# Wildland Fuel and Fire Emissions Research
## Physical Fire Processes
## Portfolio A
## Core Fire Science

**United States Department of Agriculture**

**Forest Service**

**Fuels**
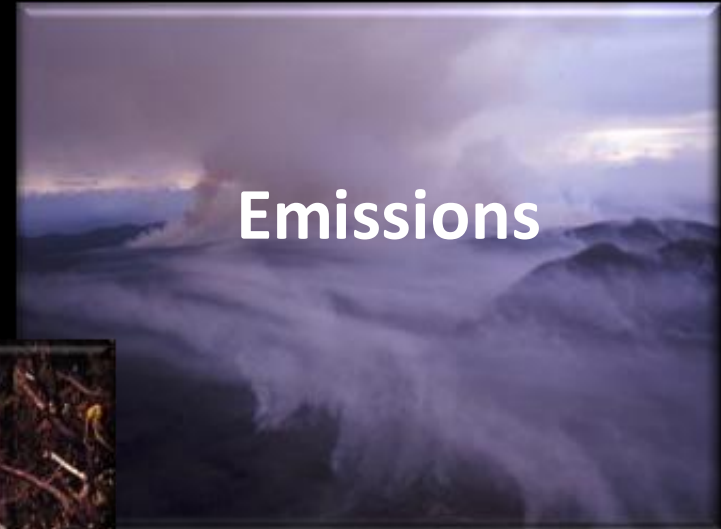
**Emissions**

**Consumption**

# Outline

- **Background**

- **Current lines of work and findings**
  - **Fuel**
  - **Emissions**

- **Research in use**

- **Research implications**

- **Transfer of information**

- **Integration and cooperation/RxCADRE**

- **Research gaps, future investments**

# Background

- **Wildland fire is managed to:**
  - **protect valuable resources**
  - **fuel treatment**
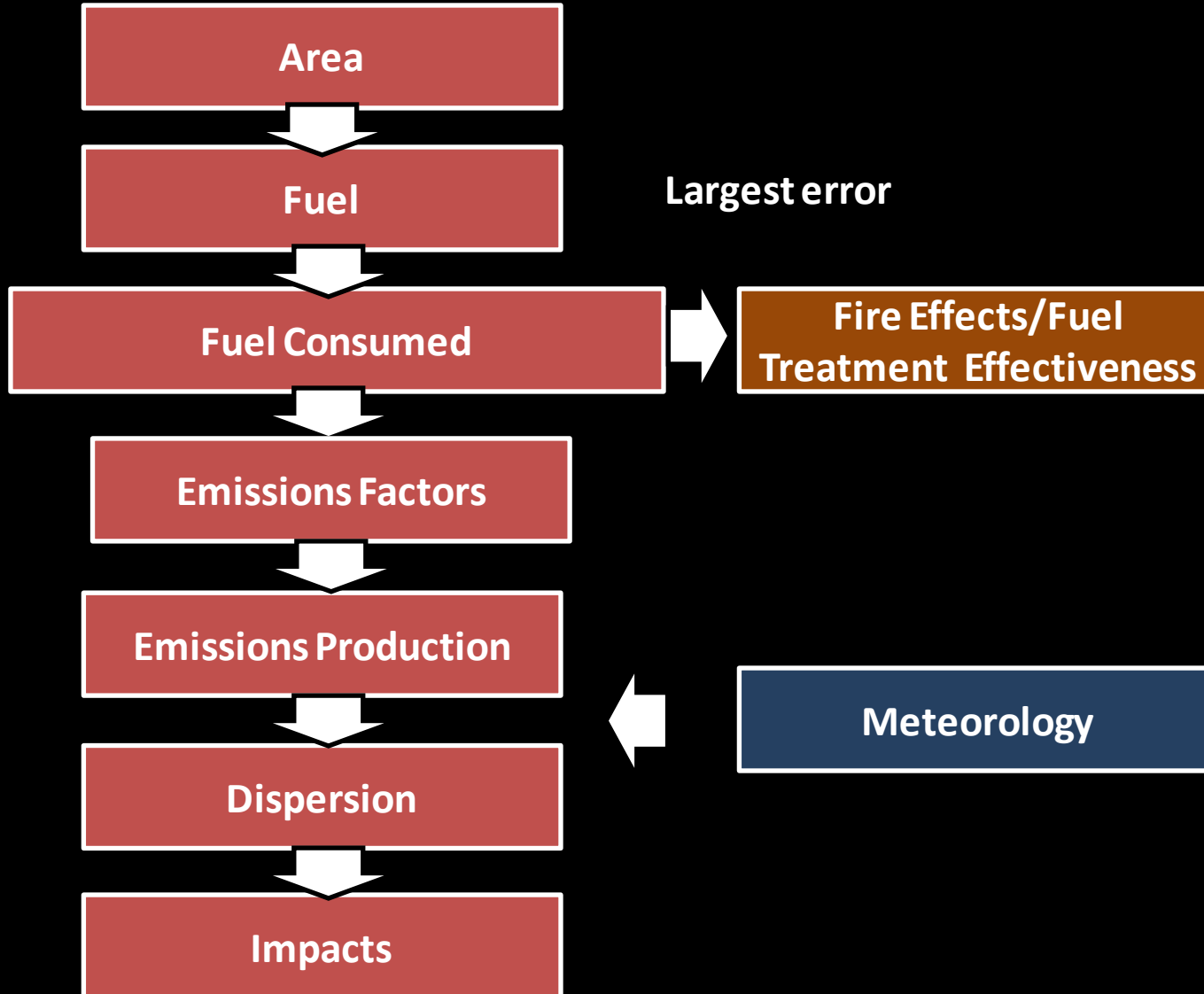  - **provide ecological process to restore and maintain functional ecosystems**

- **Smoke from wildland fire is a critical management issue**
  - **public and firefighter health**
  - **safety**
  - **regional haze/visibility**
  - **greenhouse gas emissions**
  - **nuisance**

- **Managing fire to minimize adverse effects of smoke requires new knowledge and models**

- **US Forest R&D is leading research to expand new knowledge in these areas**

# Research Plan



```
Area
  ↓
Fuel
  ↓
Fuel Consumed  →  Fire Effects/Fuel Treatment Effectiveness
  ↓
Emissions Factors
  ↓
Emissions Production  ←  Meteorology
  ↓
Dispersion
  ↓
Impacts
```
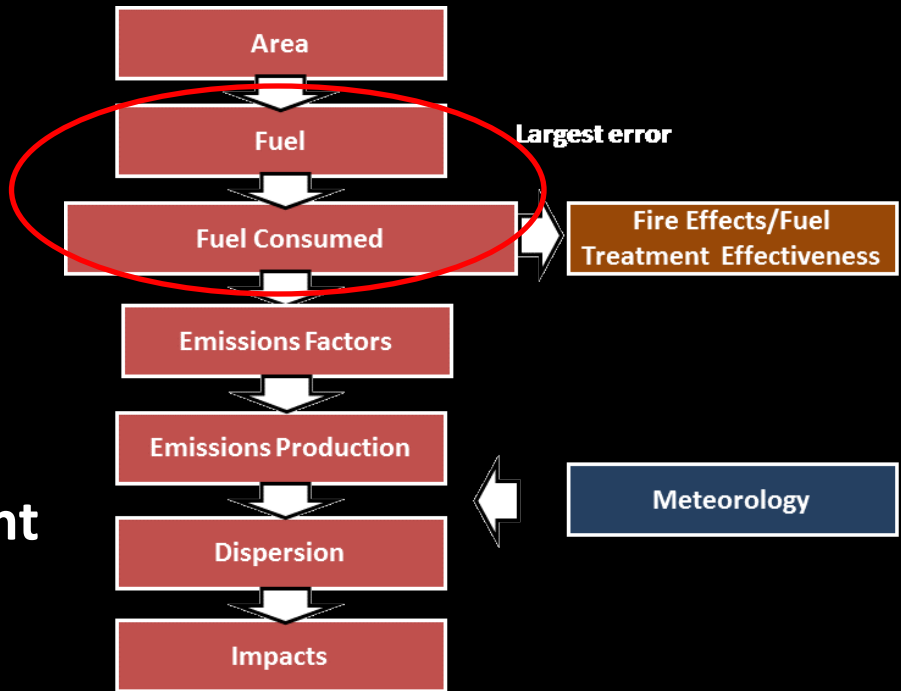
Largest error

# Research Application

- **Fire & Smoke Modelers**
- **Other Scientists**
- **Fuel & Fire Planners**
- **Firefighters**
- **Fire Ecologists**
- **Smoke and Carbon Regulators**

# Importance of Fuels and Combustion Research

- **Potential for large errors**
  - **Fuelbeds are variable geographically, seasonally, and over time**
  - **Difficult to map**
  - **Combustion varies by fuelbed component and moisture content**

Area

Fuel — **Largest error**

Fuel Consumed → **Fire Effects/Fuel Treatment Effectiveness**

Emissions Factors

Emissions Production ← **Meteorology**

Dispersion

Impacts

**Simple** → **Complex**   **High FM** → **Low FM**

# What projects have we targeted for fuel and combustion research?

- **Characterization of fuels by fuelbed categories**
  - Ground sampling
  - Visual estimates
  - Terrestrial and aerial LiDAR
  - Remote sensing
  - Models
- **Fuel Mapping**
- **Fuel moisture modeling**
- **Fuel consumption by fuel type, component, and combustion phase**
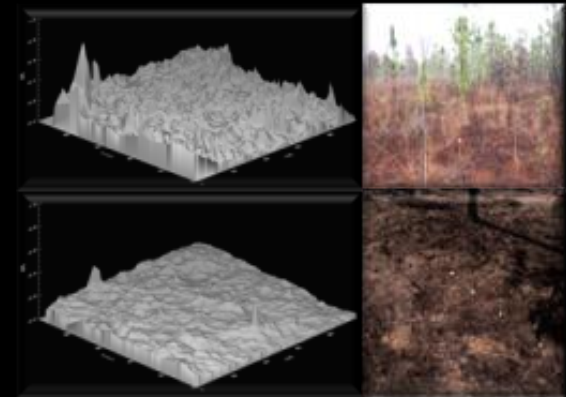
# Fuel and Consumption Project Details
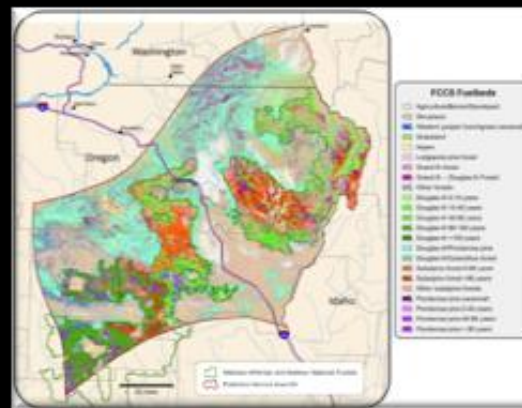
**Ground inventory**



**Fuelbed modeling and classification**



**Terrestrial LiDAR**



**Digital Photo Series**



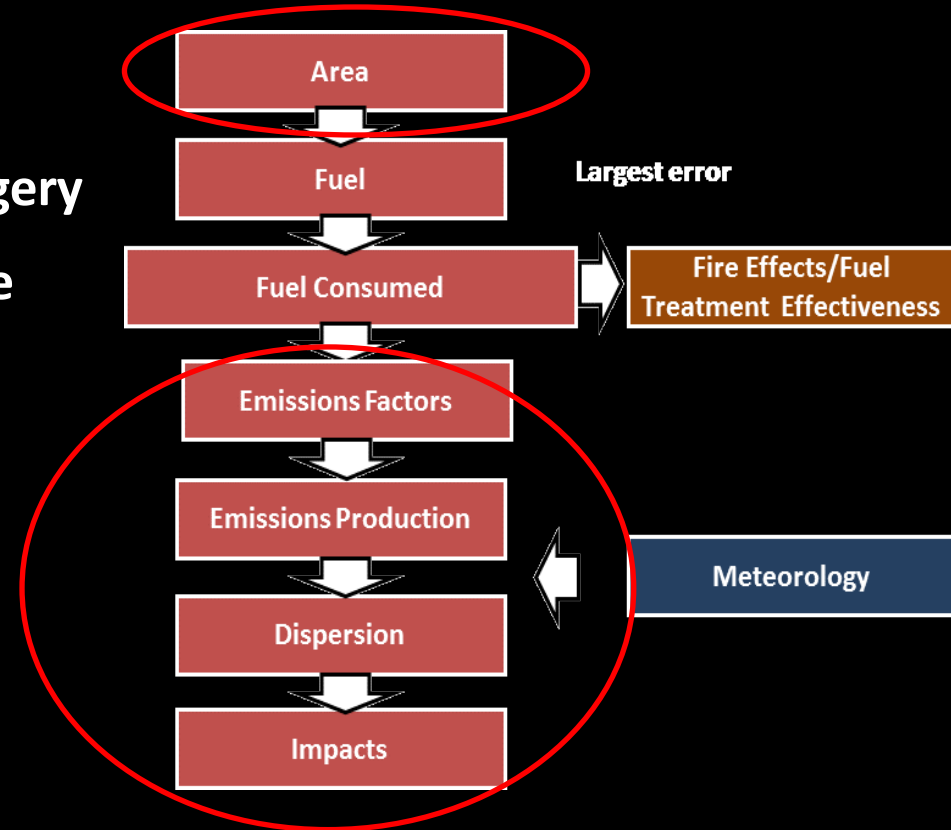**Fuelbed mapping**



**Consumption**

# Research in Use

- **Line intersect, clipping/weighing, biometric methods**

- **FIREMON**

- **FCCS**

- **Photo Series, Digital Photo Series**

- **Fuel Loading Models**

- **FireBCG, FFE-FVS, Fuel3D**

- **LANDFIRE**

- **Fuel Moisture models**

- **Consume and FOFEM**

# What projects have we targeted for <u>emissions</u> research?

- **Satellite and aerial fire perimeter imagery**
- **Field and lab emission factor data base**
- **Heat release and plume rise modeling**
- **Dispersion and visibility modeling**
- **Public impact and firefighter exposure**
- **Emissions inventory**

Area

Fuel — Largest error

Fuel Consumed → Fire Effects/Fuel Treatment Effectiveness

Emissions Factors

Emissions Production

Dispersion ← Meteorology

Impacts

**Perimeter**

**Emission factor**

**Plume rise**

**Dispersion**

**Concentration**

# Emissions Project Details

**Emission sampling**

**Exposure impacts**

**Dispersion modeling**

BlueSky

**Heat release/plume rise**

FCCS Fuelbed Map
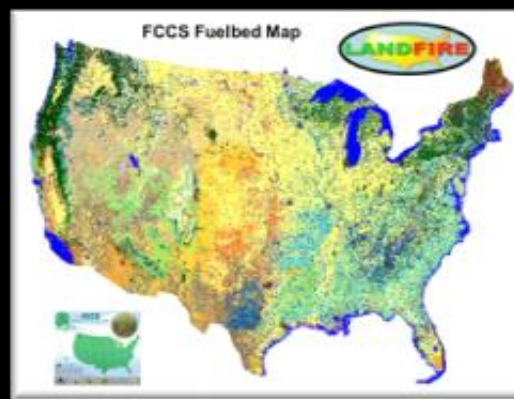
**Emissions inventory**

SMOKE MANAGEMENT GUIDE FOR PRESCRIBED AND WILDLAND FIRE 2001 Edition
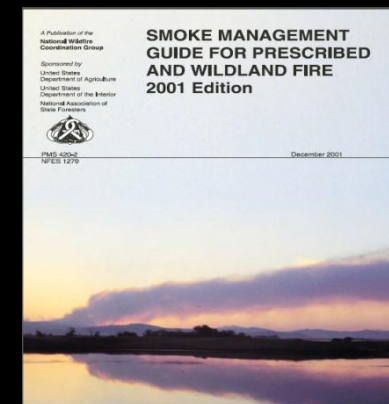
**Smoke Management Guide**

# Research in use

- **Consume, FOFEM, FEPS**

- **Emission factor database**

- **BlueSky, BlueSky Playground, V-smoke GIS, PB Piedmont**

- **Fire emissions inventory**

- **Smoke and air quality forecasts**

- **Incident command support**

- **State smoke management planning**

- **Smoke management guide**

- **Firefighter smoke exposure assessment**



V-Smoke GIS

# Research Implication

- **Manage wildland fire for air quality impacts**

- **Inputs for sophisticated fire behavior and fire effects models**

- **Fuel treatment effectiveness and longevity**

- **Fuel and fire planning**

- **Carbon accounting**
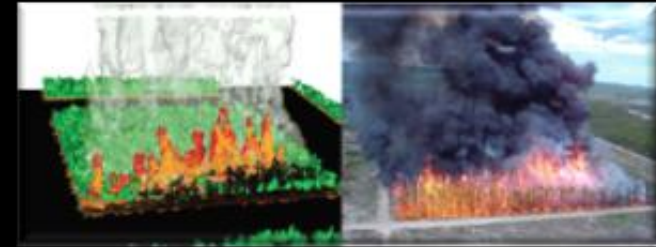
# Transfer of Information

- **Scientific and gray literature (e.g. special issue-wildland fire emissions, carbon, and climate; Wildland fuel fundamentals--book by Robert Keane)**
- **Conferences, Workshops, Field trips**
- **Practitioner fire and fuel training classes**
- **Public school and university classes**
- **Webinars**
- **Tweets**
- **Websites**
- **Data and metadata repositories**

# Integration and Cooperation

- **Federal agencies**
- **Joint Fire Science Program**
- **US and foreign universities and colleges**
- **State agencies**
- **Land managers and other practitioners**
- **Department of Defense**
- **Private consultants**
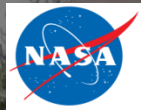- **Public schools**
- **Regulatory agencies**

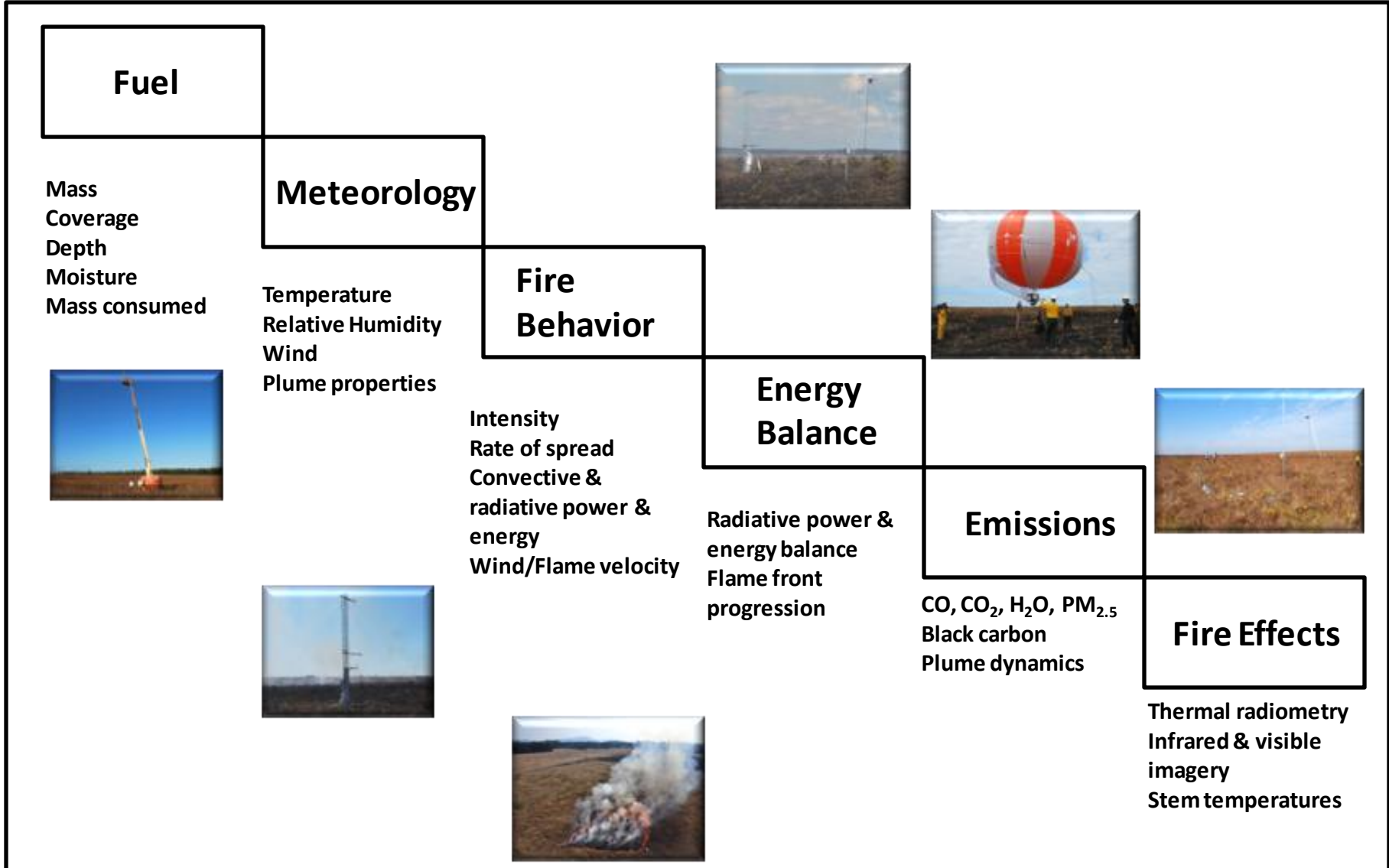# A Data Set for Fire and Smoke Model Development and Evaluation--RxCADRE

**Fuels, Meteorology, Fire Behavior, Airborne Sensing, Smoke, Fire Effects – 90 scientists and technicians, 15 Agencies, Universities, and Contractors**

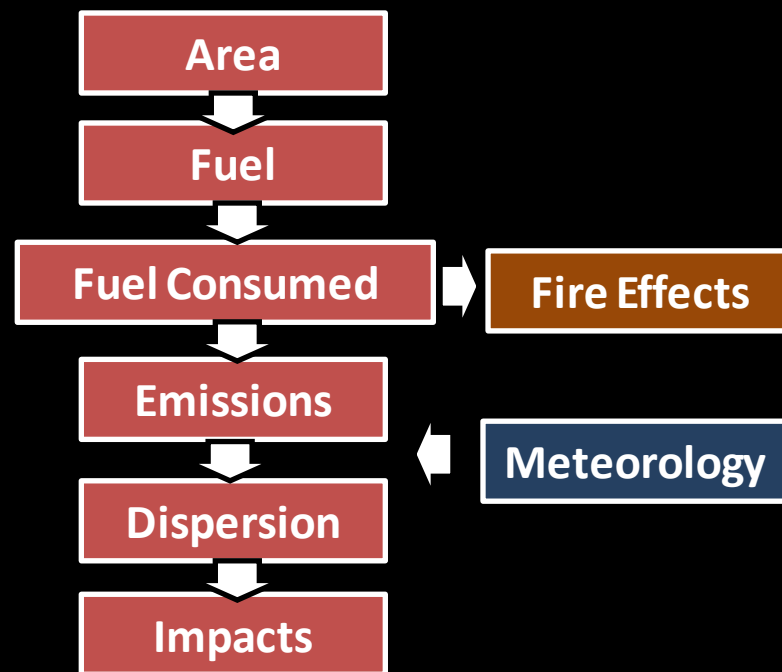**One of the largest collaborative fire research efforts**

# Integrated Approach

**Fuel**

Mass
Coverage
Depth
Moisture
Mass consumed

**Meteorology**

Temperature
Relative Humidity
Wind
Plume properties

**Fire Behavior**

Intensity
Rate of spread
Convective &
radiative power &
energy
Wind/Flame velocity

**Energy Balance**

Radiative power &
energy balance
Flame front
progression

**Emissions**

CO, $CO_2$, $H_2O$, $PM_{2.5}$
Black carbon
Plume dynamics

**Fire Effects**

Thermal radiometry
Infrared & visible
imagery
Stem temperatures

# Science Gaps and Needed Investments

- **Improved fuel and fuel consumption accounting**

- **Improved approach to mapping fuels**

- **Improved modeling of meteorology, plume rise, dispersion, and visibility prediction**

- **Long-term firefighter health effects from smoke inhalation**

- **Data repository**

- **Model validation and uncertainties**

Area → Fuel → Fuel Consumed → Fire Effects

Fuel Consumed → Emissions → Dispersion → Impacts

Meteorology → Emissions

Questions??