
FIRE & FUELS MONITORING

The Need for Monitoring

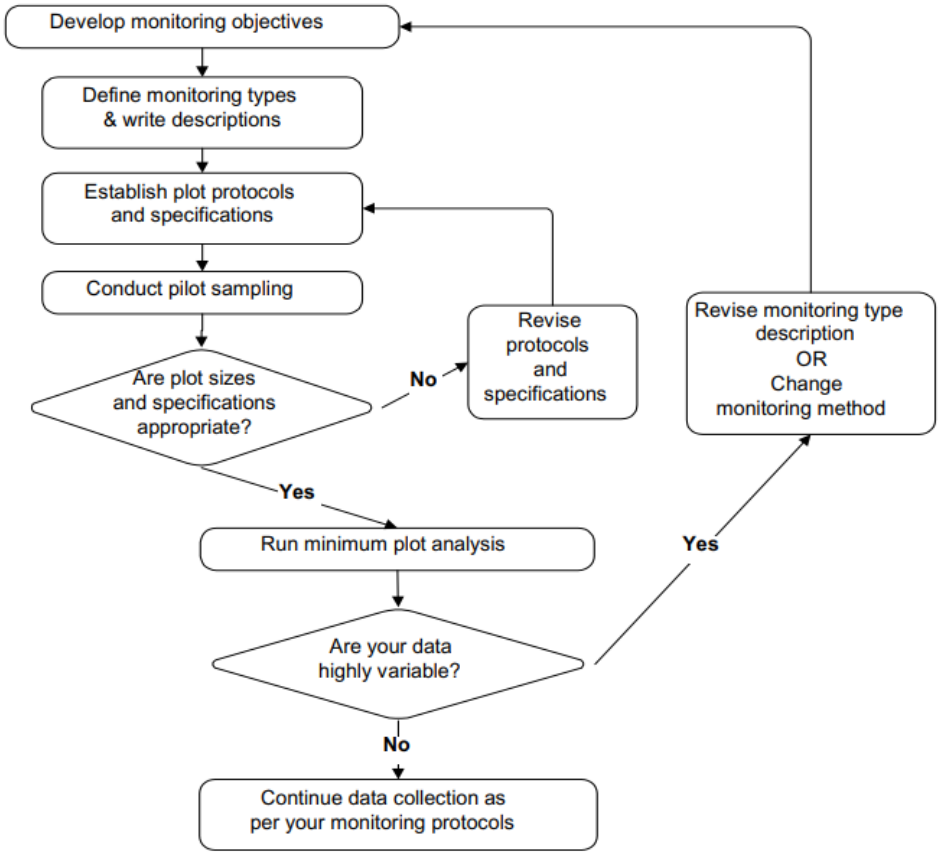
The public is holding Resource Managers increasingly accountable, and Federal / State agencies are instituting progressively more stringent guidelines for burning, monitoring, and smoke management.

Objectives for Unit 1

This unit will provide an overview for:

- Identify needs & develop goals / objectives
- Develop standards & protocols for data collection, recording, and archiving
- Implementation
- Compiling results

The Process


Develop monitoring objectives
Define monitoring types & write descriptions
Establish plot protocols and specifications
Conduct pilot sampling
Are plot sizes and specifications appropriate?
No
Revise protocols and specifications
Yes
Run minimum plot analysis
Are your data highly variable?
Yes
Revise monitoring type description OR Change monitoring method
No
Continue data collection as per your monitoring protocols

Goals and Objectives

Monitoring programs should have guiding goals and objectives.
Each project may have individual protocols based on the goals and objectives of each burn unit.

Monitoring Objectives and Protocols

What are your goals of your prescribed burns or managed fire?

What are the objectives of your prescribed burns or managed fire?

What do you need to measure to quantify your objectives?

How much time do you have to dedicate to monitoring?

a) Little time (less than 2 hours / burn unit) and / or a small work force (1 or 2 people).
b) A moderate amount of time (3 to 6 hours / burn unit) and / or a moderate work force (3-4 people).
c) Can dedicate significant time and resources to monitoring.

What is the average size of your burn units?

a) Relatively small (less than 20 acres).
b) Moderate size (20-100 acres).
c) Large burn units (100-500 acres).
d) Landscape level (500+ acres).

What is the return interval for burning?

a) 1-3 years
b) 3-7 years
c) 7-12 years
d) 12+ years

Is seasonality a factor? Such as; measurement are based on phenology, or growing season….

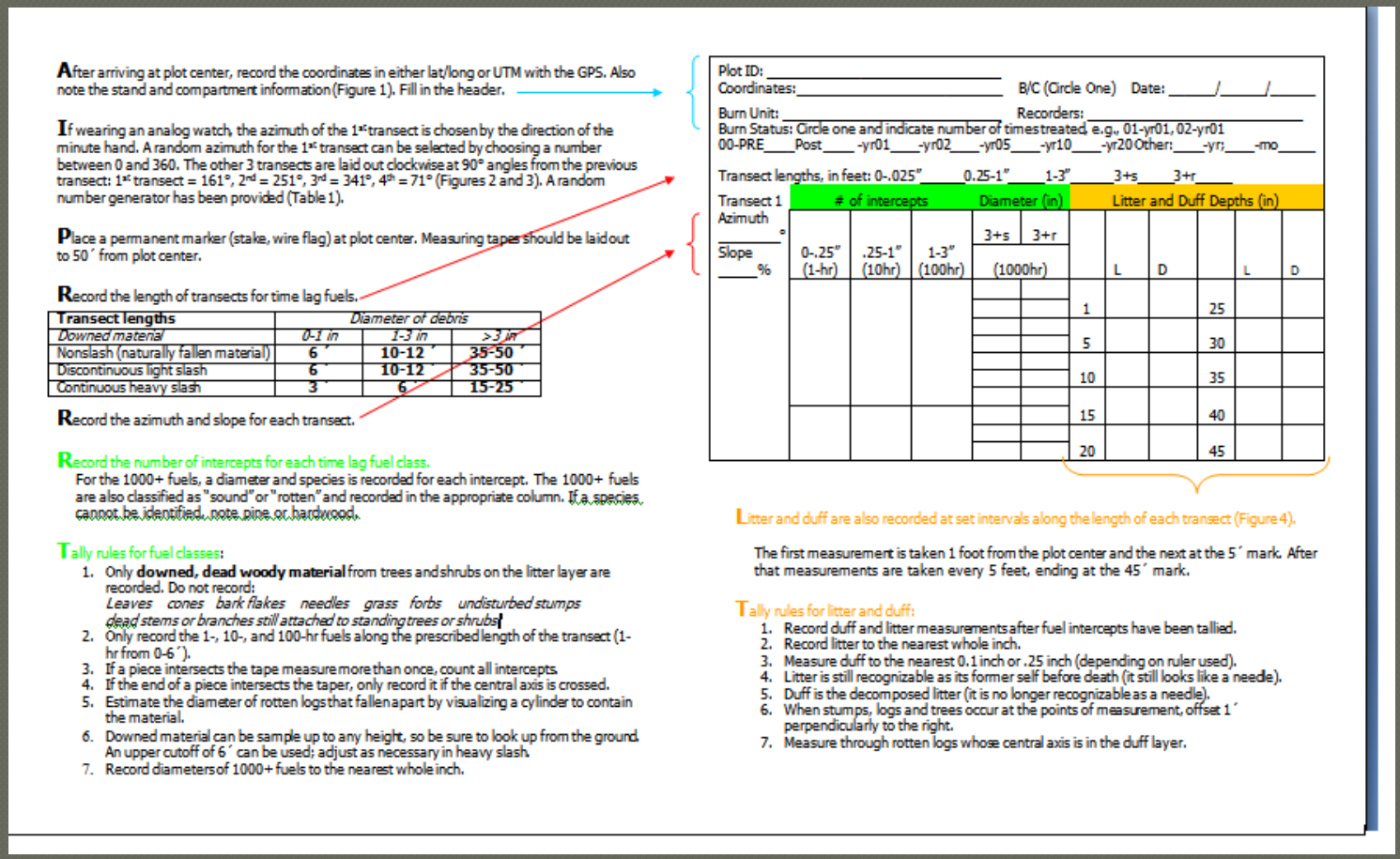
What are you going to measure for?

- Fuel loading
- Duff / litter
- Fire severity
- Surface fire behavior potential
- Photo series
- Mortality / snag creation
- Crown scorch
- Bole char / char depth
- Crown bulk density
- Soils / carbon content
- Vegetation Mapping
- Fire behavior
- Smoke
- Invasive or endangered species

Developing a Standardized System

- **Fire Monitoring Handbook. USDI National Park Service. 2003**
- http://www.nps.gov/fire/download/fir_eco_FEMHandbook2003.pdf
- It is important that the data collection and analysis is standardized and consistent.

DEVELOPING PROTOCOLS



After arriving at plot center, record the coordinates in either lat/long or UTM with the GPS. Also note the stand and compartment information (Figure 1). Fill in the header.

If wearing an analog watch, the azimuth of the 1st transect is chosen by the direction of the minute hand. A random azimuth for the 1st transect can be selected by choosing a number between 0 and 360. The other 3 transects are laid out clockwise at 90° angles from the previous transect: 1st transect = 161°, 2nd = 251°, 3rd = 341°, 4th = 71° (Figures 2 and 3). A random number generator has been provided (Table 1).

Place a permanent marker (stake, wire flag) at plot center. Measuring tapes should be laid out to 50´ from plot center.

Record the length of transects for time lag fuels.

Transect lengths	Diameter of debris		
Downed material	*0-1 in*	*1-3 in*	*>3 in*
Nonslash (naturally fallen material)	6´	10-12´	35-50´
Discontinuous light slash	6´	10-12´	35-50´
Continuous heavy slash	3´	6´	15-25´

Record the azimuth and slope for each transect.

Record the number of intercepts for each time lag fuel class.
For the 1000+ fuels, a diameter and species is recorded for each intercept. The 1000+ fuels are also classified as "sound" or "rotten" and recorded in the appropriate column. If a species cannot be identified, note pine or hardwood.

Tally rules for fuel classes:

1. Only **downed, dead woody material** from trees and shrubs on the litter layer are recorded. Do not record:
   Leaves cones bark flakes needles grass forbs undisturbed stumps dead stems or branches still attached to standing trees or shrubs
2. Only record the 1-, 10-, and 100-hr fuels along the prescribed length of the transect (1-hr from 0-6´).
3. If a piece intersects the tape measure more than once, count all intercepts.
4. If the end of a piece intersects the taper, only record it if the central axis is crossed.
5. Estimate the diameter of rotten logs that fallen apart by visualizing a cylinder to contain the material.
6. Downed material can be sample up to any height, so be sure to look up from the ground. An upper cutoff of 6´ can be used; adjust as necessary in heavy slash.
7. Record diameters of 1000+ fuels to the nearest whole inch.

Plot ID: _____
Coordinates: _____ B/C (Circle One) Date: _____/_____/_____
Burn Unit: _____ Recorders: _____
Burn Status: Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01
00-PRE____Post____-yr01____-yr02____-yr05____-yr10____-yr20 Other:____-yr;____-mo____

Transect lengths, in feet: 0-.025"____0.25-1"____1-3"____3+s____3+r____

Transect 1 Azimuth ____° Slope ____%	# of intercepts			Diameter (in)		Litter and Duff Depths (in)					
				3+s	3+r						
	0-.25" (1-hr)	.25-1" (10hr)	1-3" (100hr)	(1000hr)			L	D		L	D
						1			25		
						5			30		
						10			35		
						15			40		
						20			45		

Litter and duff are also recorded at set intervals along the length of each transect (Figure 4).

The first measurement is taken 1 foot from the plot center and the next at the 5´ mark. After that measurements are taken every 5 feet, ending at the 45´ mark.

Tally rules for litter and duff:

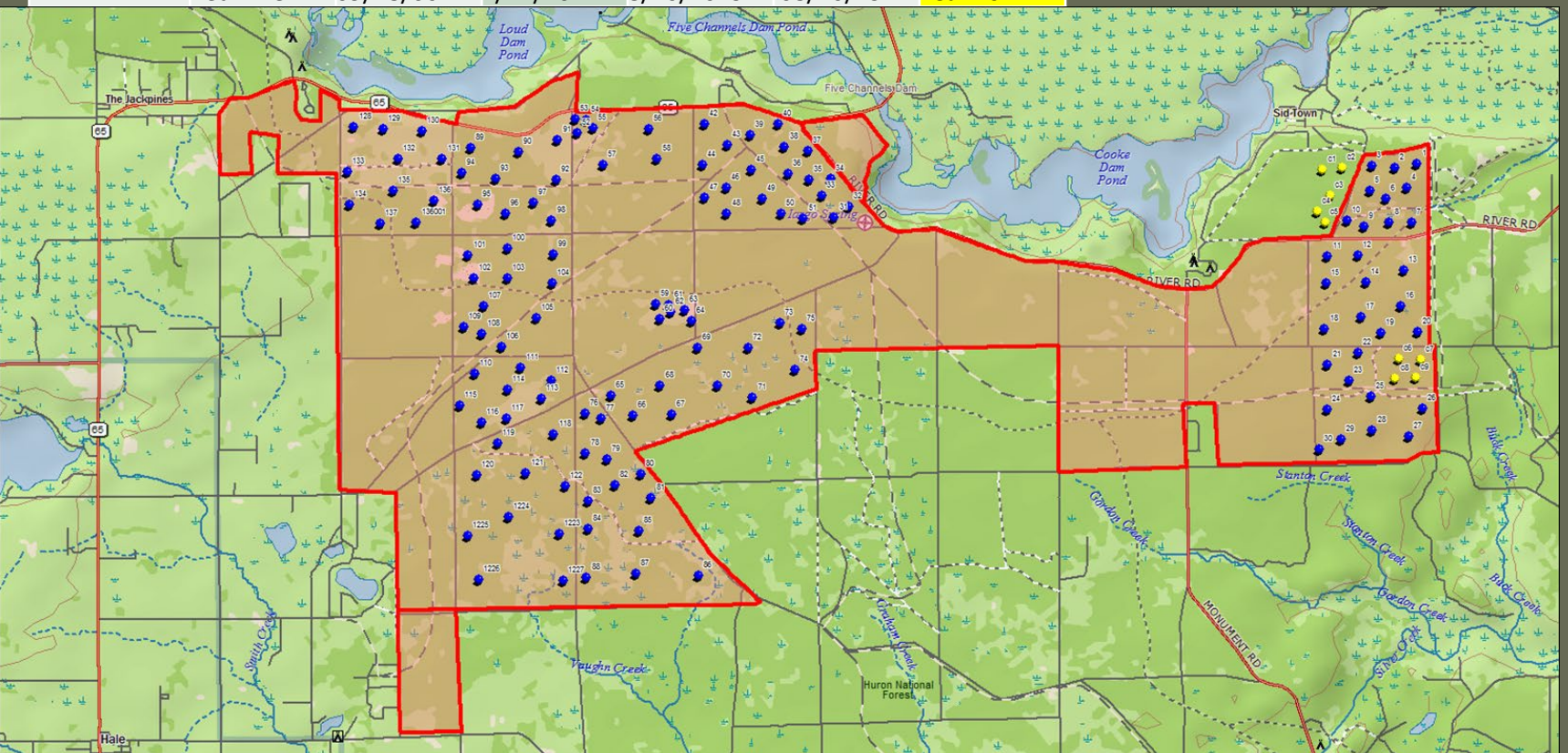
1. Record duff and litter measurements after fuel intercepts have been tallied.
2. Record litter to the nearest whole inch.
3. Measure duff to the nearest 0.1 inch or .25 inch (depending on ruler used).
4. Litter is still recognizable as its former self before death (it still looks like a needle).
5. Duff is the decomposed litter (it is no longer recognizable as a needle).
6. When stumps, logs and trees occur at the points of measurement, offset 1´ perpendicularly to the right.
7. Measure through rotten logs whose central axis is in the duff layer.

There are many versions of transect size & shape, but the importance is consistency.

Plot Measurement Schedule and Frequency

Burn Name	Primary Fuel Type	Pre-Burn Date	Last Burn Date	Mortality Study Date	Post-Burn Date	Next Measurement
Brittle Block 01	Red Pine Aspen	9/25/2008	4/28/2019	9/12/2010 6/06/2020	9/12/2010 6/06/2020	Year 2023
Brittle Block 09	Red Pine / Jack pine	5/7/2005	4/17/2018	06/24/18	6/24/2018	Year 2021
Brittle Block 10	Red Pine/ Jack pine	4/13/2014	4/28/2018	5/8/2019	5/8/2019	Year 2022
Brittle Block 12	Red Pine	09/28/06	4/24/2017	8/20/2019	08/20/19	Year 2022

- How many acres/plot?
- Control plots?
- Seasonality?
- Duration of the monitoring (how many years after the treatment?)



It is helpful to have dedicated equipment for data collection.

Equipment needed:

Permanent stakes (1 for each plot)		50´ measuring tapes (in tenths of a foot)
GPS		Compass
Rulers		Plot data sheets & clip board
Tablet or phone w/ charger or battery pack		Pen / pencils
DBH tape		Camera or tablet for photo plots
Coordinates of plots		Plastic bags for plant collection
Fuels Go-No-Go gauge		10 or 20 basal area prism
flagging		Water / radio/ food / clothes

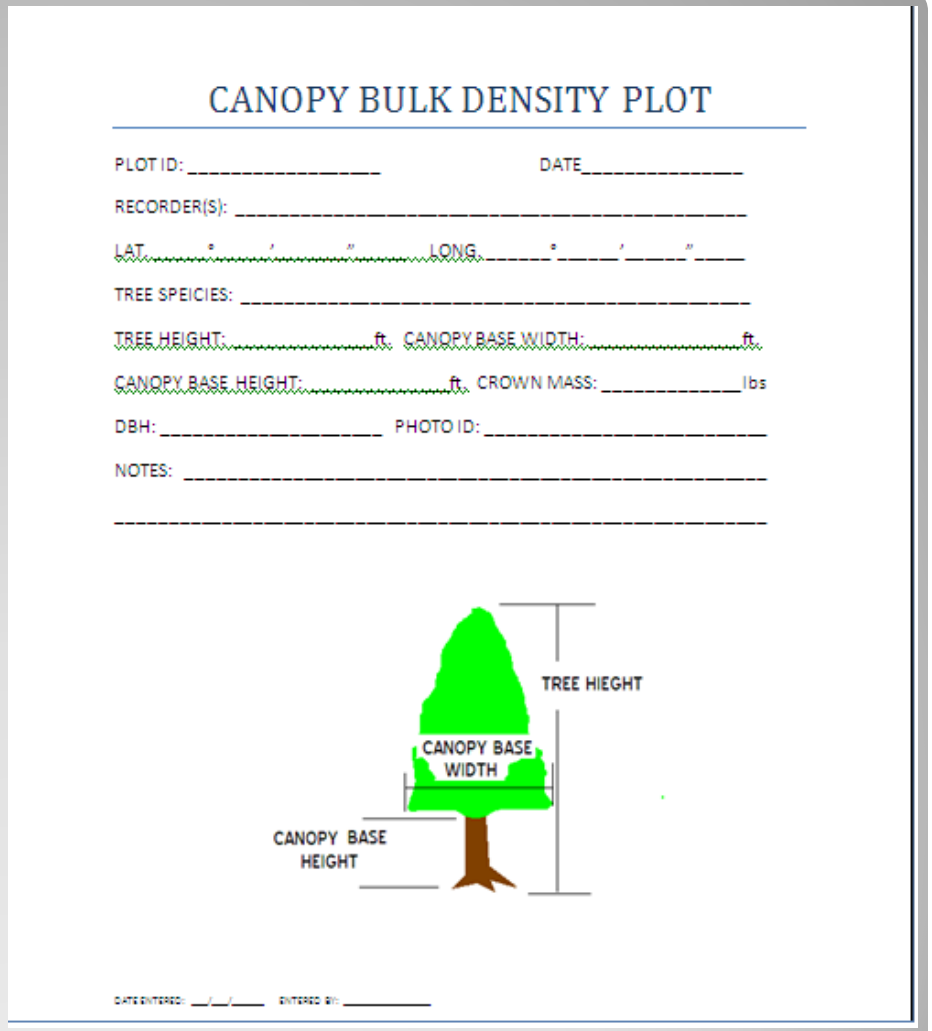
Equipment Optional:

Soil Sampling Tube		Hori Hori Knife
Densitometer		Increment Borer
Tree Caliper		Chaining Pins
Inclinometer (laser ones a nice)		Photo Scale
Duff Pins		

- The forms can be found in the Fire Monitoring Handbook.
- It is important to have a central archiving location.
- Some Software that is helpful for storing and reporting the data:

1. **Firemon**
2. **FSVeg**
3. **Fuel Characteristic Classification System**

- Develop a spread sheet. example



CANOPY BULK DENSITY PLOT

PLOT ID: _____ DATE_____

RECORDER(S): _____

LAT ____ ° ____ ' ____ " LONG ____ ° ____ ' ____ " ____

TREE SPEICIES: _____

TREE HEIGHT: _____ ft. CANOPY BASE WIDTH: _____ ft.

CANOPY BASE HEIGHT: _____ ft. CROWN MASS: _____ lbs

DBH: _____ PHOTO ID: _____

NOTES: _____

_____

DATE ENTERED: __/__/____ ENTERED BY: _____

RECORDING & ARCHIVING

IMPLEMENTATION WITH LIMITED BUDGET AND TIME

- Look into working with universities or other agencies to help collect data.
- Compare limited data to other nearby agencies, FCCS, or FEIS
- Reduce the number of control plots.
- Concentrate on 2 or 3 projects that represent a larger area.
- Bring in a Wildland Fire Module.

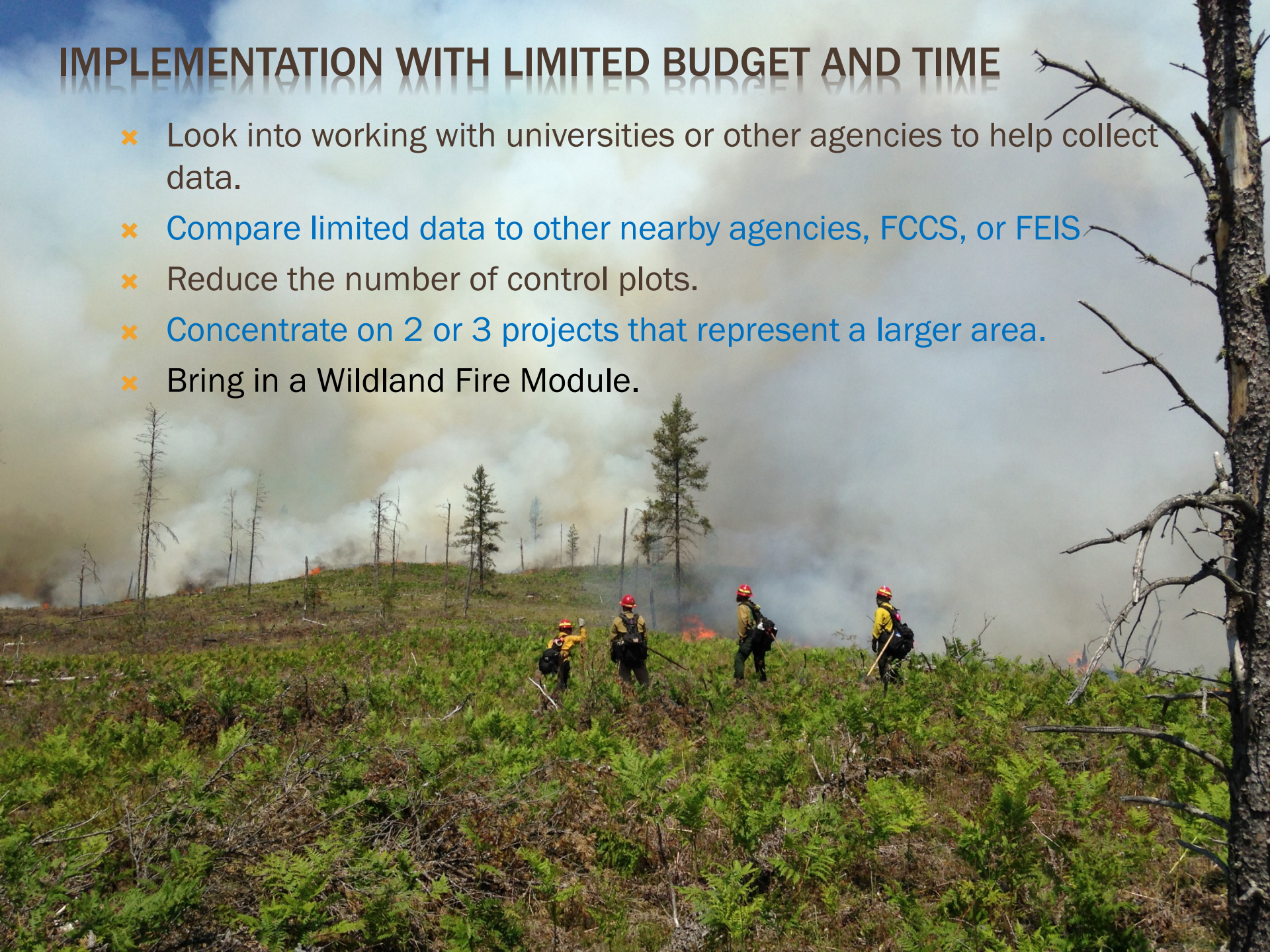


Photo Plots

Pre Burn

Post Burn

Collecting Burn Day Data

DATE	Burn Name	Time of Burn	Day of Last Rain	Rain (in)	Temp (F)	Rh %	Wind Spd	Wind Dir	F.L. (ft)	R.O.S (ft/min)	Notes	Acres	Est. Mortality
4/14/2004	Chambers	1515-1900			48-56	31-42	3 to 6	E,SE	1 --3	2--4	Opening with red pine oak.	34	<1/2%
10/12/2004	N. Memorable unit 3	16:00-18:00	10/9/04 (3)	0.07	65-56	52-66	1--5	SE, S	1--4	0.5-1	Stopped for wildfire	40	avr. 3.6%
4/9/2005	N. Memorable unit 3	17:30-19:30	4/7/05 (2)	0.08	55-66	33-48	0--7	SE, SW	1--5	1--2	Stopped for 12 hour rule / Slight lake wind	62	avr. 3.6%
4/16/2005	N. Memorable unit 2	17:00-20:00	4/7/05 (9)	0.08	63-71	29-33	1--5	SE, SW	1--5	0.5-1	Small crown fire developed	50	avr. 3.6%
4/21/2005	Little Bluestem	17:30-19:00	04/21/05 (0)	0.57	51-53	31-33%	2 to 4	E-SE	.5-3	1			N/A
4/30/2005	N. Mem. Unit 1 & 2	14:00-17:30	4/28/05 (2)	0.09	50-53	37-47	0--7	SE, S	1--6	0.5-1	Great results / Hand ignition	195	avr. 3.6%
5/17/2005	Rich Rd.	13:00-21:00	5/15/05 (2)	1.8	54-62	32-49	4--7	W, S, SE	1--6	1--2	Hand ignition.	650	< 2%
4/8/2006	Davis Unit 1	17:00-21:00	4/6/06 (2)	0.4	47-65	39-64	5--13	E, SE	1--3	1--3	Hand ignition.		< 1/2%
4/17/2006	Davis Unit 2	15:00-19:00	4/14/06 (3)	0.22	37-41	40-51	8--10	NW	1--3	1--3	Cool and Cloudy. Hand ignition.		< 1/2%
4/10/2007	Hoist	1630-1800	04/05/07 (5)	0.35	39-43	52-56	2--9	s,e,ne	2--8	1--5	Snow in the woods, small slop-over	80	< 1/2%

unfavorable results / higher than desired fire behavior

Desired fire behavior / results

Less than desired fire behavior / results

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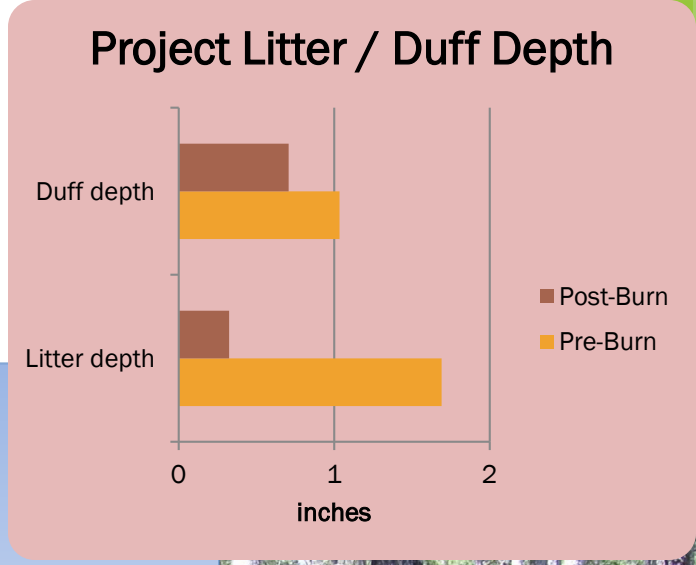
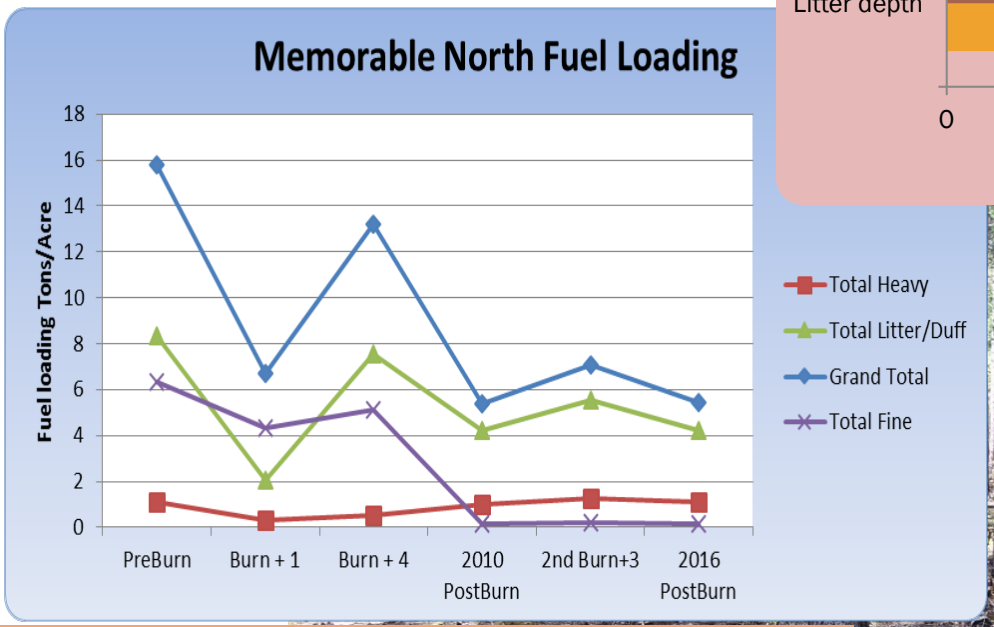
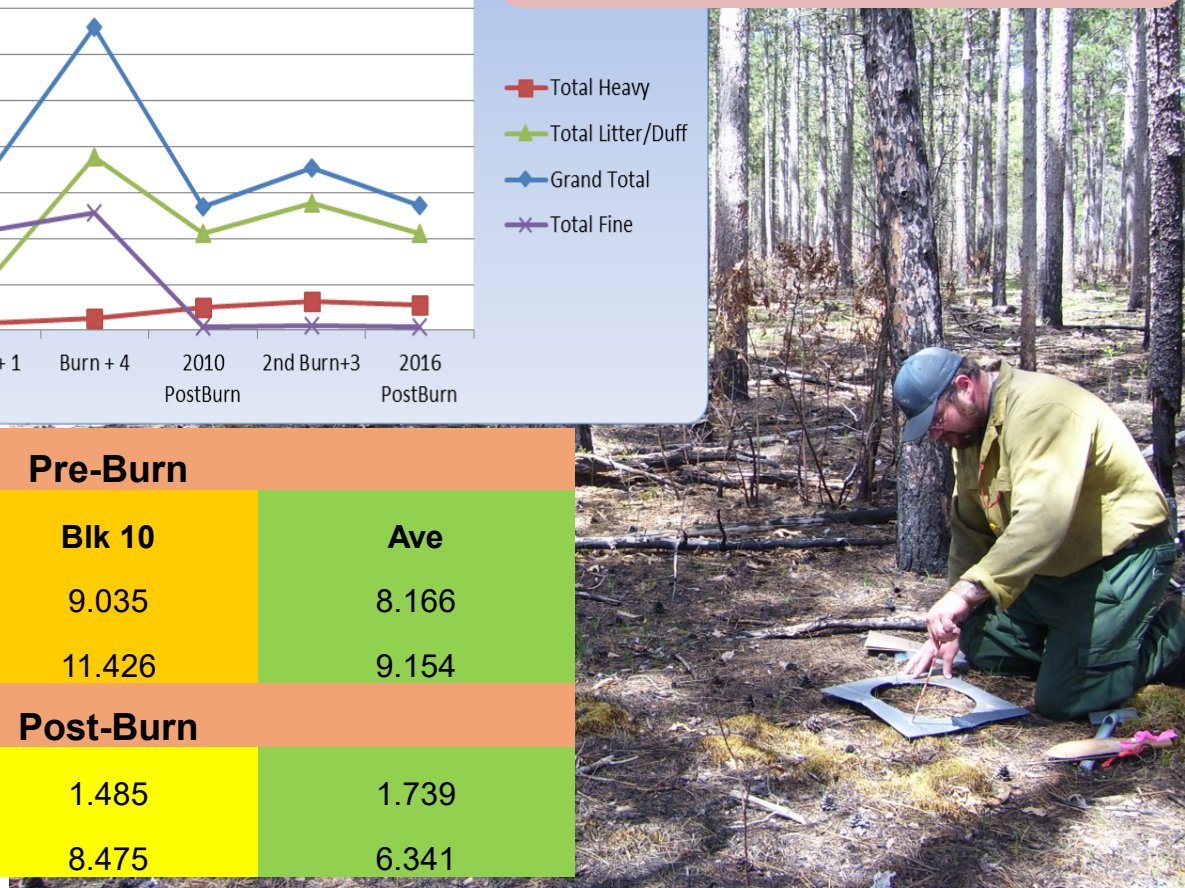
Results

- Measuring short term change and long term change
- Statistical accuracy
- Interpreting the results and measuring significance



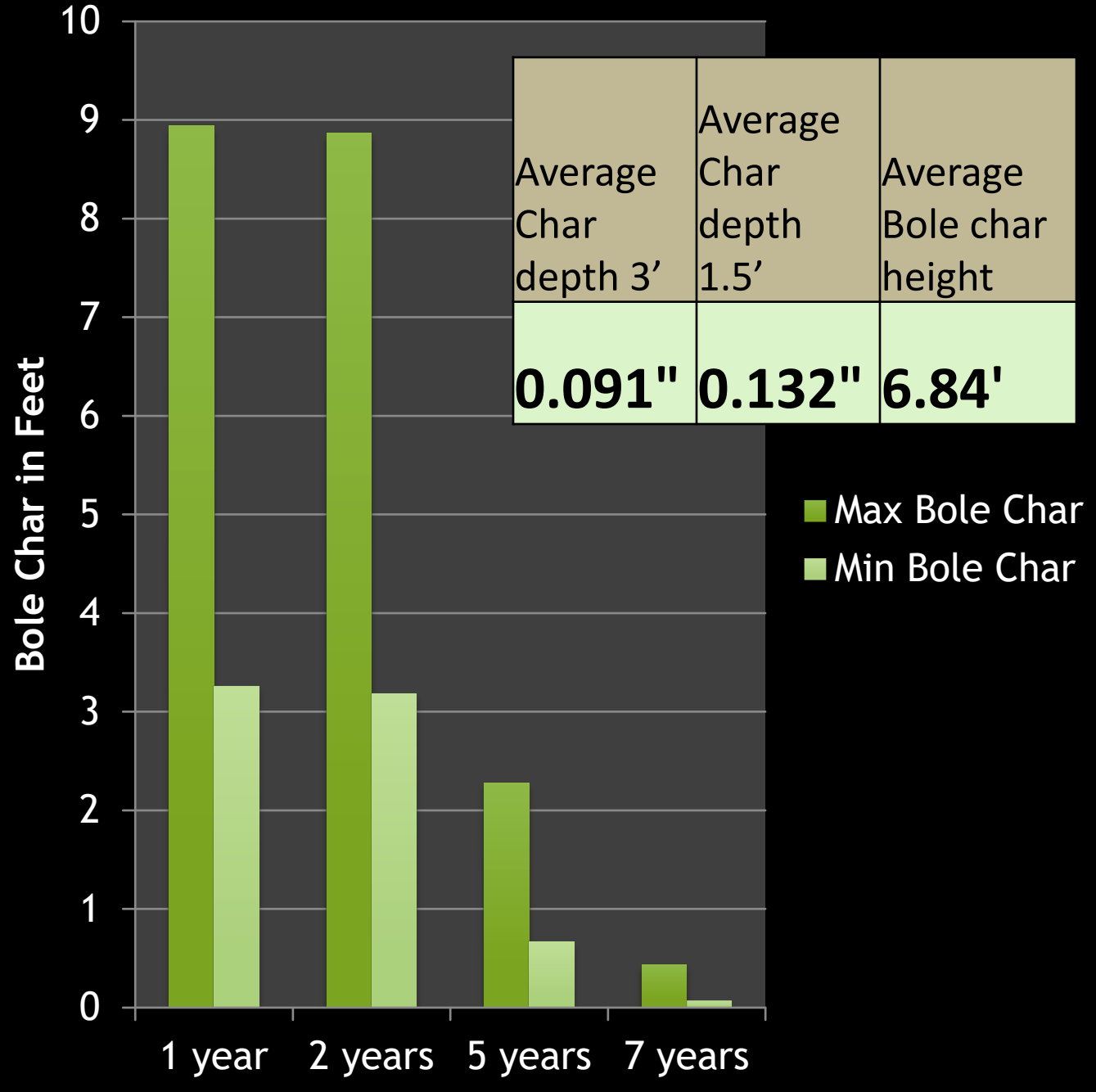


	Blk 4	Blk 10	Ave
Pre-Burn			
Litter loading	7.297	9.035	8.166
Duff loading	6.882	11.426	9.154
Post-Burn			
Litter loading	1.992	1.485	1.739
Duff loading	4.206	8.475	6.341



Bole Char in Red Pine

Average Char depth 3’	Average Char depth 1.5’	Average Bole char height
0.091"	**0.132"**	**6.84'**



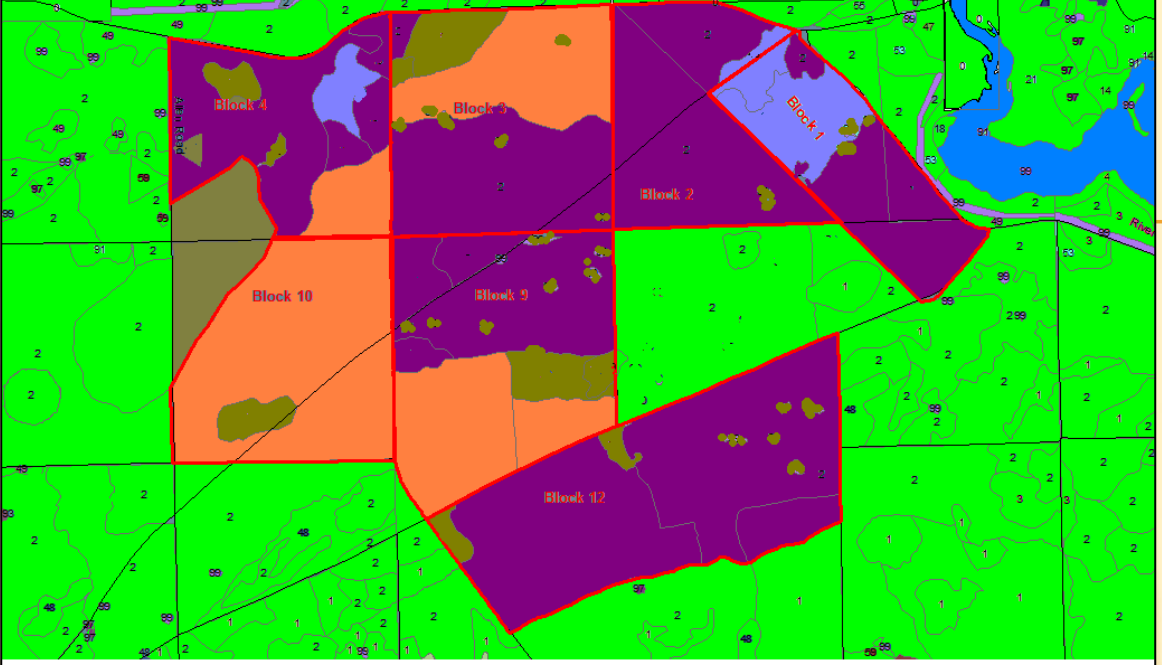
Averages For Post Burn Tree Mortality

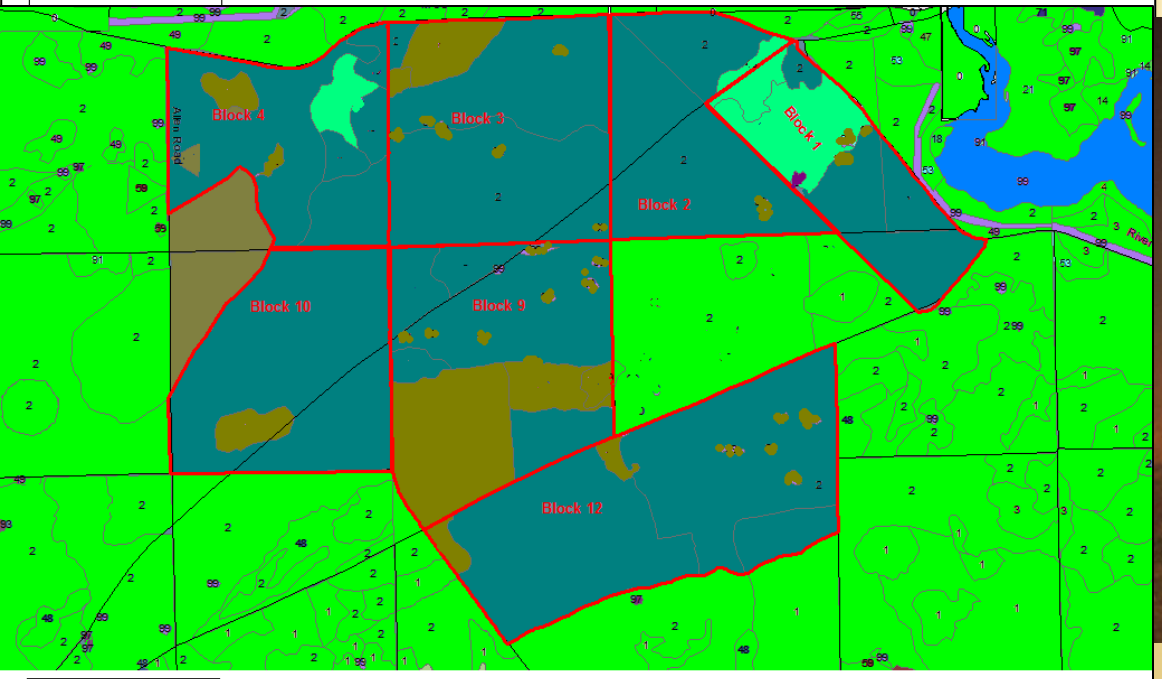
Burn Unit	Mortality
Brittle 1	0.5%
Brittle 2	0.5%
Brittle 3	1.50%
Brittle 4	0.5%
Brittle 5	0.5%
Brittle 6	1%
Brittle 9 (Crown Fire)	18%
Brittle 10	2%
Brittle 12 (head fire)	2%
Mem North	4.70%
Mem Mid.	0.50%
Mem South (head fire)	3.40%
Ave.	**2.92%**

Project Name	Memorable North			Memorable South	
	2005	2010	2013	2007	2013
Total Pre Rx dead tree %	5.3%			6.2%	
Average live BA	118			111	
Average DBH (in)	11.2	11.3	11.3	10.7	10.7
Total acres	347			459	
Total number plots	30	10		29	10
Acres/plot	10.5	35		15.8	45.9
Harvest related mortality	3.4	N/A		3.1	N/A
Rx Mortality %	3.6%	4.7%	<1/2%	< 1/2%	3.4%
Total dead /acre	9.4	9.5	9.5	7.1	8.9

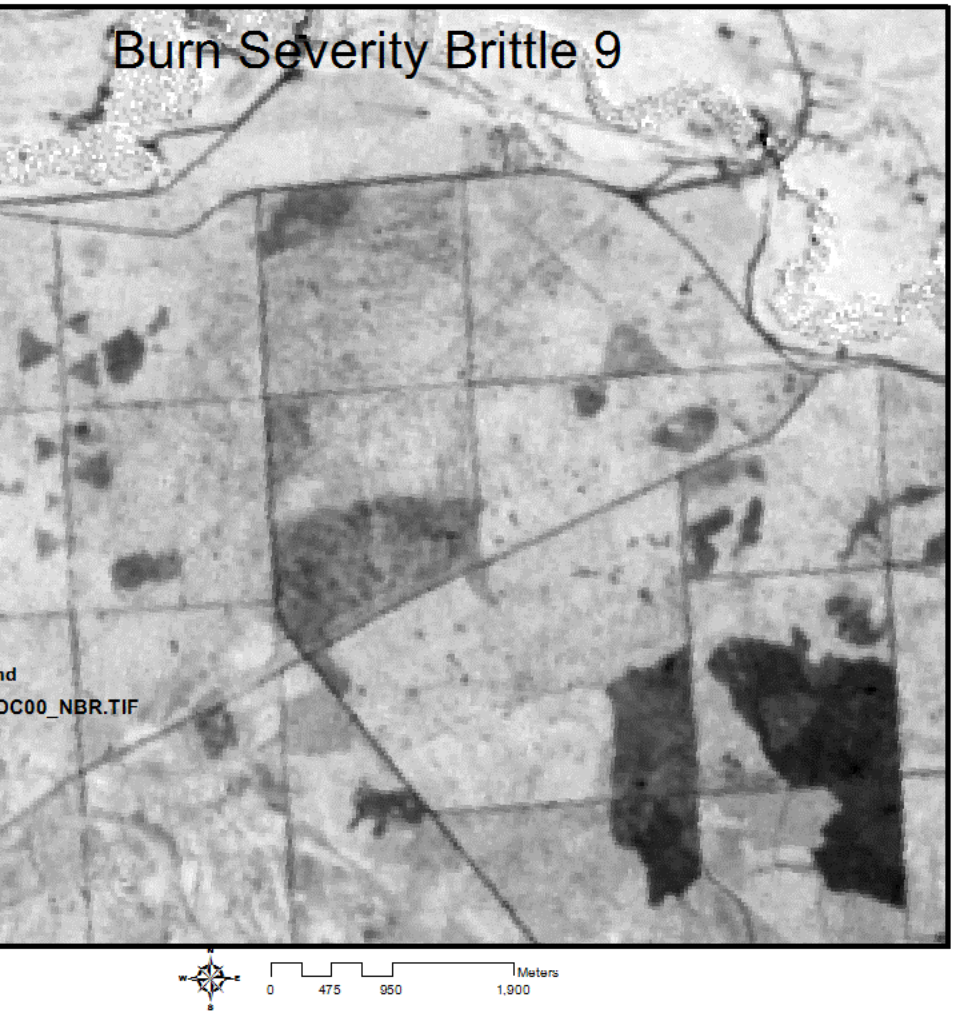
FUELS MAPPING

- Fire behavior modeling
- Tracking changes in fuel models





Burn Severity Mapping



Author: Brian Stearns

Date: Jan 28 2011 - 12:51 AM

Fuelbed Name: Red pine -- pin oak Brittle with Slash

Fuelbed Number: N/A

File Name: C:\FCCS\conf\fuelbeds\user_fuelbeds\Brittle_slash.xml

Data quality ranking:

Original FBPS fuel model (13)*: 9

Standard fuel model (40)*: TU2

Description: Red pine plantation that were typically planted in the 1930's & 40's. Dense stands on poor sandy soils.

Surface Fire Behavior Potential	**6**	Summary surface fire behavior potential, calculated as the maximum of spread potential and flame length potential scaled to an index between 0-9.
Reaction Potential	4.9	Approximates the potential reaction intensity (energy released per unit area and time).
Spread Potential	5.6	Proportional to the no-wind rate of spread in surface fuel (distance per unit time).
Flame Length Potential	3.8	Proportional to fireline intensity or flame length.
Crown Fire Potential	**5**	Weighted average of crown fire subpotentials.
Crown fire initiation potential	4.3	Potential for fire to reach canopy layer.
Crown-to-crown transmissivity potential	8.8	Potential for fire to carry through a canopy.
Crown fire spreading potential	3.3	Relative index of crown fire rate of spread.
Available Fuel Potential	**3**	Sum of fuel loadings in all combustion phases scaled to an index between 0-9.
Flame available fuel potential	1.9	Sum of fuel loadings available for the flaming phase of combustion (in units of 10 tons/acre).
Smoldering available fuel potential	1.2	Sum of fuel loadings available for the smoldering phase of combustion (in units of 10 tons/acre).
Residual Available Fuel	0.2	Sum of fuel loadings available for the residual smoldering phase of combustion (in units of 10 tons/acre).
FCCS Fire Potential Code	**653**	Three-digit code representing the surface fire behavior, crown fire, and available fuel potentials.

*Based on dry fuel conditions (D2L2 moisture scenario)

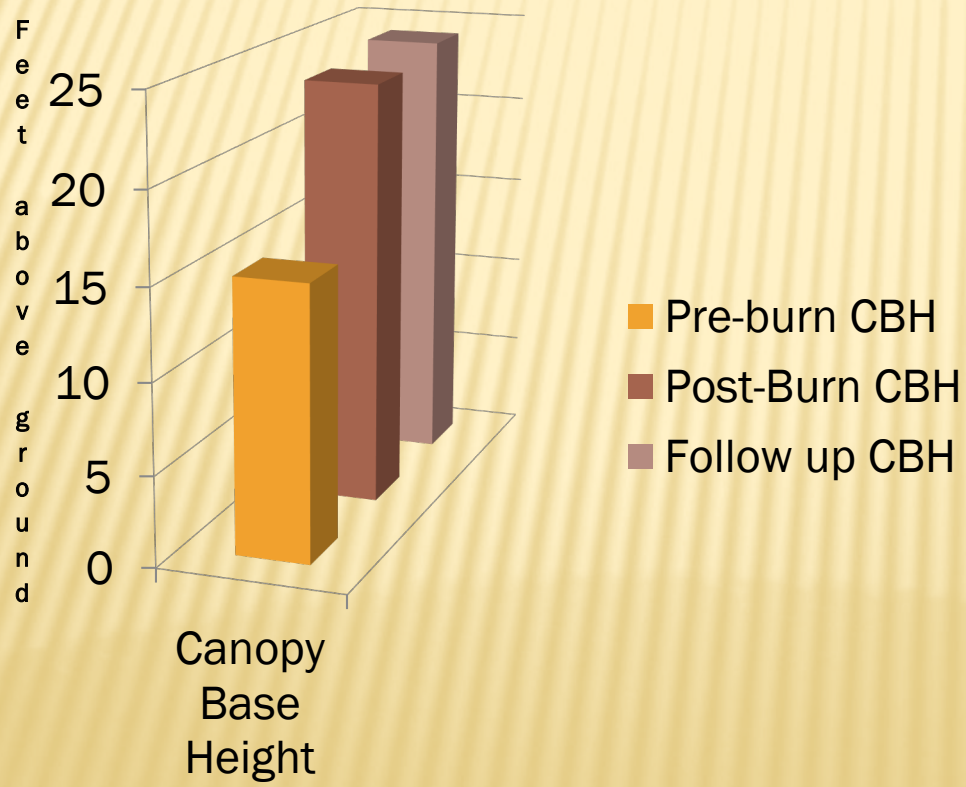
FCCS v 2.1

Fuel Potential for Brittle (Pre and Post-Burn)

Fuel bed	Fuel Model	Surface Fire Potential (1-9)	Crown Fire Initiation Potential (1-9)	Available Fuel Potential (1-9)	FCCS Fire Potential Code
Opening in Brittle Pre-burn	TU2	5	6	4	564
Opening in Brittle Post-burn	TU2	6	4	2	642
Red Pine-Oak Brittle pre-burn	TL9	6	5	3	653
Red Pine-Oak Brittle post-burn	TL8	5	4	2	542
Red Pine with slash pre-burn	SB2	6	7	3	673
Red Pine with slash post-burn	TL8	5	4	2	542
Red Pine with Aspen pre-burn	TL6	4	5	3	453
Red Pine with Aspen post-burn	TL5	4	4	2	442

USING THE RESULTS

Average Crown Scorch	Average DBH	Average Tree Height
11.40%	11.06	39.4



- Fuel loading
- Prescriptions
- Return interval measurements
- Fuel specialist reports
- Litigation
- Fire behavior fuel modeling (Scott & Burgan or custom)

Questions?