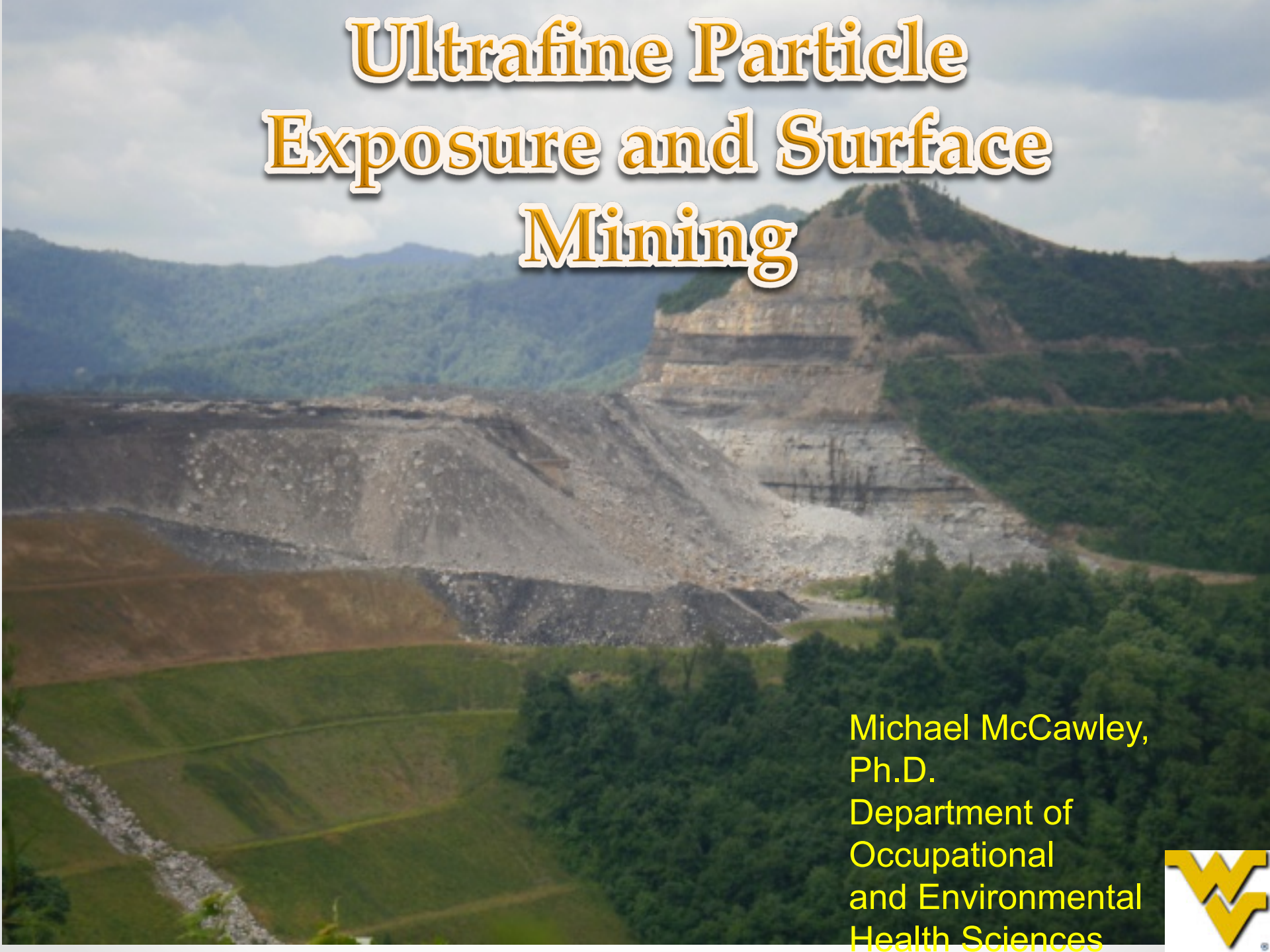
Ultrafine Particle Exposure and Surface Mining



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Overview

- Definition of “Ultrafine” particles and “Deposition”
- Mountain Top Mining and ultrafine particle exposure
- Health Effects in Surface Mining Area in West Virginia
- Methods for Determining Air Concentrations of Ultrafine Particles

Effect of UFP's

- UFP – causes greater oxidative stress, leading to inflammation (Li, et al., 2003).
- Decrement in evening peak flow in a group of asthmatic patients was best associated with the ultrafine component of the airborne particles during an episode of severe air pollution(Peters et al.,1997).
- Rats exposed to an equal airborne mass concentration of fine and ultrafine TiO2 particles, showed far more bronchoalveolar inflammation in the group with ultrafine exposure (Ferin et al., 1992).
- As little as 8,000 p/cc of a size fraction of UFP was associated with an increase in pediatric asthma admissions to emergency rooms (Anderson, et al., 2010)

HOW SMALL IS SMALL?

HUMAN HAIR

100 μ m

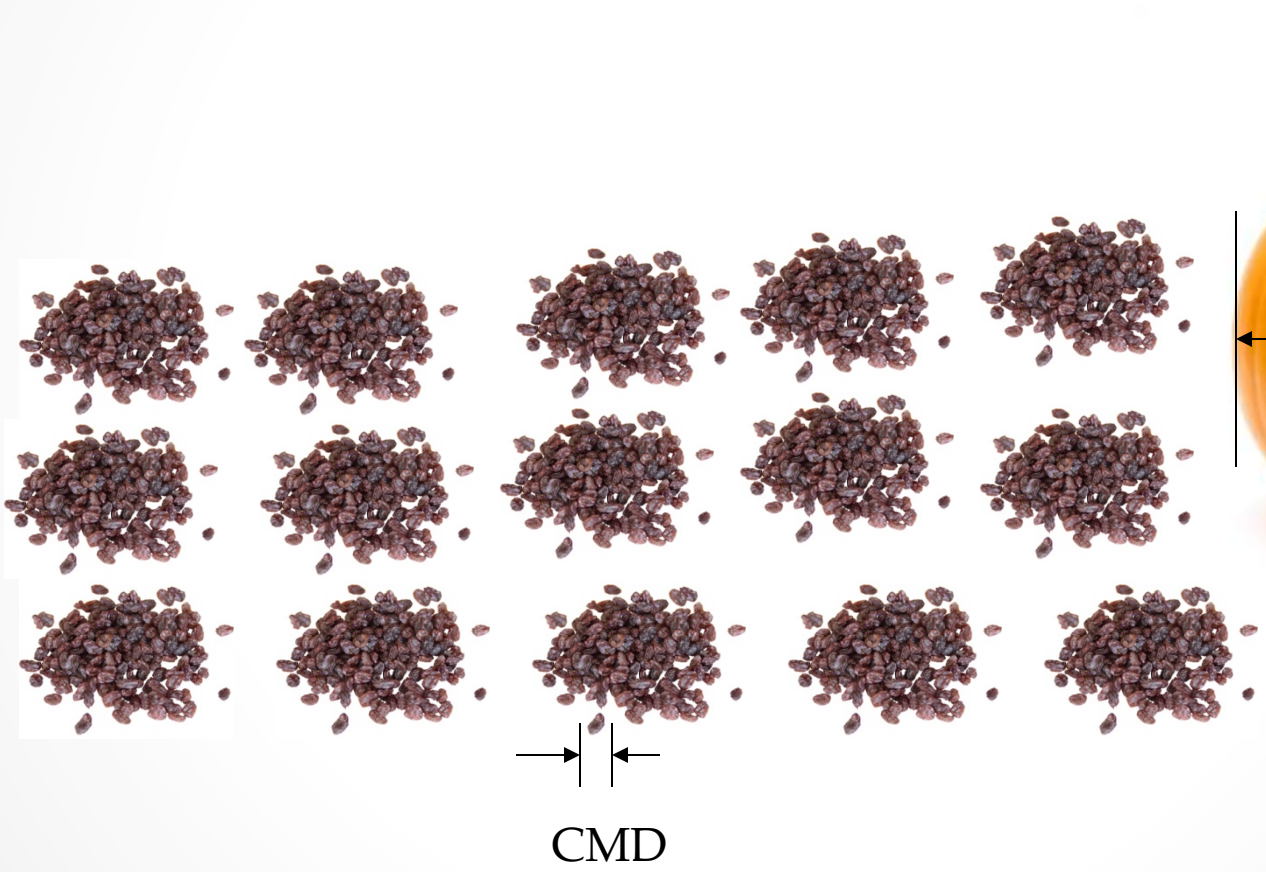
1 μ m

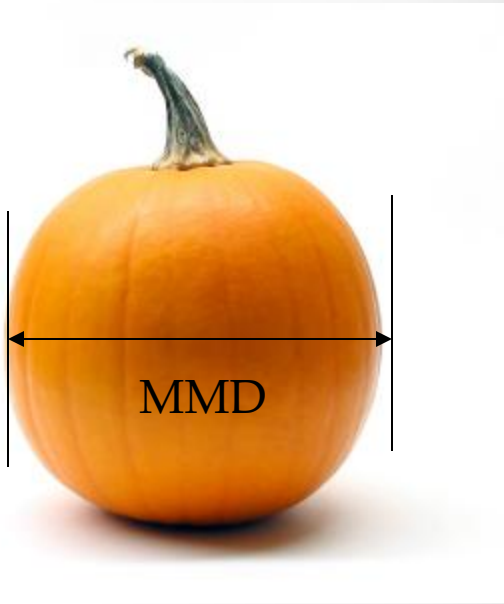
BACTERIUM

0.01 μ m

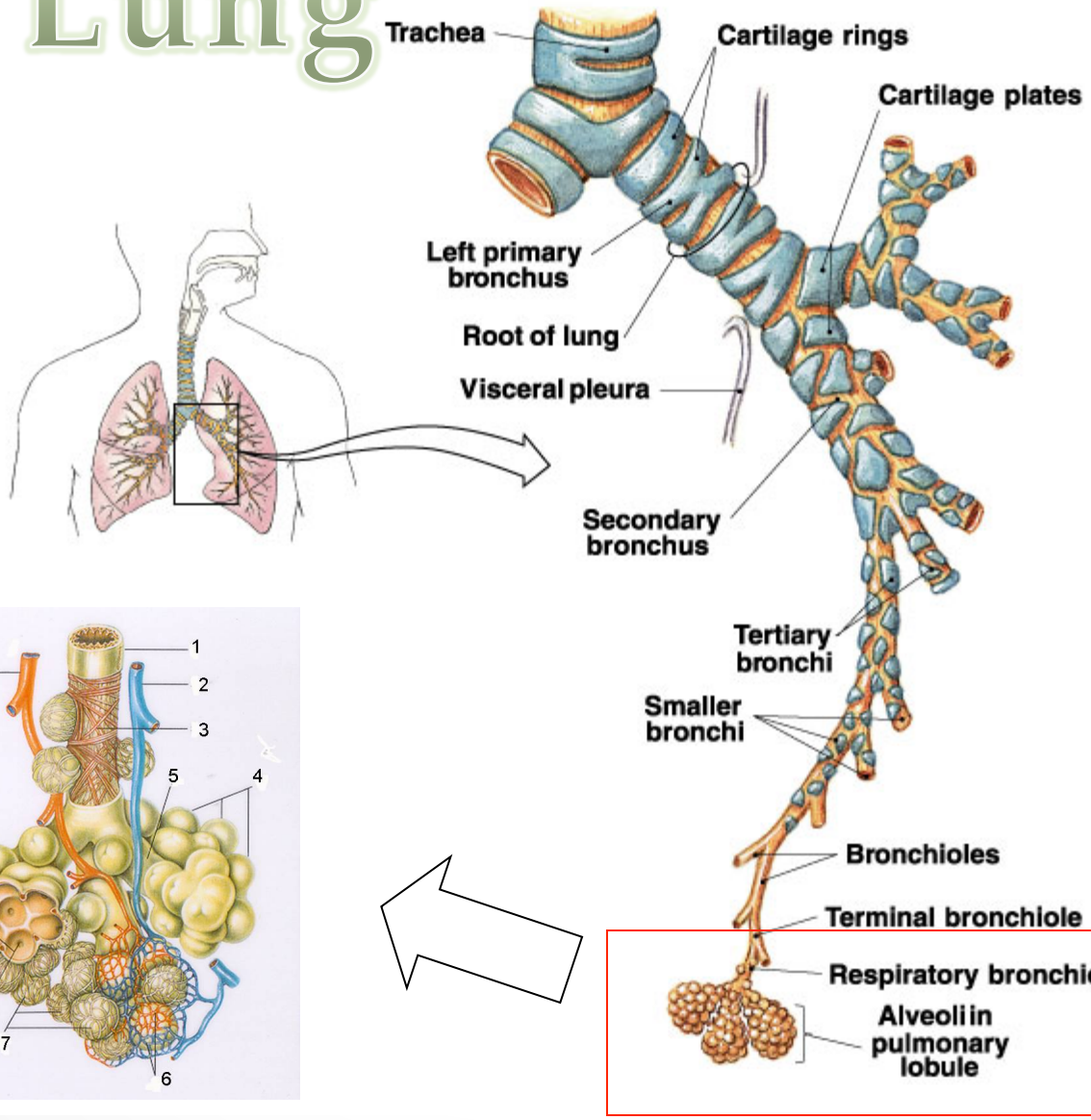
SMALL PARTICLE (TOO SMALL TO SEE)

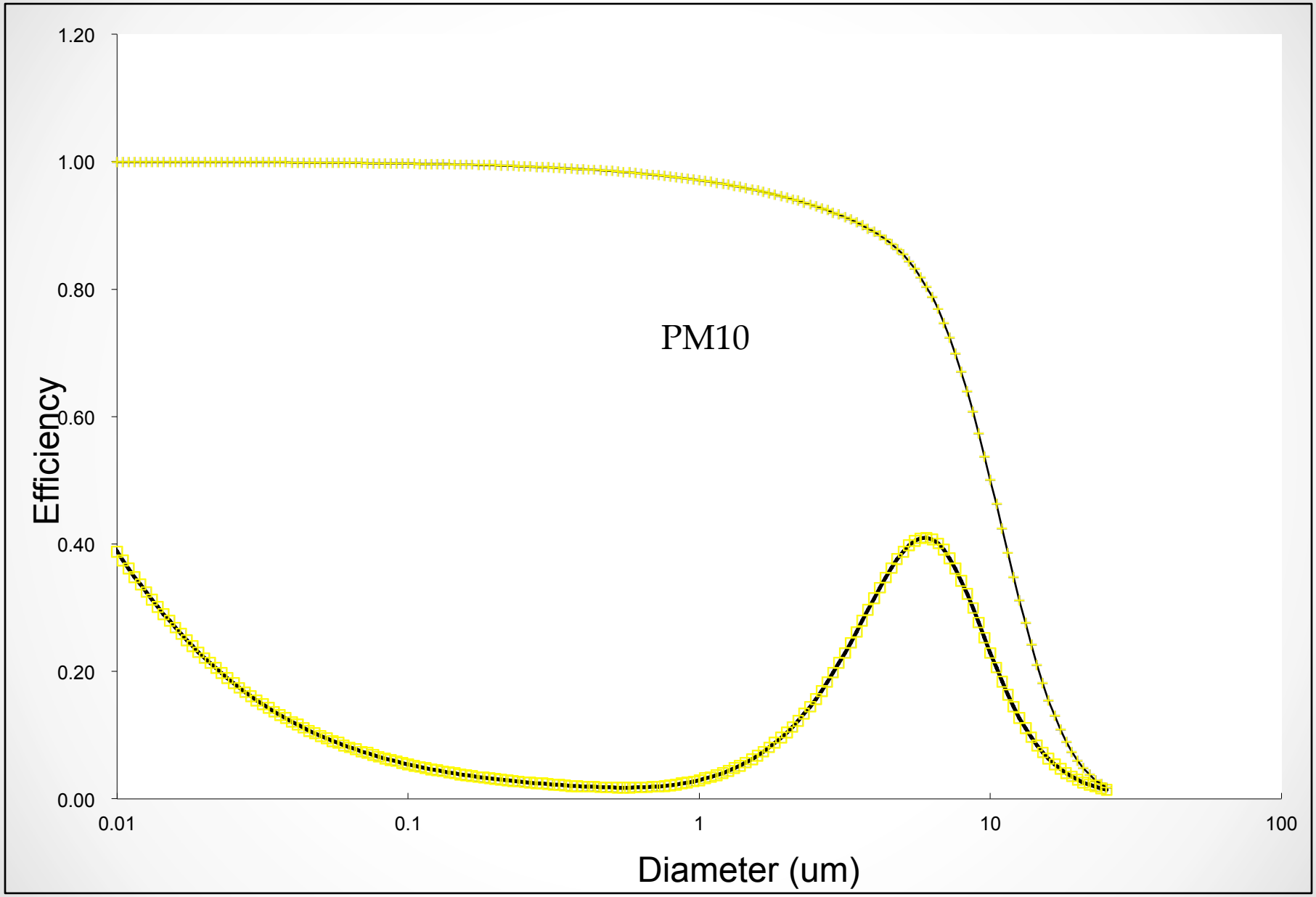
COUNT vs MASS DISTRIBUTIONS





The Lung


Trachea
Cartilage rings
Cartilage plates
Left primary bronchus
Root of lung
Visceral pleura
Secondary bronchus
Tertiary bronchi
Smaller bronchi
Bronchioles
Terminal bronchiole
Respiratory bronchiole
Alveoli in pulmonary lobule
1
2
3
4
5
6
7
8
9


1.20
1.00
0.80
0.60
0.40
0.20
0.00
Efficiency
PM10
0.01
0.1
1
10
100
Diameter (um)

Mountain Top Mining

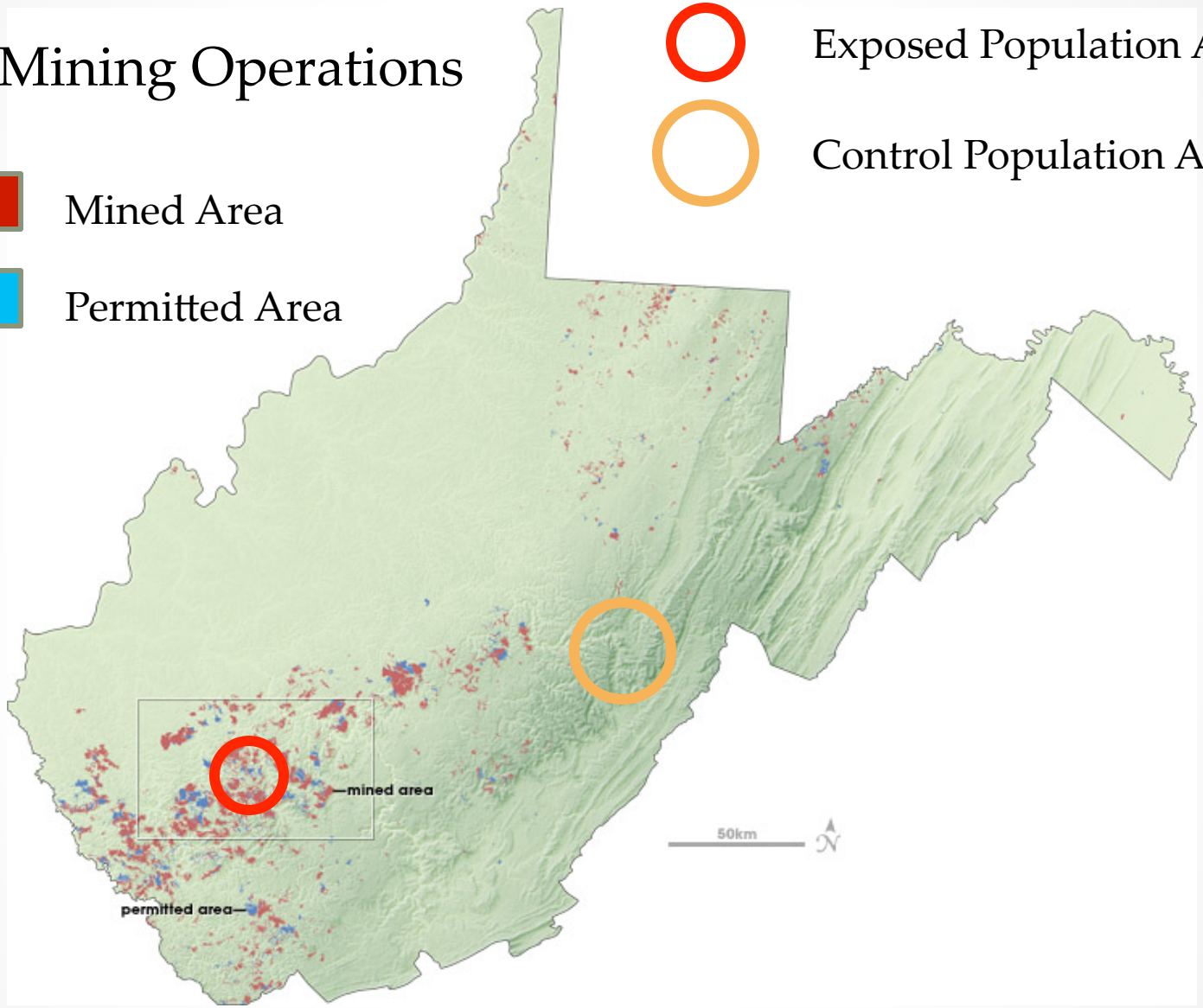
Surface Mining Operations

Mined Area

Permitted Area

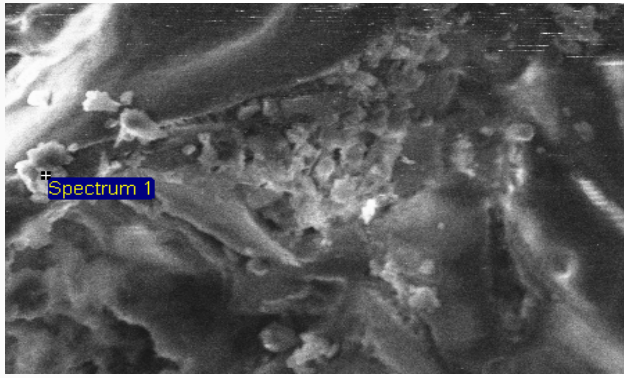
Exposed Population Area

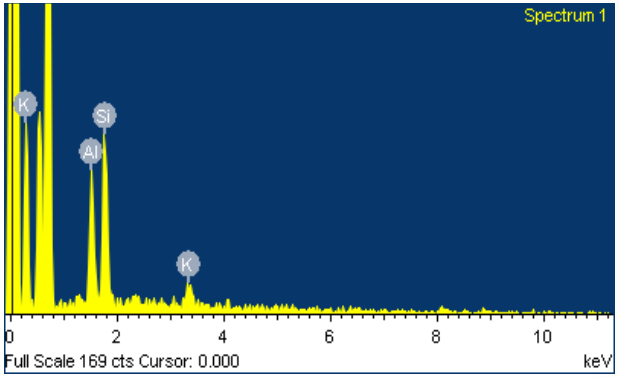
Control Population Area



Parameter	Higher Disease Rate Area (n)	Lower Disease Rate Area (n)	p-Value
Total Mass, ug/m^3 Mean	6.8 (n=18)	4.8 (n=8)	0.27
PM_{10}, ug/m^3 Mean	3.4 (n=76)	2.0 (n=31)	0.004
$PM_{2.5}$, ug/m^3 Mean	1.2 (n=76)	0.9 (n=31)	0.27
Total Number, #/cc Mean	6830 (n=90)	4770 (n=44)	<.001
Deposited Number, #/cc Mean	3082 (n=90)	2315 (n=44)	<.001

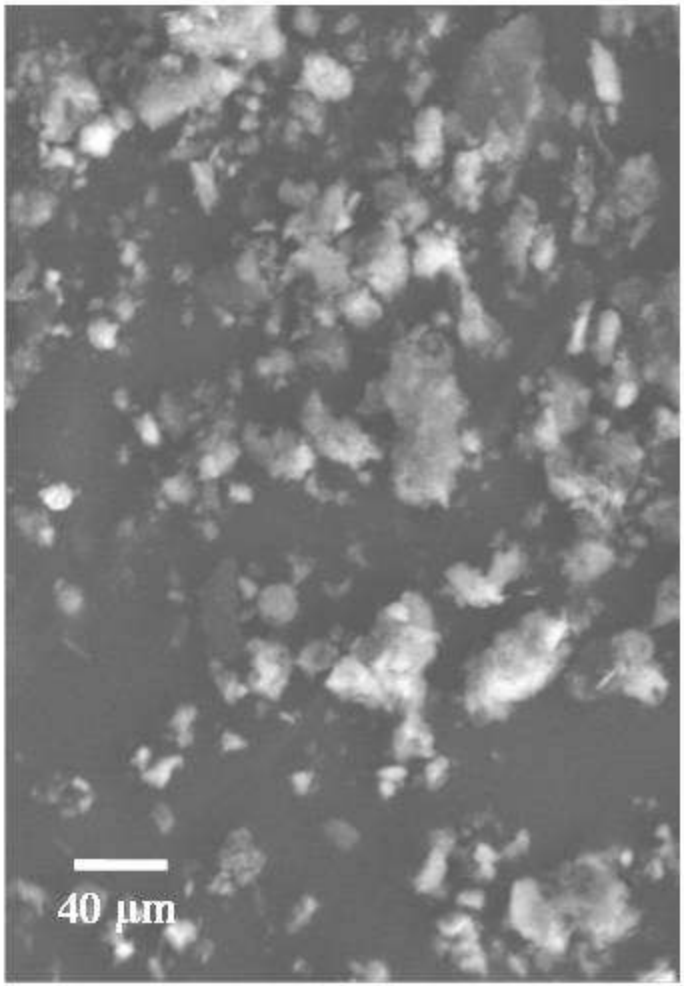
Elemental Concentration of Total PM at MTM and Non-Coal sites.





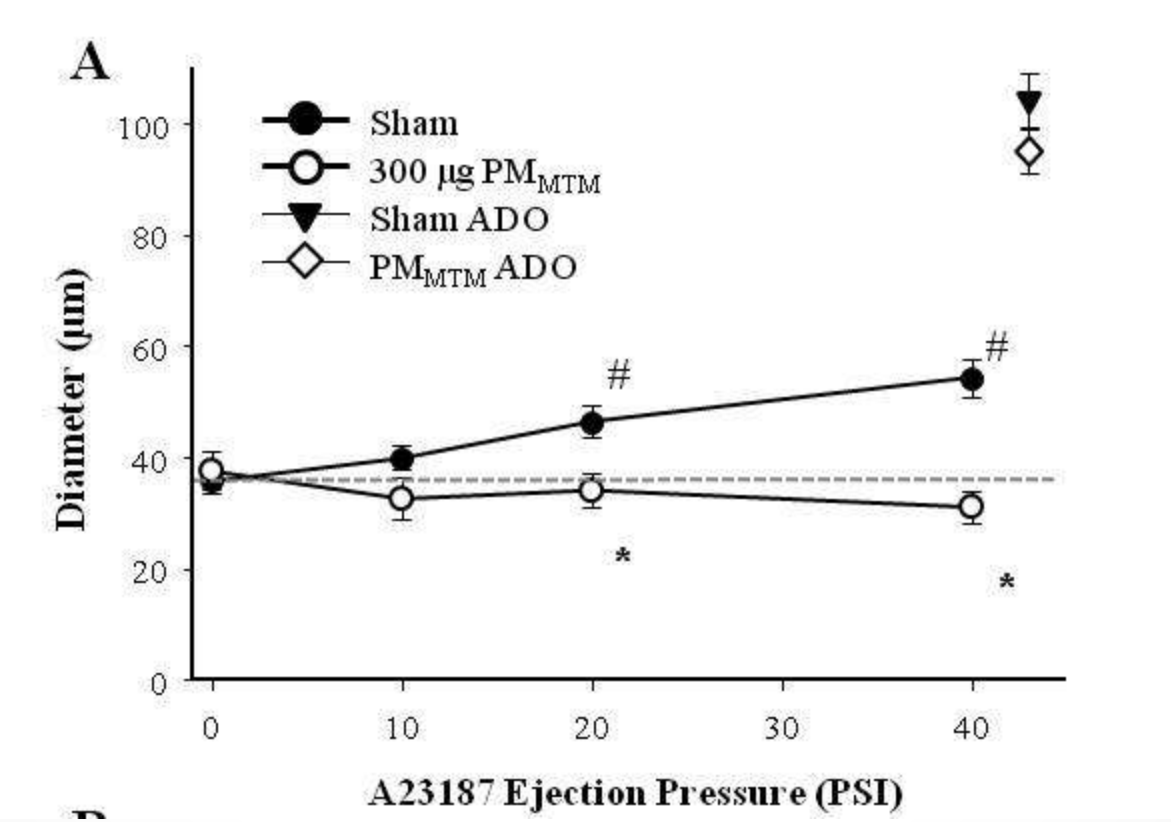
TSP filter sample from Site A (Edwight, Boone County, WV) June, 2011 Sample

Crustal Elements	Al, Ca, Fe, Ga, Rb, Mg, Si, Ti, Na, K, & rare earth elements
Anthropogenic Elements	As, Cd, Cr, Mn, Ni, Pb, V



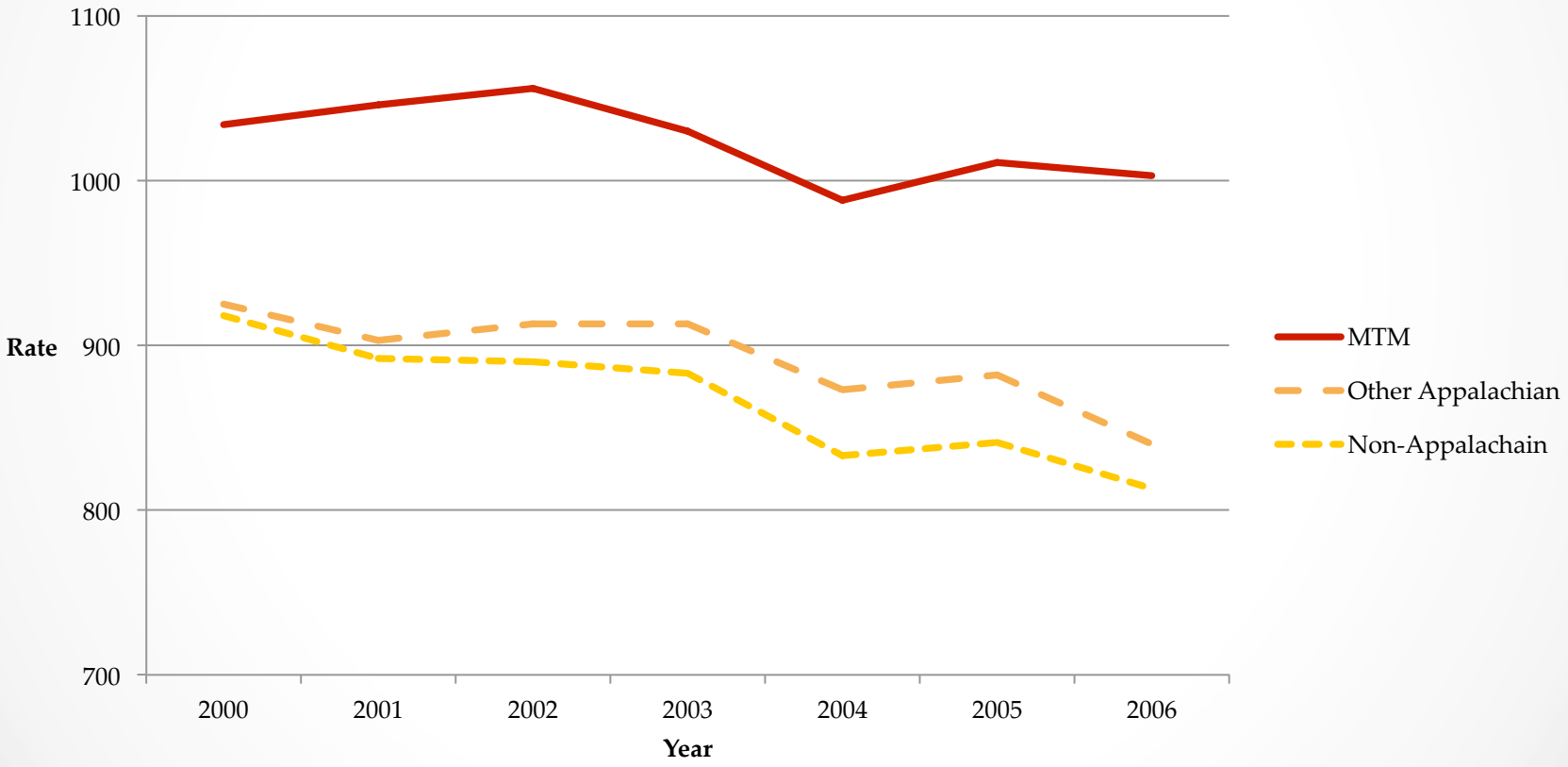
Element	Weight %
Al^{+}	6.8
Ca^{++}	10.6
Cl^{-}	0.2
Cu^{++}	0.1
Fe^{++}	4.3
K^{+}	8.8
Mg^{++}	0.3
Mo^{+6}	0.6
Na^{+}	2.5
P^{+3}	0.6
S^{+6}	37.8
Si^{+4}	24.3
Ti^{+4}	1.1
Zn^{++}	2.0
Total	100.0

PMMTM exposure inhibits endothelium dependent vasodilation in skeletal muscle arterioles *in vivo.*



Knuckles, T, et al. (2012) Microciculation (in press)

Age-adjusted total mortality per 100,000 by MTM county status



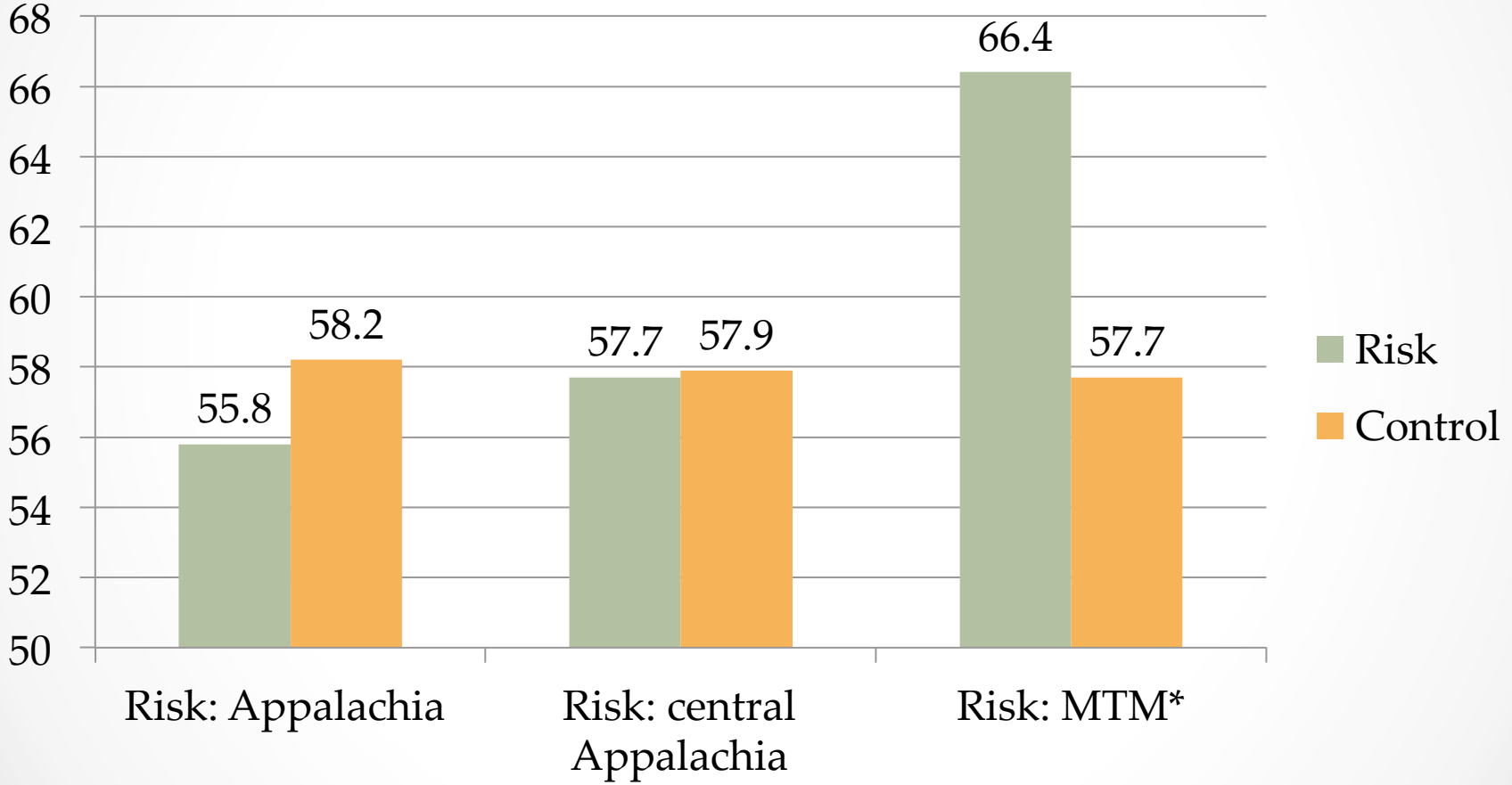
Hendryx, Journal of Health Disparities Research and Practice, 2011, 4(3), 44-53.

Self-reported cardiovascular and respiratory symptoms (N=895)

	MTM Community	Non-mining control
	Odds ratio (95% CI)*	
Cardiovascular (chest pain, arrhythmia	1.44 (1.10, 1.88)	1.00
Respiratory (persistent cough, shortness of breath, wheezing)	1.71 (1.35, 2.15)	1.00

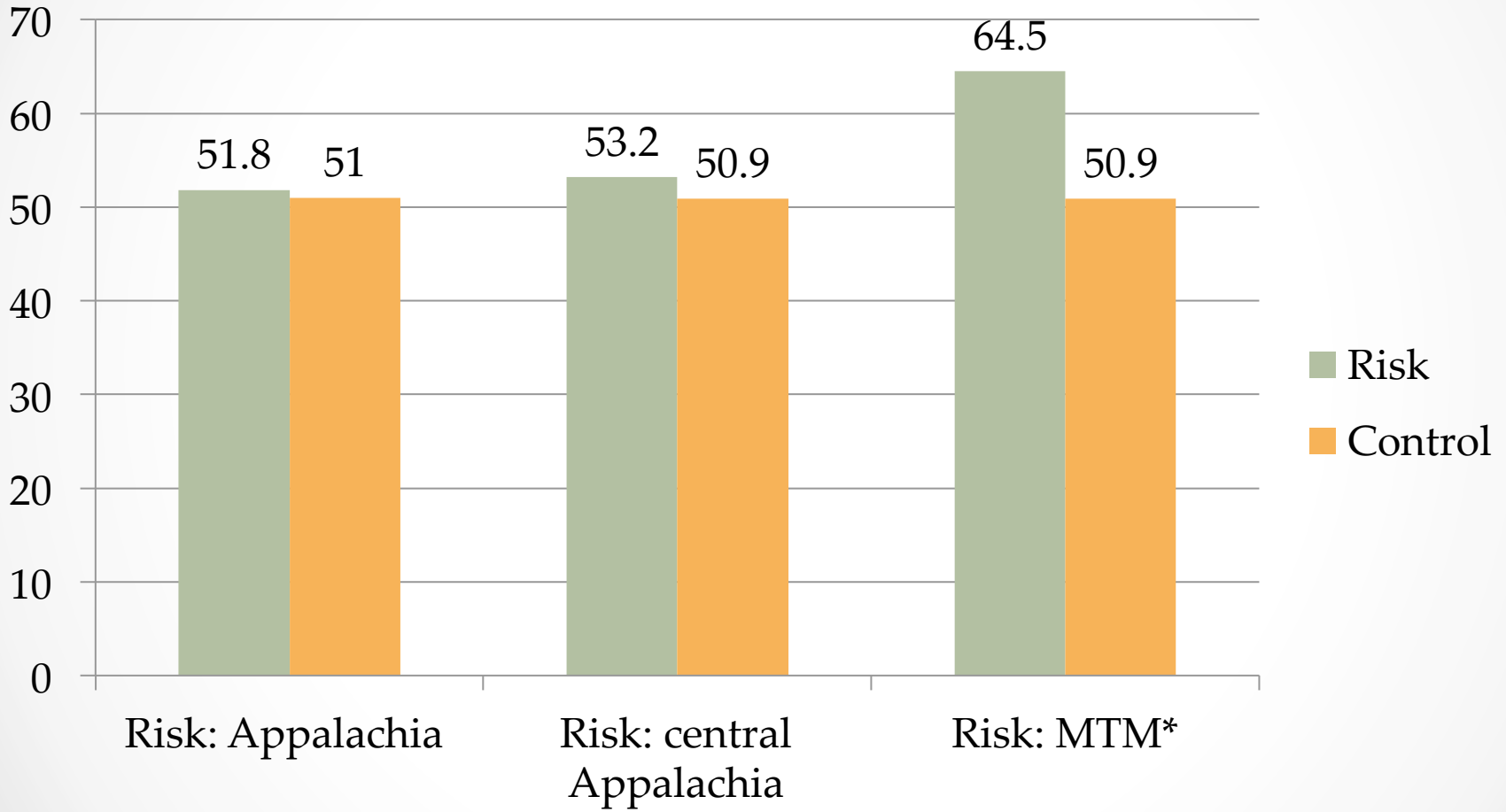
*Controlling for age, sex, smoking, occupational history as a miner, obesity, marital status, education ; survey of eastern KY adults, Spring 2012 (Hendryx, 2012, under review).

Controlling for covariates, *there is no Appalachian disparity except in MTM counties*: Age-Adjusted Lung Cancer Deaths per 100,000, 2005-2009



Appalachia versus rest of nation; central Appalachia versus rest of nation; MTM versus rest of nation. Controlling for rates of smoking, obesity, sex, race/ethnicity, poverty, education, rural/urban setting, supply of practicing physicians. *p<.0001

Controlling for covariates, *there is no Appalachian disparity except in MTM counties*: Age-Adjusted Non-Cancer Lung Disease Deaths per 100,000, 2005-2009



Appalachia versus rest of nation; central Appalachia versus rest of nation; MTM versus rest of nation. Controlling for rates of smoking, obesity, sex, race/ethnicity, poverty, education, rural/urban setting, supply of practicing physicians. *p<.0001

Chronic cardiovascular deaths are higher in MTM counties

- MTM associated with a 63.3 excess deaths per 100,000 compared to non-mining areas
- Other forms of non-MTM mining associated with 21.9 excess deaths per 100,000
- Controlling for age, sex, race/ethnicity, smoking, poverty, obesity, rural/urban, supply of physicians

(Esch and Hendryx, Journal of Rural Health, 2011)

Past Bio Studies of Ultrafine Particles

- Induce cellular heme oxygenase-1 (HO-1) expression and deplete intracellular glutathione, both important in oxidant stress responses (**Li et al., 2003**)
- Epithelial cells exposed to suspensions of both urban ultrafine particles and diesel exhaust particles had decreased membrane potential and loss of mitochondrial membrane mass as well as undergoing increased apoptosis (**Xia et al., 2004**)
- Increased biologic potency of ultrafine particles is related to the content of redox cycling organic chemicals and ability to damage mitochondria (**Sioutas, 2005**).
- Cardio-respiratory symptoms significantly increased at total particle concentrations between 6000 and 8000 p/cc (**Andersen et al 2008**).
- Ultrafine (< 0.1 mm) particle number concentration from traffic sources may be associated with asthma exacerbation (**Wichmann et al., 2000, DeHartog, et al., 2003, Li et al., 2003, Peters, et al., 2006, Timonen et al., 2006, Andersen et al., 2008**).

Sampling Methods

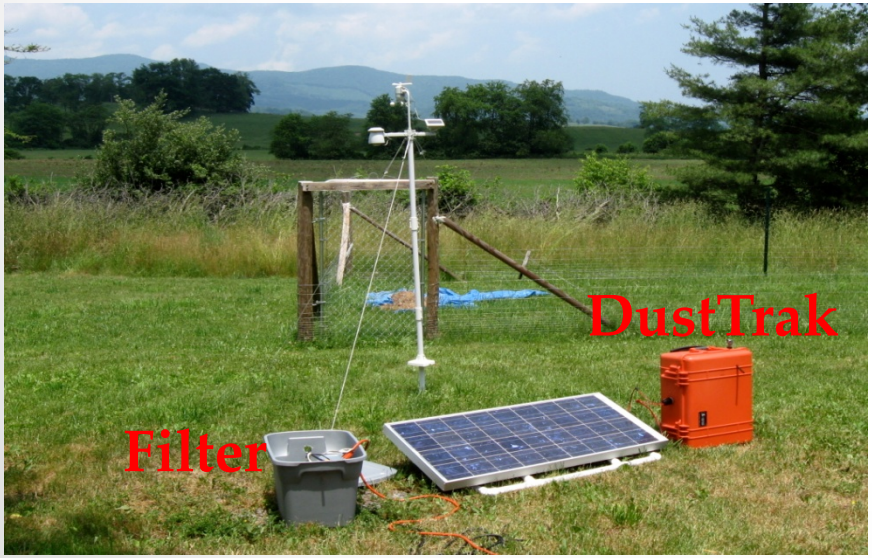
Aim 1. To quantify the elemental concentration of total PM at MTM and non-coal sites.

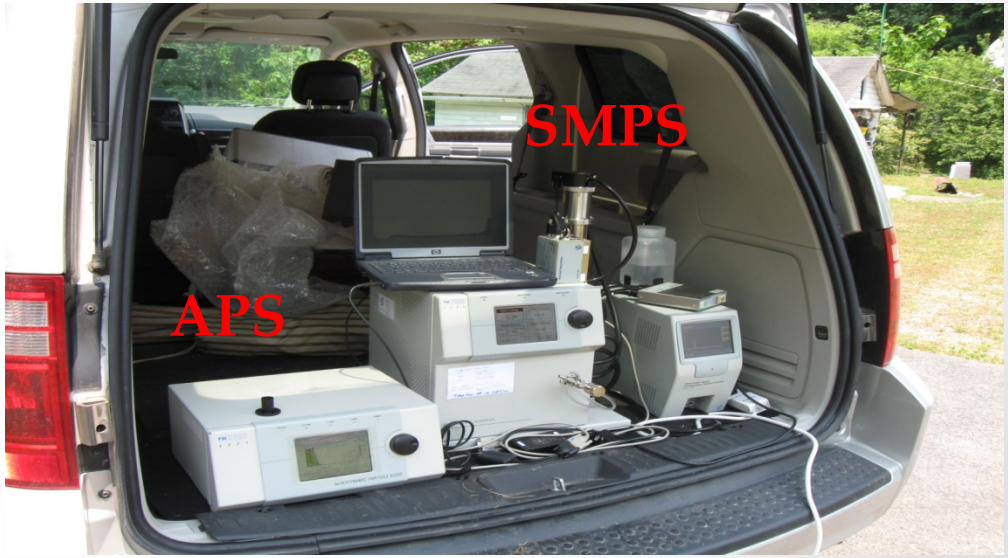
- Methods:
  - 1. Monthly samples of total suspended particles from 3 sites over 1 year (12 samples x 3 sites= 36 samples).

Filters with collected TSP

Brief sampling (25-32 hrs) was conducted at 9 sites within 3 sampling areas.

- Mass concentration (mg/m^3) was obtained - gravimetric filter analysis.
- Derive variability measures for filter mass-DustTrak II.
- Particle size and number distributions were determined with an Aerodynamic Particle Sizer and Submicrometer Particle Sizer.





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