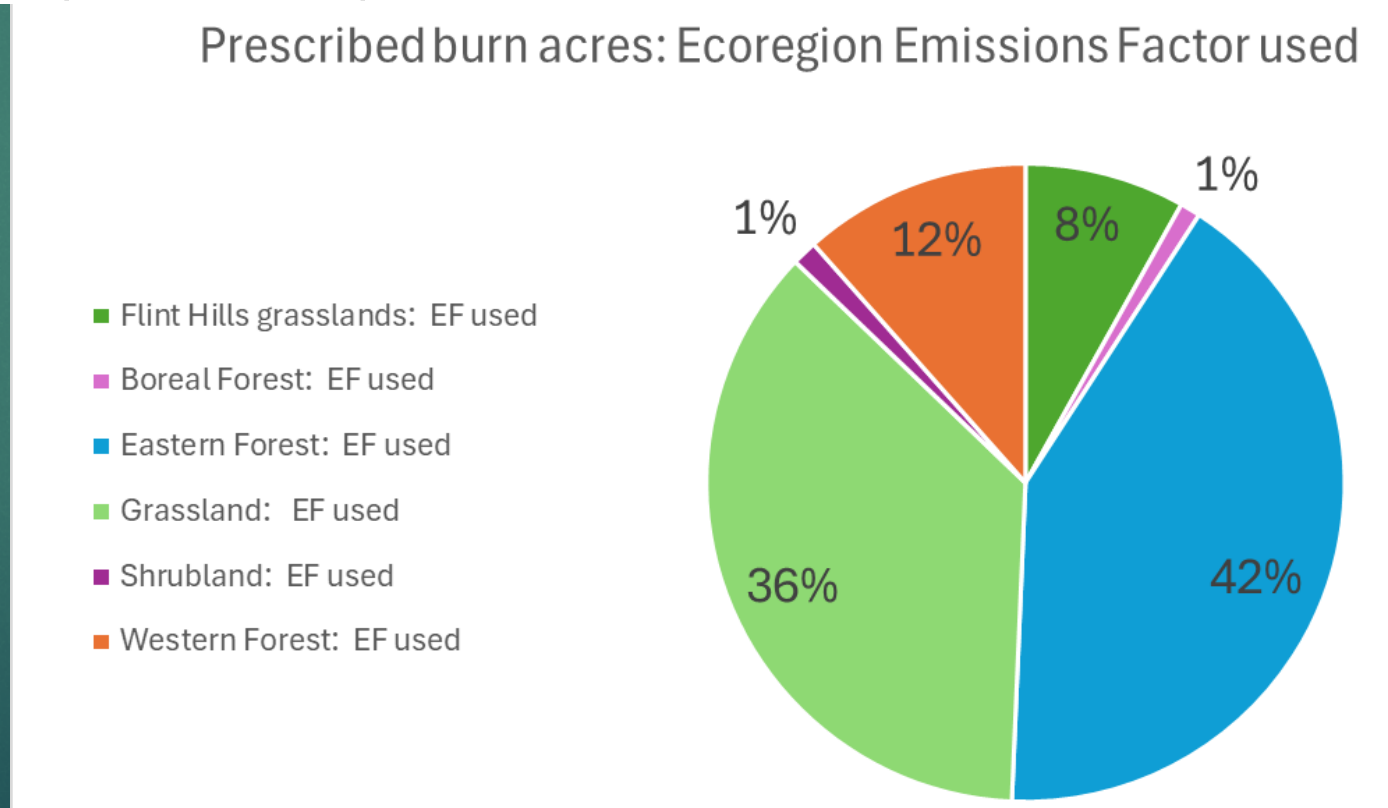
Poll Question 6:Would a more user-friendly FIRELOC file improve your data analysis?

Other postprocessing/analyses

Ecoregion	ACRES BURNED	% OF TOTAL
Flint Hills grasslands: EF used	1,114,723	8.1%
Boreal Forest: EF used	140,879	1.0%
Eastern Forest: EF used	5,696,344	41.5%
Grassland: EF used	5,004,938	36.5%
Shrubland: EF used	173,779	1.3%
Western Forest: EF used	1,585,674	11.6%
TOTAL	13,716,336	100.0%

Prescribed burn acres

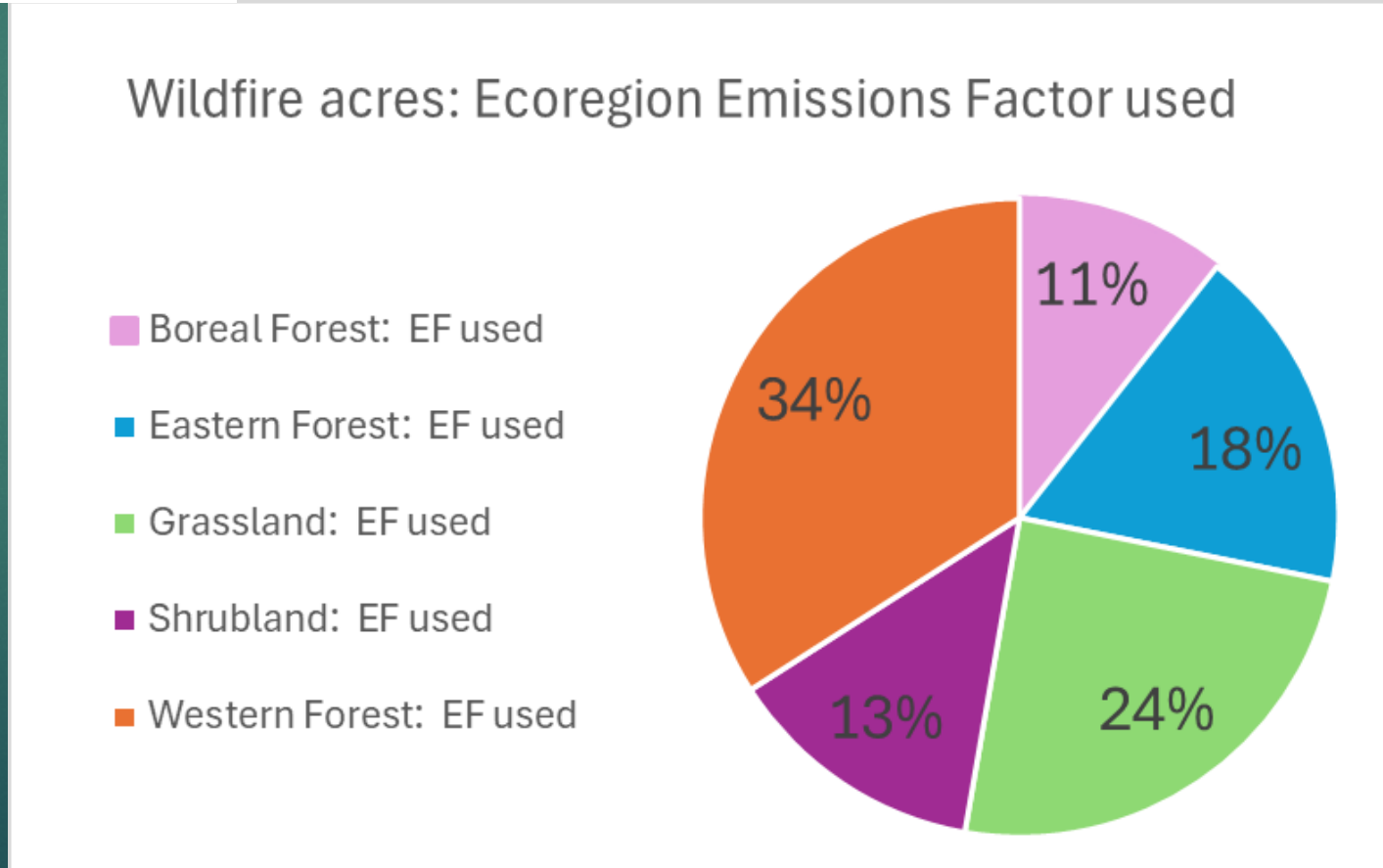
- Ecoregion emission factor applied analysis
- Grasslands EFs used on 44% of acres
- Eastern Forest EFs used on 42% of acres



Ecoregion	ACRES BURNED	% OF TOTAL
Boreal Forest: EF used	295,147	10.6%
Eastern Forest: EF used	489,909	17.6%
Grassland: EF used	683,720	24.6%
Shrubland: EF used	367,253	13.2%
Western Forest: EF used	948,202	34.1%
TOTAL	2,784,231	100.0%

Wildfire acres

- Ecoregion emission factor applied analysis
- Grasslands EFs used on 24% of acres
- Western Forest EFs used on 34% of acres
- Almost all of the Boreal is in Alaska



National emissions by combustion phase by fire type

Prescribed burns

Pollutant	2023 beta Flaming phase (tons)	% of total from flaming and smoldering	2023 beta Residual smoldering phase (tons)	% of total from residual smoldering	2023 beta total (tons)
CO	7,228,077	82.4%	1,545,448	17.6%	8,773,525
NH3	67,752	87.8%	9,405	12.2%	77,156
NOX	129,239	98.5%	1,938	1.5%	131,177
PM2.5	1,036,683	82.6%	217,688	17.4%	1,254,371
SO2	79,430	94.0%	5,091	6.0%	84,521
VOC	1,558,702	71.7%	615,221	28.3%	2,173,923

- Doesn't include pile burn emissions

National emissions by combustion phase by fire type

Wildfires

Pollutant	2023 beta Flaming phase (tons)	% of total from flaming and smoldering	2023 beta Residual smoldering phase (tons)	% of total from residual smoldering	2023 beta total (tons)
CO	4,163,459	62.6%	2,484,492	37.4%	6,647,951
NH3	44,214	69.2%	19,693	30.8%	63,907
NOX	61,444	93.1%	4,554	6.9%	65,998
PM2.5	516,586	59.9%	346,236	40.1%	862,822
SO2	36,693	75.4%	11,961	24.6%	48,655
VOC	1,079,011	46.5%	1,241,677	53.5%	2,320,689

Final Q&A session

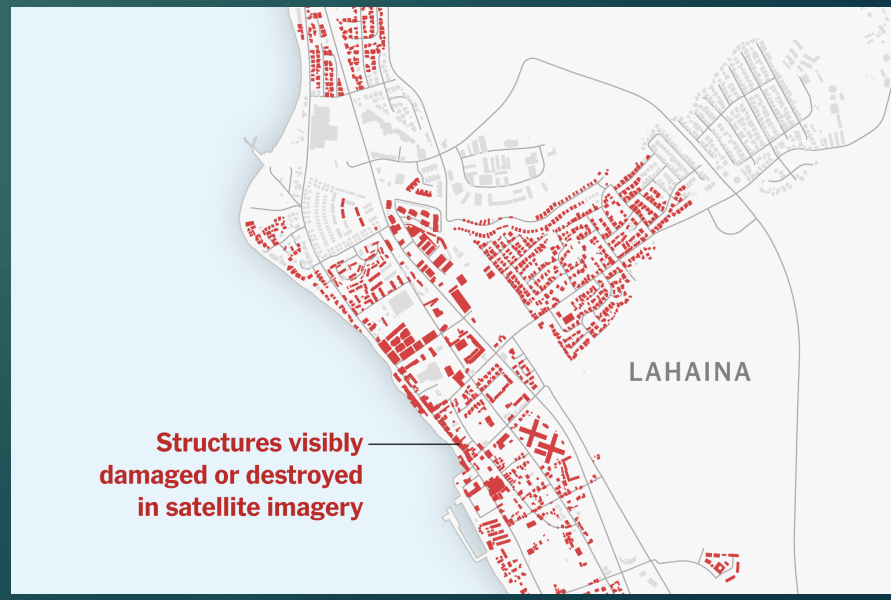
Extra Slides

Possible improvements for future NEIs

- BSP version update including updates to Consume, FCCS
- Dead fuel moisture (gridMET?)
- FCCS raster version update (using 2020_220 version currently)
- Use of disturbance aware fuels from LF
- WUIs (have a Maui WUI slide in Extra Slides section)
- Using acres burned shapes instead of specific points
- Fire Radiative Power (FRP) scaling to improve consumption estimates (temporally, residual smoldering)
- Speciation update currently being tested for VOC/PM for volatility

Maui County wildfires and Wildland Urban Interface (WUI) fire

- WUI stands for Wildland-Urban Interface, and WUI fires are wildfires that occur in the area where human development and undeveloped land meet or intermingle
- Week of August 7, 2023, saw numerous wildfires break out in Maui County including a WUI fire that impacted town of Lahaina
- EPA ORD and OAQPS have been researching WUI fires and estimating emissions for these events with no full methodology yet in place
- For the 2023NEI, Lahaina WUI case a two-part method is used:
  - The state of Hawaii AG report https://d1gi3fvbl0xj2a.cloudfront.net/2024-10/FSRI_Lahaina_Report__Redactions_10022024_Rev1%20(1)_0.pdf indicates about 2117 structures destroyed and others damaged and about 3643 vehicle fires
  - The structure and vehicle fire emissions will be provided as a nonpoint source outside of wildland fire sector
  - Surrounding shrubland emissions is included in the wildland inventory; acres of shrubland corrected in final version



Wildfire month assumptions in python-SmartFire2

- Wildfire month assumptions for 2023
  - AZ/CA/NV/NM: Jun-Aug
  - OR/WA/ID/MT/CO/UT/WY: Jul-Sep