Understanding the Wind

Brad Woodson
McHenry County Conservation District

Wind Speed Direct Implications for:

- Smoke Management
- Flame Length
- Rate of Spread
- Firebreak Width and Type
- Crew Size
- Firing Technique
- Success

Wind Speed Direct Implications for:

- Smoke Management
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- Crew Size
- Firing Technique
- Success……Failure

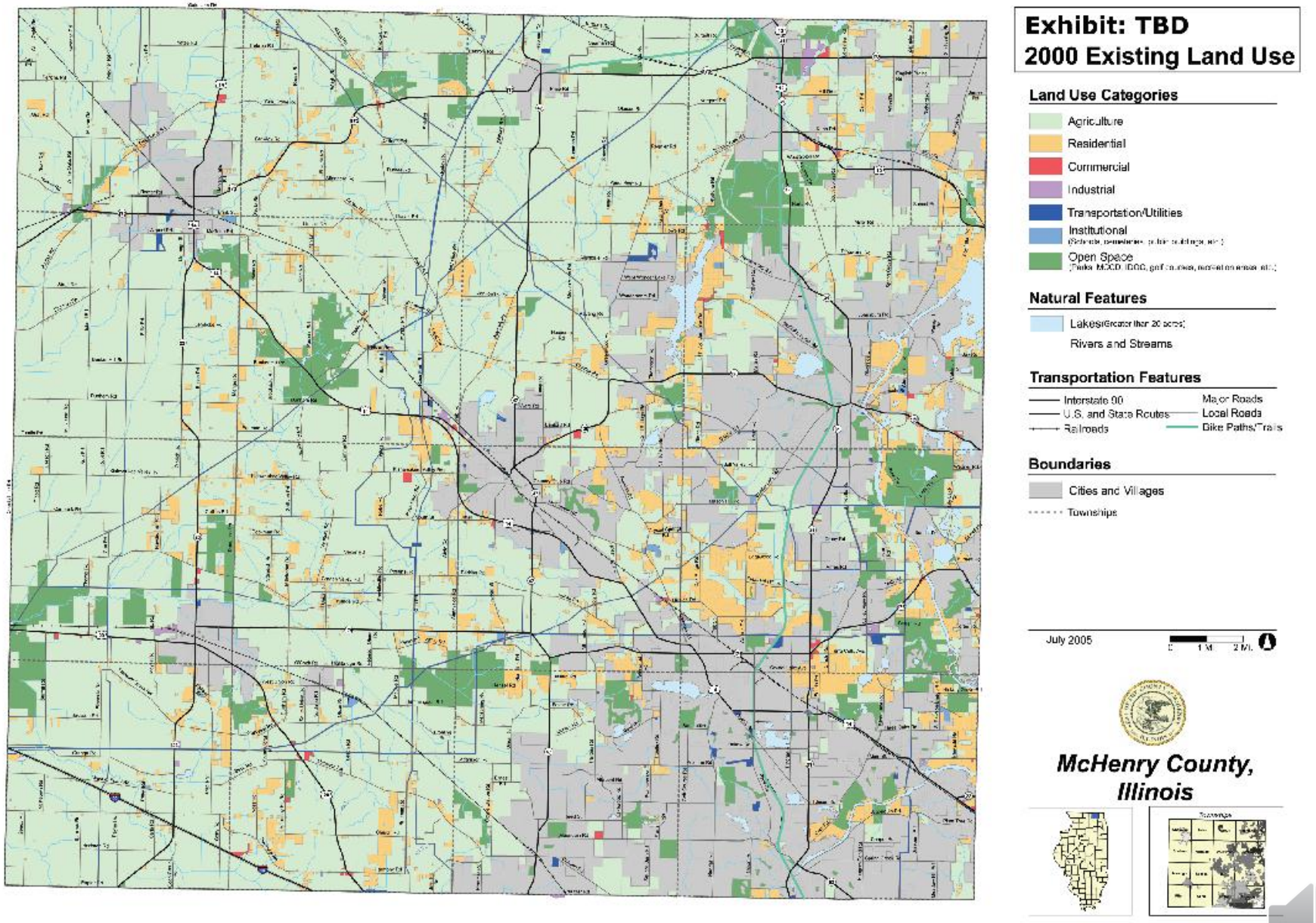
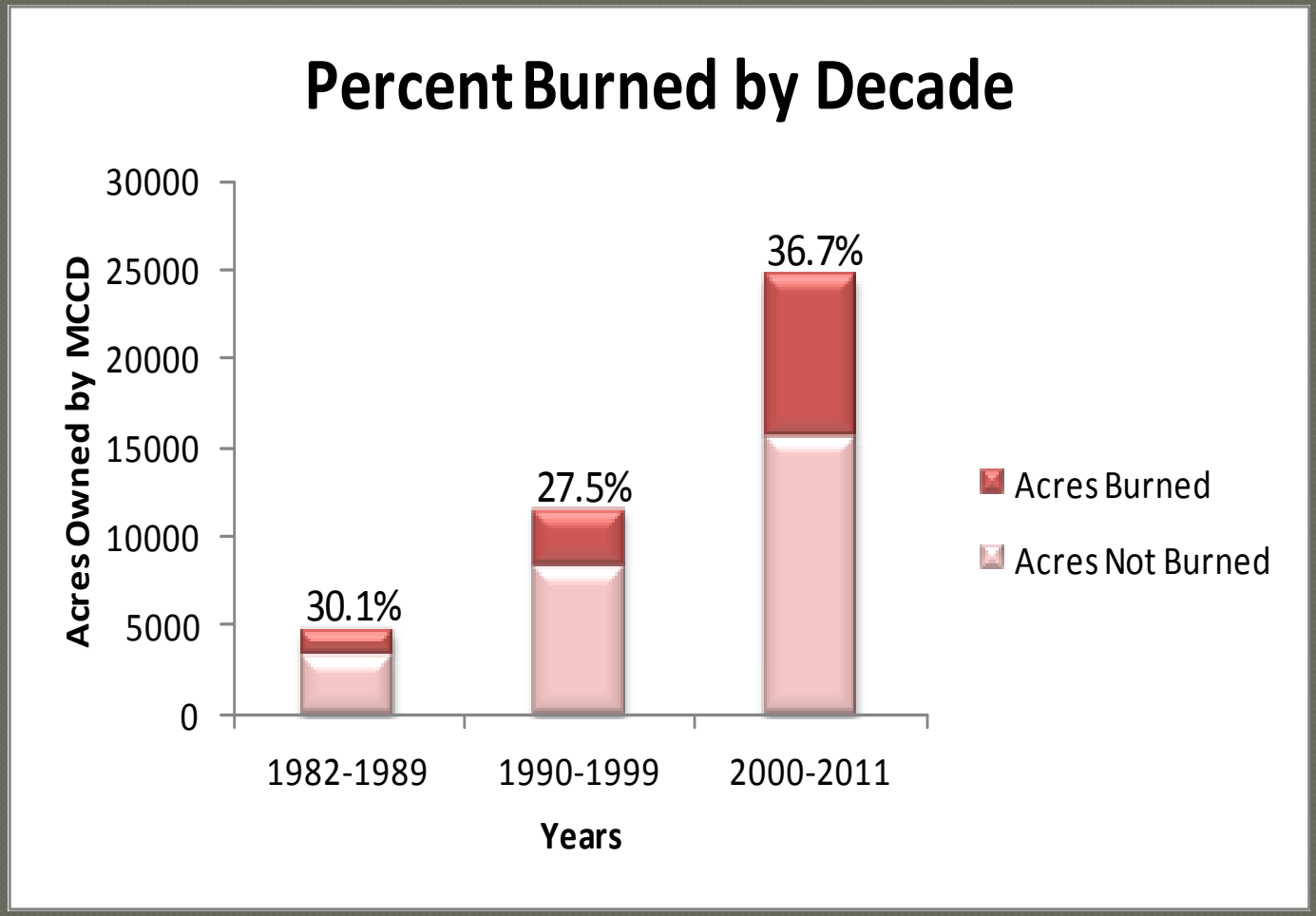


Exhibit: TBD
2000 Existing Land Use
Land Use Categories
Agriculture
Residential
Commercial
Industrial
Transportation/Utilities
Institutional
Open Space
Natural Features
Lakes(Greater than 20 acres)
Rivers and Streams
Transportation Features
Interstate 90
U.S. and State Routes
Railroads
Major Roads
Local Roads
Bike Paths/Trails
Boundaries
Cities and Villages
Townships
July 2005
0 1 M 2 Mi.
McHenry County,
Illinois


Percent Burned by Decade
30000
25000
20000
15000
10000
5000
0
Acres Owned by MCCD
30.1%
27.5%
36.7%
1982-1989
1990-1999
2000-2011
Years
Acres Burned
Acres Not Burned

Recommended Wind Speed for Prescribed Burning

Kansas State Univ.	5-18 mph	Max 20 mph
Nebraska Guide	3-12 mph	
Michigan DNR	3-7 mph	
Iowa NRCS	5-15 mph	
Illinois DNR		Max 20
Wisconsin NRCS	3-18 mph	
Oklahoma	4-15 mph	

Better Recommendations

Kentucky	6-18 mph @ 20' winds 1-3 mph @ eye level
Indiana DNR	6-18 mph @ 20' winds 1-3 mph @ eye level

Outline

1. Wind Adjustment Factor in the Open
2. Wind Adjustment Factor in Woodlands
3. Topography's Influence on Wind speed
4. Recommendations for Prescribed Burning

Hourly Weather Forecast Graph

National Weather Service, Chicago, IL

Weather Elements

- Temperature (°F)
- Dewpoint (°F)
- Wind Chill (°F)
- Surface Wind
- Sky Coverage
- Precipitation Potential
- Relative Humidity
- Thunder
- Rain
- Snow
- Freezing Rain
- Sleet

Fire Weather

- Mixing Height (x100ft)
- Haines Index
- Trans. Wind
- 20ft Wind
- Vent Rate (x1000 mph-ft)

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- Wind Direction

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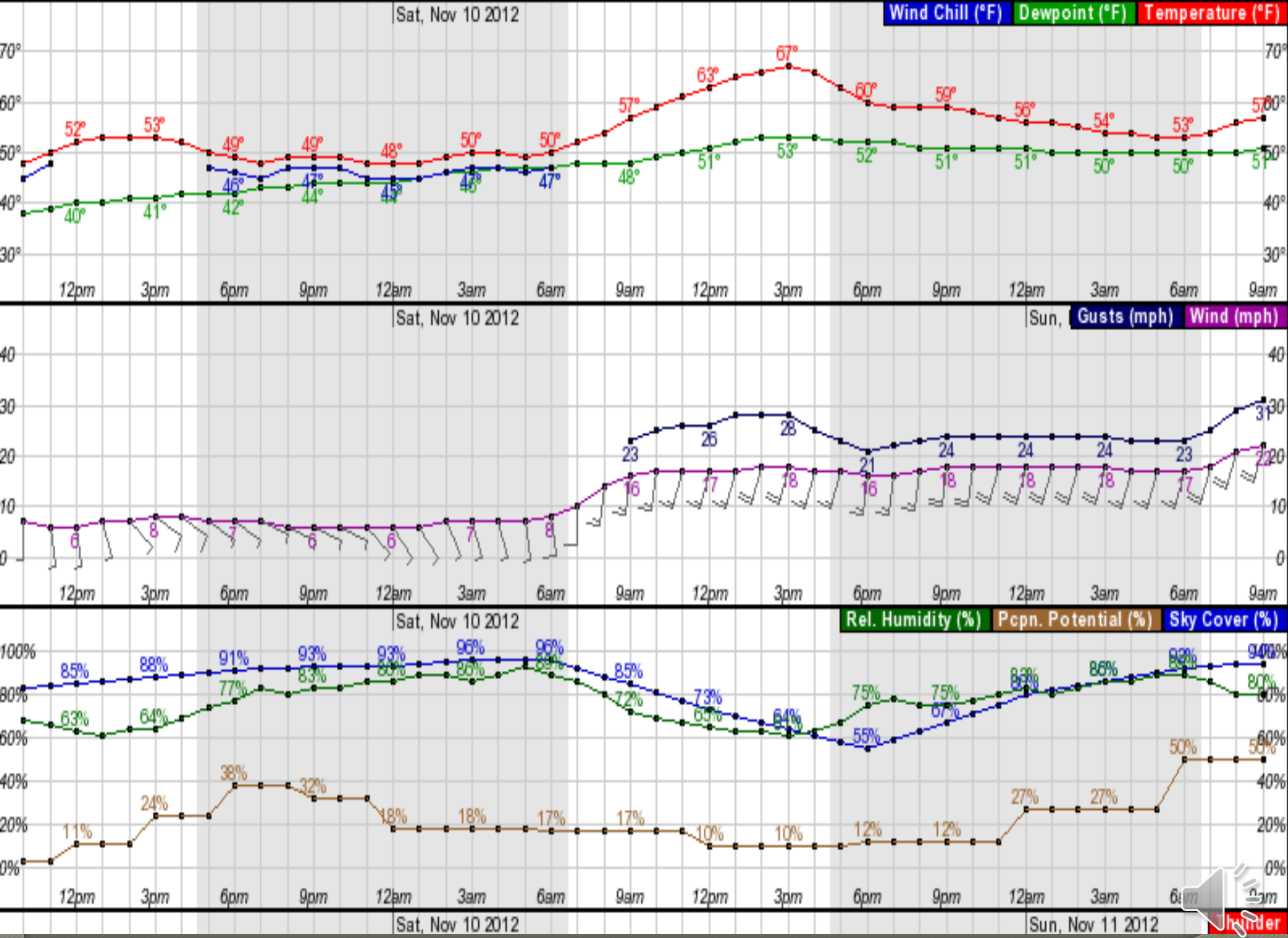

Sat, Nov 10 2012
Wind Chill (°F)
Dewpoint (°F)
Temperature (°F)
70°
60°
50°
40°
30°
52° 53° 49° 49° 48° 50° 50° 57° 63° 67° 60° 59° 56° 54° 53° 57°
40° 41° 42° 44° 45° 47° 48° 51° 53° 52° 51° 51° 50° 50° 51°
12pm 3pm 6pm 9pm 12am 3am 6am 9am 12pm 3pm 6pm 9pm 12am 3am 6am 9am
Sat, Nov 10 2012
Sun,
Gusts (mph)
Wind (mph)
40
30
20
10
0
23 26 28 21 24 24 24 23 31
16 17 18 16 18 18 18 17 22
6 8 7 6 6 7 8
12pm 3pm 6pm 9pm 12am 3am 6am 9am 12pm 3pm 6pm 9pm 12am 3am 6am 9am
Sat, Nov 10 2012
Rel. Humidity (%)
Pcpn. Potential (%)
Sky Cover (%)
100%
80%
60%
40%
20%
0%
85% 88% 91% 93% 93% 96% 96% 85% 73% 64% 55% 86%
63% 64% 77% 83% 86% 86% 72% 65% 64% 75% 75% 86% 80%
11% 24% 38% 32% 18% 18% 17% 17% 10% 10% 12% 12% 27% 27% 50%
12pm 3pm 6pm 9pm 12am 3am 6am 9am 12pm 3pm 6pm 9pm 12am 3am
Sat, Nov 10 2012
Sun, Nov 11 2012
Thunder

Why are your 20’ winds lower than the surface winds on your hourly weather graph?

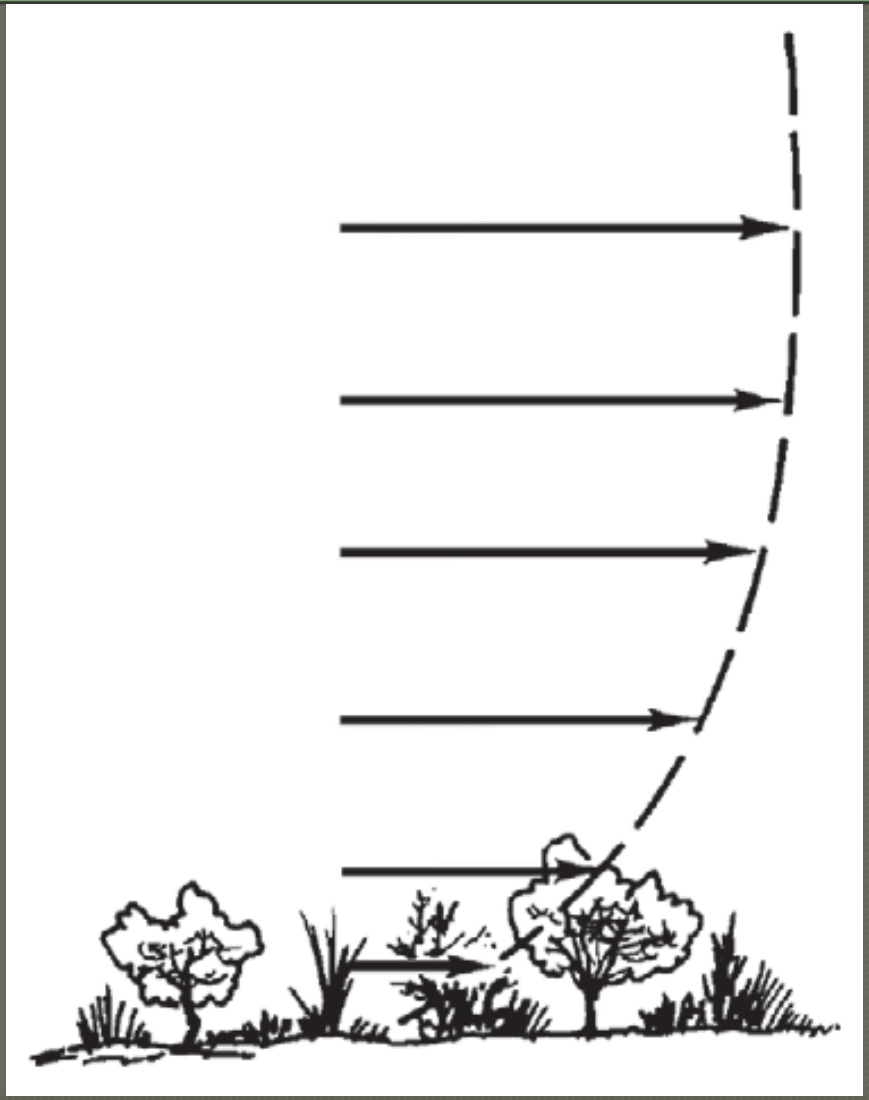
Surface winds (in meteorology) are defined as the wind speed at 10 meters (roughly 33 feet) above the ground. All of the wind speeds and gusts at all of the airport locations (UGN, PWK, ORD, DPA, RFD, DKB, etc.) are all measured at 10 meters. Whenever you see a wind forecast, if it doesn't specifically say 20 foot (or some other height), you should automatically assume it is for 10 meters.

Casey Sullivan NOAA Chicago Office

But there's more…

That is why the 20 foot wind is lower than the surface wind (which is at 10 meters). We (NWS Chicago) use a standard 20% reduction in wind speeds from 10 meters to 20 feet. So a wind forecast of 10 mph would produce a 20 foot wind of 8 mph. There are a few times when this will not be the case. Strong cold air advection winds can be more efficient mixing stronger winds further to the surface, so in those cases, it might only be 85%, as an example. Likewise, strong warm air advection over cold ground (or snow covered ground) might be 75%, meaning less wind (then the standard 80%) is making it to 20 feet.

General wind velocity profile near surface (from Rothermel 1983).



Sources of Information

http://math.fire.org

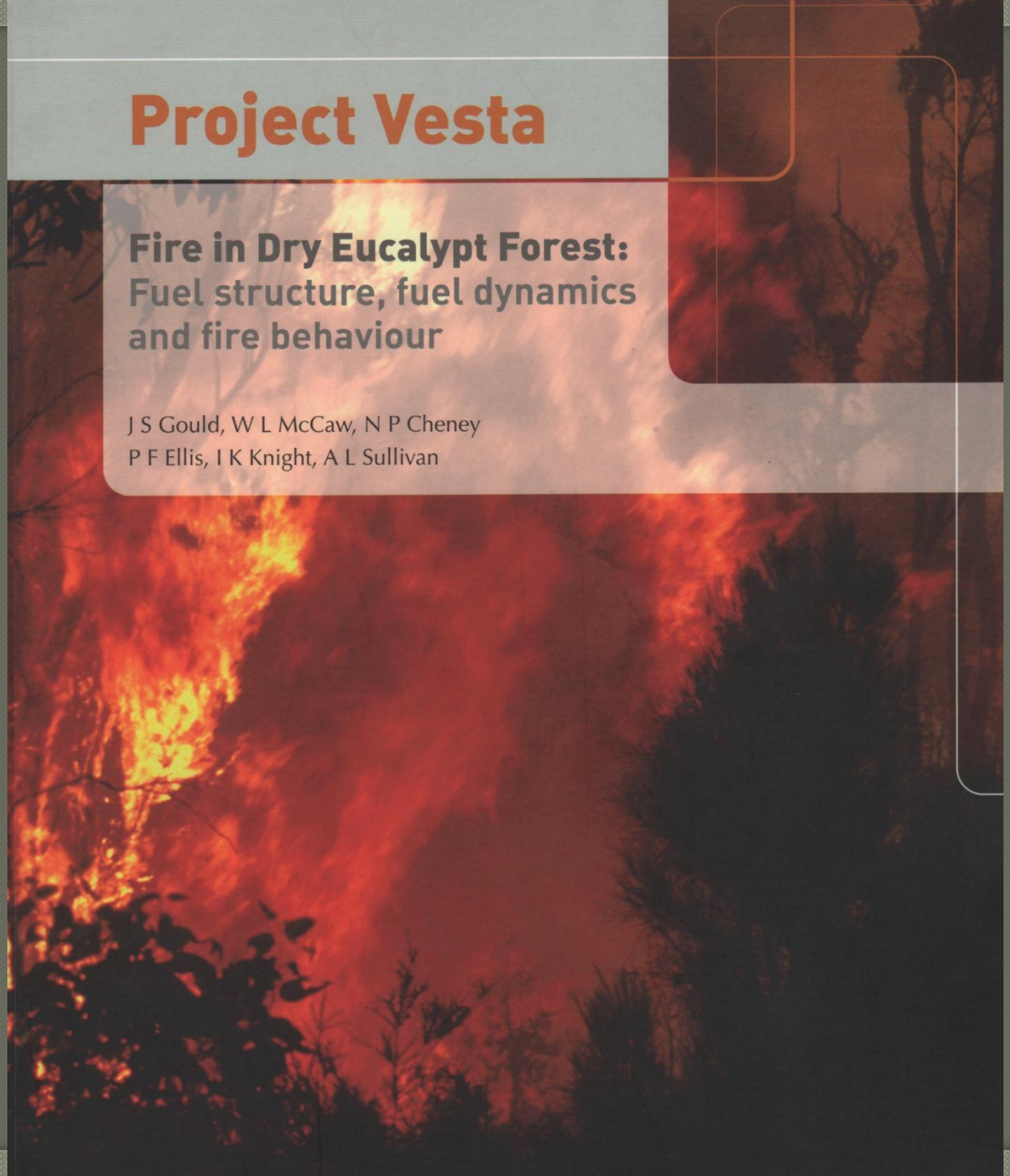
http://www.firemodels.org/behave

http://www.srh.noaa.gov

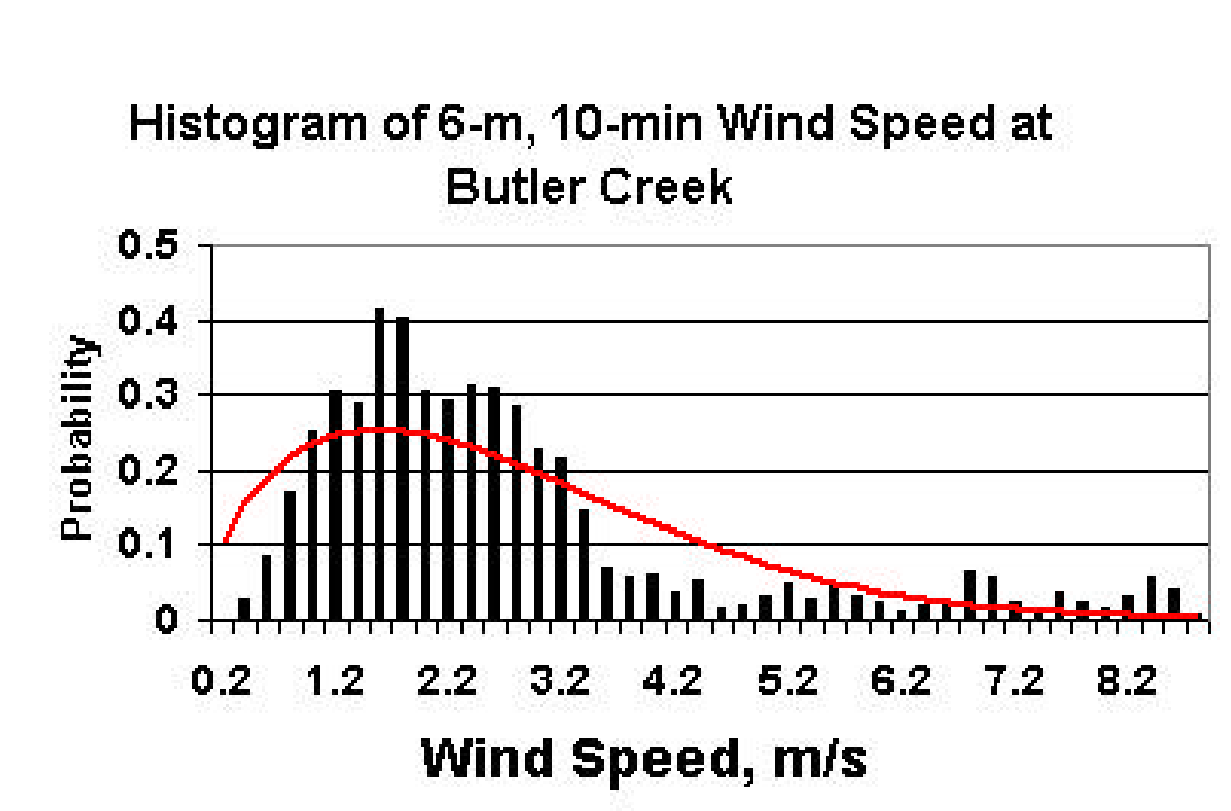
Modeling Wind Adjustment Factors and Midflame Windspeed for Rothermel Surface Fire Spread Model

Particia Andrews USDA Forest Service Gen. Tech. Rep. RMRS-GTR-266. 2012

Keyword – Wind Adjustment Factor


Project Vesta
Fire in Dry Eucalypt Forest:
Fuel structure, fuel dynamics
and fire behaviour
J S Gould, W L McCaw, N P Cheney
P F Ellis, I K Knight, A L Sullivan

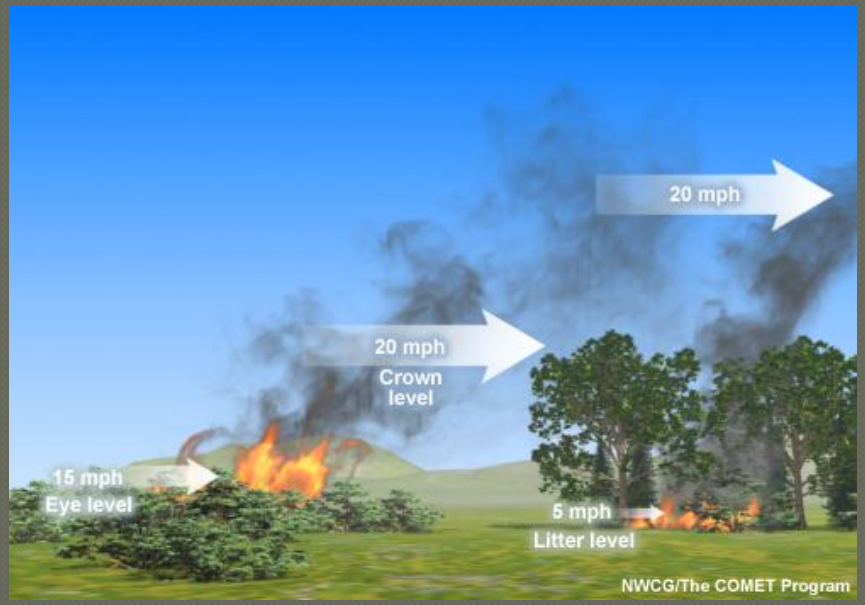
Analysis of Average Wind Speeds. Bradshaw, Petrescu and Grenfell



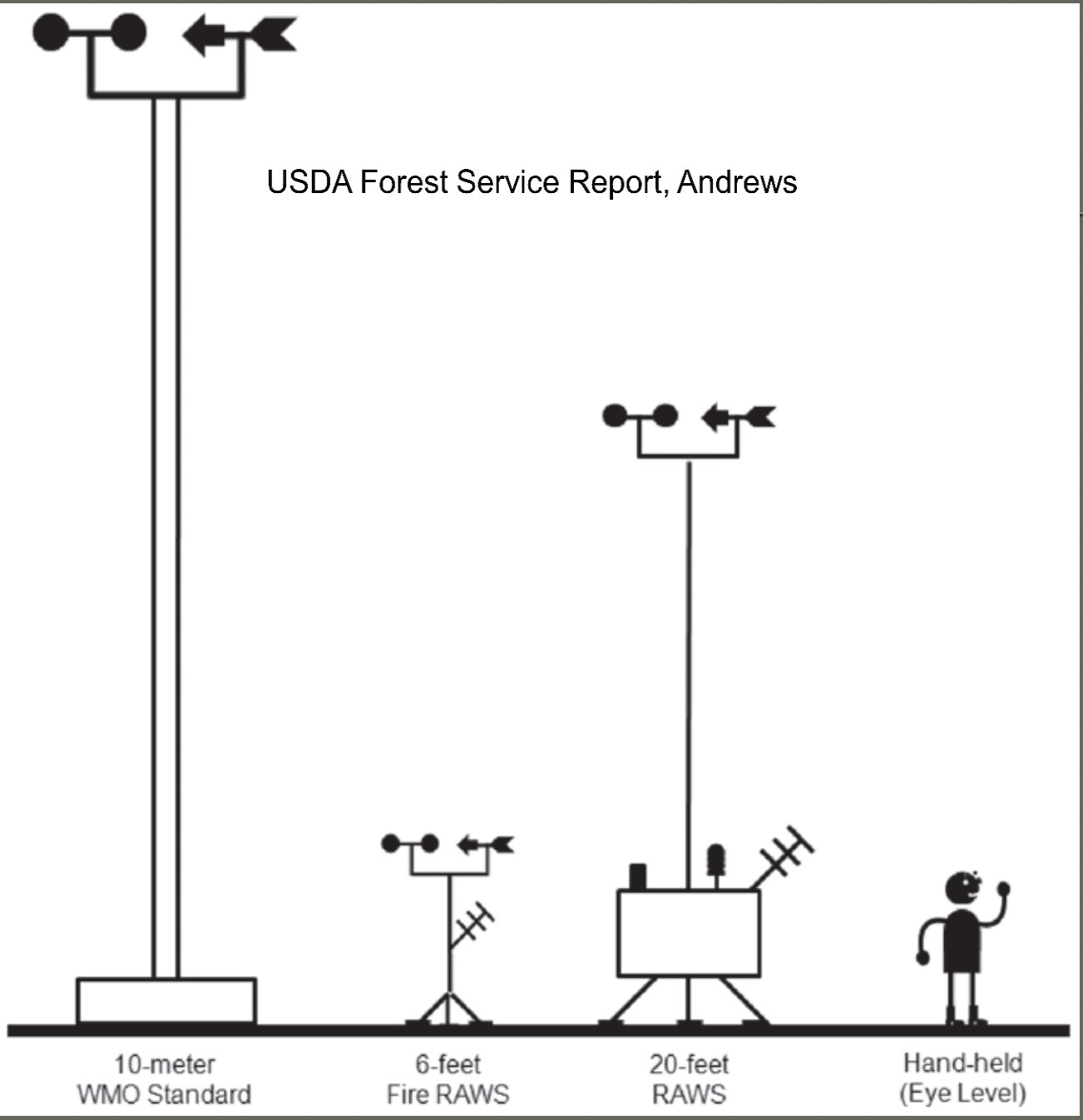
20’ Wind

firefightermath.org

- Sustained winds averaged over a 10 minute period and measured 20’ above the average height of nearby vegetation.
- This is the standard reported by the remote automated weather stations (raws)



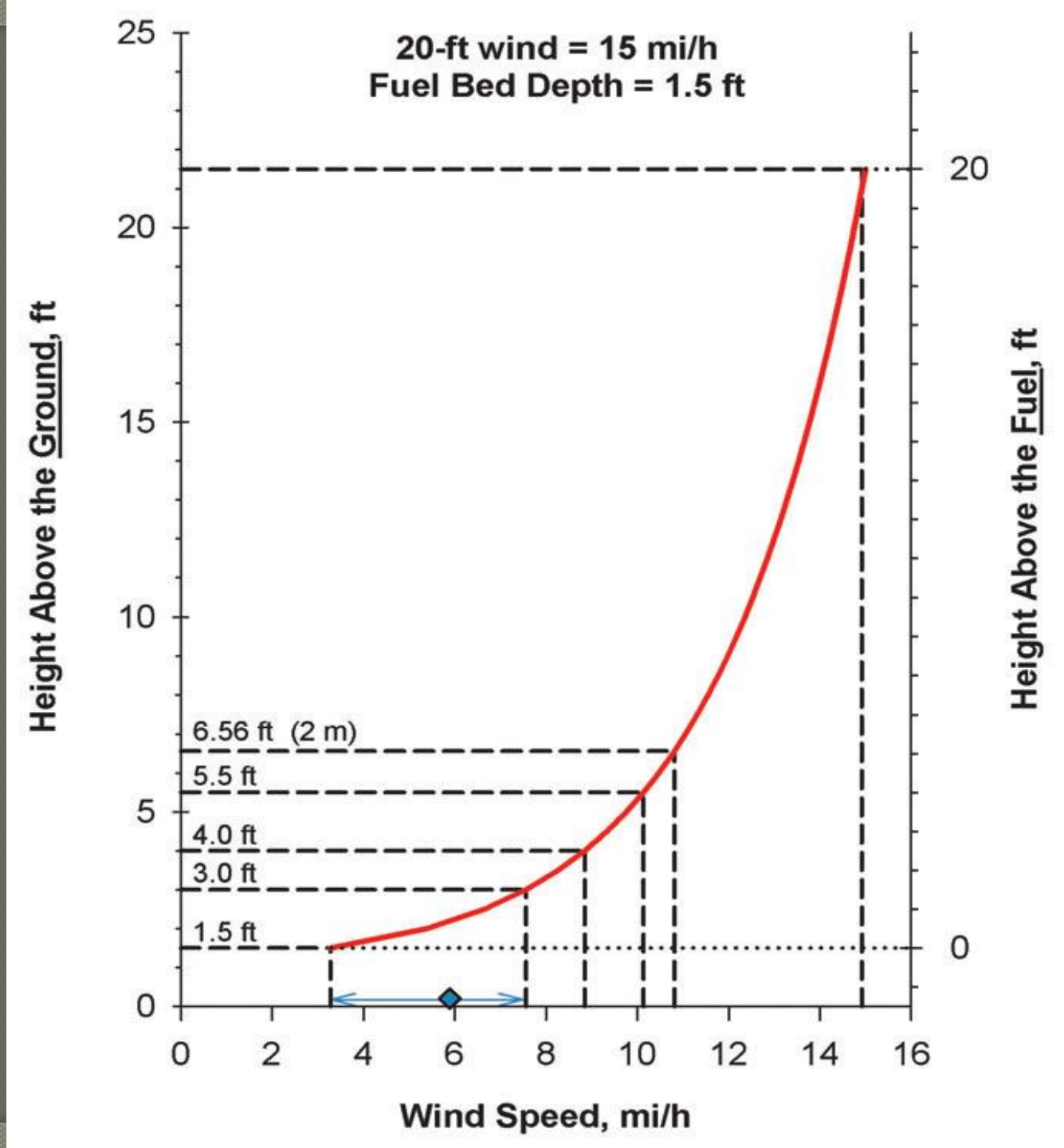
USDA Forest Service Report, Andrews



Hand Held Wind Meters

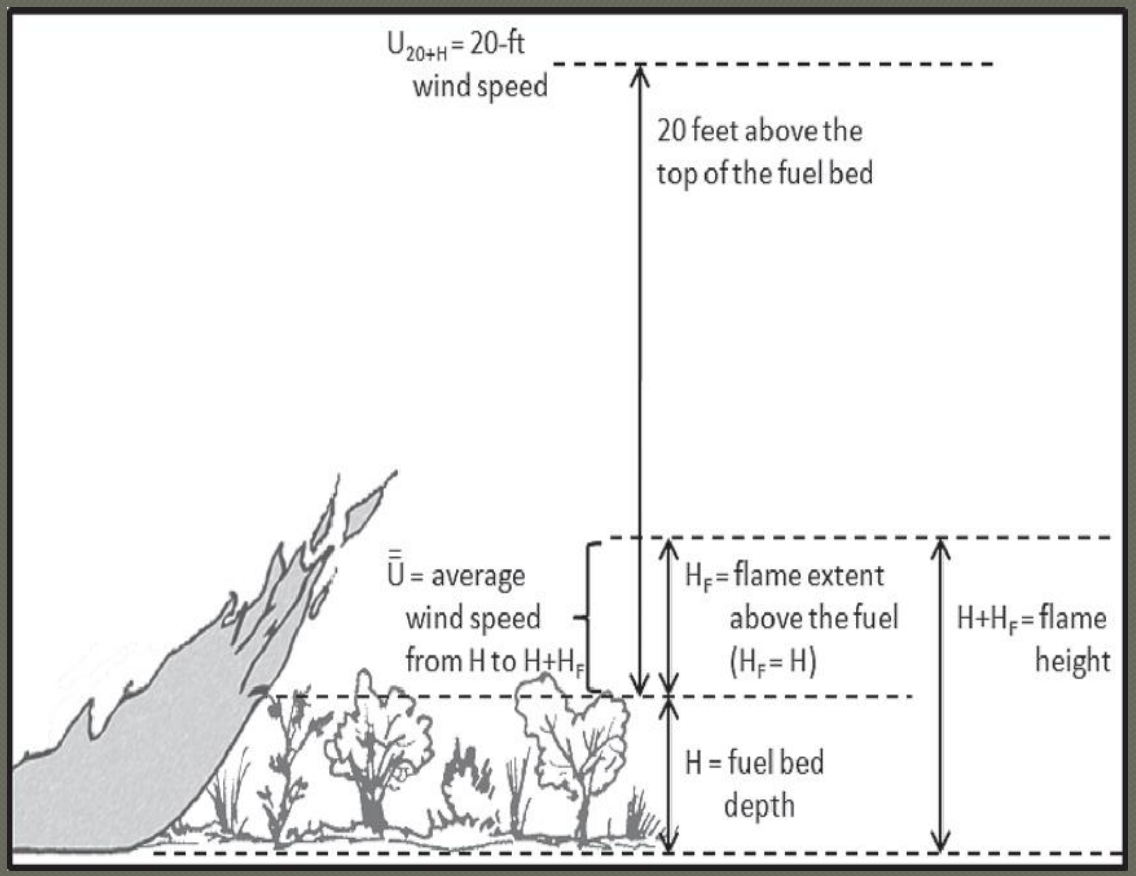
KESTREL 1000 ~ $75

KESTREL 3000 ~ $150


20-ft wind = 15 mi/h
Fuel Bed Depth = 1.5 ft
Height Above the Ground, ft
Height Above the Fuel, ft
Wind Speed, mi/h
25
20
15
10
5
0
20
0
0
2
4
6
8
10
12
14
16
6.56 ft (2 m)
5.5 ft
4.0 ft
3.0 ft
1.5 ft

Midflame Wind Speed. Andrews

- Velocity of the wind taken at the mid-height of the flames



Midflame Height

How do you measure midflame height
prior to burning to make a useful prediction?

Midflame Height

Average wind from 1.5’ to 3’ above the ground

Average wind speed from top of the fuel bed to twice the fuel bed height.

Midflame is poorly defined and in practice is often taken to be at eye level.

4’ prairie/grassland= 4’ – 8’
Woodland/leaf litter = 3” – 6” ??

Wind Adjustment Factor "No Trees"

Fuel Model	Behave Plus	Fireline Handbook	Smith (2007)
1 Short grass prairie	.4	.4	.36
2 Grass w/ scattered trees	.4	.4	.36
3 Tallgrass prairie	.4	.4	.44

10 mph (20' wind) X .4 = 4 mph midflame height wind
25 mph (20' wind) X .4 = 10 mph midflame height wind

Wind Adjustment Factor "No Trees"

Forecast	Actual	Brad's
10 M	Eye Level	WAF
6 mph	2 mph	.33
9 mph	3.5 mph	.38

9 mph (20% less) = 7.2 mph equals 20' wind
7.2 mph x .4 = 2.88 mph equals midflame wind

Predicted 2.8 mph vs. actual of 3.5 mph

Pick your Parameters

20’ wind about 20% less than 10 meter “surface”

10 meter X .4 = 3.6
20’ wind X .4 = 2.8 mph

actual eye level wind = 3.5 mph

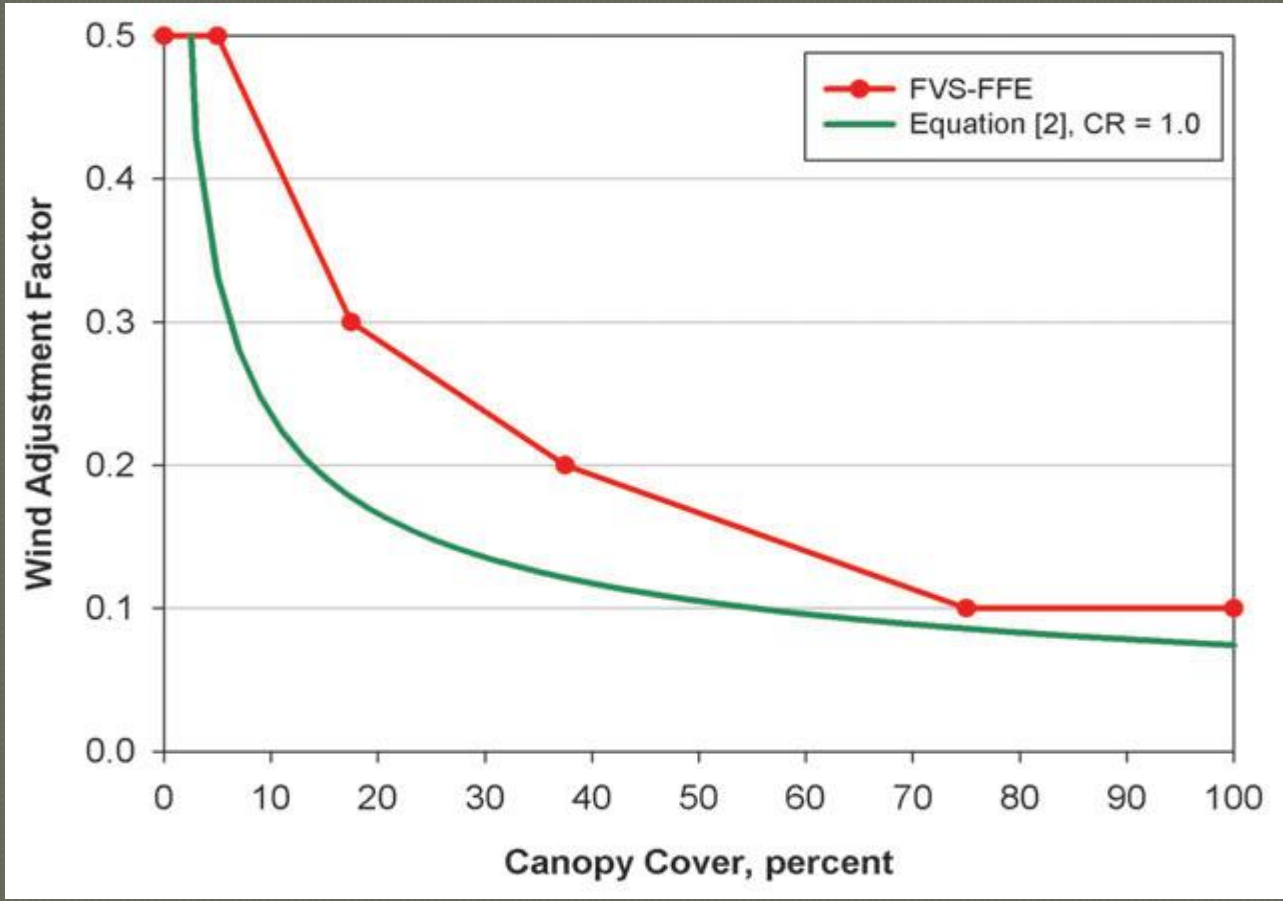
Keep it Simple .4 WAF Works

10 M Forecast		Eye Level Wind
5 mph	x .4 =	2 mph
10 mph	x .4 =	4 mph
15 mph	x .4 =	6 mph
20 mph	x .4 =	8 mph
25 mph	x .4 =	10 mph
30 mph	x .4 =	12 mph

“Savannas” and “Brushy Woodlands”

Canopy Results in 50%-90% Reduction

Patricia Andrews



Wind Adjustment Factor "Woodlands"

Fuel Model		Behave Plus	Fireline Handbook	Smith (2007)
9	Oak Woodland	.3	.4	.28

10 mph (20' wind) X .3 = 3 mph midflame height wind
25 mph (20' wind) X .3 = 7.5 mph midflame height wind

Wind Adjustment Factor "Open Woods"

Forecast	Actual	Brad's
10 M	Eye Level	WAF
9 mph	1.5 mph	.16

9 mph (20% less)	= 7.2 mph	equals 20' wind
7.2 mph x .3	= 2.1 mph	equals midflame wind

Predicted 2.1 mph vs. actual of 1.5 mph

Wind Adjustment Factor "Open Woods"

Forecast	Actual	
10 M	Eye Level	WAF
23 mph	4 mph	.2

23 mph x (20% less) = 18.4 mph equals 20' wind
18.4 mph x .3 = 5.5 mph equals midflame wind

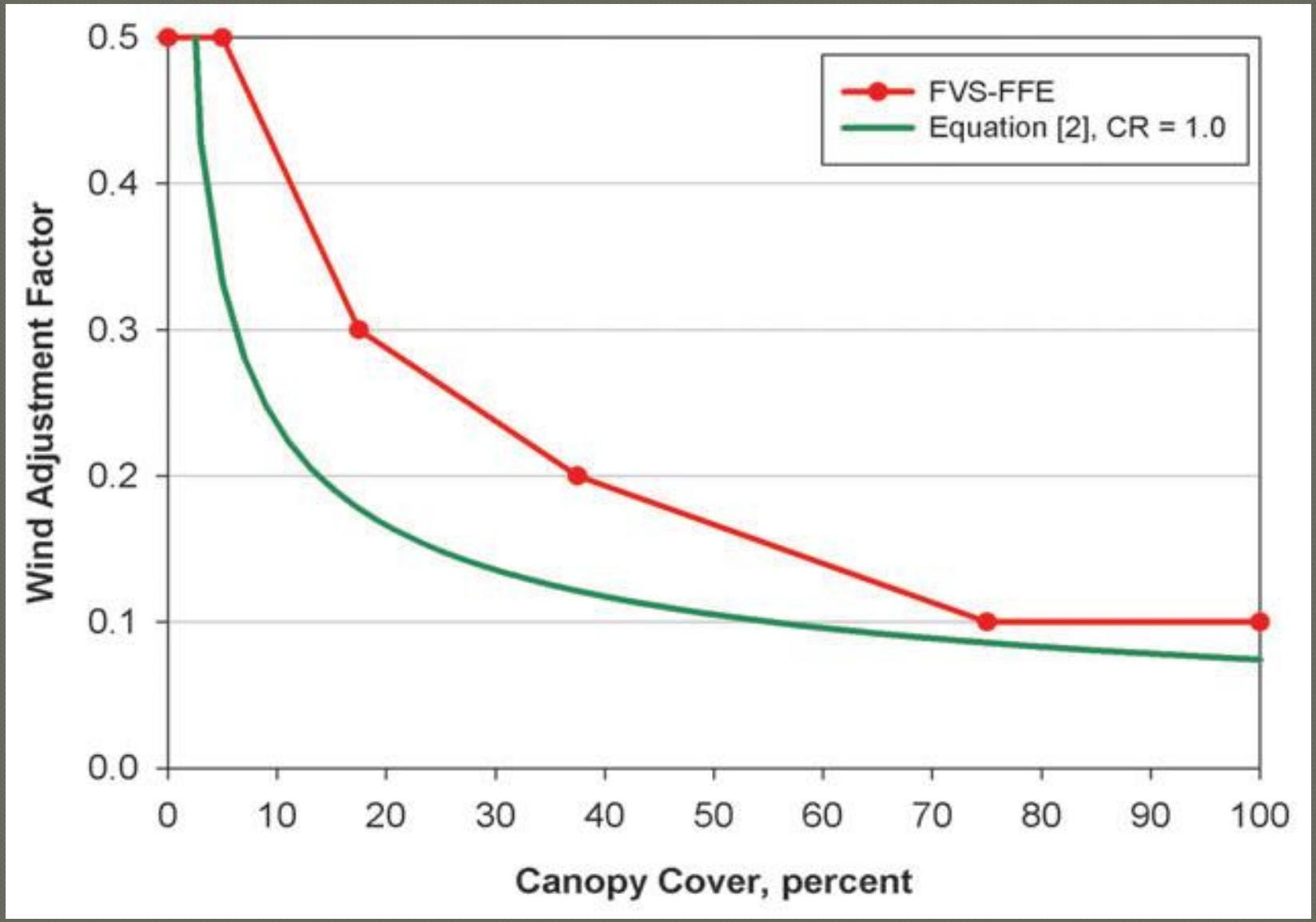
Predicted 5.5 mph vs. actual of 4 mph

Wind Adjustment Factor "Brushy Woods"

Forecast	Actual	Brad's
10 M	Eye Level	WAF
23 mph	2 mph	.1

23 mph (20% less) = 18.4 mph equals 20' wind
18.4 mph x .3 = 5.5 mph equals midflame wind

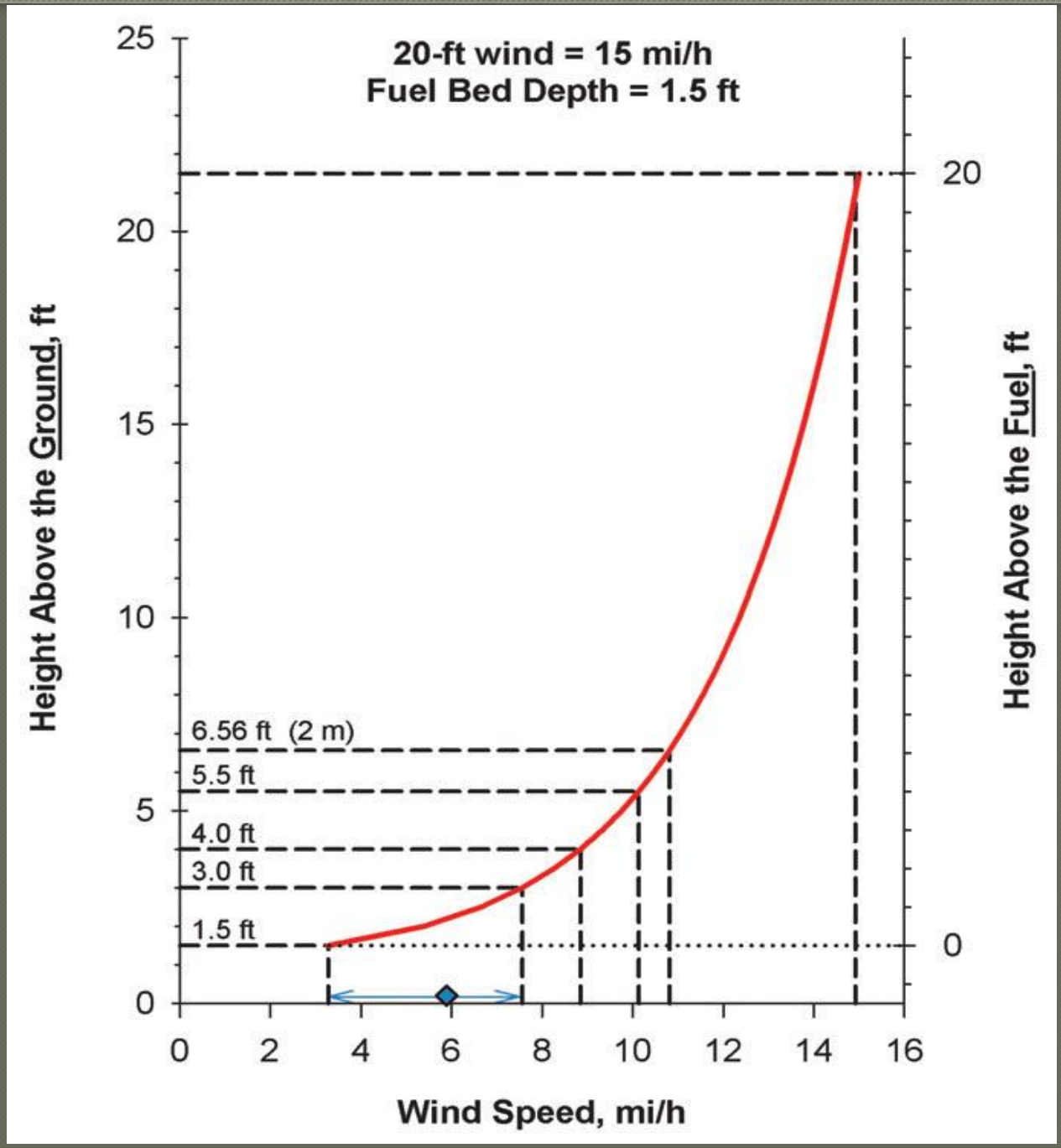
Predicted 5.5 mph vs. actual of 2 mph


FVS-FFE
Equation [2], CR = 1.0
Wind Adjustment Factor
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
Canopy Cover, percent

"High Winds" Needed .1 WAF

10 Meter Wind	Eye Level Wind
10 mph x .1 =	1 mph
15 mph x .1 =	1.5 mph
20 mph x .1 =	2 mph
25 mph x .1 =	2.5 mph
30 mph x .1 =	3 mph

Remember – 70% for midflame height!


20-ft wind = 15 mi/h
Fuel Bed Depth = 1.5 ft
Height Above the Ground, ft
Height Above the Fuel, ft
Wind Speed, mi/h
25
20
15
10
5
0
20
0
0
2
4
6
8
10
12
14
16
6.56 ft (2 m)
5.5 ft
4.0 ft
3.0 ft
1.5 ft

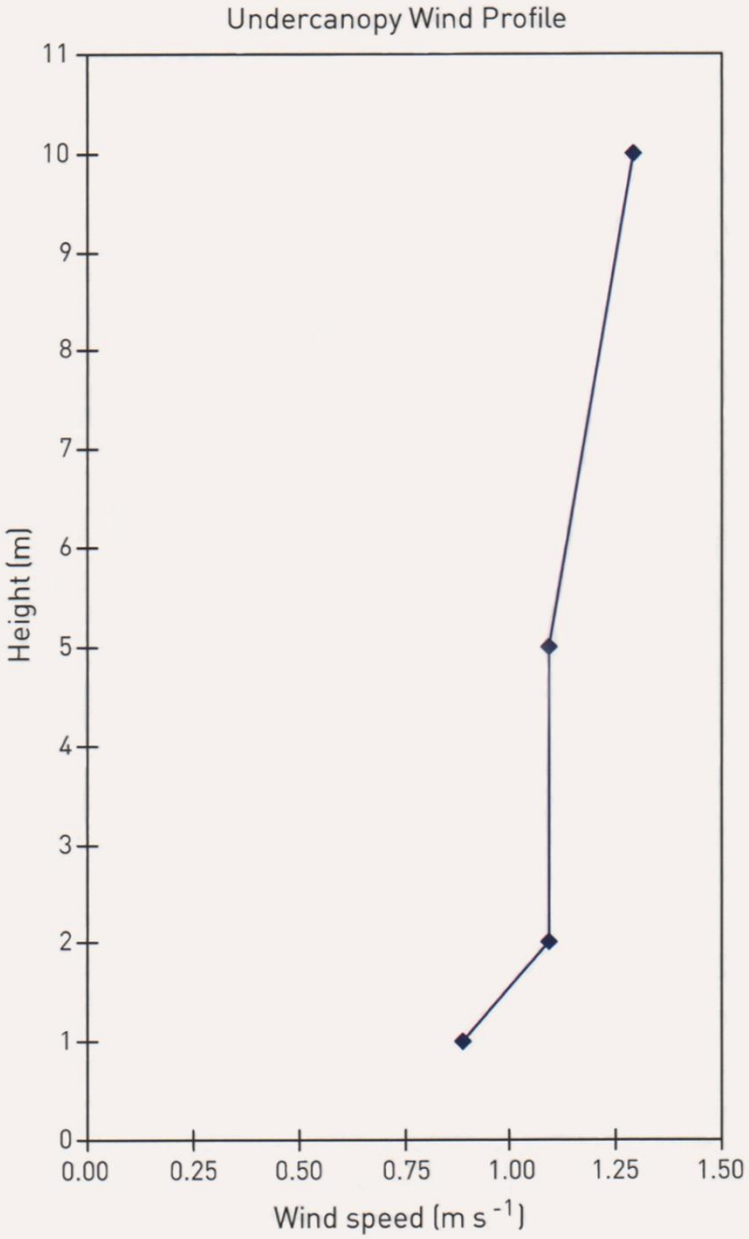


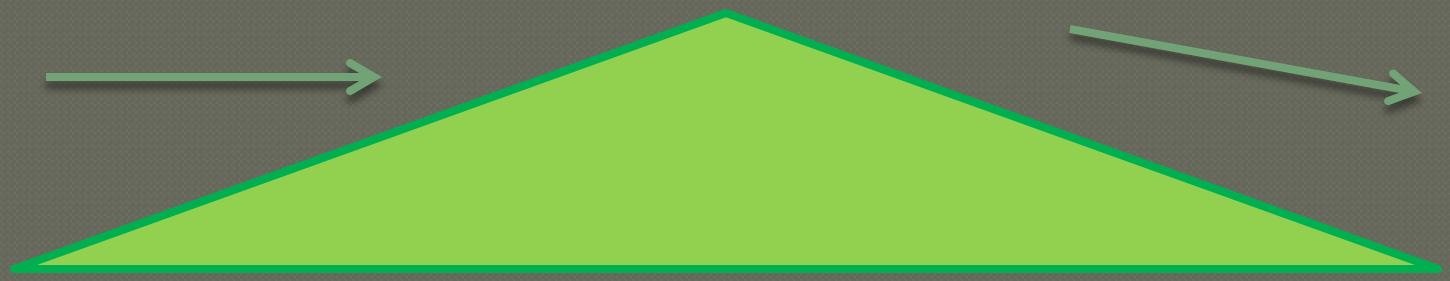
Figure 4.3 Preliminary profile measurements of under-canopy wind used to determine optimum height at which to measure under-canopy wind flow.

Midflame Height in Oak Woods with Leaf Litter Fuel

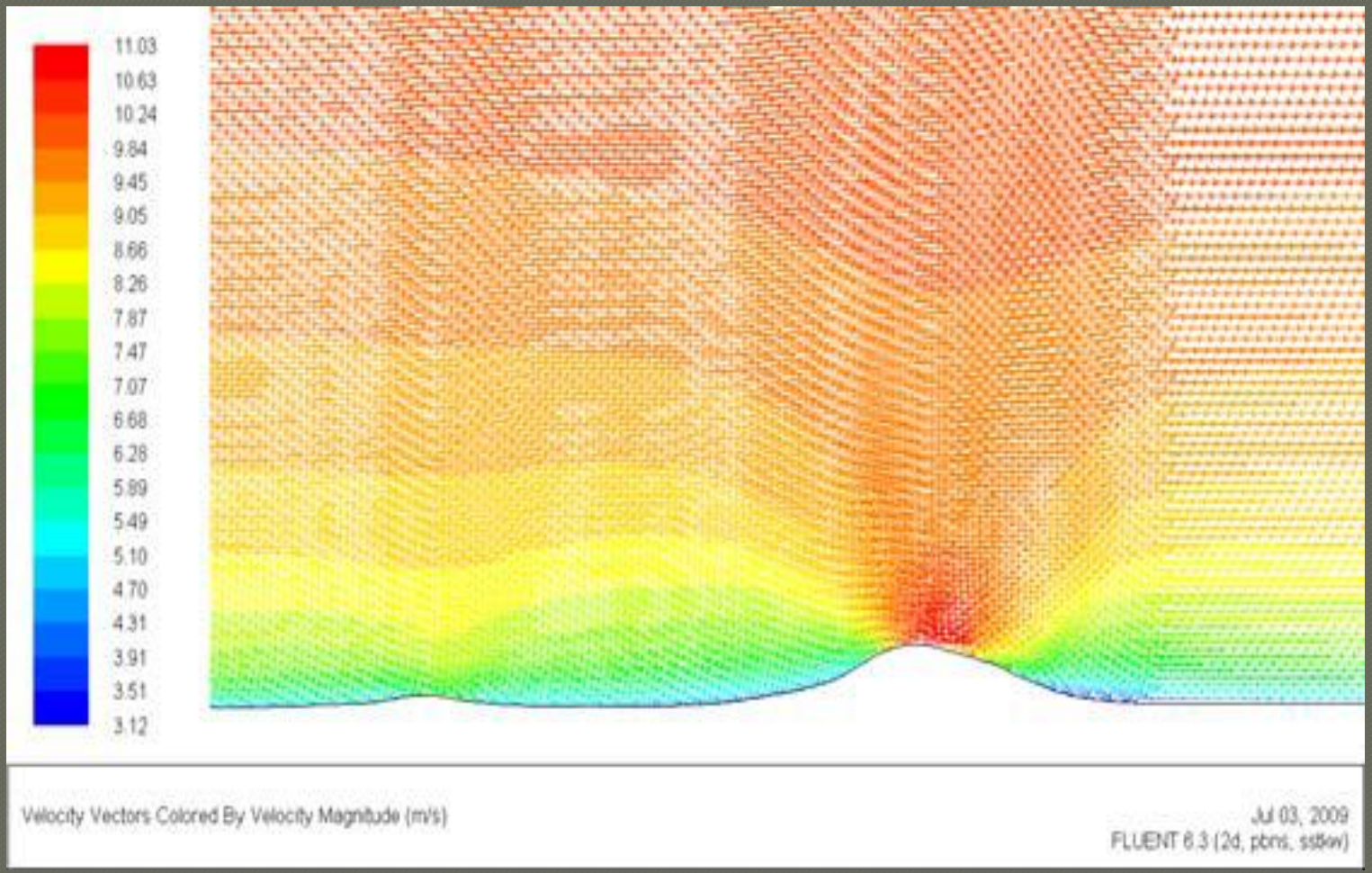
10 M Forecast wind = 17 mph

Eye Level wind	= 4 mph	= .23 WAF
1' wind	= 2 mph	= .11 WAF

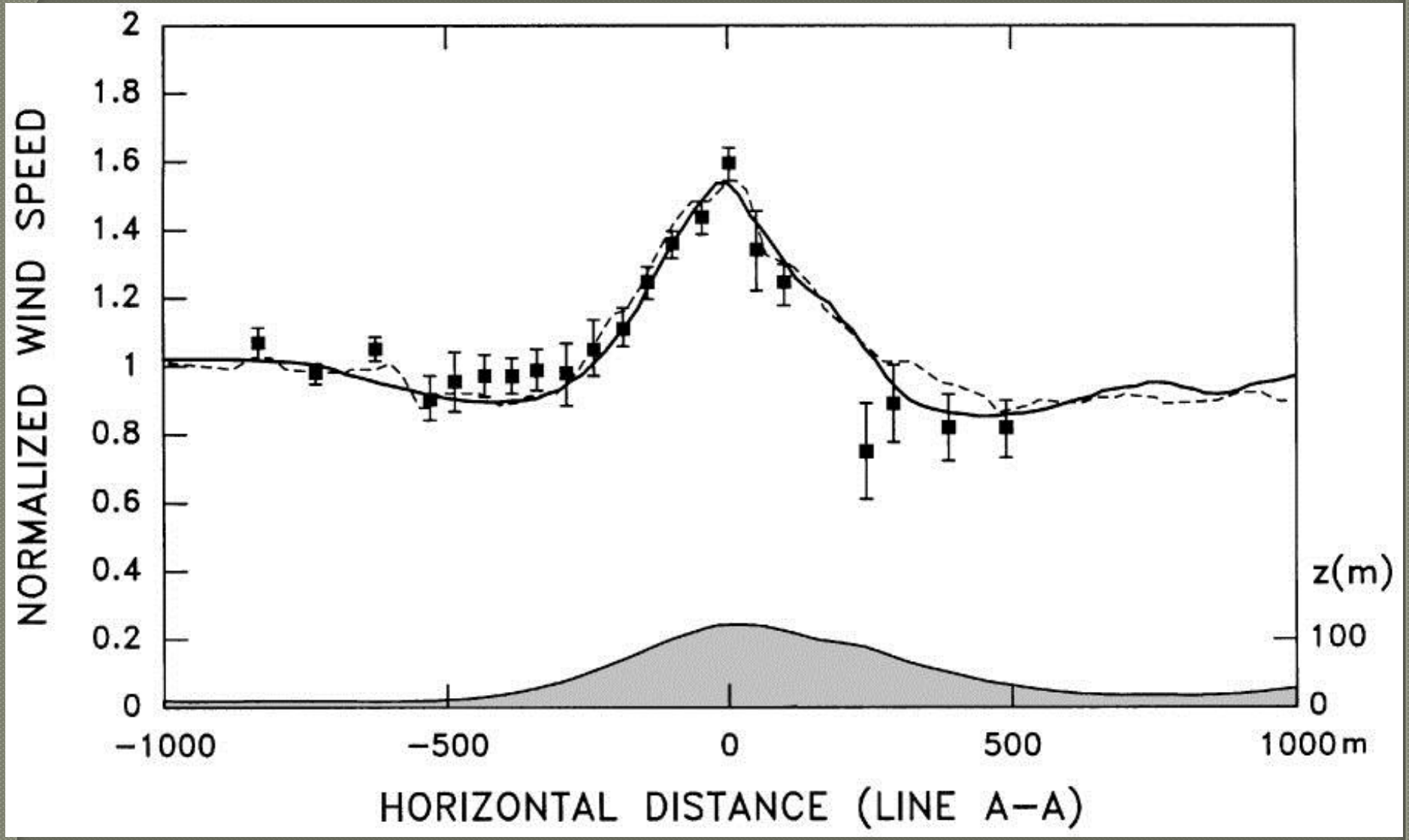
Topography vs. Wind Speed

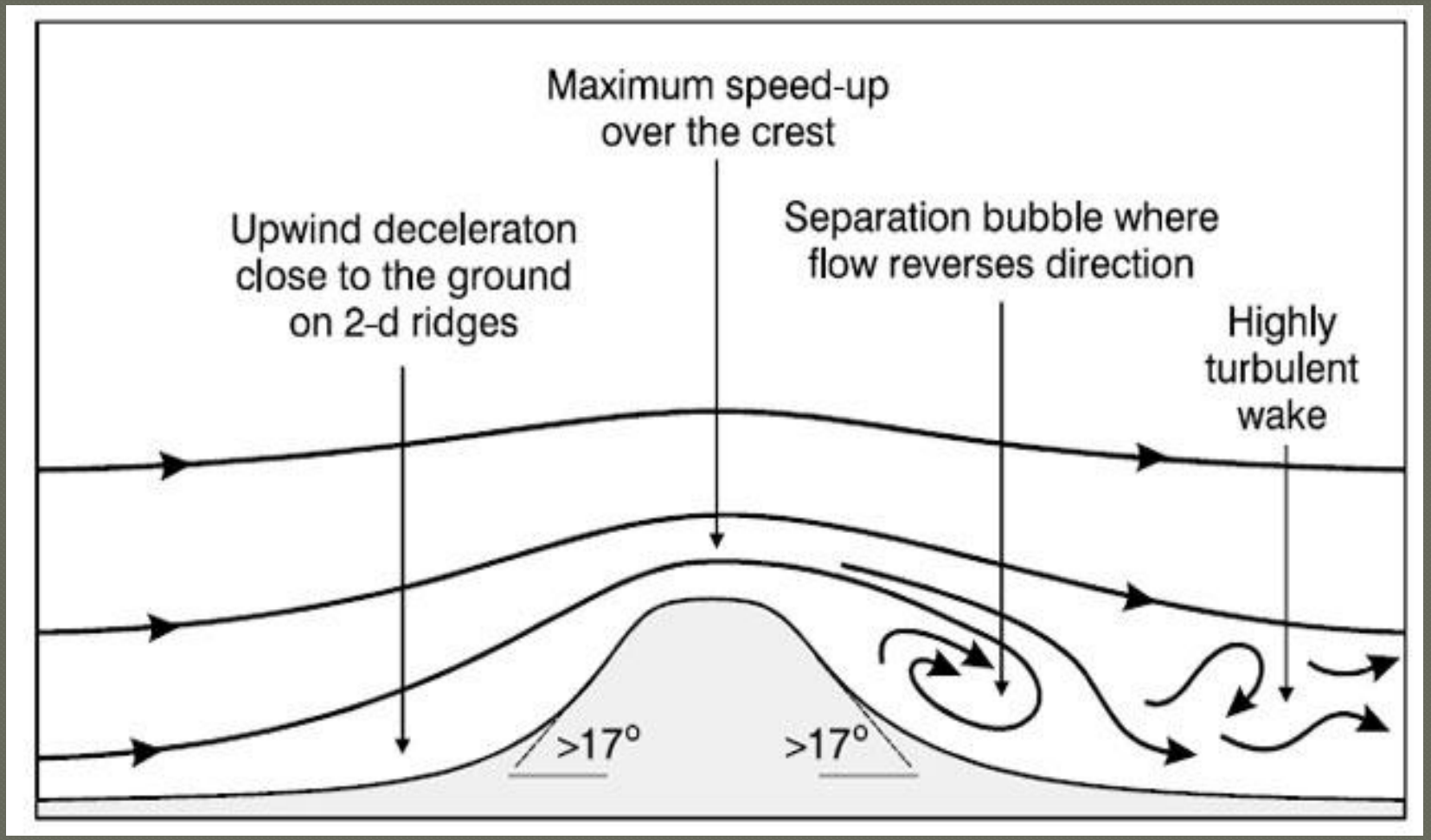


Wind Speed Increase Up Slope

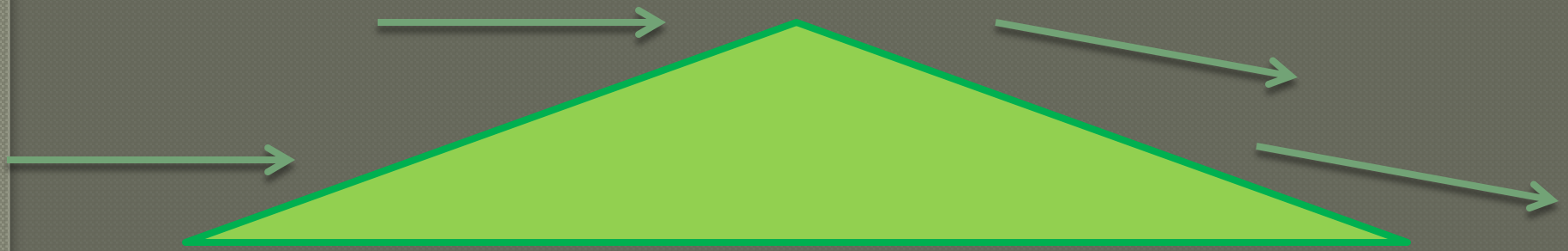



Down slope wind reduction

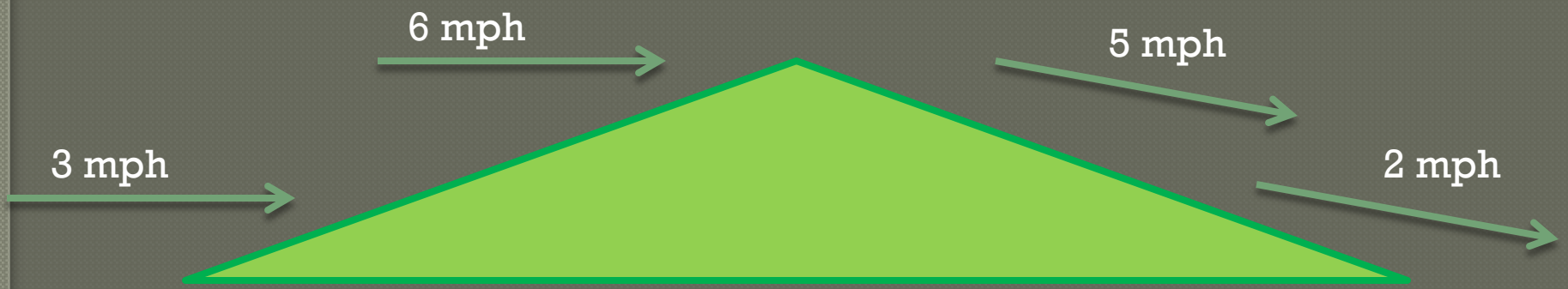

NORMALIZED WIND SPEED
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
z(m)
100
0
−1000
−500
0
500
1000 m
HORIZONTAL DISTANCE (LINE A–A)


Maximum speed-up
over the crest
Upwind deceleraton
close to the ground
on 2-d ridges
Separation bubble where
flow reverses direction
Highly
turbulent
wake
>17°
>17°

Forecast 7 mph at 10 Meters



Forecast 7 mph at 10 Meters



Topography Influences Wind Speed and Direction

How to get more done.

Increase the number of burn days.
Increase efficiency

"Weather Constraints to Scheduling Prescribed Burns"

4 Year Study 1995-1998

	Conditions
Temp (F)	>35 and < 80
Relative humidity	>25 and <75
Wind Speed	>5 and <15
Precipitation	none

Oklahoma Study – Rangelands 21(6)

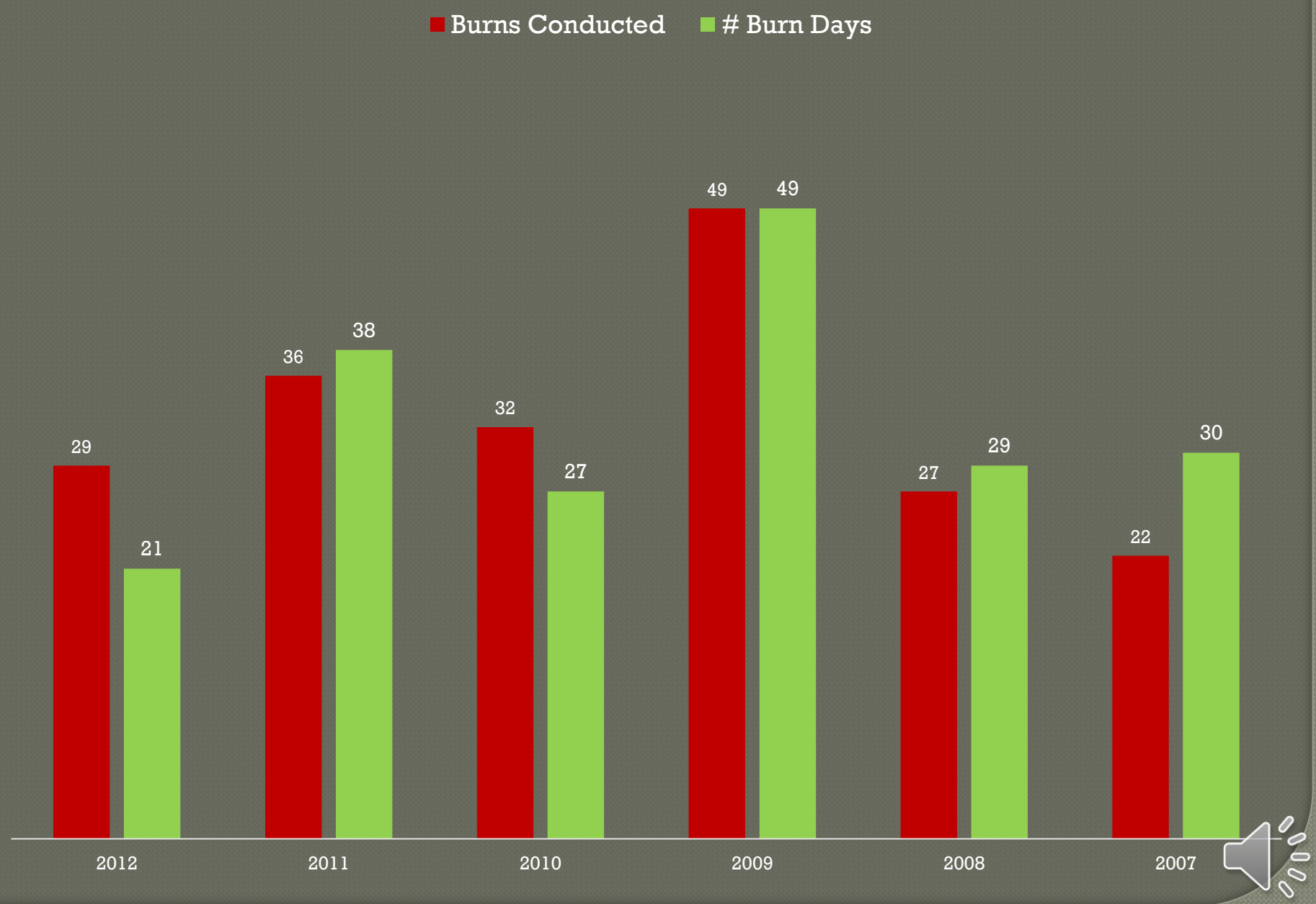
	Unacceptable days	Reason
Tallgrass prairie		
(Feb)	9	High Wind
(March)	14	High Wind
Pine forest		
(Feb)	25	Low Wind
(March)	22	Low Wind

Spring

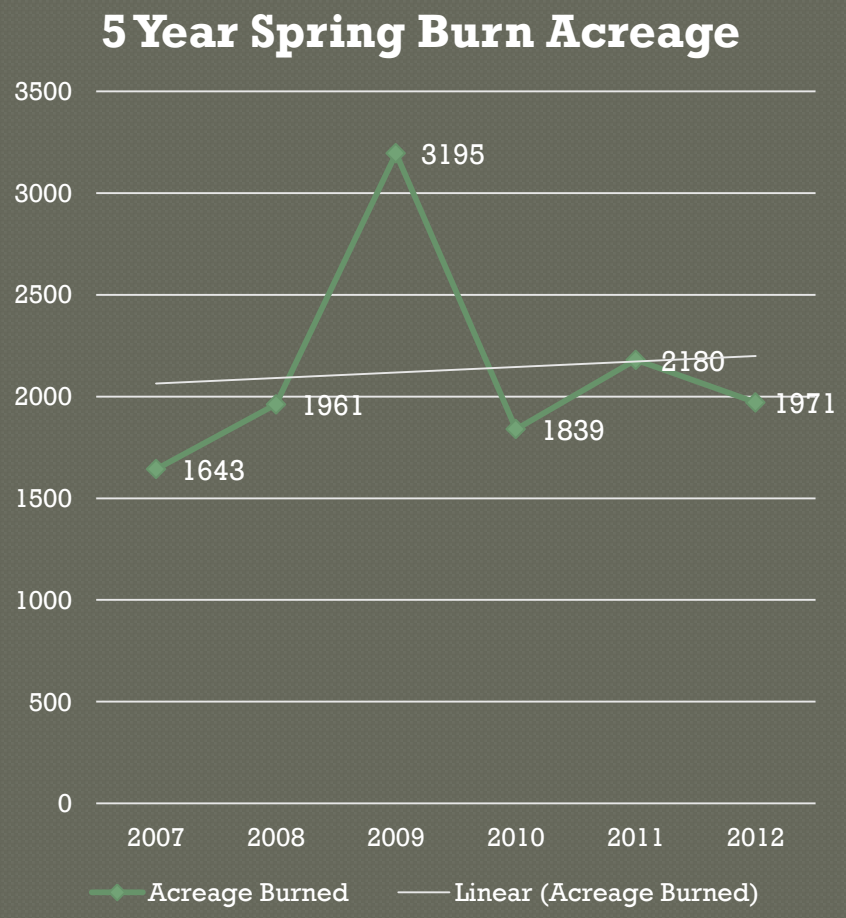
Spring Burn Season	Days	# Burns	Acreage	Ave Size
*2012 Mar 09-Mar 29	21	29	1780	61
2011 Mar 14-April 21	39	36	2180	60
2010 Mar 18-April 14	28	32	1840	57
2009 Mar 06-April 24	49	49	3195	65
2008 Mar 26-April 24	29	27	1961	72
2007 Mar 19-April 18	31	22	1600	72

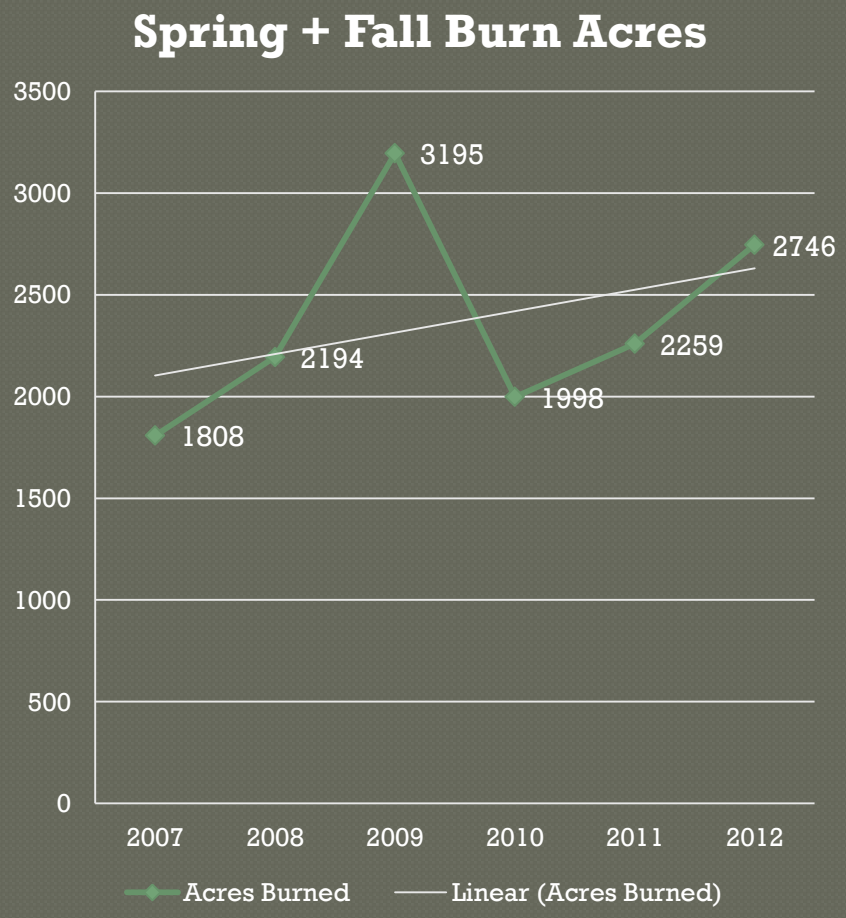
"Season" is time from our 1st to our last burn. Includes weekends.
*Did 4 burns in January of 2012 for an additional 191 acres

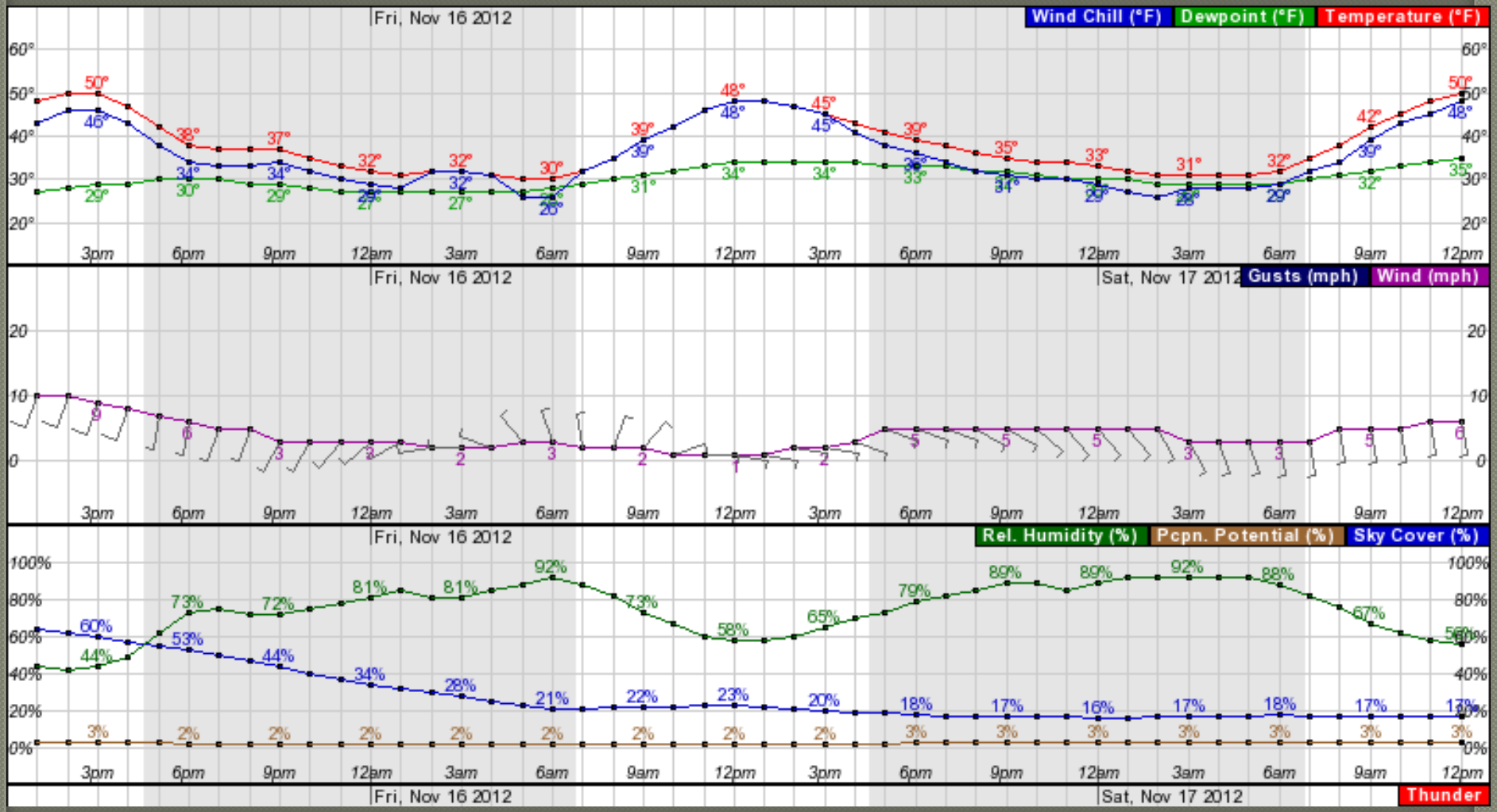
6 Year Spring Burns Trends



How to Increase Productivity






Fri, Nov 16 2012
Wind Chill (°F)
Dewpoint (°F)
Temperature (°F)
Sat, Nov 17 2012
Gusts (mph)
Wind (mph)
Rel. Humidity (%)
Pcpn. Potential (%)
Sky Cover (%)
Thunder
3pm
6pm
9pm
12am
3am
6am
9am
12pm


HUM RR Prairie 20 Miles long
60’ wide

"Day of" Burn Planning

Site	Unit	Size	Wind Direction	Breaks Complete	Priority/ last burned	Community Type	Timing
MAR		8	any	no	2006	woodland	
KLP		80	w, sw,	yes	2007	rest. Prairie	
BEC		26	not north	yes	never	mitigation	early

"New" Burn Planning

Site	Size	Wind Direction	Wind Speed	Breaks Complete	Priority/ last burned	Community Type
MAR	8	w	18-30	yes	2006	woodland
KLP	80	w, sw	5-10	yes	2007	rest. Prairie
BEC	26	not north	5- 20	yes	never	mitigation
HUM	3	any	1-10	yes	2010	prairie

Recommendations

Know your Forecast

10 meter or 20' wind

Know your WAF

.4 unsheltered

.1 to .3 sheltered

Wind Speed Recommendation

Grassland 5-20 Forecast = 2-8 mph (.4 WAF)

Woodland 18-30 Forecast = 2-9 mph (.1-.3 WAF)

Recommendations

Topography

- influence on wind direction
- reduction in down slope wind speed
- enhance up slope wind speeds
- burn into “sheltered” wooded slopes

Getting more Done…..

In 2012, burned in Jan, March, Oct, Nov, Dec

Split Crews on Small easy burns

Maximize burn days "light and variable" – 30 mph

Managing the Burn Season - Picking the right burn

Difficulty in Modeling Fire Behavior bases only on weather.

Improving Operational Models of Fire Behavior. Sullivan

Questions/Discussion