Advancing Smoke Management In North Carolina With Fire Management Tools And Adjustments To Fire Emissions Inventories

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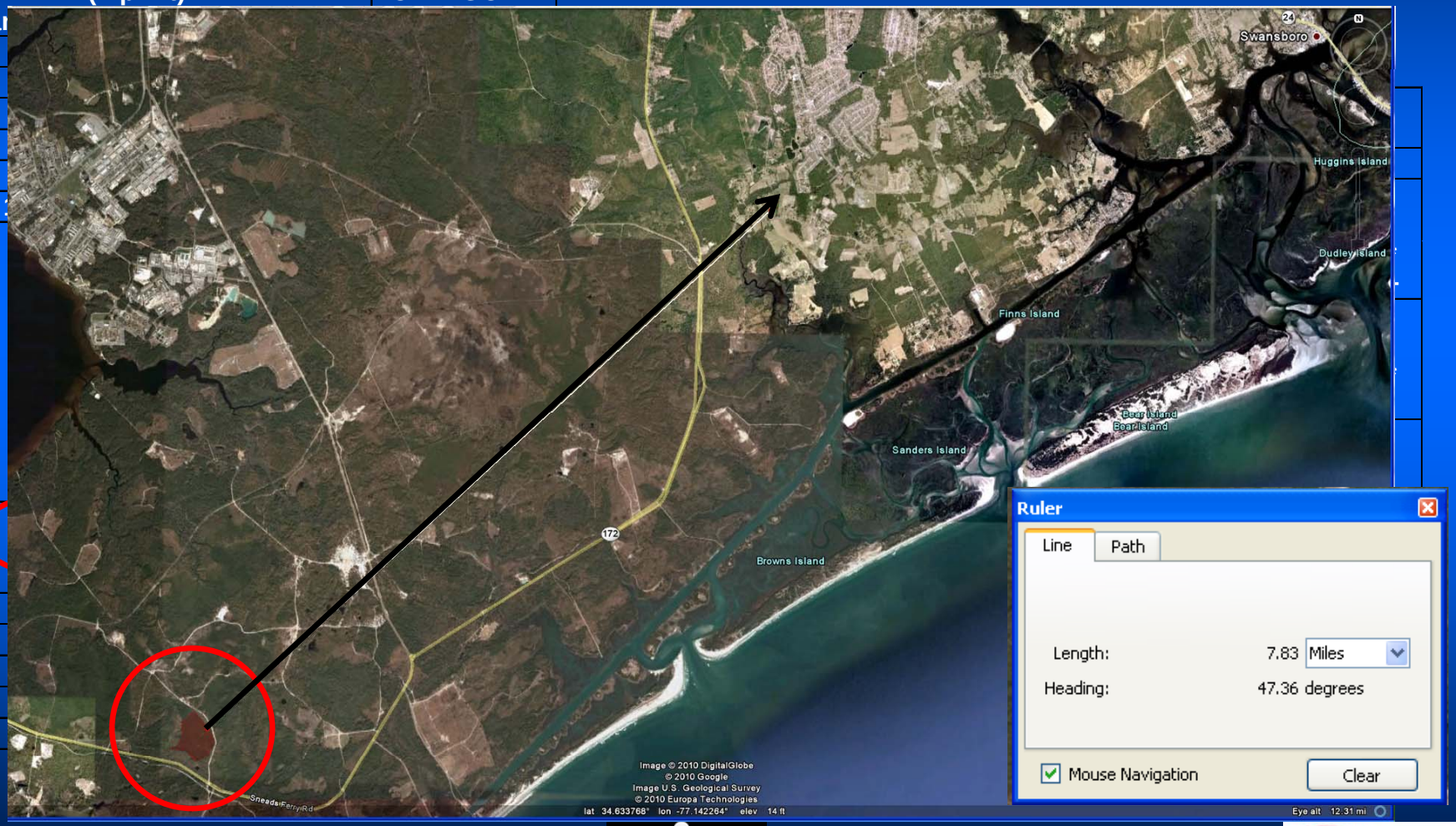
Gary Curcio, North Carolina Division of Forest Resources, and
Jim Reardon, RMRS Fire Science Laboratory Missoula, MT

Presently Prescribed Fires in NC are conducted under a Ventilation Index System (VIS)

DAYTIME VENTILATION RATE (mph-ft)	BURN CATEGORY
(Tra	

Permissible Emissions in Tons per



Operational Research Evaluation Burns (OREBS) has been the catalyst & conduit that has facilitated the use of new research findings ("ESP") & tools (NFDRS, FEPS, VSMOKE, etc.) to advance Prescribe Fire in NC

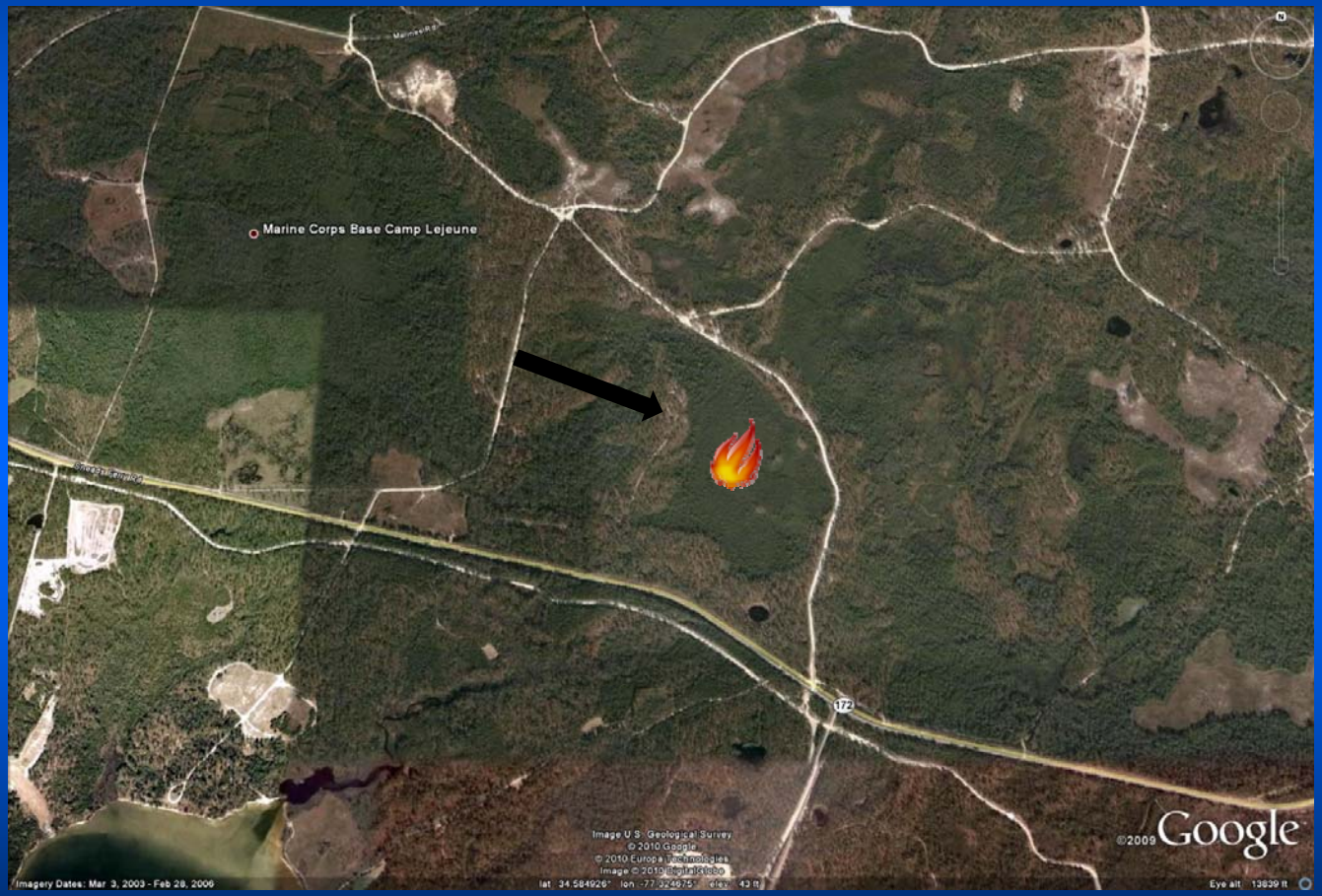
Fiscal Year	Tract Units	Acres Burned	Burning Days
2004	14	8,422	5
2005	4	8,116	3
2006	47 (14)	20,723 (90)	17 (2)
2007	6,729	6,729	5
#	#	#	#
2009	10 + (1)	10,820 + (618)	5 + (1)
2010	? *	? *	? *
Totals	95 + (15)	53,840 + (708)	35 + (3)

Duly Note:
In 2008 year of Burn Ban

* In 2010 several prescribed burns were conducted on a Burning Category 1 Day

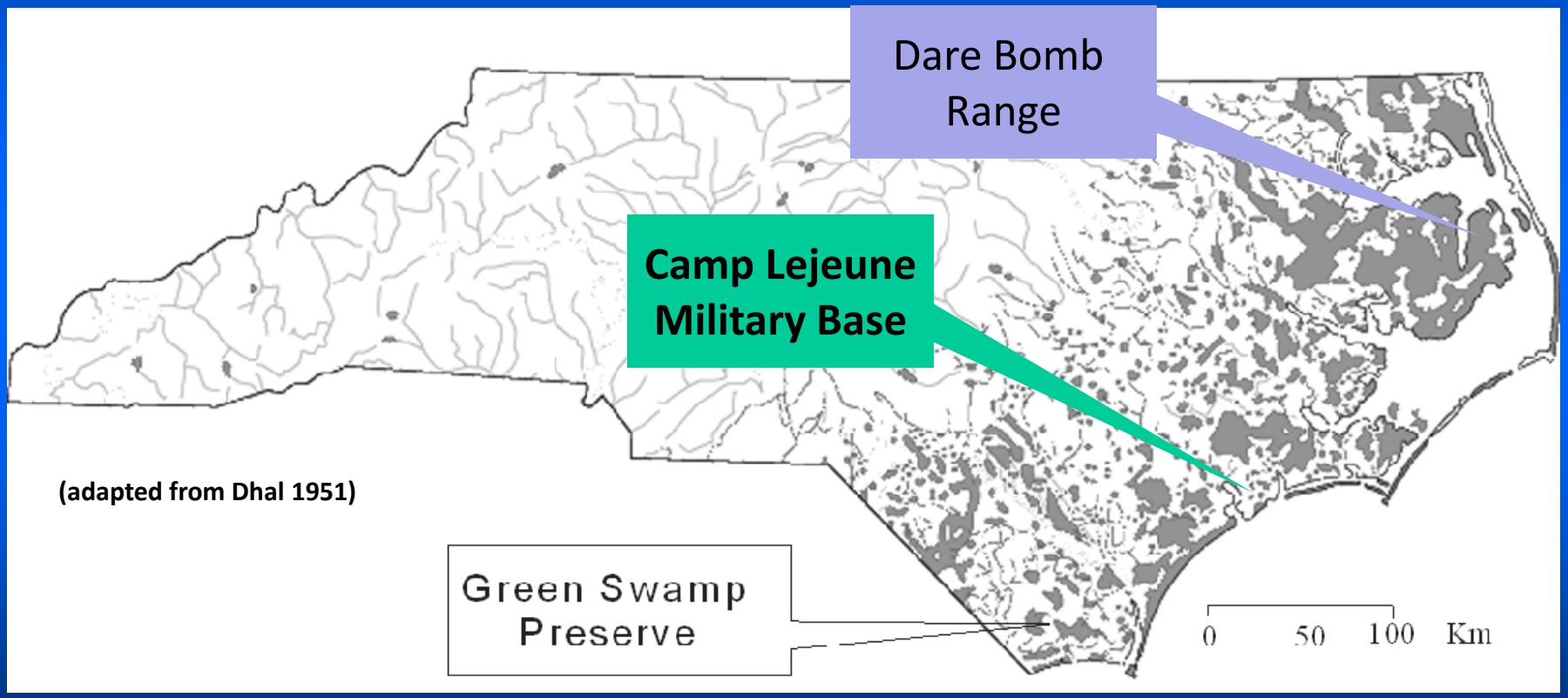
38 Prescribed Burns have been conducted to date & there have been two incidents with negative outcomes

Camp LeJeune – Jacksonville NC
JFSP / OREBS Research Burn



On April 6th, 2010 the Camp Lejeune Burn was conducted under high fire danger conditions

NC's Coastal Plain representing the eastern 1/3 of the state is populated with wetlands composed of organic soils



(adapted from Dhal 1951)

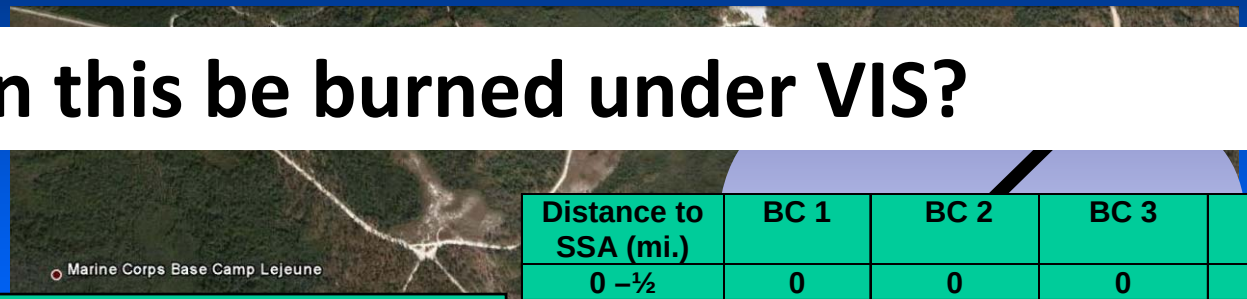
Generally when the "Root Mat" or Organic Soil moisture content reaches "<u>150 % or less</u>", the probability of sustained ignition dramatically increases & residual smoke from smoldering type burning becomes a serious issue.

Information / Tools available for fire practitioners when conducting prescribed burns

- NWS: NFDRS Point, Spot, Fire Weather & Smoke Management Forecasts, Rawinsondes
  - Point Fire Weather Matrix (PFW)
- NC SMP - VIS or ADM – through OREBS
  - VIS restricted to PREDETERMINED set emissions while ADM has VARIABLE emissions as PM 2.5 and Visibility plumes are projected and evaluated
- National Fire Danger Rating System
- Estimated Smoldering Potential (ESP)
- FCCS / Fuel Photo-series
- Fire Emissions Productivity Simulator
  - DFR's FEWG adjustment concerning fuel consumption in pocosins
- VSMOKE or HYSPLIT– atmospheric dispersion models

The Camp Lejeune Joint Fire Science Program Research Burn was 100 acres of pocosin fuel

Can this be burned under VIS?



Assuming 9.4 tons per acre of consumable fuels to be released to the atmosphere, can you burn this under VIS with the nearest SSA miles?

9.4 T/Ac x 100 Acs. = 940 tons to be released to atmosphere

Distance to SSA (mi.)	BC 1	BC 2	BC 3	BC 4	BC 5
0 –½	0	0	0	(1030)	(1350)
½ - 5	0	360 (720)	450 (900)	720* 1440+ (1440)* (2160)+	900* 1800+ (1800)* (2700)+
5 – 10	0	720 (1440)	900 (1800)	1400* 2880+ (2880)* (4320)+	1800* 3600+ (3600)* (5400)
10 – 20	0	1080 (2160)	1350 (2700)	2160* 4320+ (4320)* (6480)+	2700* 5400+ (5400)* (8100)+
20 – 30	0	1200 (2400)	1600 (3200)	2500* 5000+ (5000)* (7500)+	3000* 6000+ (6000)* (9000)+
30+ *NTD= VP/P +NTD = F/G ( ) only UB	0	1440 (2880)	1800 (3600)	2880* 5760+ (5760)* (8640)+	3600* 7200+ (7200)* (10800)+

How was 9.4 T/acre determined?

Using Photo-series
P – S 05 Pocosin Shrub

3.85 = litter
3.21 = dead aerial
2.41 = live foliage & fine stems
9.47 T/acre

If the root mat ignites, 1" = 16 T/day/Ac & TT goes to~ 25 T/acre

	Loading (tons/ac)	Vegetation Layer (Height Above the Ground) < 1.6 ft (< 0.5 m)	1.6 - 3.3 ft (0.5 - 1 m)	3.3 - 4.9 ft (1 - 1.5 m)	> 4.9 ft (> 1.5 m)	> 0 ft (> 0 m)
Live:	Foliage	0.44	0.39	0.42	1.16	2.41
	≤0.25"	0.84	0.55	0.68	1.77	3.84
	0.26-1.0"	2.92	2.51	2.12	1.65	9.20
	Subtotal	4.20	3.45	3.22	4.58	15.45
Dead:	Foliage	0.03	0.01	0.00	0.00	0.04
	≤0.25"	0.84	0.56	0.56	0.52	2.48
	0.26-1.0"	0.72	0.35	0.14	0.12	1.33
	Subtotal	1.59	0.92	0.70	0.64	3.85
All:	Foliage	0.47	0.40	0.42	1.16	2.45
	≤0.25"	1.68	1.11	1.24	2.29	6.32
	0.26-1.0"	3.64	2.86	2.26	1.77	10.53
Grand Total		5.79	4.37	3.92	5.22	19.30

LITTER

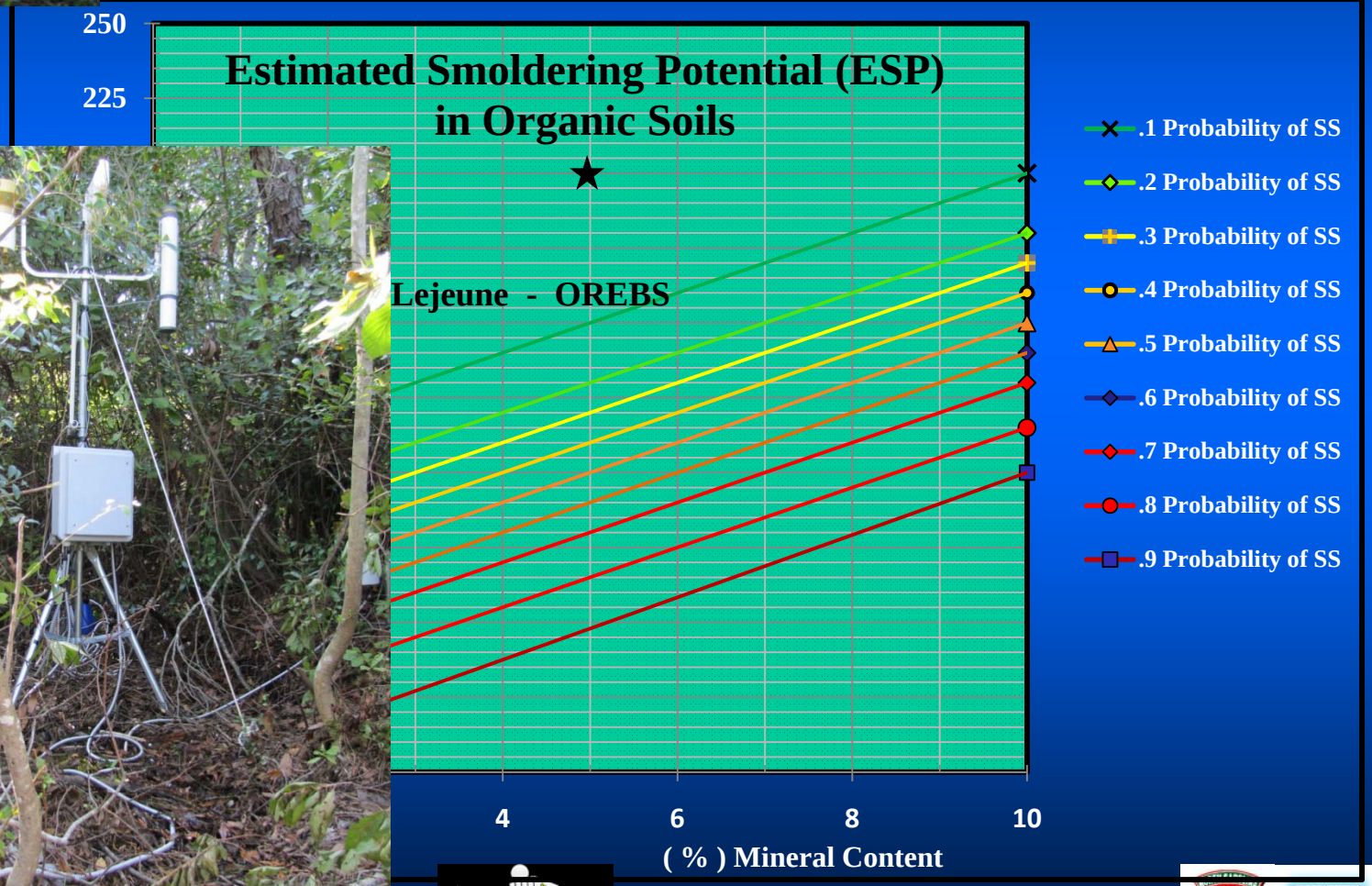
	n	Depth (in)	Loading (tons/ac)	Bulk Density (lbs/ft^3)
Litter	10	1.1	3.85	1.96

NCDFR fuel tonnage assumptions / Estimate Guides

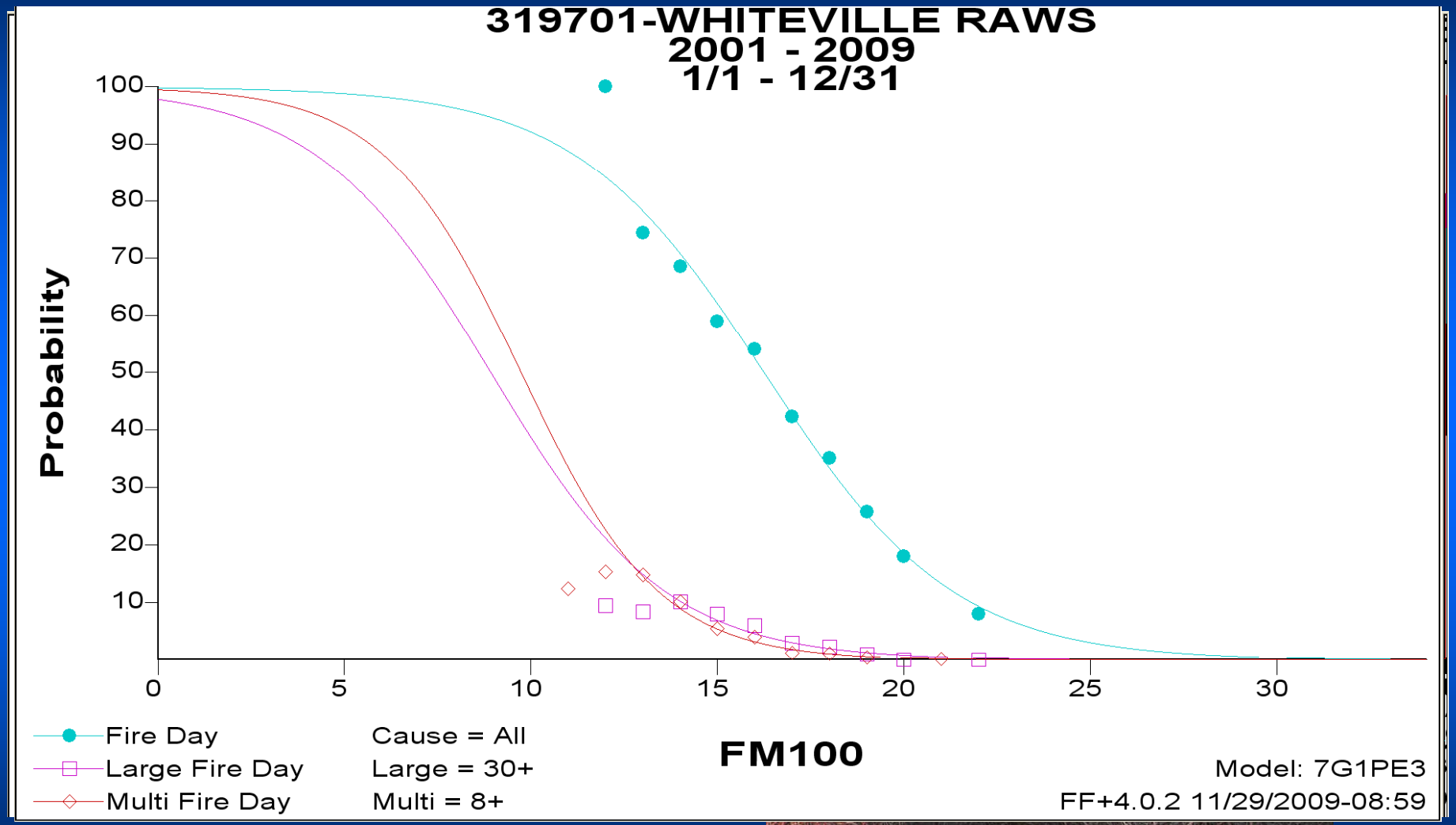
- Hardwood Leaf Litter = 1.5 tons/acre/inch
  - **(NCDFR SOP @ 1 t/ac/in)**
- Pine Needle Litter = 3 tons/acre/inch
  - **(NCDFR SOP @ 2t/ac/in)**
- Black duff (formed from decayed leaves) = 5.3 tons/acre/inch
- Black duff (formed from needle decay) = 12 tons/acre/inch
  - **(NCDFR 16 t/ac/in)**
- Red duff (formed from wood decay) = 18.7 tons/acre/inch
- Moss/duff = 3 tons/acre/inch
- Brush Fuels (pocosins, laurel, & rhododendron) = 100% canopy & woody
  - **(NEW NCDFR SOP FOR BRUSH 100% CANOPY + 15% WOODY)**

NC FEWG input modifications to CONSUME to adjust fuel consumption for Southeast ericaceous brush fuels

Knowing " ESP " provides Fire Mgrs. the ability to eliminate "root mat"/ "organic soils" tonnage from emission estimates



NFDRS is the only game in town where fuel moistures are modeled & Business Thresholds for



Remember 38 Prescribed Burns
& only two incidents with negative outcomes

April 6th , 2010

Sandy Run FD Station

NFDRS Values

model 78

Actual / Forecasted

IC = 24 / 26

SC = 29 / 38

ERC = 47 / 42

BI = 82 /89

KBDI = 154 /155

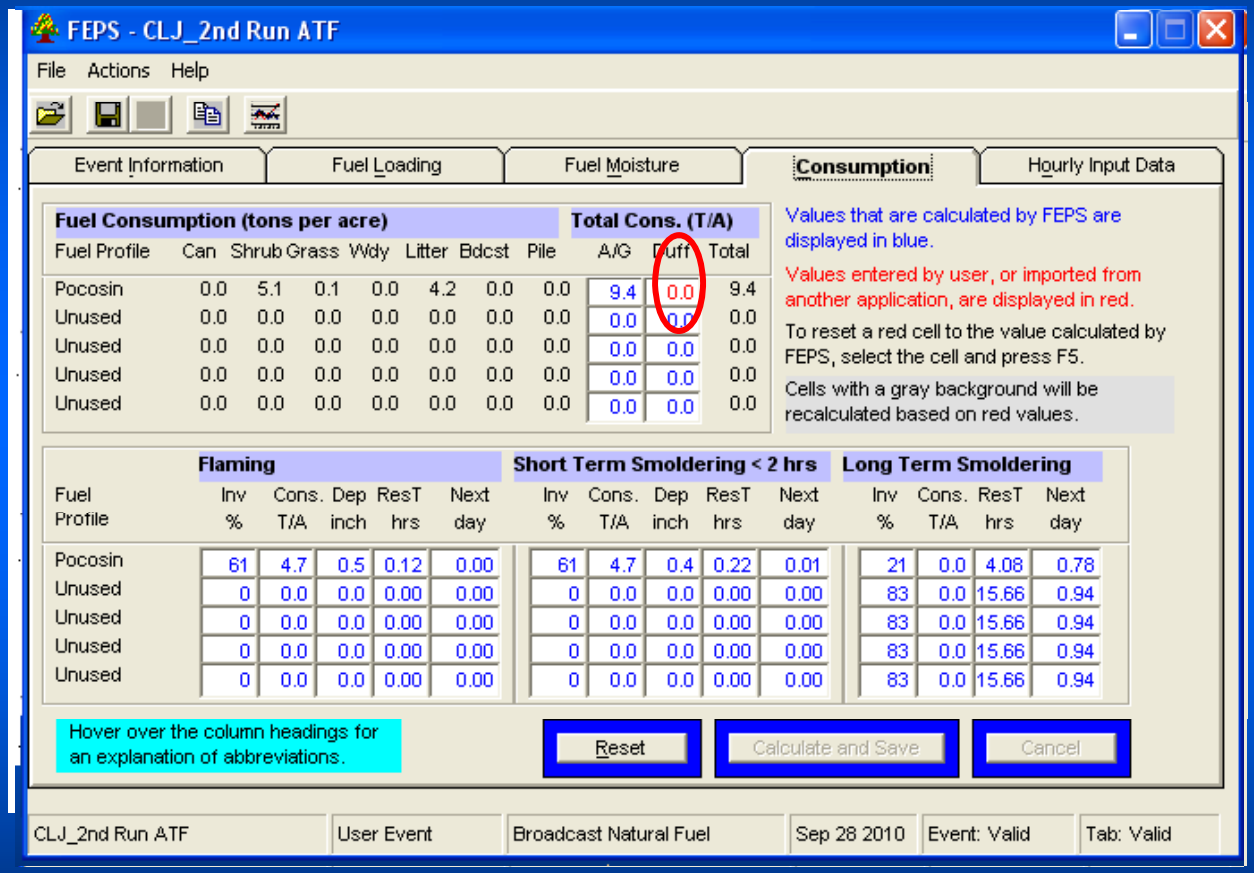
Actual

Station ID	Obs Dt	Tm	O T	MSGC	WS	WDY	HRB	1H	10	HU	TH	XH	IC	SC	EC	BI	SL	R	KBDI	FL	LR	LO	HR	HO
319505	040610	13	O	7O1P3	7	70	6	7	8	15	19	19	24	28	47	82	4	H	154	58	0	0	0	0
319505	040610	13	O	7G1P3	7	70	6	7	8	15	19	19	23	8	31	37	3	M	154	26	0	0	0	0

Forecasted

Station ID	Obs Dt	Tm	O T	MSGC	WS	WDY	HRB	1H	10	HU	TH	XH	IC	SC	EC	BI	SL	R	KBDI	FL	LR	LO	HR	HO
319505	040610	13	F	7O1P3	10	70	7	7	11	16	19	19	26	38	42	89	4	H	155	63	0	0	0	0
319505	040610	13	F	7G1P3	10	70	7	7	11	16	19	19	26	11	29	42	3	M	155	30	0	0	0	0
319505	040510	13	O	7O1P3	7	70	8	8	10	16	19	19	17	25	43	75	4	M	138	53	0	0	0	0
319505	040510	13	O	7G1P3	7	70	8	8	10	16	19	19	17	7	29	35	3	M	138	25	0	0	0	0

FEPS is worked through to generate outputs for VSMOKE or HYSPLIT

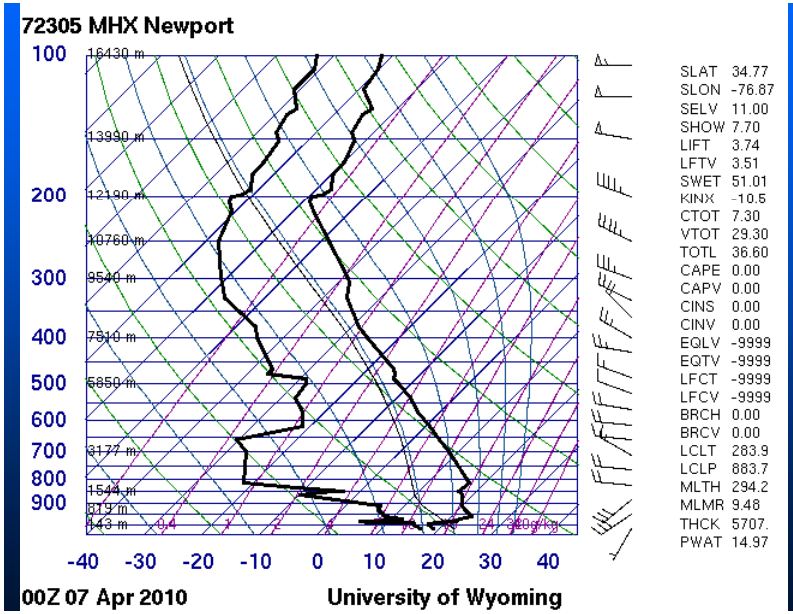


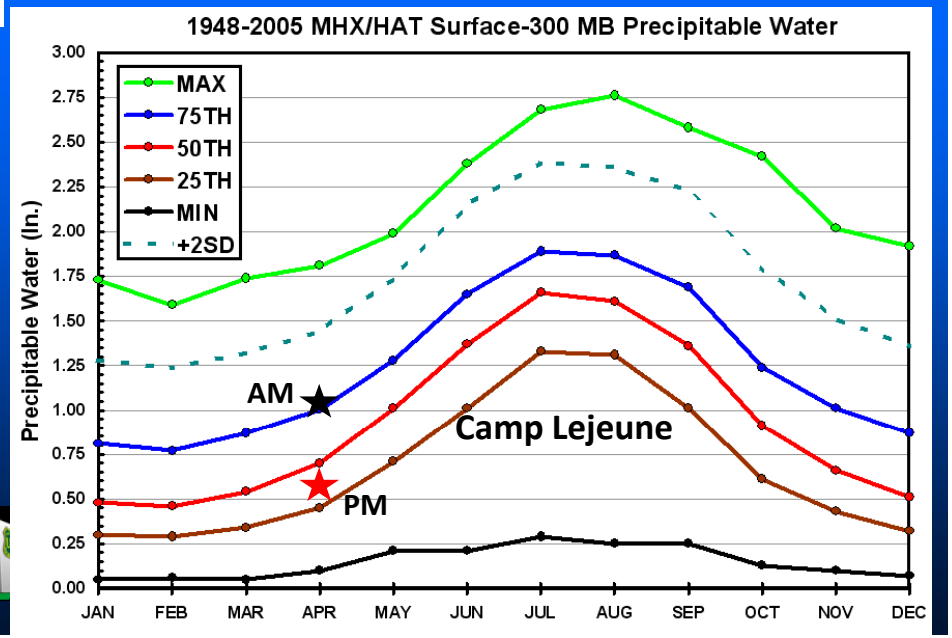
72305 MHX Newport Observations at 00Z 07 Apr 2010

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1016.0	11	18.8	16.6	87	11.83	210	7	290.6	324.1	292.7
1000.0	143	17.4	15.0	86	10.83	220	27	290.6	321.3	292.4
996.0	177	17.4	14.9	85	10.80	221	29	290.9	321.6	292.8
988.0	247	18.6	14.0	75	10.27	223	32	292.8	322.2	294.6
987.0	255	19.2	14.3	73	10.48	223	33	293.4	323.6	295.3
986.0	264	19.8	6.8	43	6.32	224	33	294.1	312.7	295.3
985.0	273	20.2	5.2	37	5.66	224	33	294.6	311.4	295.6
982.0	299	21.6	6.6	38	6.26	225	35	296.3	314.9	297.4
981.3	305	21.6	7.5	40	6.68	225	35	296.4	316.2	297.6
979.0	326	21.8	10.8	50	8.37	226	35	296.7	321.4	298.2
969.0	415	21.8	11.8	53	9.05	229	33	297.6	324.2	299.2
960.0	496	23.6	8.6	38	7.35	231	32	300.2	322.3	301.6
947.5	610	22.7	7.7	38	6.99	235	30	300.4	321.4	301.7
925.0	819	21.0	6.0	38	6.38	220	29	300.8	320.0	301.9
914.9	914	20.3	5.9	39	6.39	215	31	301.0	320.3	302.2
908.0	979	19.8	5.8	40	6.41	218	31	301.1	320.5	302.3
882.9	1219	18.9	-3.0	22	3.49	230	29	302.6	313.6	303.3
864.0	1405	18.2	-9.8	14	2.11	245	22	303.8	310.6	304.2
852.0	1524	17.3	-5.5	21	2.99	255	17	304.1	313.6	304.6
850.0	1544	17.2	-4.8	22	3.16	250	18	304.1	314.2	304.7
846.0	1584	16.8	-3.2	25	3.59	254	18	304.1	315.4	304.8
834.0	1706	17.2	-11.8	13	1.87	264	20	305.8	311.9	306.1
822.0	1829	17.2	-17.2	8	1.21	275	21	307.1	311.2	307.3
812.0	1933	17.2	-21.8	5	0.83	275	22	308.1	311.0	308.3
792.8	2134	15.8	-22.6	6	0.79	275	23	308.8	311.5	308.9
764.5	2438	13.6	-23.8	6	0.74	275	21	309.6	312.2	309.8
737.2	2743	11.5	-24.9	6	0.69	275	20	310.5	313.0	310.7
710.9	3048	9.3	-26.1	6	0.64	300	17	311.4	313.7	311.5
700.0	3177	8.4	-26.6	6	0.62	285	16	311.8	314.0	311.9

Station information and sounding indices

Station identifier:	MHX
Station number:	72305
Observation time:	100407/0000
Station latitude:	34.77
Station longitude:	-76.87
Station elevation:	11.0
Showalter index:	7.70
Lifted index:	3.74
LIFT computed using virtual temperature:	3.51
SWEAT index:	51.01
K index:	-10.50
Cross totals index:	7.30
Vertical totals index:	29.30
Totals totals index:	36.60
Convective Available Potential Energy:	0.00
CAPE using virtual temperature:	0.00
Convective Inhibition:	0.00
CINS using virtual temperature:	0.00
Bulk Richardson Number:	0.00
Bulk Richardson Number using CAPV:	0.00
Temp [K] of the Lifted Condensation Level:	283.99
Pres [hPa] of the Lifted Condensation Level:	883.78
Mean mixed layer potential temperature:	294.21
Mean mixed layer mixing ratio:	9.48
1000 hPa to 500 hPa thickness:	5707.00
Precipitable water [mm] for entire sounding:	14.97





Distance from fire	PM2.5 (ug/m3)	CO (ppm)
328 ft	5,539.16	60.52
413 ft	4,908.63	53.84
518 ft	4,321.31	47.61
656 ft	3,782.34	41.89
823 ft	3,303.49	36.82
1037 ft	2,868.96	32.21
0.25 mi	2,478.75	28.07
0.31 mi	2,131.86	24.39
0.39 mi	1,826.36	21.15
0.49 mi	1,559.57	18.32
0.62 mi	1,328.14	15.87
0.78 mi	1,127.22	13.74
0.98 mi	948.84	11.85
1.24 mi	803.46	10.31
1.56 mi	686.57	9.07
1.96 mi	572.96	7.86

Distance from fire	PM2.5 (ug/m3)	CO (ppm)
2.47 mi	468.30	6.75
3.11 mi	376.80	5.78
3.92 mi	299.47	4.96
4.94 mi	235.14	4.28
6.21 mi	182.33	3.72
7.82 mi	139.91	3.27
9.85 mi	106.83	2.92
12.40 mi	81.82	2.66
15.61 mi	63.43	2.46
19.65 mi	50.21	2.32
24.74 mi	40.87	2.22
31.14 mi	34.41	2.15
39.21 mi	30.50	2.11
49.36 mi	28.22	2.09
62.14 mi	26.66	2.07

Distance from fire	Crossplume Visibility (miles)	Contrast Ratio (miles)
317 ft	0.10	0.00
422 ft	0.11	0.00
528 ft	0.13	0.00
634 ft	0.15	0.01
845 ft	0.17	0.01
1056 ft	0.19	0.02
0.25 mi	0.22	0.04
0.31 mi	0.26	0.06
0.39 mi	0.32	0.09
0.49 mi	1.28	0.13
0.62 mi	4.51	0.18
0.78 mi	7.30	0.23
0.98 mi	9.68	0.30
1.24 mi	11.44	0.37
1.56 mi	12.60	0.43
1.96 mi	13.58	0.49

Distance from fire	Crossplume Visibility (miles)	Contrast Ratio (miles)
2.47 mi	14.40	0.55
3.11 mi	15.10	0.62
3.92 mi	15.71	0.68
4.94 mi	16.31	0.73
6.21 mi	16.91	0.78
7.82 mi	17.54	0.83
9.85 mi	18.18	0.86
12.40 mi	18.79	0.89
15.61 mi	19.37	0.91
19.65 mi	19.89	0.93
24.74 mi	20.34	0.94
31.14 mi	20.73	0.95
39.21 mi	20.96	0.95
49.36 mi	21.04	0.96
62.14 mi	21.07	0.96

Distance from fire	Plume Height (feet)	Horizontal Dispersion Coefficient (feet)	Vertical Dispersion Coefficient (feet)
317 ft	174	41	29
422 ft	203	47	32
528 ft	237	55	36
634 ft	276	65	41
845 ft	322	76	46
1056 ft	375	91	53
0.25 mi	438	109	61
0.31 mi	510	132	71
0.39 mi	595	159	83
0.49 mi	694	193	98
0.62 mi	809	235	115
0.78 mi	943	287	137
0.98 mi	1,100	351	163
1.24 mi	1,200	430	195
1.56 mi	1,200	527	233
1.96 mi	1,200	646	280

Distance from fire	Plume Height (feet)	Horizontal Dispersion Coefficient (feet)	Vertical Dispersion Coefficient (feet)
2.47 mi	1,200	792	336
3.11 mi	1,200	972	403
3.92 mi	1,200	1,192	485
4.94 mi	1,200	1,462	584
6.21 mi	1,200	1,793	703
7.82 mi	1,200	2,198	847
9.85 mi	1,200	2,693	1,021
12.40 mi	1,200	3,298	1,232
15.61 mi	1,200	4,037	1,485
19.65 mi	1,200	4,938	1,791
24.74 mi	1,200	6,036	2,161
31.14 mi	1,200	7,372	2,608
39.21 mi	1,200	8,996	3,146
49.36 mi	1,200	10,967	3,797
62.14 mi	1,200	13,357	4,582

Analysis period is during the day

Use Time of Day in VSMOKE-GIS

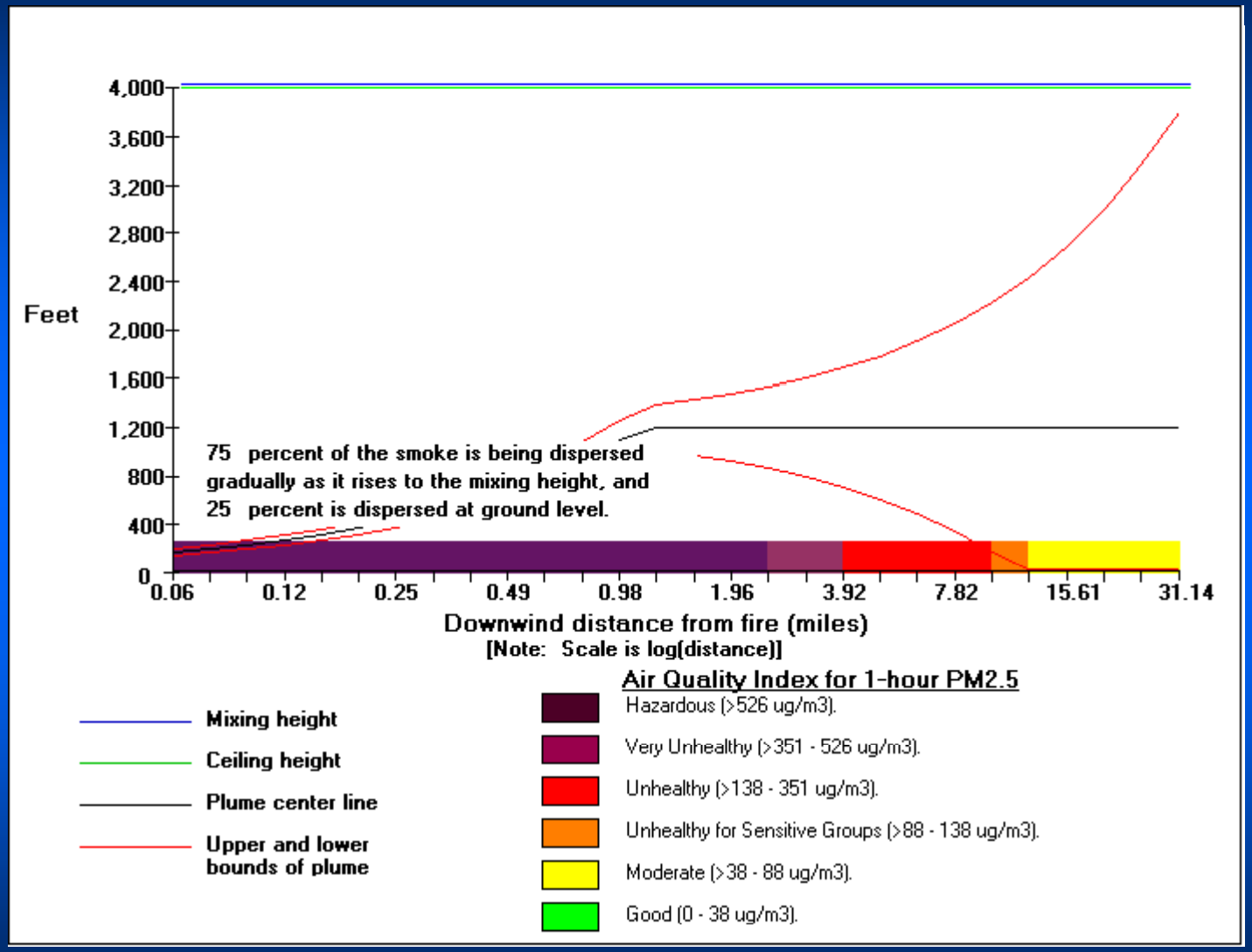
STABILITY CLASS = **4 (Near neutral)**

Use Stability in VSMOKE-GIS

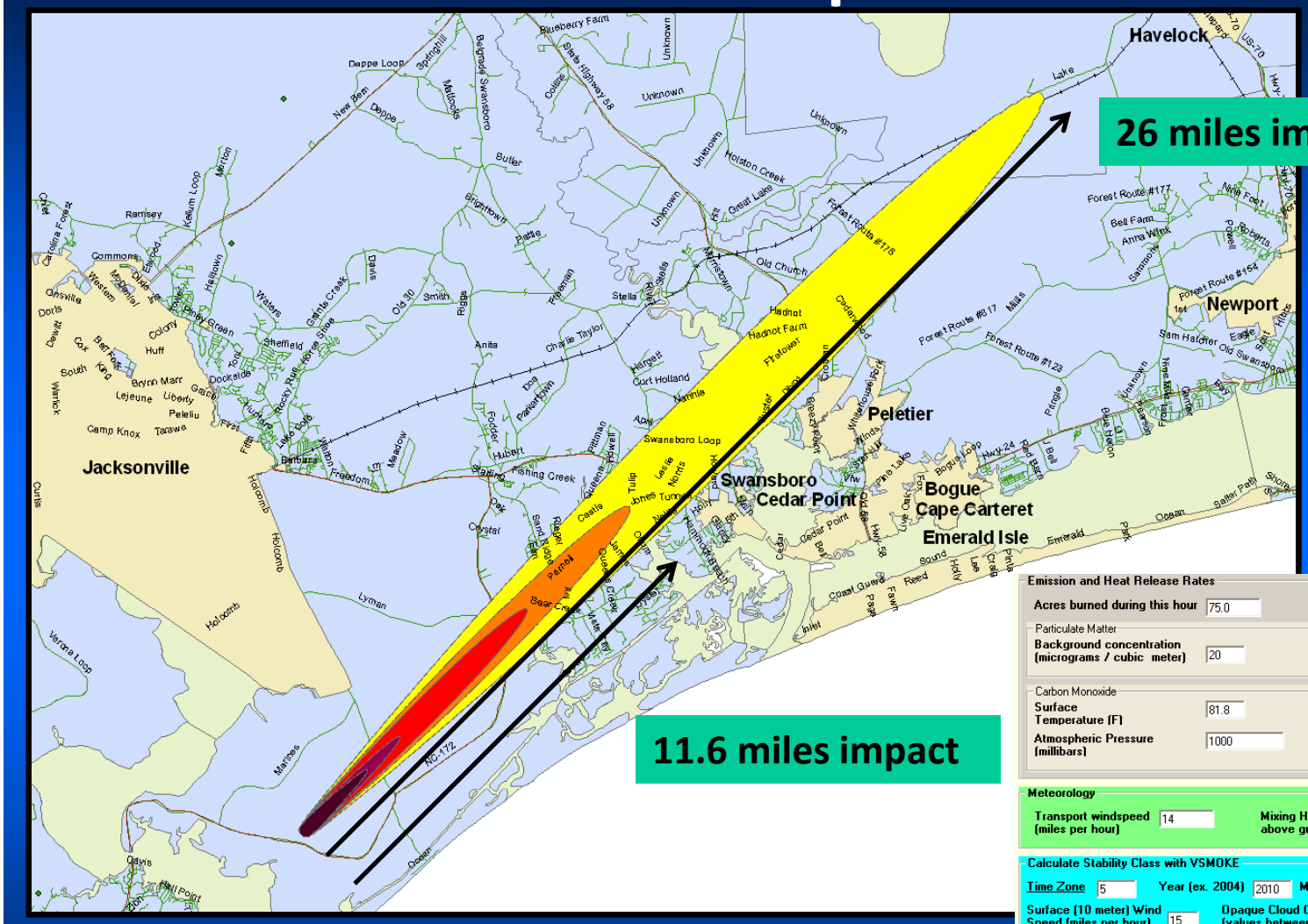
Dispersion Index: 37 - fair to good

Low Visibility Occurrence Risk Index (LVORI): 1 - equal to the base line

The base line risk of having low visibility is about 1 in 1000 accidents.


4,000
3,600
3,200
2,800
2,400
2,000
1,600
1,200
800
400
0
Feet
75 percent of the smoke is being dispersed gradually as it rises to the mixing height, and 25 percent is dispersed at ground level.
0.06
0.12
0.25
0.49
0.98
1.96
3.92
7.82
15.61
31.14
Downwind distance from fire (miles)
[Note: Scale is log(distance)]
Mixing height
Ceiling height
Plume center line
Upper and lower bounds of plume
Air Quality Index for 1-hour PM2.5
Hazardous (>526 ug/m3).
Very Unhealthy (>351 - 526 ug/m3).
Unhealthy (>138 - 351 ug/m3).
Unhealthy for Sensitive Groups (>88 - 138 ug/m3).
Moderate (>38 - 88 ug/m3).
Good (0 - 38 ug/m3).

VSMOKE GIS MAP Output



Emission and Heat Release Rates

Acres burned during this hour	75.0	Total Sensible Heat Emission Rate (megawatts)	102.0
Particulate Matter			
Background concentration (micrograms / cubic meter)	20	Total Source Emission Rate (gm / sec)	518.120
Carbon Monoxide			
Surface Temperature (F)	81.8	Background Concentration (parts per million)	2
Atmospheric Pressure (millibars)	1000	Total Source Emission Rate (gm / sec)	6318.470

Meteorology

Transport windspeed (miles per hour)	14	Mixing Height (feet above ground level)	4000	Relative Humidity (%)	49

Calculate Stability Class with VSMOKE

Time Zone	5	Year (ex. 2004)	2010	Month	04	Day	06	Hour of simulation (enter 14.5 for 2:30 pm)	14
Surface (10 meter) Wind Speed (miles per hour)	15	Opaque Cloud Cover (values between 0 and 10)	10	Cloud Cover Ceiling Height (feet above ground level)	4000				

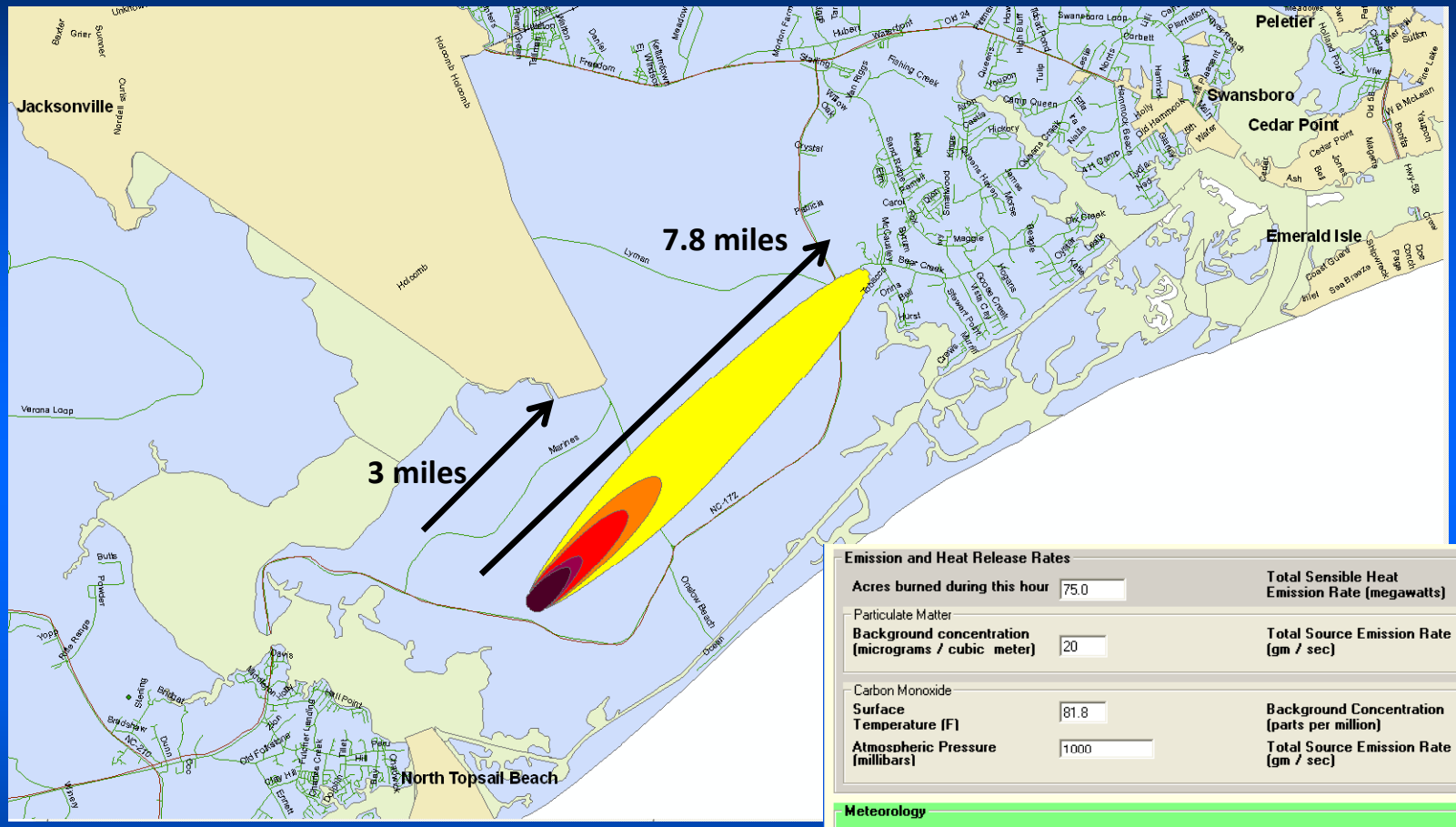
Inputs used only in VSMOKE-GIS

☑ Check if time period is before sunset (daylight)

Wind Direction (degrees) 225

Stability Class for VSMOKE-GIS 4 (Near neutral)

Over Ride - VSMOKE



Emission and Heat Release Rates

Acres burned during this hour	75.0	Total Sensible Heat Emission Rate (megawatts)	102.0

Particulate Matter

Background concentration (micrograms / cubic meter)	20	Total Source Emission Rate (gm / sec)	518.120

Carbon Monoxide

Surface Temperature (F)	81.8	Background Concentration (parts per million)	2
Atmospheric Pressure (millibars)	1000	Total Source Emission Rate (gm / sec)	6318.470

Meteorology

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Surface (10 meter) Wind Speed (miles per hour)	15	Opaque Cloud Cover (values between 0 and 10)	10	Cloud Cover Ceiling Height (feet above ground level)	4000				

Inputs used only in VSMOKE-GIS

☑ Check if time period is before sunset (daylight)

Wind Direction (degrees) 225

Stability Class for VSMOKE-GIS 2 (Moderately unstable)

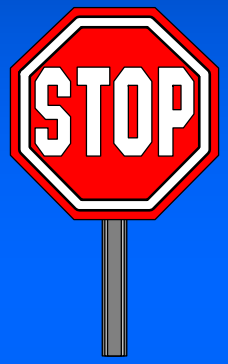
Fire Management Tools like ADM, ESP, NFDRS & Wildland Fire Decision Support System make it possible for Natural Resource Agencies to meet their objectives & thereby introduce fire to more acres

http://firesmoke.us/wfdss/

What is next to do?

- GIS mapping of the coastal plain & mountains organic soils, root mats, & deep duffs as well as determine mineral content.
- Develop ESP equation for mountain deep duffs
- Identify an acceptable risk level for ESP
- Develop, Refine, & provide Tech Support on decision support tools & use upper atmosphere impacts to the PBL
- Skillful management & understanding of the NFDRS model
- Re-establishing NFDRS time-lag FM & Indices / Components climatology & business thresholds due to Nelson's algorithms
- Modeling for eastern fuels "non-sound" time lag fuels
- Institutionalizing the use of: ADM's, CONSUME (Eastern fuels adjustments), FEPS, NFDRS, Rawinsondes, etc.
- Development of interagency Smoke Management Database

Gary M. Curcio – Fire Environment

Best way to reach me: (c) 919-810-5623

gary.curcio@ncdenr.gov