

2014 Fire NEI Workshop: Emissions Processing – *Details*



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Outline

- How do we compute emissions?
 - area burned, available fuel loading, consumption efficiency, emission factors

How Fire Emissions Are Modeled

$$E_{(s)} = A \times AFL \times \beta \times Ef_{(s)}$$

Emissions of species s =

Area burned x

Available fuel load x

Consumption efficiency x

Emission factor of species s

All these terms must be correct to produce correct emissions estimates

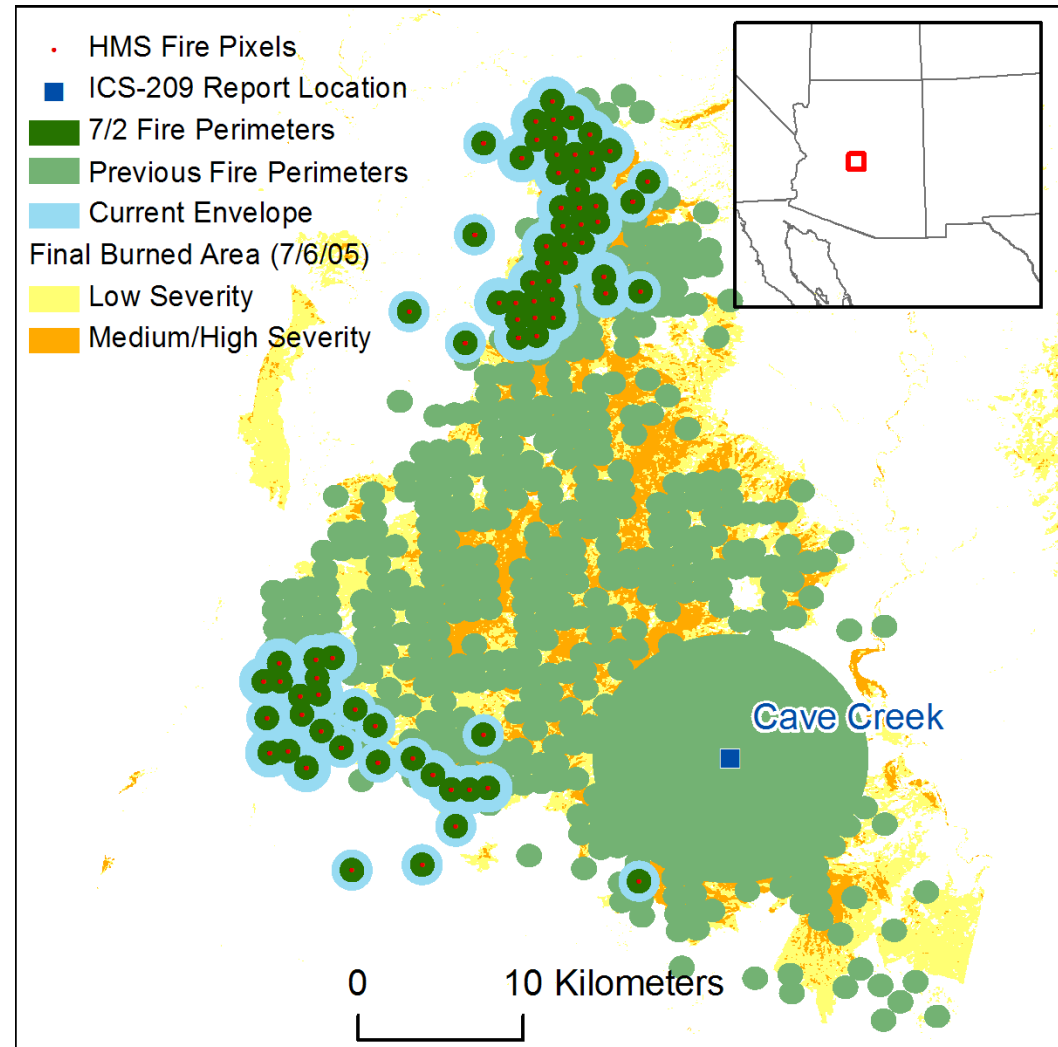
Area Burned

$$E = A \times AFL \times \beta \times Ef$$

How big is the fire?

Common data sources

- State databases
- Satellite detection
 - Burn scars
 - Hot spots
- Federal databases
- Wildfire operations (Helicopter perimeters)



The Fire Information Problem

There is no single complete, best fire information data source

- Coverage is limited (by size, type, jurisdiction) or incomplete (clouds)
- Timeliness varies from near real-time to years later
- Each data source has strengths and weaknesses and information can be redundant

Area Burned – NEI Method

- Gather as many sources as possible that provide information on fire occurrence
- Merge them into a single, reconciled data set of daily fires

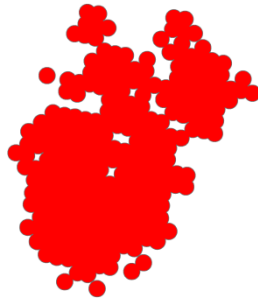
SmartFire 2 was developed to merge and reconcile fire information

Area Burned – SmartFire 2

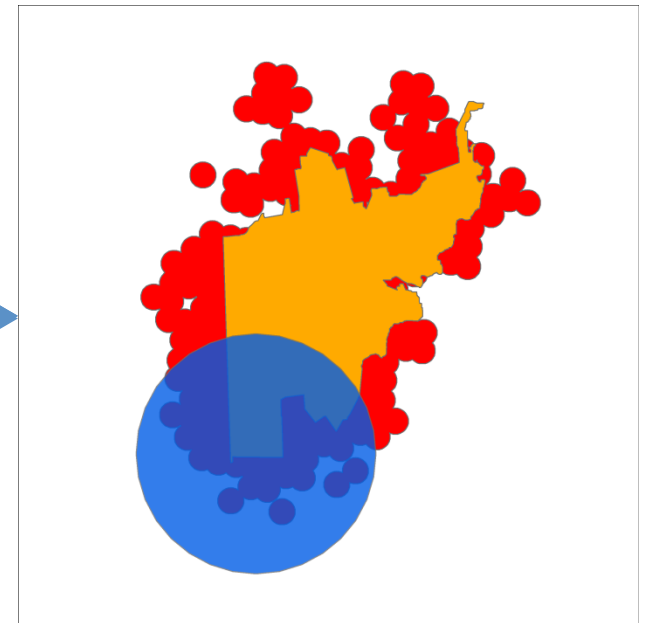
Burn scar analysis
Most accurate sizes



Satellite detection
Best coverage of
small fires



Official databases
Best type determination

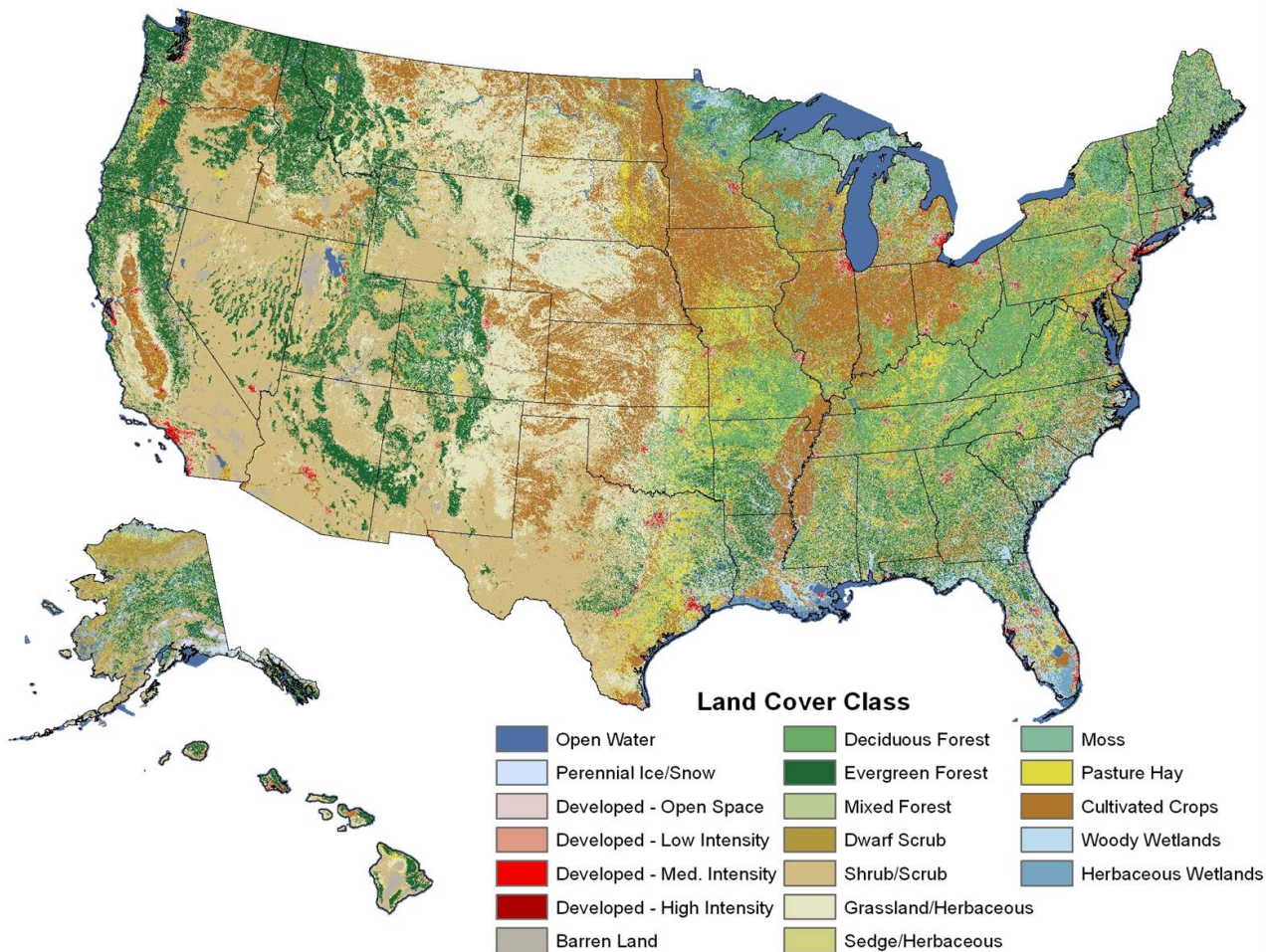


Area Burned – SmartFire 2

- Fires from multiple sources that are nearby in time and space are associated
- Associated fires are reconciled by taking the best information from all available sources
 - E.g., if a burn scar is available, it's size will be used
- More detail on this later in the class

Separation of Agricultural Burns

- Agricultural burns are removed from our analysis and processed separately for the NEI (see George Pouliot's talk Wednesday).
- A 30-m 2014 cropland data layer from the USDA National Agricultural Statistics Service is used to identify agricultural lands.
- Note that rangeland fires are not segregated and are part of our inventory (as both wild and prescribed fires)



Available Fuel Loading $E = A \times AFL \times \beta \times Ef$

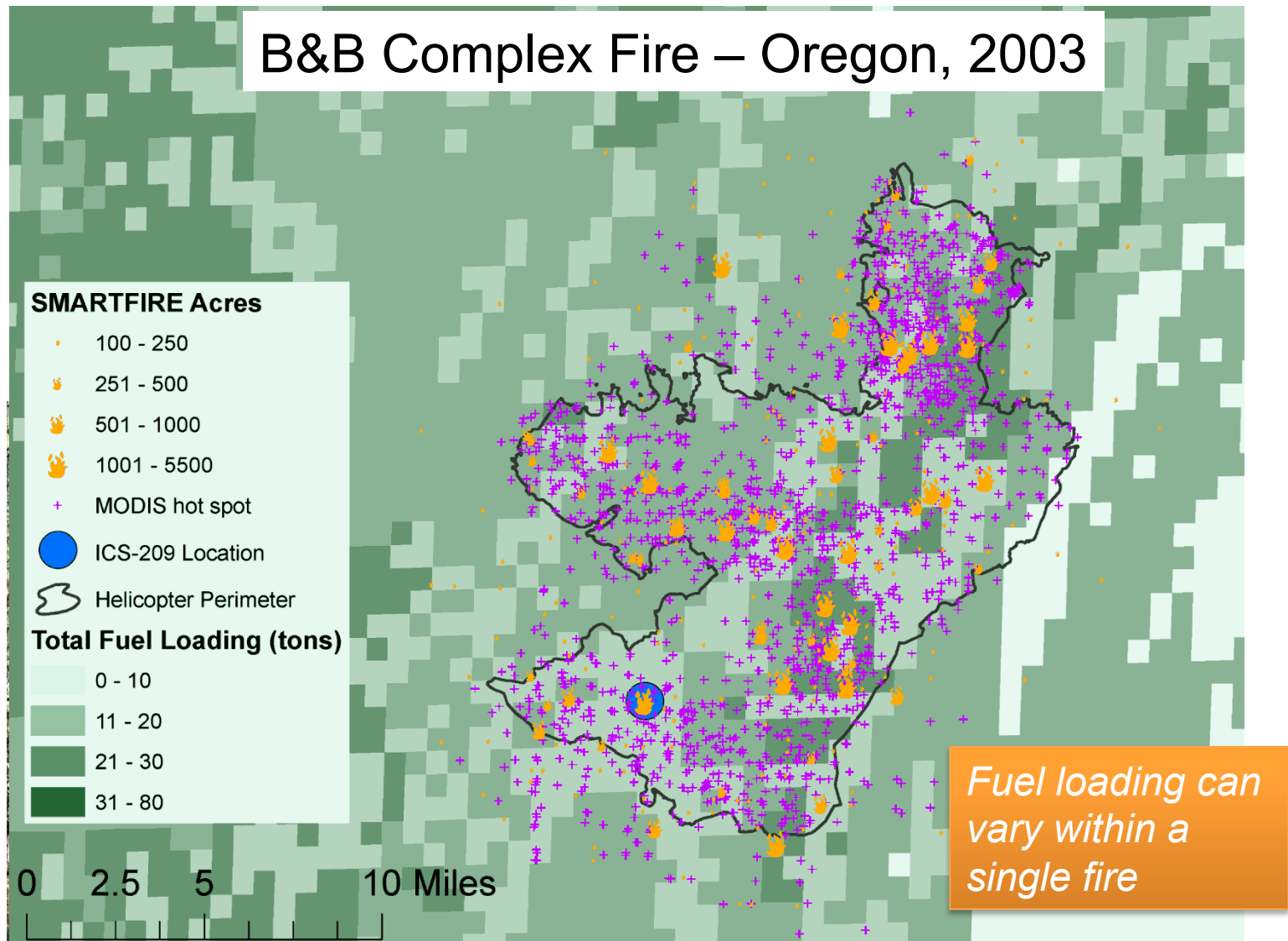
How much fuel (wood, soil, grass) is *available* to burn?

Common methods:

- Specialized vegetation databases (plot surveys)
- Satellite-based land cover
- Constant values based on land use



Available Fuel Loading $E = A \times AFL \times \beta \times Ef$









Available Fuel Loading – NEI Method

Fuel loadings from the Fuel Characteristic Classification System (FCCS)

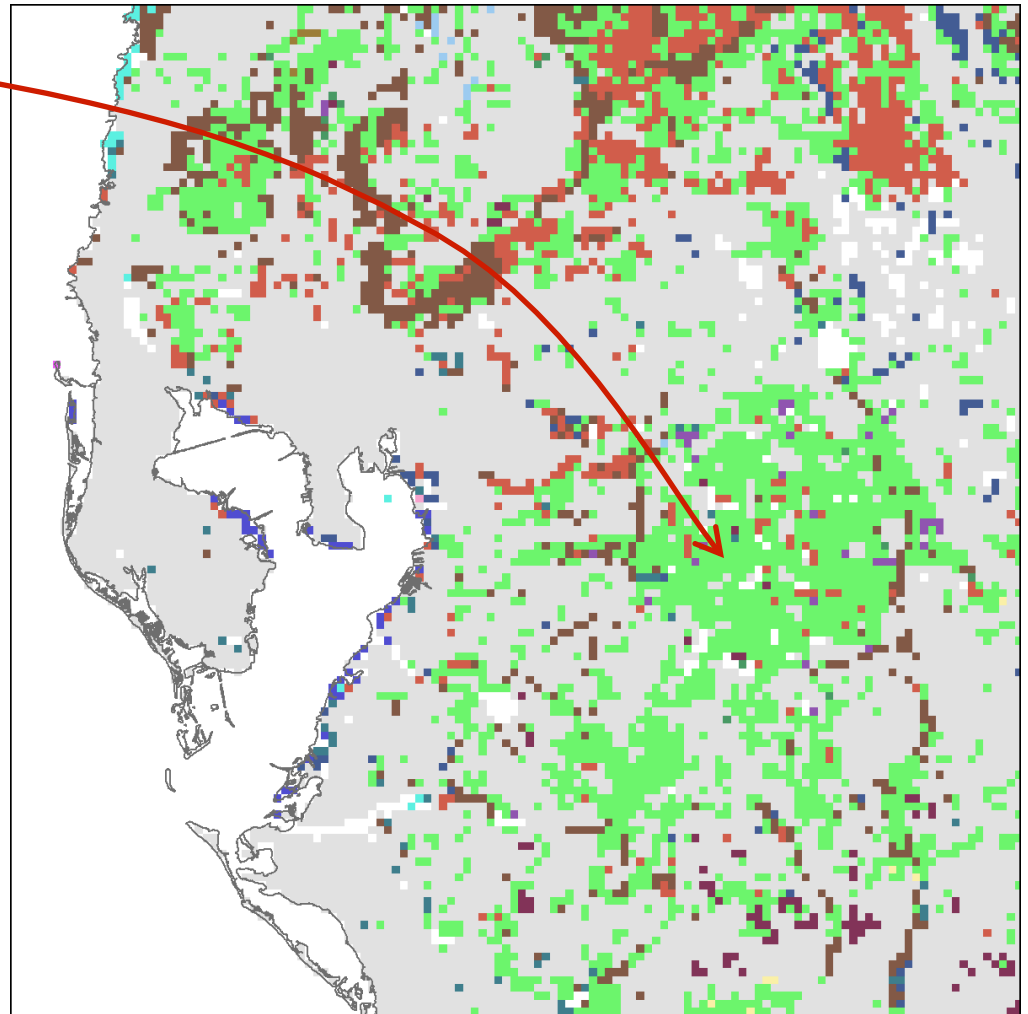
- 1-km resolution map assigns fires to one of several hundred “fuelbeds”
- A fuelbed describes the live and dead vegetation structure of a region for use in fire effects models
 - Tons/acre available to burn in the canopy, shrubs, ground fuels, fallen wood, etc.

Available Fuel Loading – FCCS Strata

Stratum		Category
CANOPY		Trees, snags, ladder fuels
SHRUBS		Primary and secondary layers
NONWOODY VEGETATION		Primary and secondary layers
WOODY FUELS		All wood, sound wood, rotten wood, stumps, and woody fuel accumulations
LITTER-LICHEN-MOSS		Litter, lichen, and moss layers
GROUND FUELS		Duff, basal accumulations, and squirrel middens

Available Fuel Loading – Outside Tampa

- Fuelbed map lookup
- Fuelbed = 191
- Longleaf pine – slash pine / galberry forest
- “This forest is found throughout the Southeast coastal plain from Virginia south to Florida and west to into Texas, and is characterized by an open overstory of longleaf pine with occasional slash pine. The shrub layer is moderate to very dense with clumps of gallberry (*Ilex glabra*). The herbaceous layer is sparse and dominated by wiregrasses (*Aristida* spp.) or bluestem (*Andropogon* spp.).”



Available Fuel Loading – Fuelbed 182

Available fuel loading by strata

Stratum	Available fuel (tons/acre)
Canopy	37.8
Shrubs	4.9
Nonwoody vegetation	0.2
Downed wood	1.8
Litter, lichen, and moss	3.0
Ground fuels	4.2

Category*	Available fuel (tons/acre)	Approximate diameter (inches)
1-hour	0.08	< ¼
10-hour	0.35	¼ - 1
100-hour	0.4	1 – 3
1,000-hour	1	3 – 9
10,000-hour	0	9 – 20
>10,000-hour	0	> 20

Fuelbed 182 = Longleaf pine - Slash pine / Saw palmetto – Gallberry forest

* 1-hour, 10-hour, etc. categories represent size categories of dead twigs, branches, logs, etc. Categories are related to the length of time needed for a stick of that size to dry out.

Consumption Efficiency

$$E = A \times AFL \times \beta \times Ef$$

What fraction of available fuel is consumed?

Common methods

- Model based on weather and land type
- Function of forest cover
- Constant values

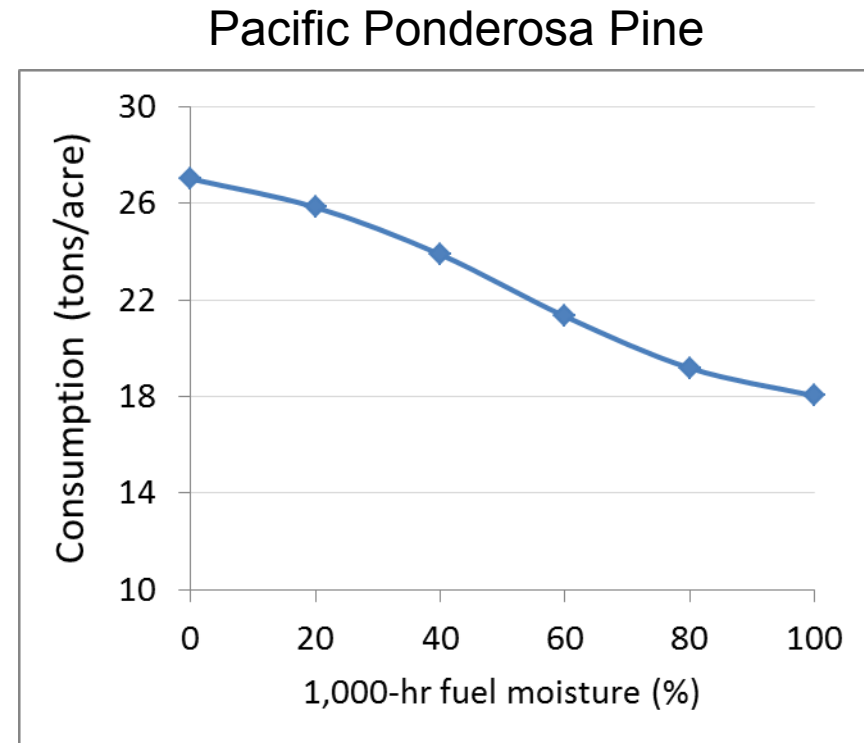


Consumption Efficiency – NEI Method

- USFS FERA Consume 4.1 Fire Effects Model
- Consume predicts fuel consumption, emissions, and heat release
 - For the NEI method, we use only the consumption predictions
- Inputs include available fuel loadings and fuel moisture
- Outputs include consumption by combustion phase

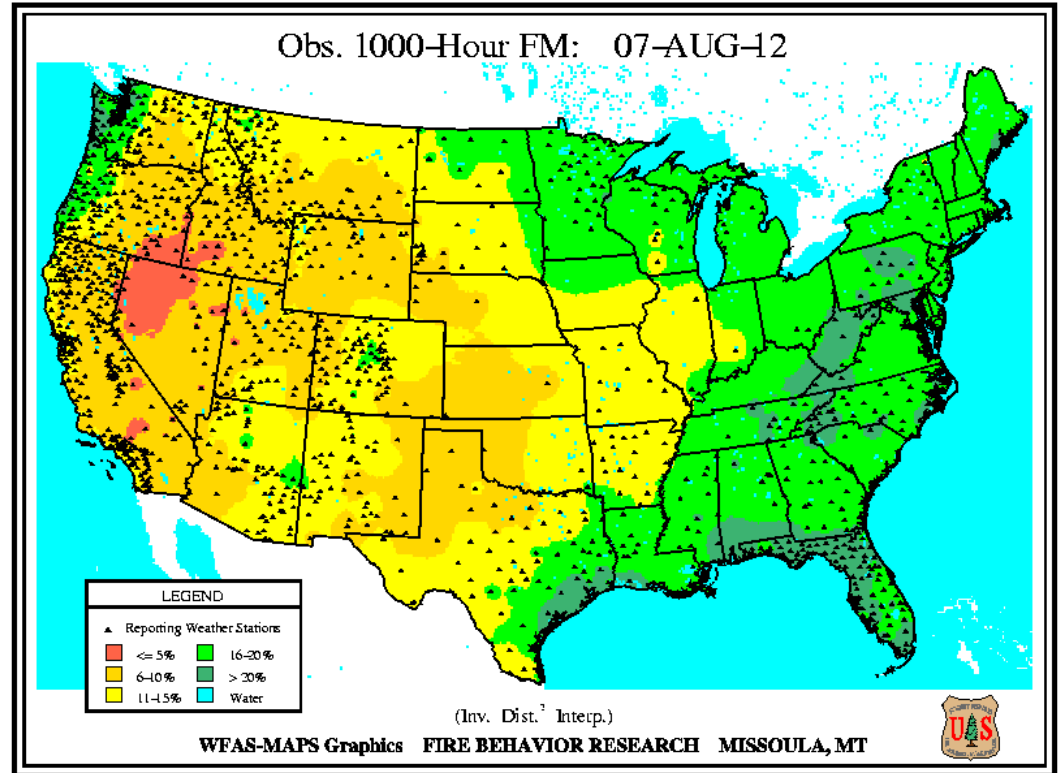
Consumption Efficiency – Fuel Moisture

- Consumption depends on moisture in the fuels
 - 1000-hr woody fuel
 - Duff
- Prescribed burns are typically conducted under more moist conditions than wildfires which reduces consumption



Consumption Efficiency – Fuel Moisture

- Moisture values are retrieved from the Wildland Fire Assessment System (WFAS)
- Daily observed 1000-hr fuel moisture values at fire weather stations



Consumption Efficiency – Results by Phase

Consumption results are modeled by combustion phase

- Flaming
 - most efficient phase of combustion
 - produces the least amount of smoke per unit of fuel consumed
 - products are primarily carbon dioxide and water vapor
- Smoldering
 - least efficient phase of combustion
 - produces the most smoke
 - no flame
 - oxygen is limited – either by char of fuels or by tightly packed fuels like duff and organic soils or in wet fuels
- Residual smoldering
 - continued smoldering beyond the first two hours



Consumption Efficiency – Ground Fuels Reduction Correction

- Some fuelbeds have a deep layer of ground fuels that may burn
- During prescribed burn conditions, significant ground fuel reduction is uncommon
- Consume 4.1 has a known issue of predicting too much ground fuel reduction for Rx burns
- For NEI 2011, ground fuel consumption was capped at 5 tons/acre in the East and 20 tons/acre in the West
- For 2014, approach may be similar

Evans Road Fire (NC, 2008)



Emission Factors

$$E = A \times AFL \times \beta \times Ef$$

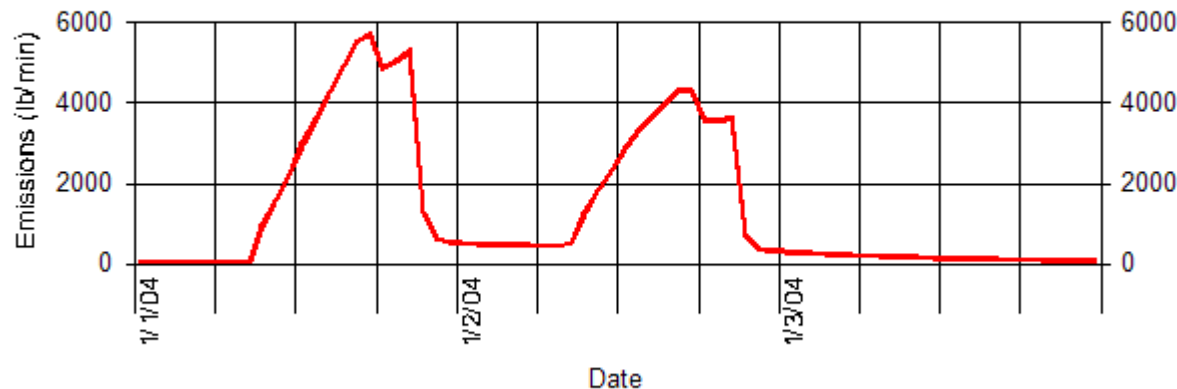
How much CO₂, CH₄, etc. is produced per mass burned?

Common methods

- Model uses combustion efficiency to adjust literature combustion rates
- Constant literature values



CO Emissions

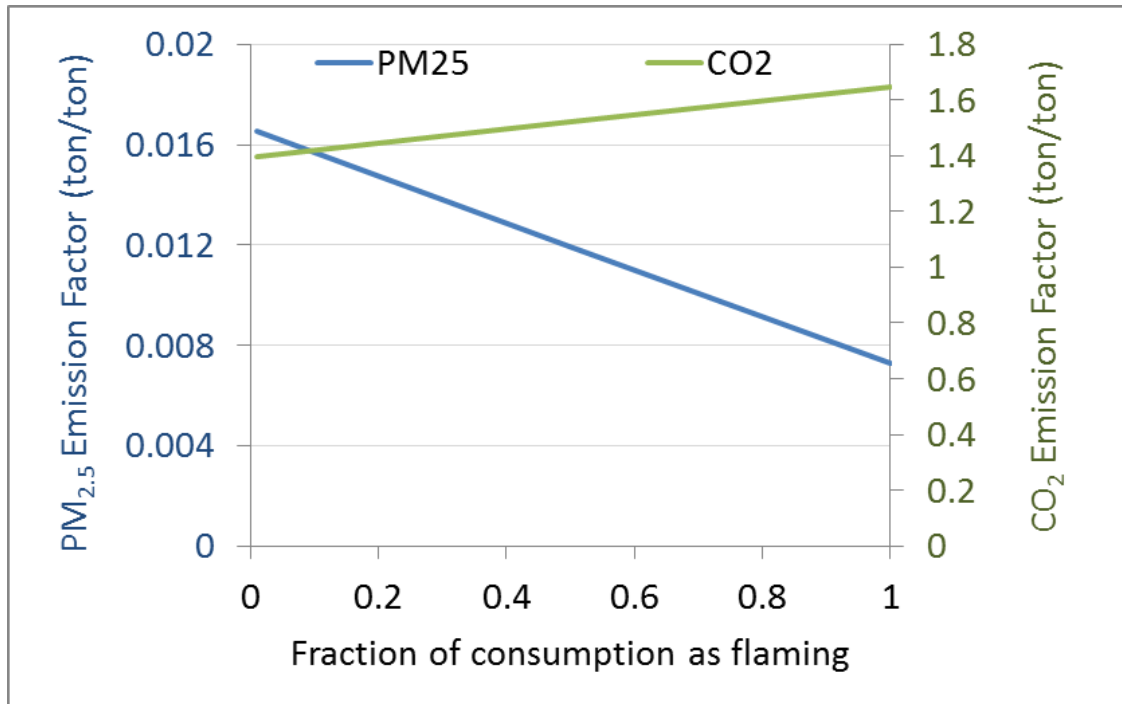


Emission Factors – NEI Method

- USFS FERA Fire Emissions Production Simulator (FEPS)
 - Uses two sets of emission factors, one for flaming and one for smoldering combustion
 - Final emission factors for each fire depend on the ratio of flaming to smoldering combustion (at each hour)
- Also calculate 35 hazardous air pollutants with constant emission factors (from EPA)

Emission Factors – FEPS Output

- A fire consisting entirely of flaming would produce somewhat more CO₂ but much less PM_{2.5} than a fire consisting entirely of smoldering combustion
- Different fuels and burning conditions produce differing ratios of flaming to smoldering



NEI Method – Tying Information Together

