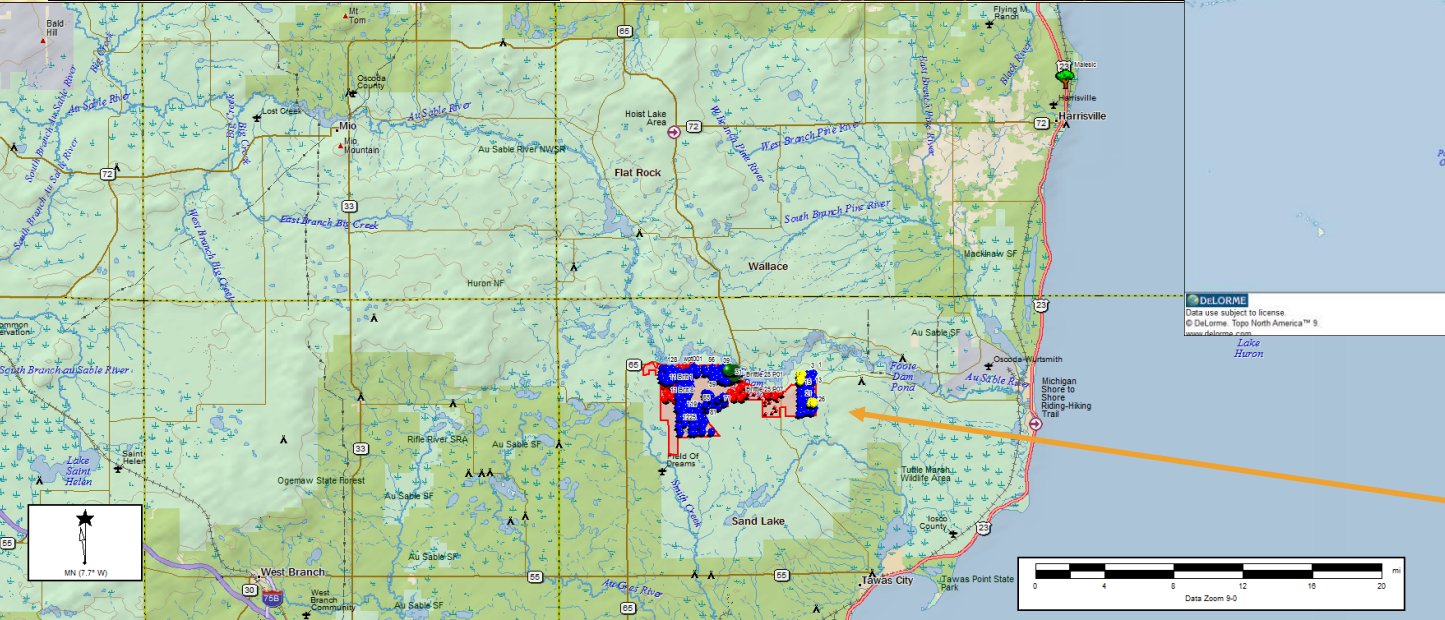
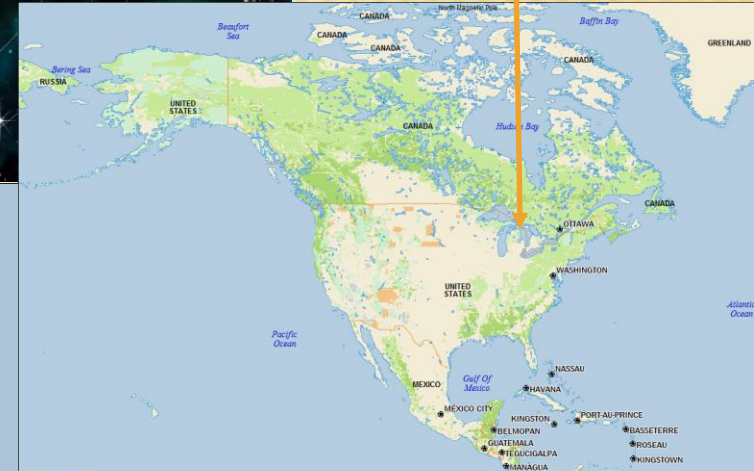
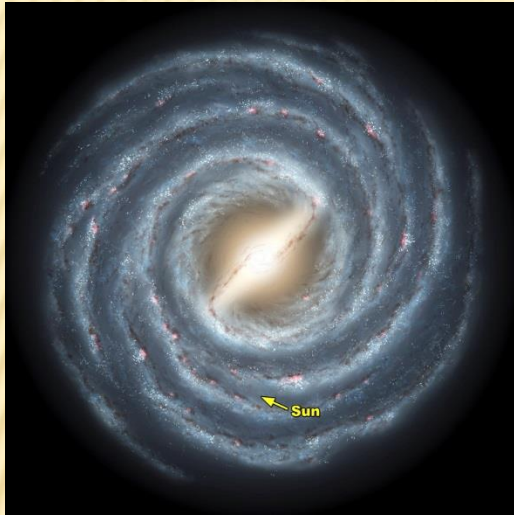
A photograph of a forest landscape during a prescribed fire. The foreground is filled with bright orange and yellow flames and thick white smoke rising from the ground. In the background, there are several tall, thin trees, some of which are bare and others with green needles. The overall scene is hazy and smoky.

# Case Study of Landscape Prescribed Burning and Monitoring in the Great Lakes Region



# LOCATION



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MN (15.1° W)

# BACKGROUND

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- The Huron National Forest is roughly 437,287 acres. We are currently treating about 40,000 acres with Rx burning.
- The landscape has a potential for fast moving crown fires in the Wildland Urban Interface (WUI).
- Numerous fire dependent sensitive species.





# Three distinct landscapes

**Fire-resistant moist-mesic morainal ecosystems**



Moderately fire-prone dry-mesic ice-contact ecosystems

Highly fire-prone xeric outwash ecosystems

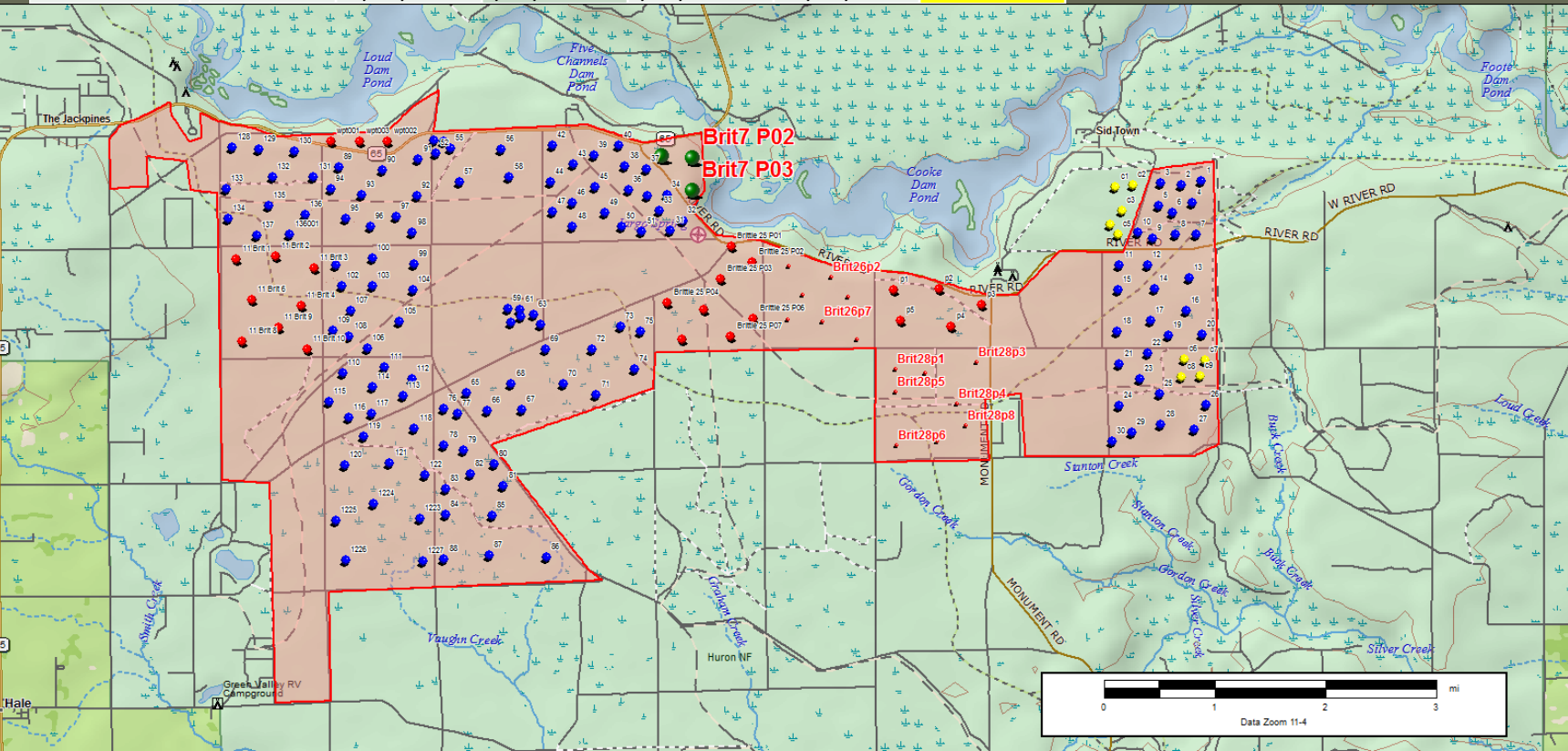




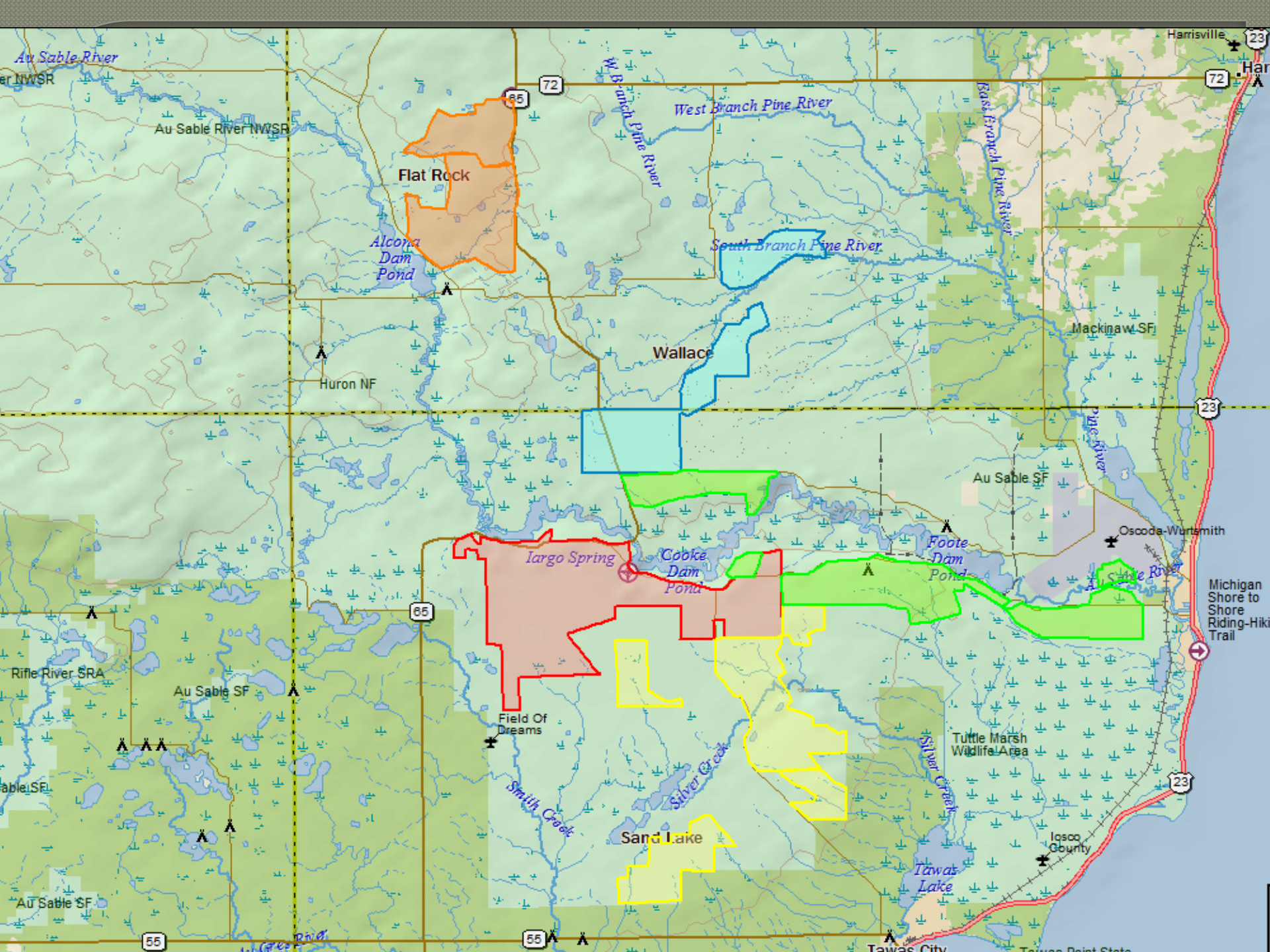
# Current Project Area

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	4/28/2009	6/06/2014	9/12/2010 6/06/2014	Year 2017
Brittle Block 09	Red Pine / Jack pine	5/7/2005	4/17/2008	06/24/09	6/24/2009	Year 2014
Brittle Block 10	Red Pine/ Jack pine	4/13/2014	4/28/2014	5/8/2014	5/8/2014	Year 2017
Brittle Block 12	Red Pine	09/28/06	4/24/2007	8/20/2009	08/20/09	Year 2015

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









# Foundation of Our Monitoring Program

- We included other disciplines when we were identifying needs & developing goals.
- The monitoring program gained momentum when other disciplines within the agency were opposed to prescribed burning.







# Measurements

- ▶ Fuel loading
- ▶ Duff / litter
- ▶ Fire severity
- ▶ Surface fire behavior potential
- ▶ Photo series
- ▶ Mortality / snag creation
- ▶ Crown scorch / CBH
- ▶ Bole char / char depth
- ▶ Crown bulk density
- ▶ Soils / carbon content
- ▶ Vegetation mapping
- ▶ Fire behavior
- ▶ Smoke
- ▶ Needle Density

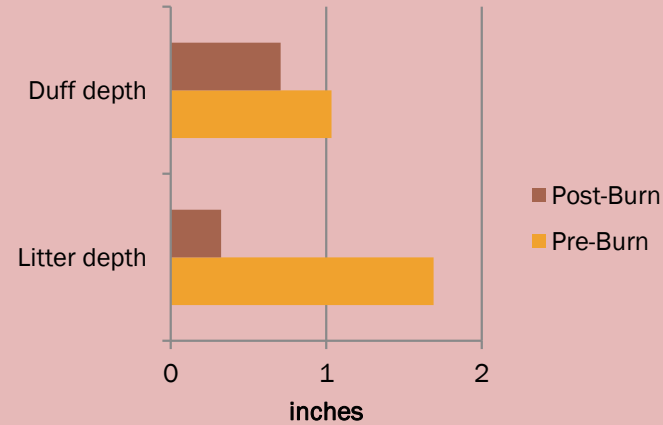




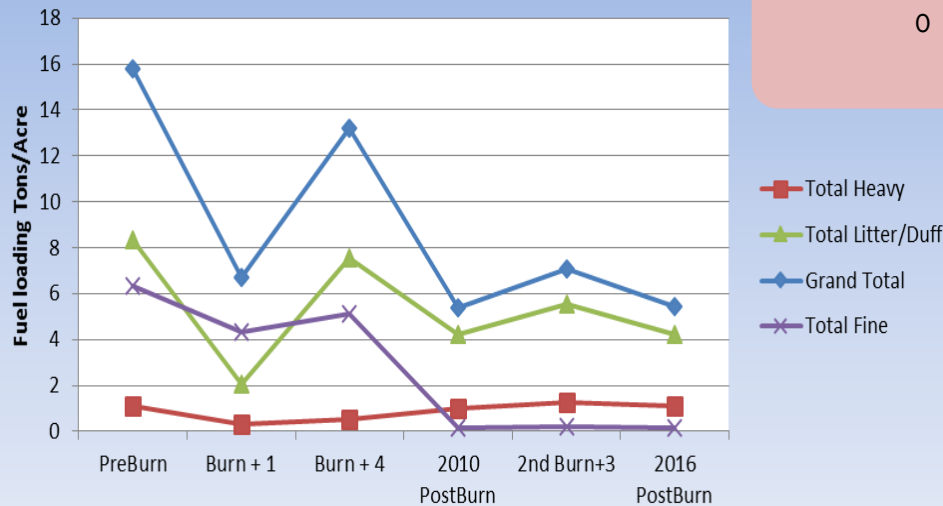
# Results

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

## Project Litter / Duff Depth



## Memorable North Fuel Loading



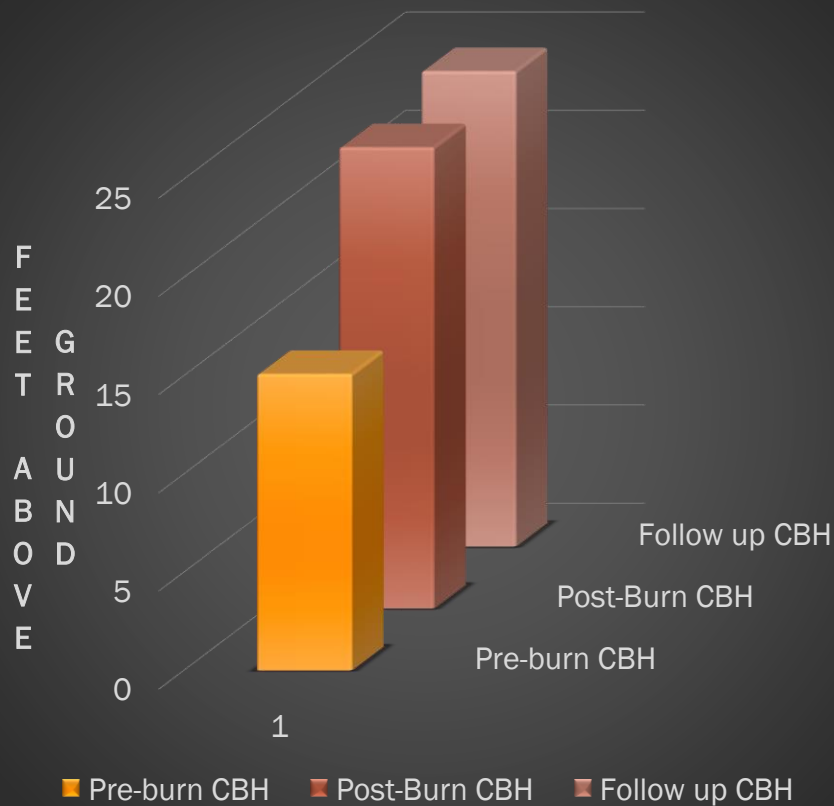
	Pre-Burn		
	Blk 4	Blk 10	Ave
Litter loading	7.297	9.035	8.166
Duff loading	6.882	11.426	9.154
	Post-Burn		
Litter loading	1.992	1.485	1.739
Duff loading	4.206	8.475	6.341



# USING THE RESULTS

Average Crown Scorch	Average DBH	Average Tree Height
11.40%	11.06	43.4

- ✘ Fuel loading
- ✘ Prescriptions
- ✘ Return interval measurements
- ✘ Fuel specialist reports
- ✘ Environmental Assessments
- ✘ Litigation
- ✘ Fire behavior fuel modeling
- ✘ Protect the burn program from opposition





# 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



# Photo Plots



Pre Burn

Post Burn





# Averages For Post Burn Tree Mortality

Burn Unit	Mortality
Brittle 1	0.50%
Brittle 2	0.50%
Brittle 3	1.50%
Brittle 4	0.50%
Brittle 5	0.50%
Brittle 6	1.0%
Brittle 9 (Crown Fire)	18.0%
Brittle 10	2.0%
Brittle 11	2.4%
Brittle 12 (head fire)	2.0%
Brittle 18	2.1%
Brittle 20	1.8%
Brittle 23	3.9%
Brittle 25	1.3%
Brittle 26	1.5%
Brittle 27	1.9%
Brittle 28	1.4%
Mem North (Crown Fire)	4.70%
Mem Mid.	0.50%
Mem South (head fire)	3.40%
<b>Ave.</b>	<b>2.57%</b>

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



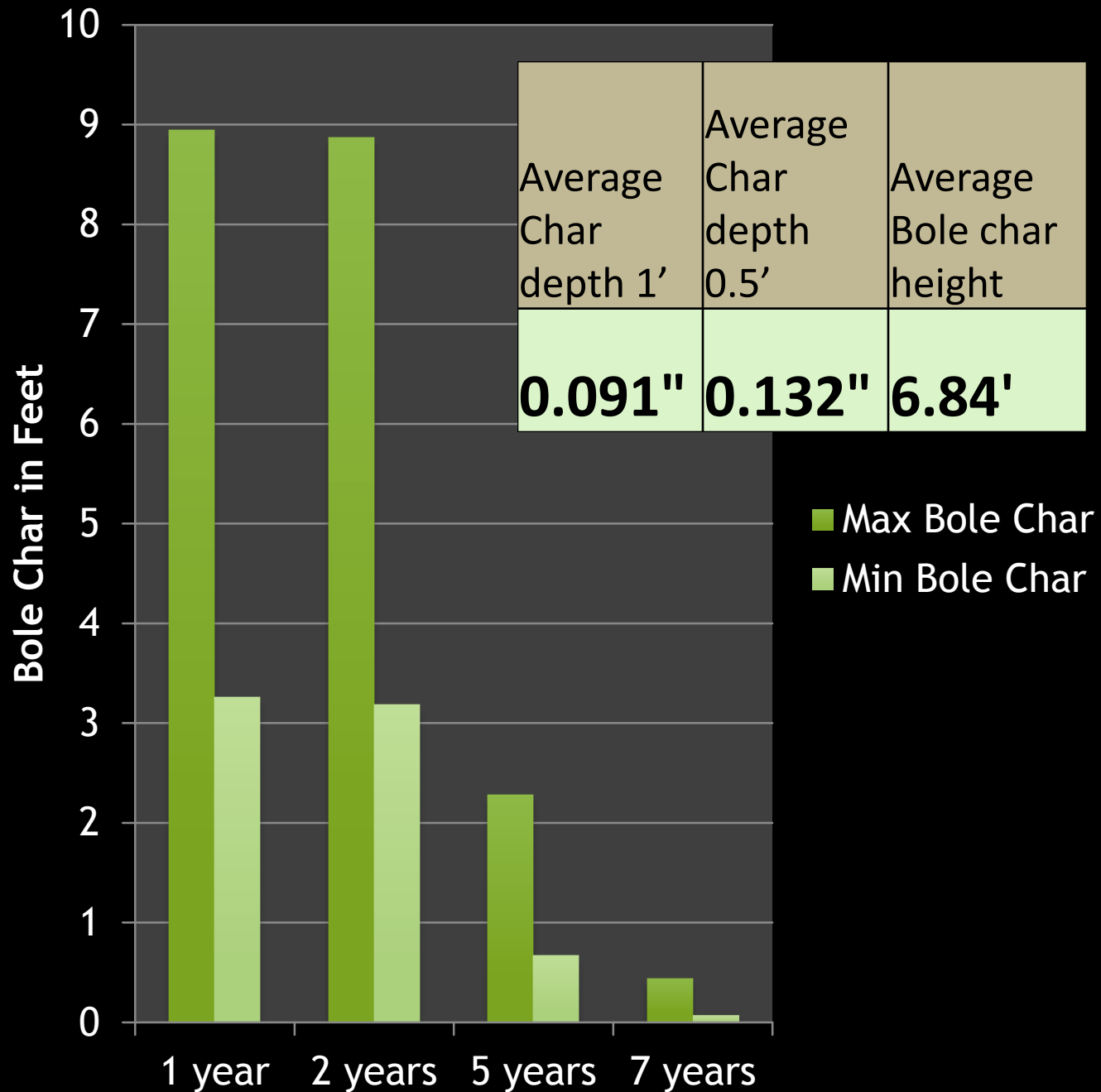


1 year Post-Burn



7 years Post- Burn

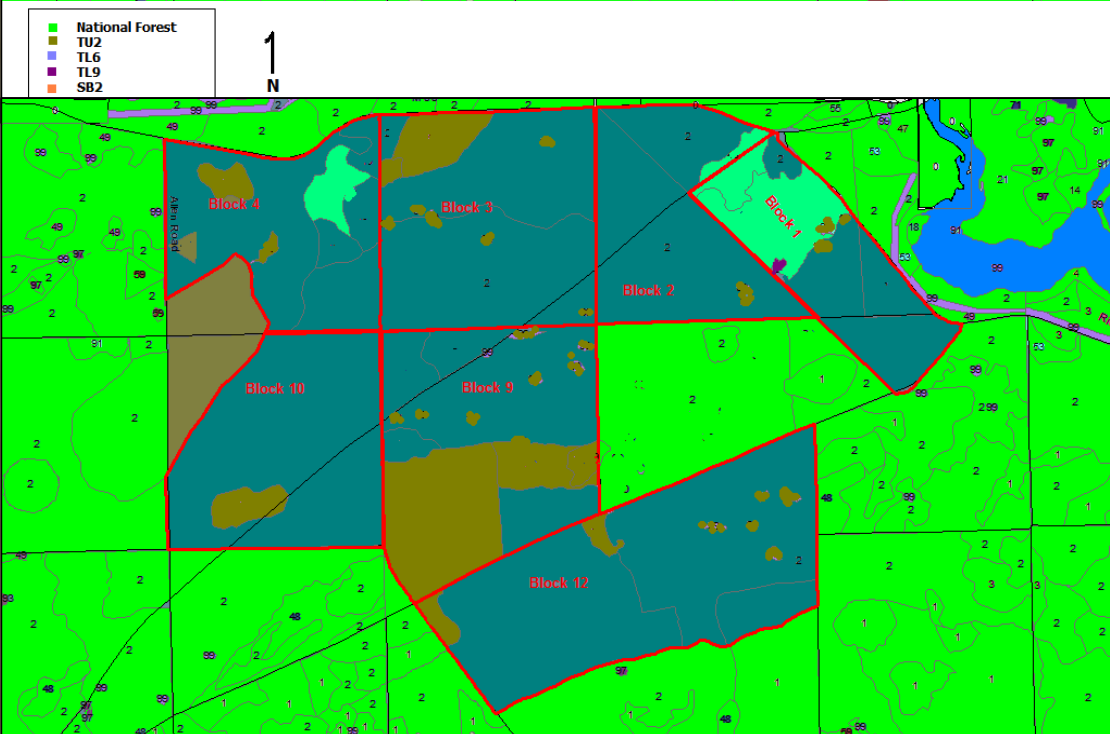
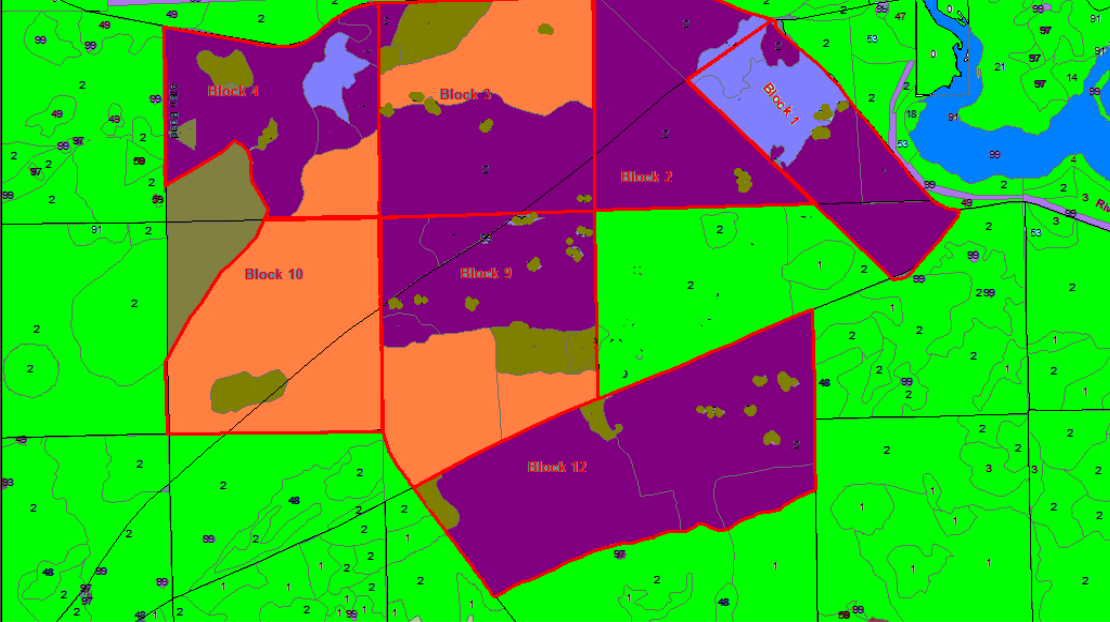
# Bole Char in Red Pine





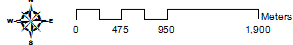
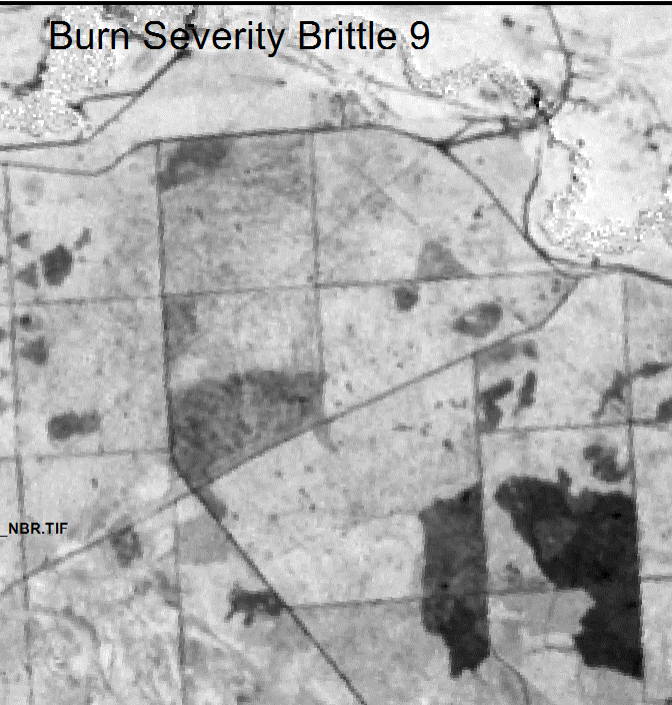
# FUELS MAPPING

- ✘ Fire behavior modeling
- ✘ Tracking changes in fuel models

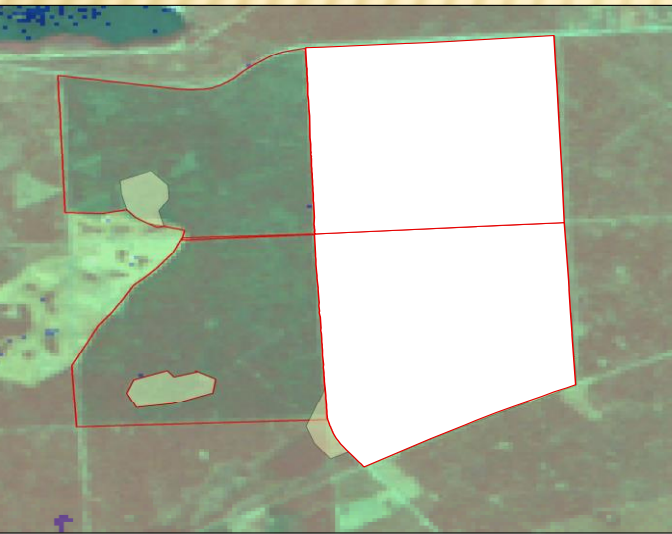




# Burn Severity Mapping



Brittle Block Burn Intensity Map



**Low Severity**  
Smoldering and creeping fire behavior. Fuels consumed under the shrub layer. Leaves on shrubs are scorched but not consumed. Low severity is denoted in **yellow** on figure 3 map.



**Moderate Severity**  
Consumption of course woody material in the 100 hour and 1000 hour categories. Leaves on the shrub layer are consumed and some crown scorch on the canopy. Moderate severity is denoted in **orange** on figure 3 map.



**High Severity**  
Most of the surface fuels are consumed and most of the crowns of the canopy is consumed or scorched. High severity is denoted in **red** on figure 3 map.

**\*Extreme Burn Severity**  
All of the limbs and canopy consumed and over 90% of surface fuels consumed. No extreme burn severity was observed on the Bean Fire.



**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.

<b>Surface Fire Behavior Potential</b>	<b>6</b>	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.
<b>Crown Fire Potential</b>	<b>5</b>	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.
<b>Available Fuel Potential</b>	<b>3</b>	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).
<b>FCCS Fire Potential Code</b>	<b>653</b>	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

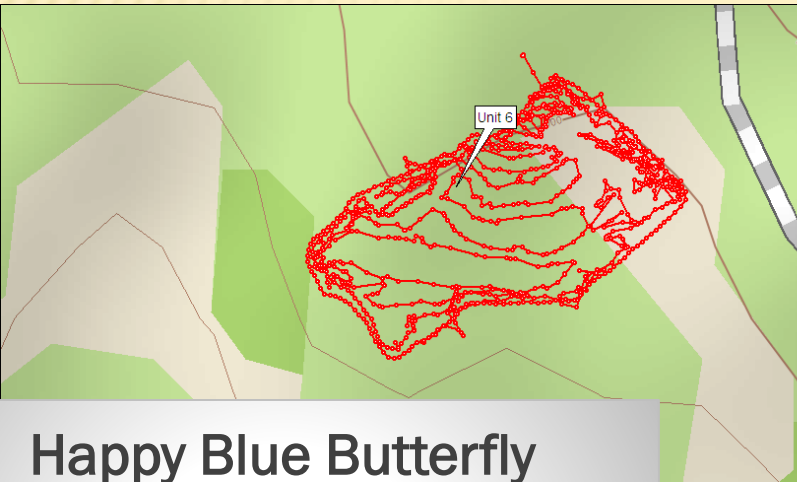
# Fuel Potential for Brittle (Pre and Post-Burn)

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	<b>TU2</b>	<b>5</b>	<b>6</b>	<b>4</b>	<b>564</b>
Opening in Brittle Post-burn	<b>TU2</b>	<b>6</b>	<b>4</b>	<b>2</b>	<b>642</b>
Red Pine-Oak Brittle pre-burn	<b>TL9</b>	<b>6</b>	<b>5</b>	<b>3</b>	<b>653</b>
Red Pine-Oak Brittle post-burn	<b>TL8</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>542</b>
Red Pine with slash pre-burn	<b>SB2</b>	<b>6</b>	<b>7</b>	<b>3</b>	<b>673</b>
Red Pine with slash post-burn	<b>TL8</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>542</b>
Red Pine with Aspen pre-burn	<b>TL6</b>	<b>4</b>	<b>5</b>	<b>3</b>	<b>453</b>
Red Pine with Aspen post-burn	<b>TL5</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>442</b>



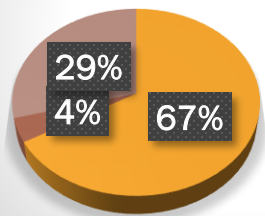


# OTHER MONITORING PROJECTS



Happy Blue Butterfly Rx.	Unit 3	Unit 6
Total Pre Rx dead tree %	0.14%	0.04%
Total Post Rx dead tree %	0.19%	0.25%
Average DBH (in)	1.5	2.9
Average DBH (in) of Mortality Trees	1.6	2.6
Total acres	2	4
Total number plots	2	3
Acres/plot	1	1.3
Expansion Factor	2.1%	1.6%

## Happy Blue Butterfly Unit 6 Mortality



- Live Trees
- Pre-burn Mortality

AGE CLASS	PLOT ID	TREE HEIGHT ft.	CANOPY BASE HEIGHT ft.	CANOPY HEIGHT ft.	CANOPY BASE WIDTH ft.	CANOPY BASE AREA ft <sup>2</sup> .	CROWN VOLUME FT <sup>3</sup>	CROWN BIOMASS lbs	FOLIAR MOISTURE %	BIOMASS ADJUSTMENT LBS	CROWN BULK DENSITY LBS/FT <sup>3</sup>
3-5 YEARS	1	10.2	0.5	9.7	7.5	23.5	227.95	20	126.3	4.8	0.021057249
3-5 YEARS	2	9.9	1.2	8.7	9.3	29.2	254.04	21	126.3	5	0.01968194
3-5 YEARS	3	9.5	1	8.5	7	22	187	14	126.3	3.3	0.017647059
3-5 YEARS	4	7.7	1	6.7	6.3	19.8	132.66	12	126.3	2.9	0.021860395
										<b>AVERAGE</b>	<b>0.020061661</b>
6-10 YEARS	5	16.6	3.8	12.8	12	37.7	482.56	45	117.6	11.5	0.023831233
6-10 YEARS	6	16.8	3	13.8	13.7	43	593.4	46	117.6	11.7	0.019716886
6-10 YEARS	7	14.7	3.4	11.3	9.7	30.5	344.65	23	117.6	5.9	0.017118816
6-10 YEARS	8	14.1	3.2	10.9	9	28.3	308.47	23	117.6	5.9	0.019126657
										<b>AVERAGE</b>	<b>0.019948398</b>

$$\text{CROWN VOLUME (ft}^3\text{/ft}^2\text{)} = (\text{TREE HEIGHT} - \text{CROWN BASE HEIGHT}) * \text{CANOPY BASE AREA}$$

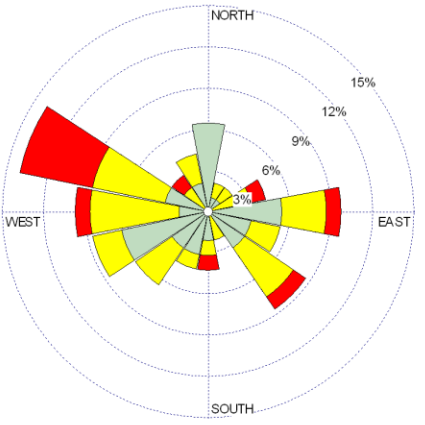
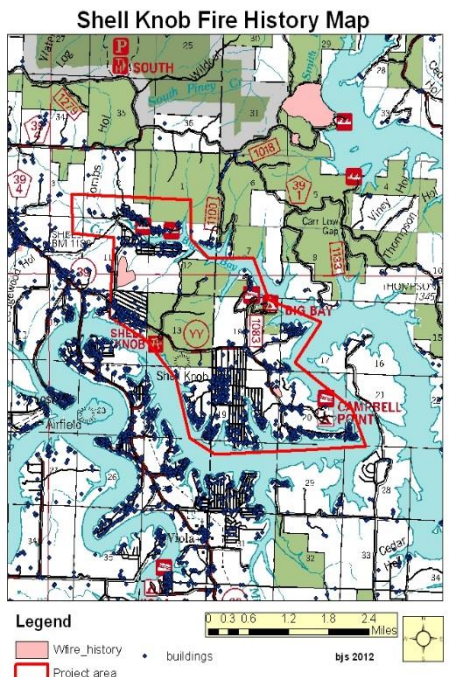
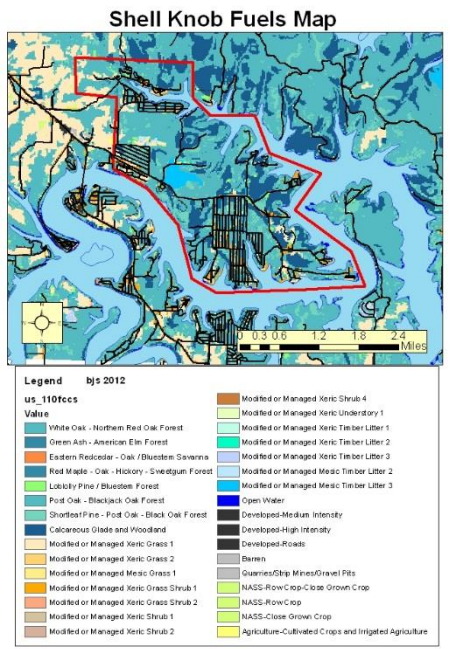
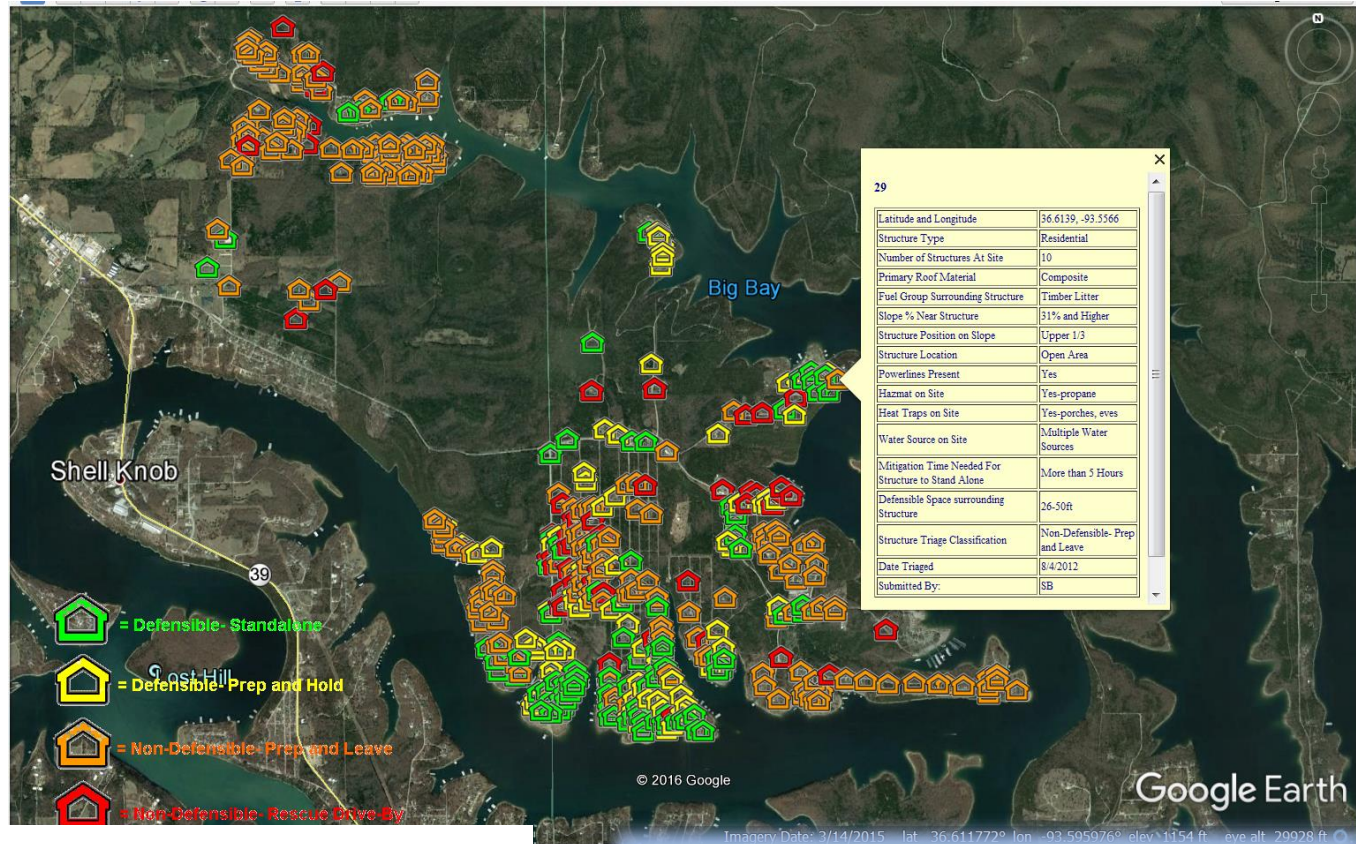
DATA COLLECTED

$$\text{CROWN BULK DENSITY (LBS/FT}^3\text{)} = \frac{\text{CROWN BIOMASS (LBS)}}{\text{CROWN VOLUME (FT}^3\text{)}}$$

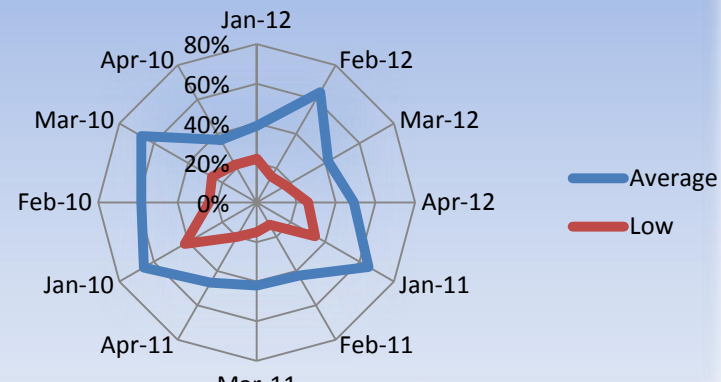
DATA CALCULATED

$$\frac{\text{CROWN BIOMASS} / \text{FOLIAR MOISTURE}}{\text{BIOMASS ADJUST.} / \text{MINIMUM FOLIAR MOISTURE (30%)}}$$

# Other Applications

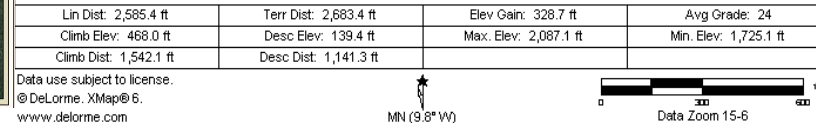
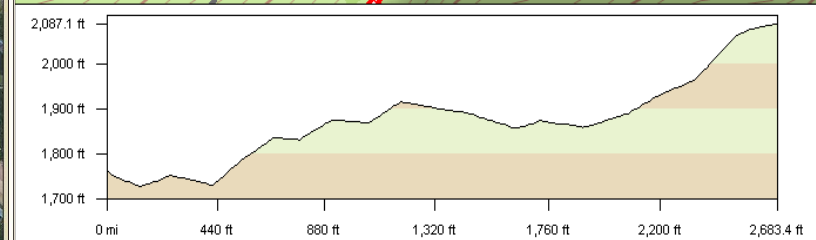
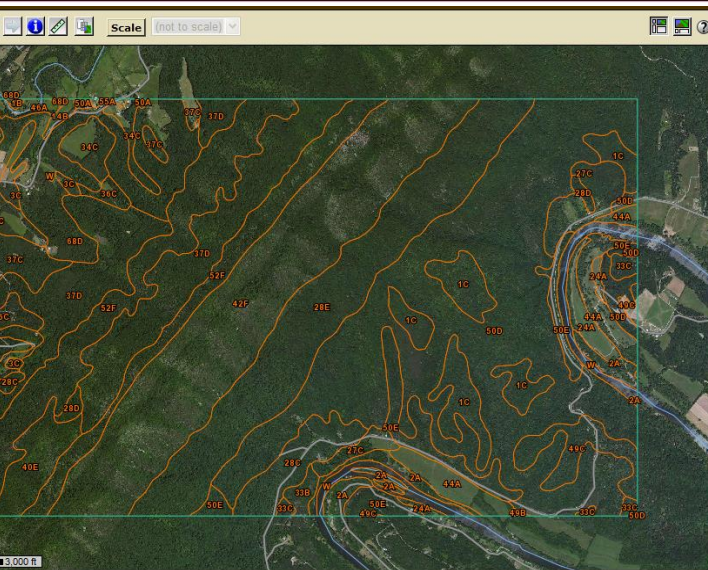
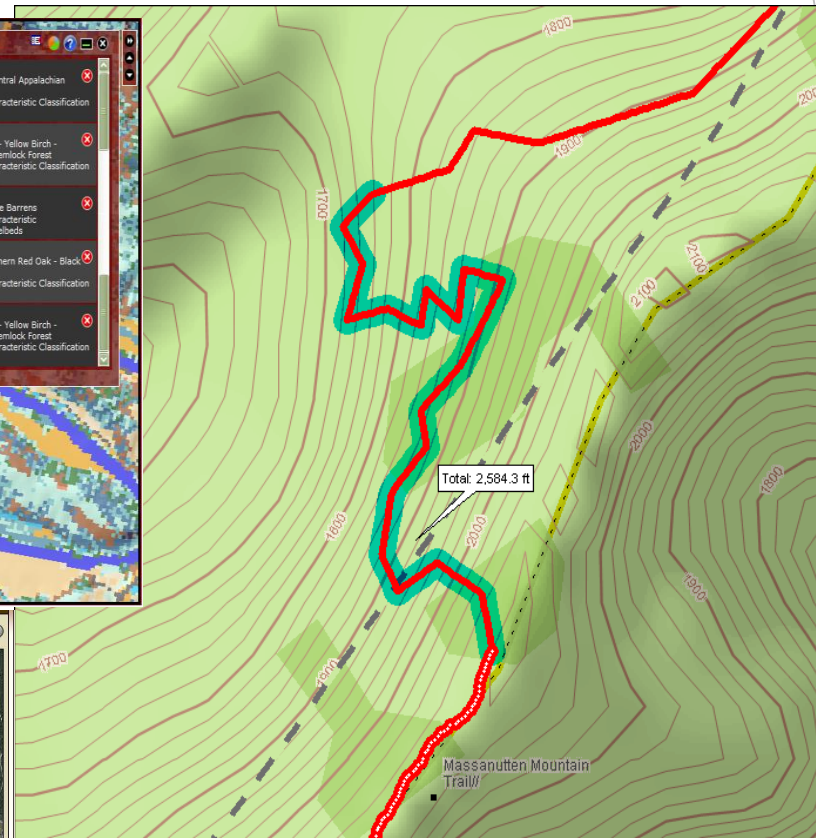
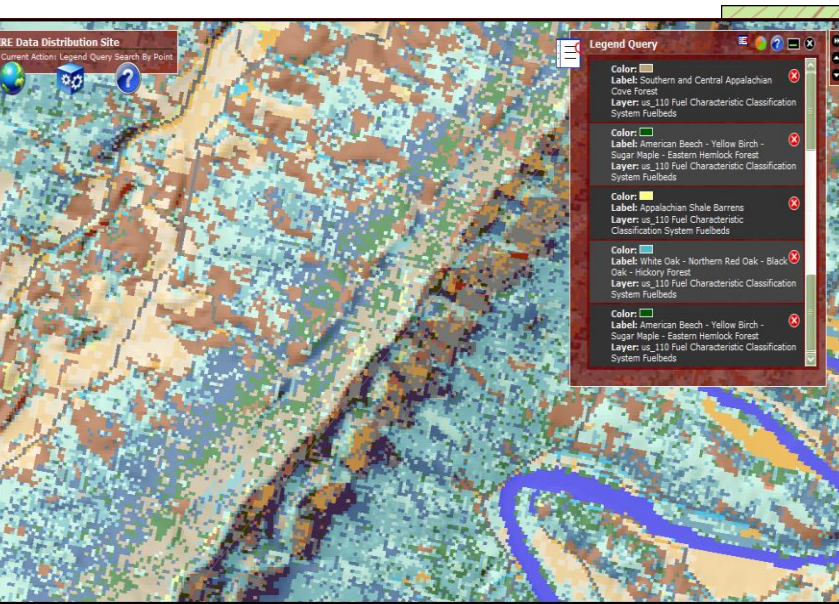


## Average Relative Humidity





# Fire Rehabilitation





# THE END

✘ Questions?

