Research -
Fuel Consumption and Smoke Emissions from Prescribed Fires in Eastern Hardwoods

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Fix:

Raccoon Environmental Management Area
To
Racoon Ecological Management Area, just say REMA

Some slides too busy, esp. Indiana bat slide

Fuel Consumption and Smoke Emissions from Prescribed Fires in Eastern Hardwoods

Project goals:

Research

Use aerial infrared (IR) surveillance and in-fire monitoring to obtain basic data on consumption and emissions over prescribed burns in Appalachian mixed-oak forests.

Linkage

Management

1. Facilitate Smoke Management Program development
2. Train on applying smoke management tools to hardwoods
3. Understand of uncertainties inherent in smoke emission modeling by having our fire management partners estimate consumption/emissions on a set of prescribed burns and compare those estimates with research results from the same fires

Fuel Consumption and Smoke Emissions from Prescribed Fires in Eastern Hardwoods

Joint Fire Science Program funding and <u>in-kind support</u> (a lot)

<u>Principals on grant</u>

MATTHEW DICKINSON - USDA Forest Service, Northern Research Station
ANN ACHESON – USDA Forest Service; Region 9; Soil, Water & Air Staff
ROBERT KREMENS - Rochester Institute of Technology, Center for Imaging Science, Wildfire Airborne Sensor Program

<u>Other important players</u>

CINDY HUBER – USDA Forest Service; Region 8; Soil, Water & Air Staff
Lots of people involved. On the NF burns it will ultimately be the District FMO or Burn Boss that will count for getting the burns done:
Ohio Department of Natural Resources staff
Daniel Boone National Forest
Wayne National Forest staff

Fuel Consumption and Smoke Emissions from Prescribed Fires in Eastern Hardwoods

Outline - Research steps

Map fire heat release, fuel consumption, and emissions over prescribed burns:

A. Aerial infrared (IR) imaging and analysis.

B. Validate those maps with in-fire heat release and fuel consumption data along with emissions data through the burning period.

To use aerial IR to map fire heat release, fuel consumption, and emissions, we have to calibrate IR heat flux measurements with data from test burns.

Fire Monitoring Research

Test burns - Calibrating aerial IR data for estimating heat release & fuel consumption

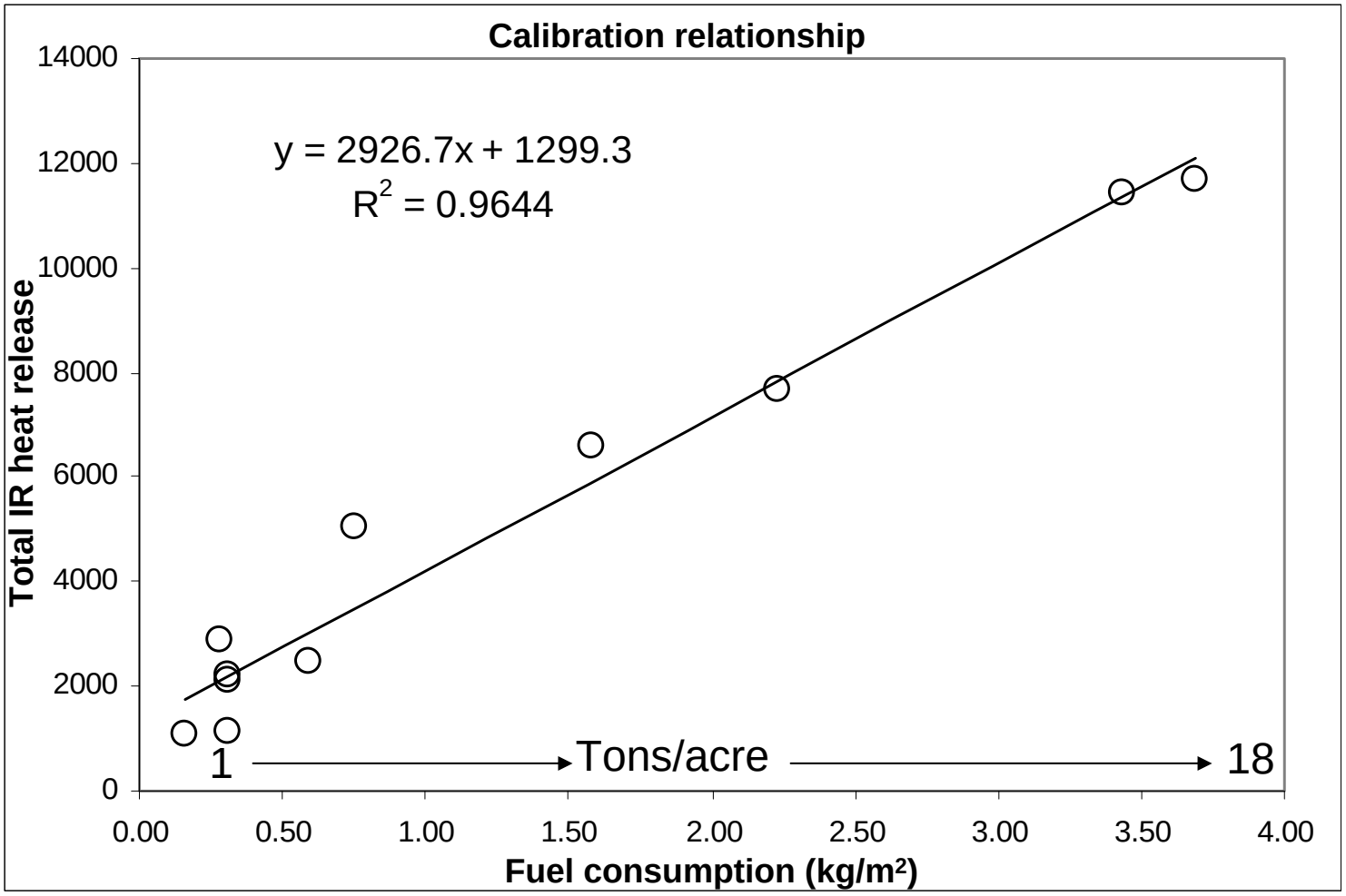
Test burns

1. Large range in loading
2. IR, rate of spread, emissions, and met sensors in plot
3. Fuel consumption from fuel loading pre- and post-fire

Fire Monitoring Research

Test burns - Calibrating aerial IR data for estimating heat release & fuel consumption

Calibration relationship



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Fire Monitoring Research

Mapping heat release and fuel consumption on prescribed burns

WASP – Wildfire Airborne Sensor Program, Rochester Institute of Technology (RIT)

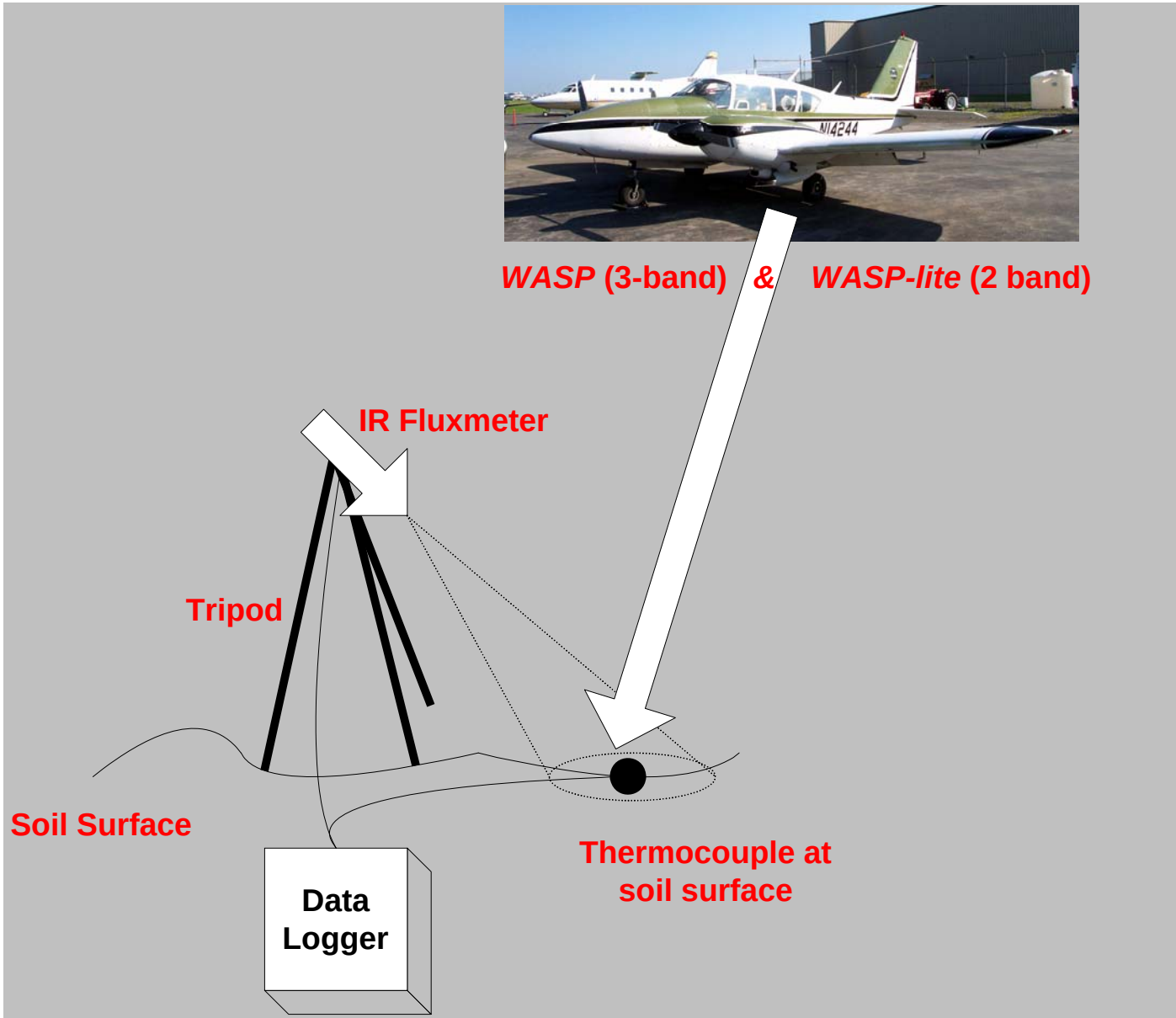
***WASP* (3-band) & *WASP-lite* (2 band)**

Aerial surveillance

1. WASP *vs* WASP-*lite*

2. Correction for atmospheric interference
=
(Flux leaving ground/ Flux at airplane)

Heat flux = heat release rate per unit area

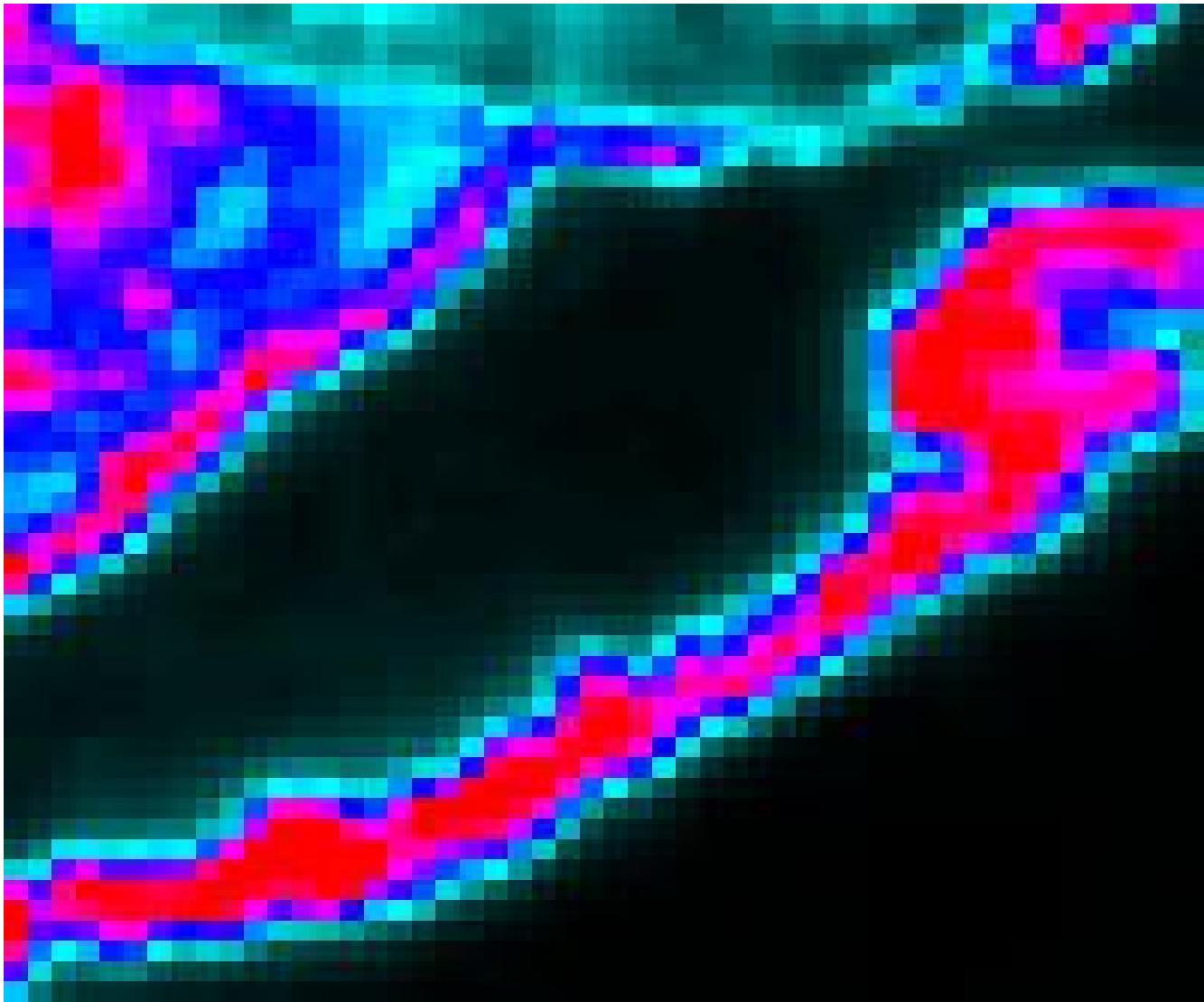


Fire Monitoring Research

Mapping heat release & consumption on prescribed burns

Test burn – Arch Rock A (Racoon Environmental Management Area, Vinton County, Ohio)

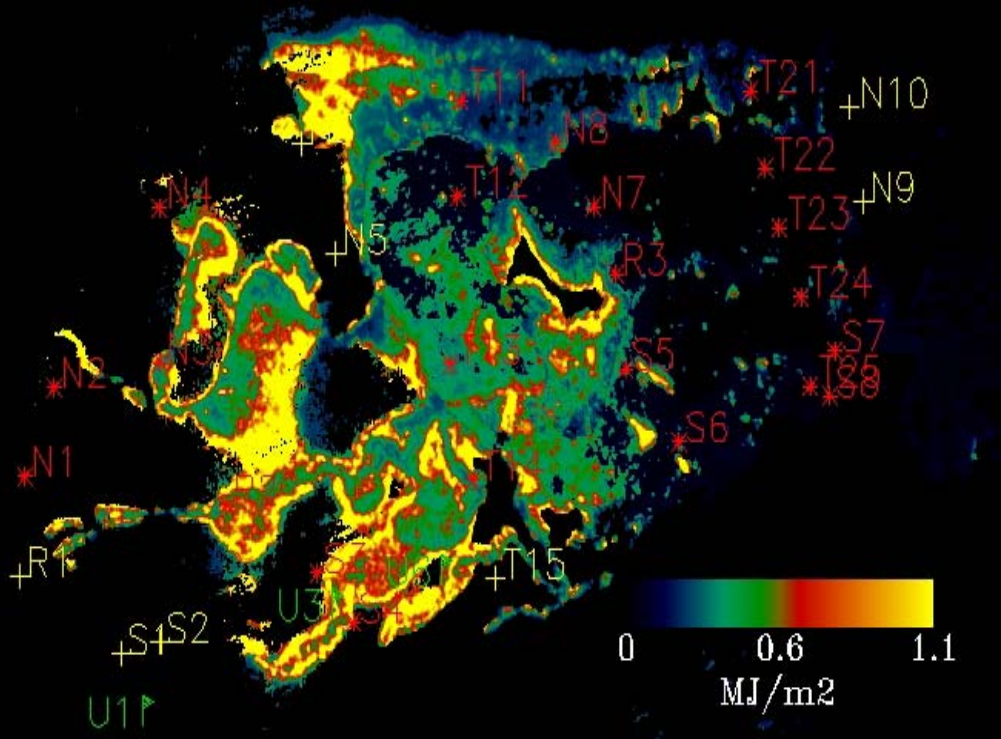
IR flux (W/m^2) snapshot



Fire Monitoring Research

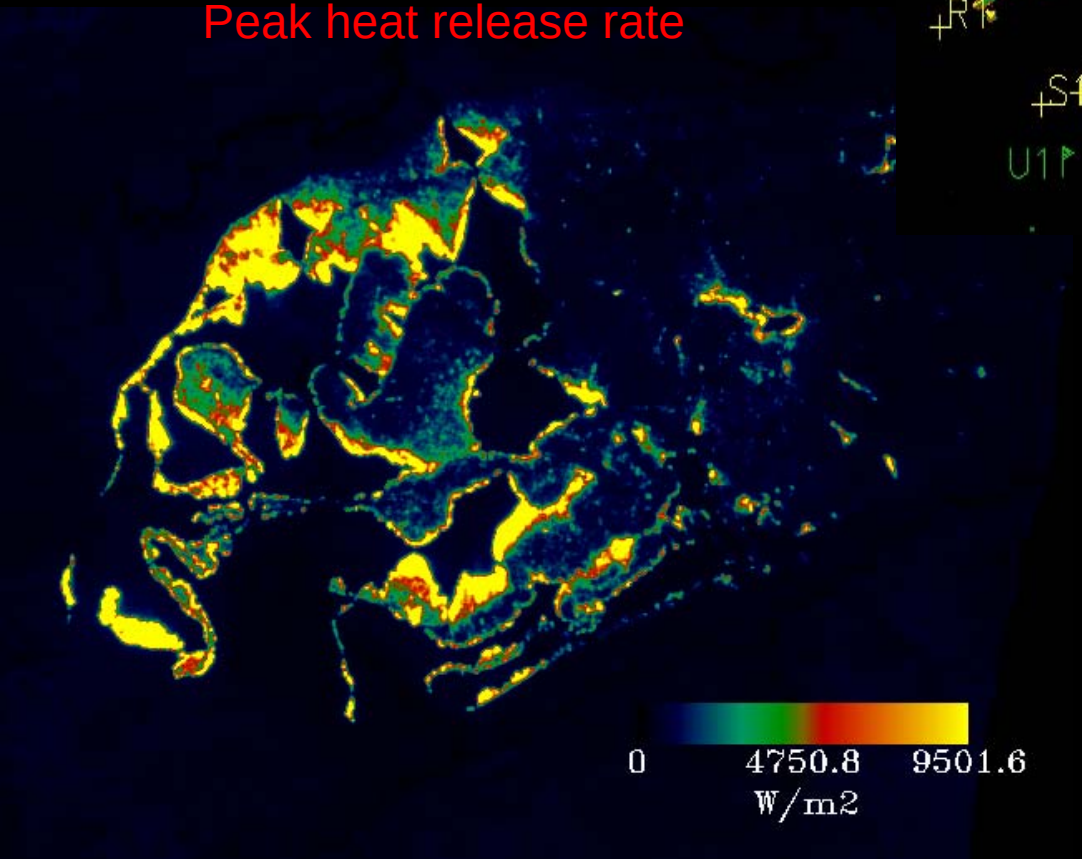
Mapping heat release & consumption on prescribed burns

Test burn – Arch Rock A (Racoon Environmental Management Area, Vinton County, Ohio)



Total heat release

Peak heat release rate



Maps are incomplete because we couldn't fly "cold to cold" over whole burn (need work on coordination)

Fire Monitoring Research

Mapping heat release and consumption on prescribed burns

Test burn

Using a low threshold for total heat release, unburned areas emerge that can be deducted from emissions budget

Map coincided 100% with 9 unburned and 31 burned fuel consumption plots

Fuel Consumption and Smoke Emissions from Prescribed Fires in Eastern Hardwoods

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Map fire heat release, fuel consumption, and emissions over prescribed burns:

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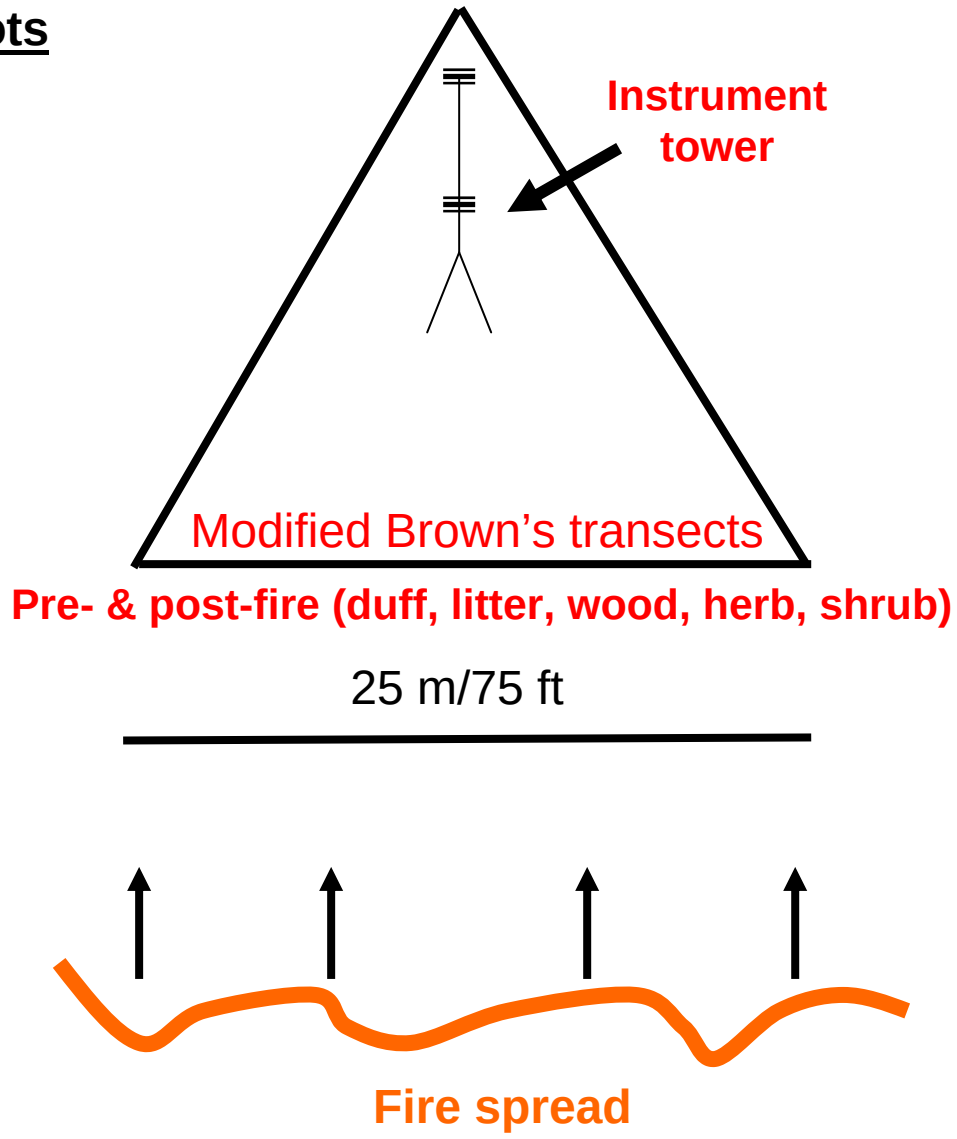
To aerial IR to map fire heat release, fuel consumption, and emissions over burns, we have to calibrate IR sensor heat flux measurements with data from test burns.

Fire Monitoring Research

In-fire monitoring - Validating heat release, fuel consumption, and emissions maps

Instrumented fuel plots

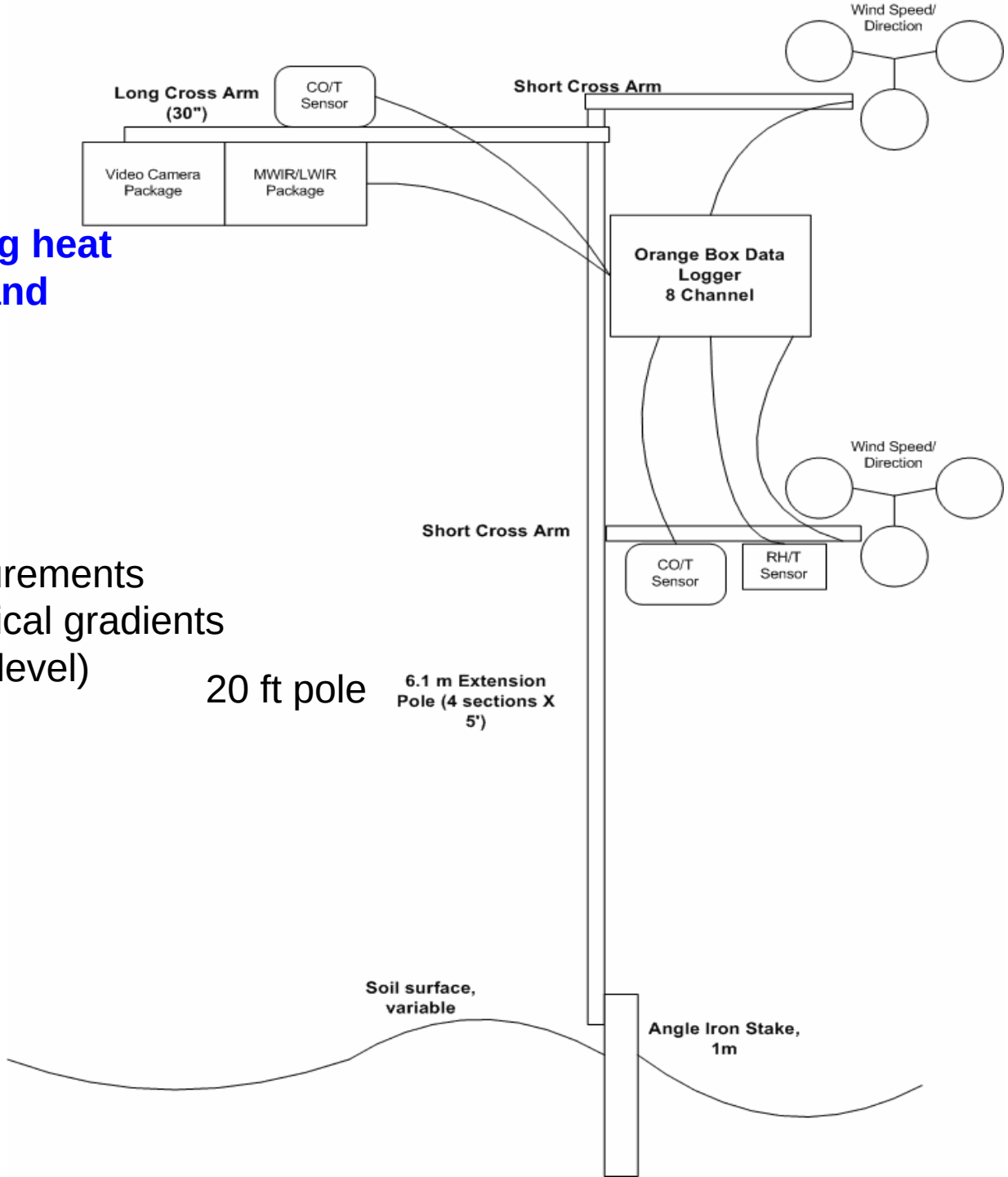


Fire Monitoring Research

In-fire monitoring - Validating heat release, fuel consumption, and emissions maps

Instrument tower

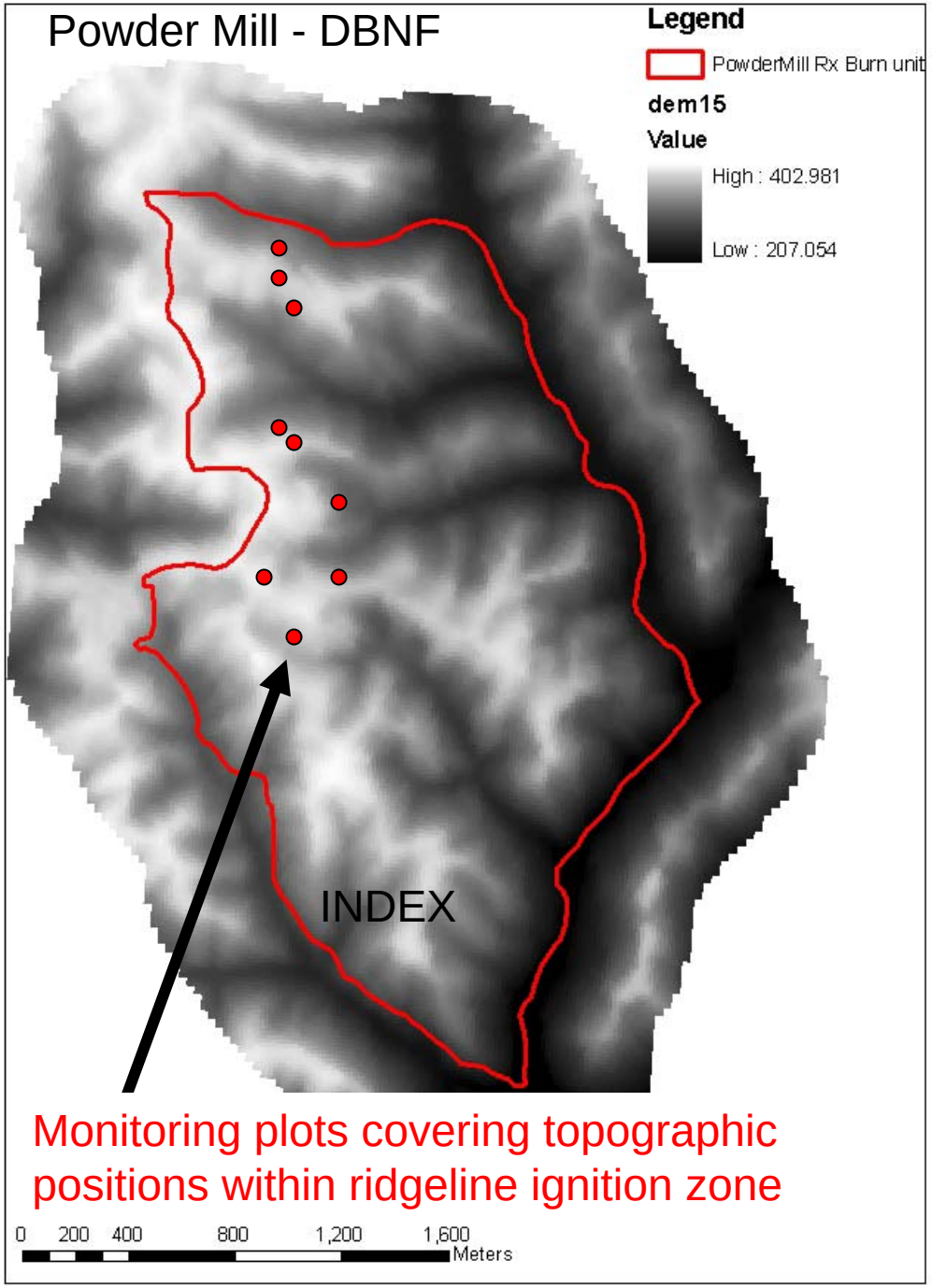
CO and meteorological measurements at two heights to describe vertical gradients for estimating source (ground-level) emissions.



Fire Monitoring Research

In-fire monitoring - Validating heat release, fuel consumption, and emissions maps

Fuel plot layout



Fire Monitoring Research

Progress and logistics

IR Calibration test fires

Spring 2006, 11 burns completed, ~1 to 17 tons/acre consumption
Summer 2007, heavier wood and shrub fuel loadings (TNC, Albany Pine Bush, New York)
Bracket extremes in hardwood fires

Prescribed burn lineup

Burn unit criteria: mixed oak, all topo. positions (large), uncomplicated, undisturbed or ice storm disturbed.

			(Indiana bat behavior)
Land Management Agency	***Years***	***Dormant season burns***	***Growing season burns***
Daniel Boone NF	**'06-'07**	**2**	**3**
Ohio DNR			
Undisturbed	**'07-'08**	**1**	**-**
Ice storm	**'07-'08**	**1**	**-**
Wayne NF			
Undisturbed	**'08-'09**	**1**	**-**
Ice storm	**'08-'09**	**1**	**-**
Total (minimum)		**6**	**3**

Fire Monitoring Research

Progress and logistics

Coordinating work with our management partners

Operations Plan – adapted from a western US wildfire Rapid Response project

Coordination tool:

1. Everyone knows what everyone else is doing
2. Safety
3. Successful research

DRAFT - OPERATIONS PLAN

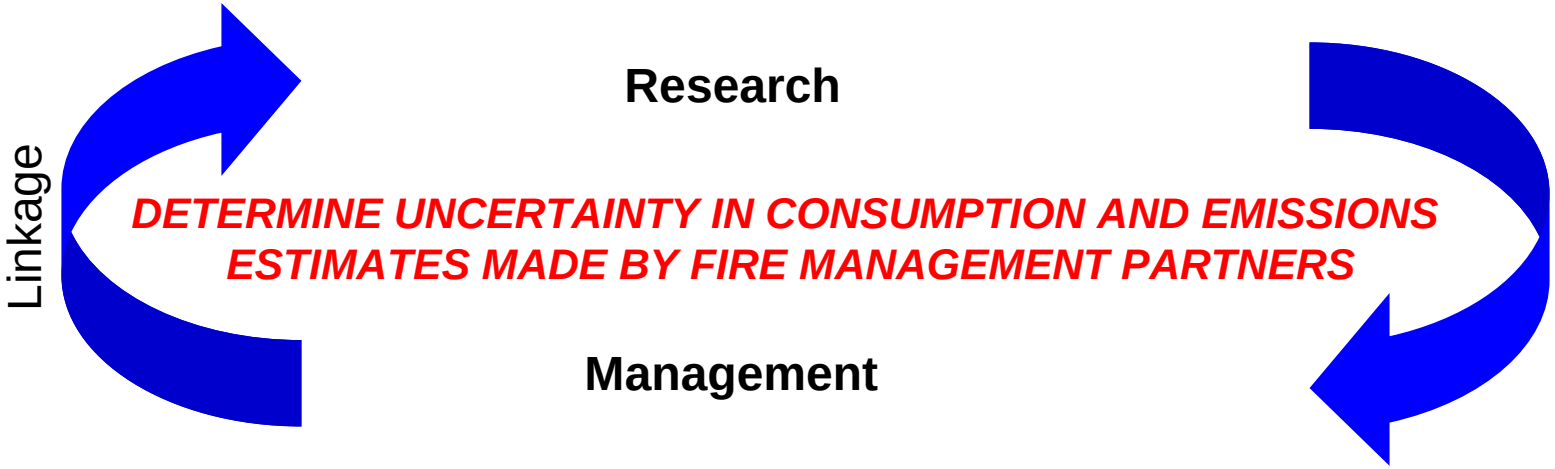
CHARACTERIZING SMOKE EMISSIONS AND BEHAVIOR OF LANDSCAPE-SCALE RX FIRES IN OHIO AND KENTUCKY WITH AIRBORNE AND IN-FIRE SENSORS AND FIELD SAMPLING

And

RADIO TRACKING NORTHERN BATS BEFORE, DURING, AND AFTER RX BURNS

Powder Mill Unit – Daniel Boone National Forest

Linkage between research and management parts of project



Ideal – Fire Management partners decide to map fuels and estimate consumption & emission for all your prescribed burns as part of the Ohio and Kentucky Smoke Management Programs. *No one rose to that challenge!*

Fallback – work with Fire Management partners to produce very basic fuel maps for burn units (e.g., single fuel type with FCCS) and use those maps and CONSUME 3.0 to develop consumption/emissions estimates for comparison with research results from the same burns.

Tools from the November 2006 workshop:

Fuel Characteristics Classification System (FCCS)
Natural Fuel Photo Series
CONSUME 3.0

Project timeline – 2006-2007

2006											
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
					Funded	Operations Plan prepared in collaboration with RX fire staff (e.g., FMOs)					1st Workshop - Purpose: Build foundation for research project and link to potential Smoke Mgt Program
											FERA-Natural Fuels Photo Series, FCCS, & CONSUME training
			Calibration burns		Develop list of RX burns			Monitor/characterize RX burns			

2007											
Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
	Joint field visits to characterize fuels on burn units? Estimate consumption?				In planning 2nd Workshop: Smoke management modeling training, continue SMP development				Independent field visits to characterize fuels on burn units? Estimate consumption?		
							Annual report to JFSP				
	Monitor/characterize RX burns				Develop/confirm list of RX burns		Calibration burns	Monitor/characterize RX burns			

Management-related
Research-related
Administrative

Legend

Completed!

Project timeline – 2008-2009

2008											
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
		Independent field visits to characterize fuels on burn units? Estimate consumption?			3rd Workshop: Finalize SMP's for Ohio and Kentucky*				Independent field visits to characterize fuels on burn units? Estimate		
							Annual report to JFSP				
	Monitor/characterize RX burns				Develop/confirm list of RX burns			Monitor/characterize RX burns			
2009											
Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
					4th and Final Workshop: Complete smoke modeling exercises and quantify uncertainty in fuel consumption and smoke emission predictions.						
Analyze data and estimate of fuel consumption and emissions over landscape burns for 4th Workshop					Prepare and submit scientific manuscripts on fire mapping			Final report to JFSP			Enjoy the holidays drinking hot toddys in front of the fire
* The timeline for the 3rd workshop may need to change depending on whether the group wants to have the SMP considered as part of Regional Haze SIP submittal											

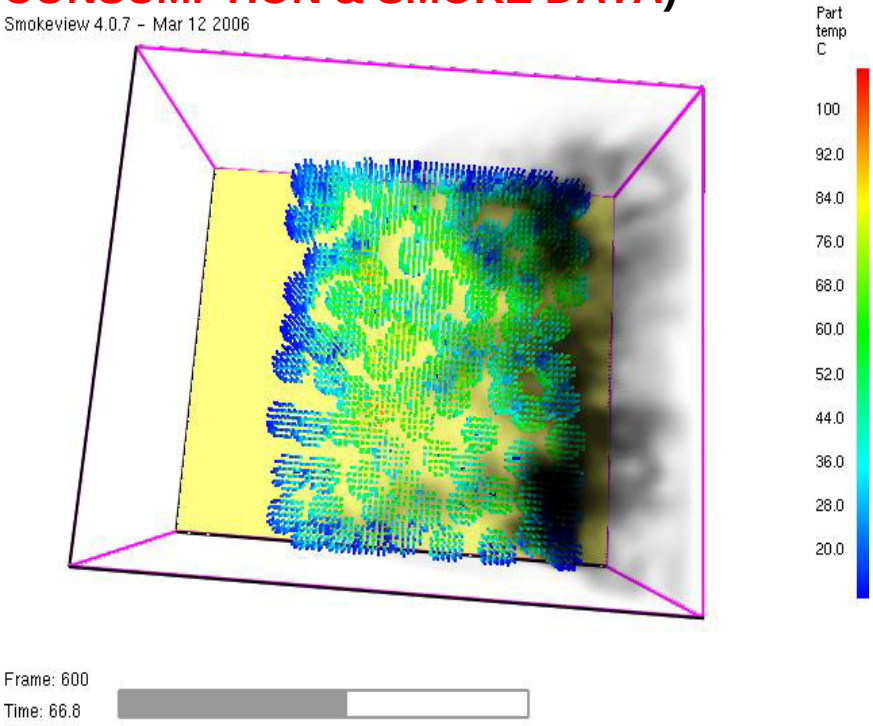
Legend

Management-related
Research-related
Administrative

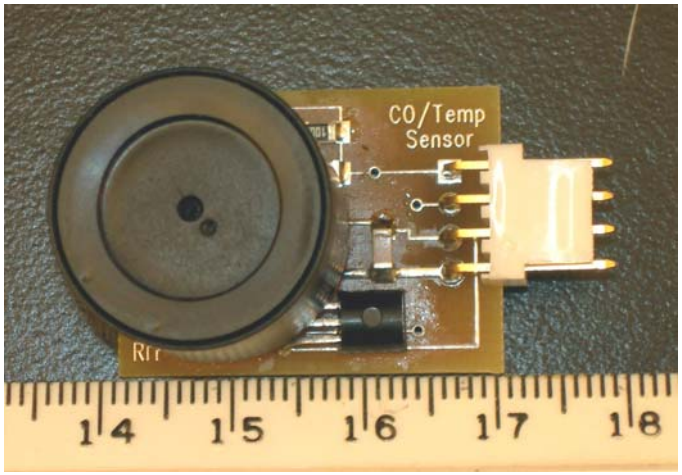
Fuel Consumption and Smoke Emissions from Prescribed Fires in Eastern Hardwoods

Linkage with Indiana bat project – "Direct Effects of Smoke and Heat on Roosting Indiana Bats"

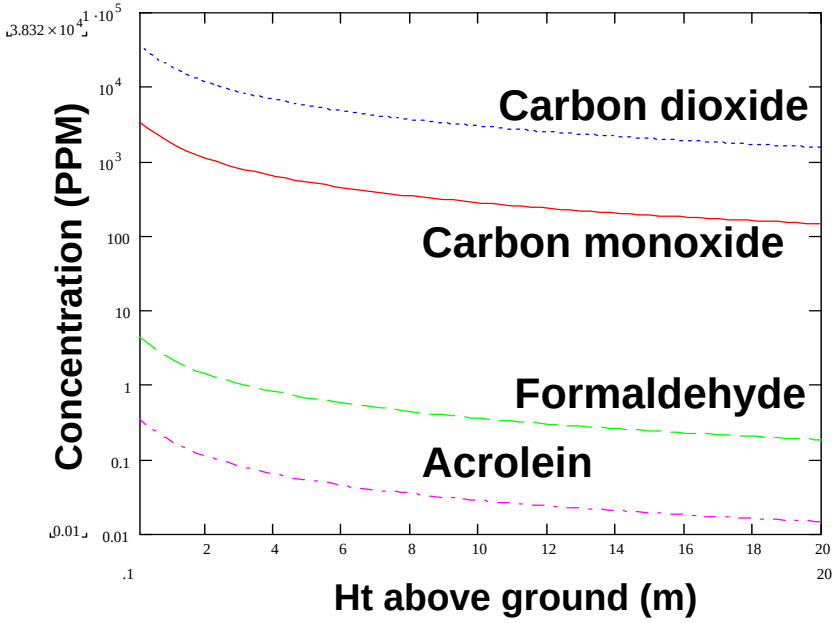
1. Smoke transport (modeling and CONSUMPTION & SMOKE DATA)



2. Smoke mixing into roosts (modeling and SMOKE DATA)



3. Bat toxicology (modeling and SMOKE DATA)



4. Bat behavior before, during, and after DBNF growing-season fires (radio tracking and fire mapping)

Fuel Consumption and Smoke Emissions from Prescribed Fires in Eastern Hardwoods

Project Website: **http://www.fs.fed.us/ne/delaware/4153/fuels/FFBE.htm**

Direct Effects of Smoke and Heat on Roosting Indiana Bats

Project Website: **http://www.fs.fed.us/ne/delaware/4153/fuels/FFBE.htm**