Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Performance of Particulate Matter Samplers When Exposed to Coarse Fraction Aerosol Particles

Bryan W. Shaw, Ron E. Lacey, Sergio Capareda, Calvin B. Parnell, John Wanjura, Lingjuan Wang, and William Faulkner

Center for Agricultural Air Quality Engineering and Science
Biological and Agricultural Engineering Department
Texas A&M University
College Station, Texas

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

PM NAAQS

- PM_{10} – 150 µg/m^3
- $PM_{2.5}$ – 65 µg/m^3
- PM_{CF} – Being developed to address confounding issues

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

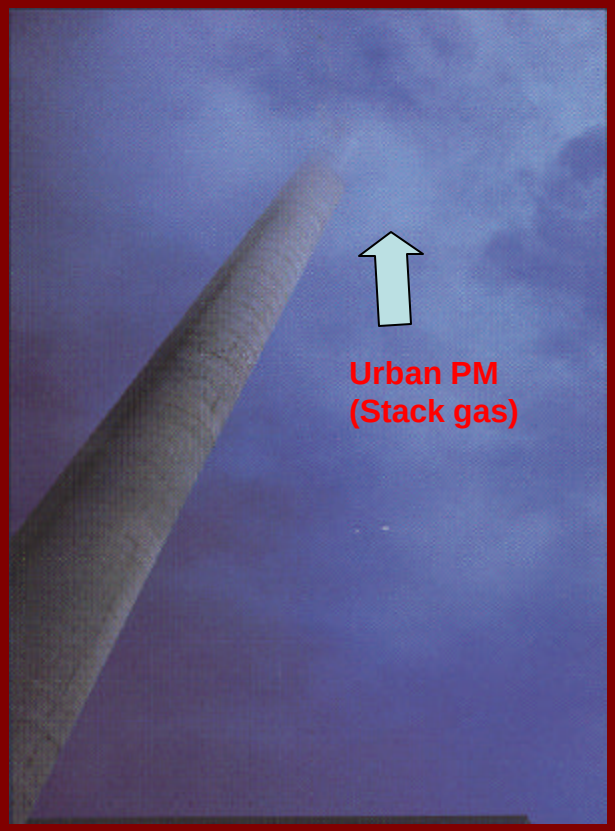
Concerns with PM NAAQS in Rural Environments

- FRM sampler overestimation
- Sampler performance in “real world”
- Basis for NAAQS development

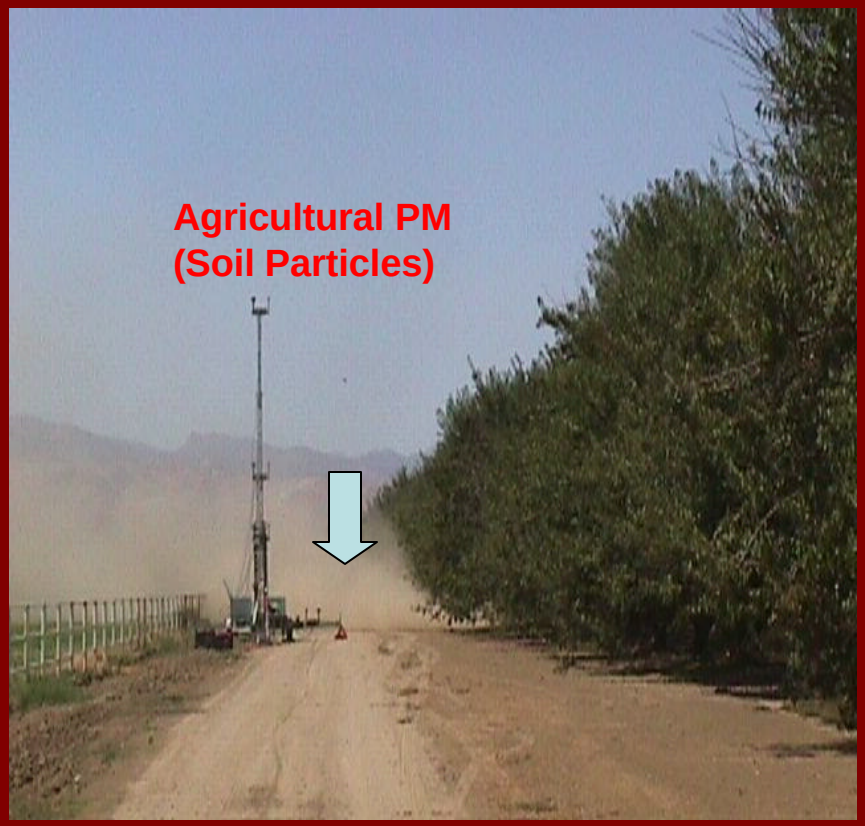
Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Center for Agricultural Air Quality Engineering & Science
CAAQES

Urban Dust



Agricultural Dust



The PSD of PM emitted from agricultural operations is significantly larger than PM present in urban areas.

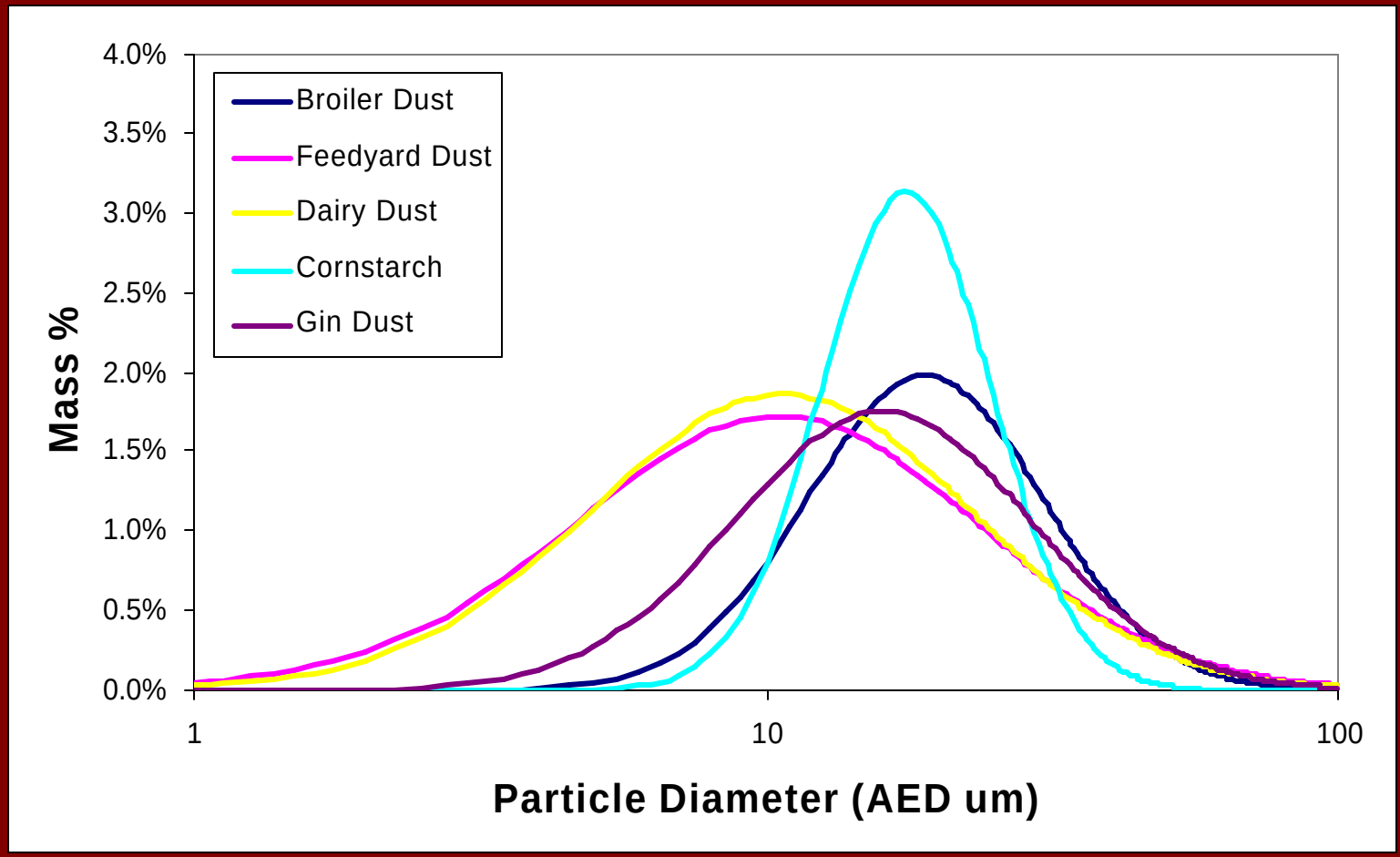
Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Physical Differences

	Urban Dust	Rural Dust
Sources	Combustion Boilers Stack Gases	Soil Dried Manure Pollens
Typical Size	< 10 micron	> 10 micron
(MMD & GSD)	MMD < 10 μm GSD = 1.5	MMD > 10 μm GSD = 2

Center for Agricultural Air Quality Engineering & Science
CAAQES

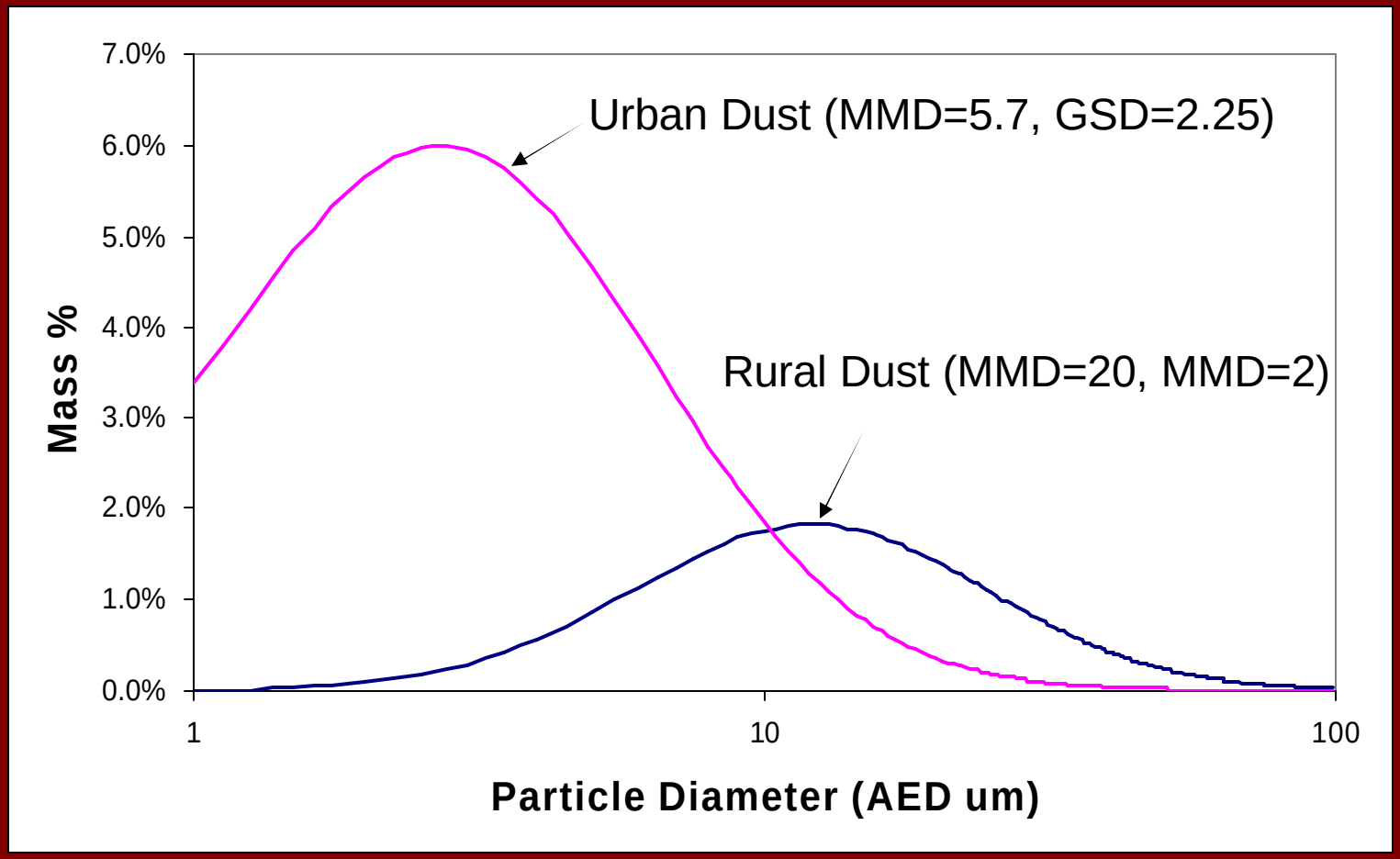
PSD of Agricultural Dusts



Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Center for Agricultural Air Quality Engineering & Science
CAAQES

Idealized Urban vs Rural Dust

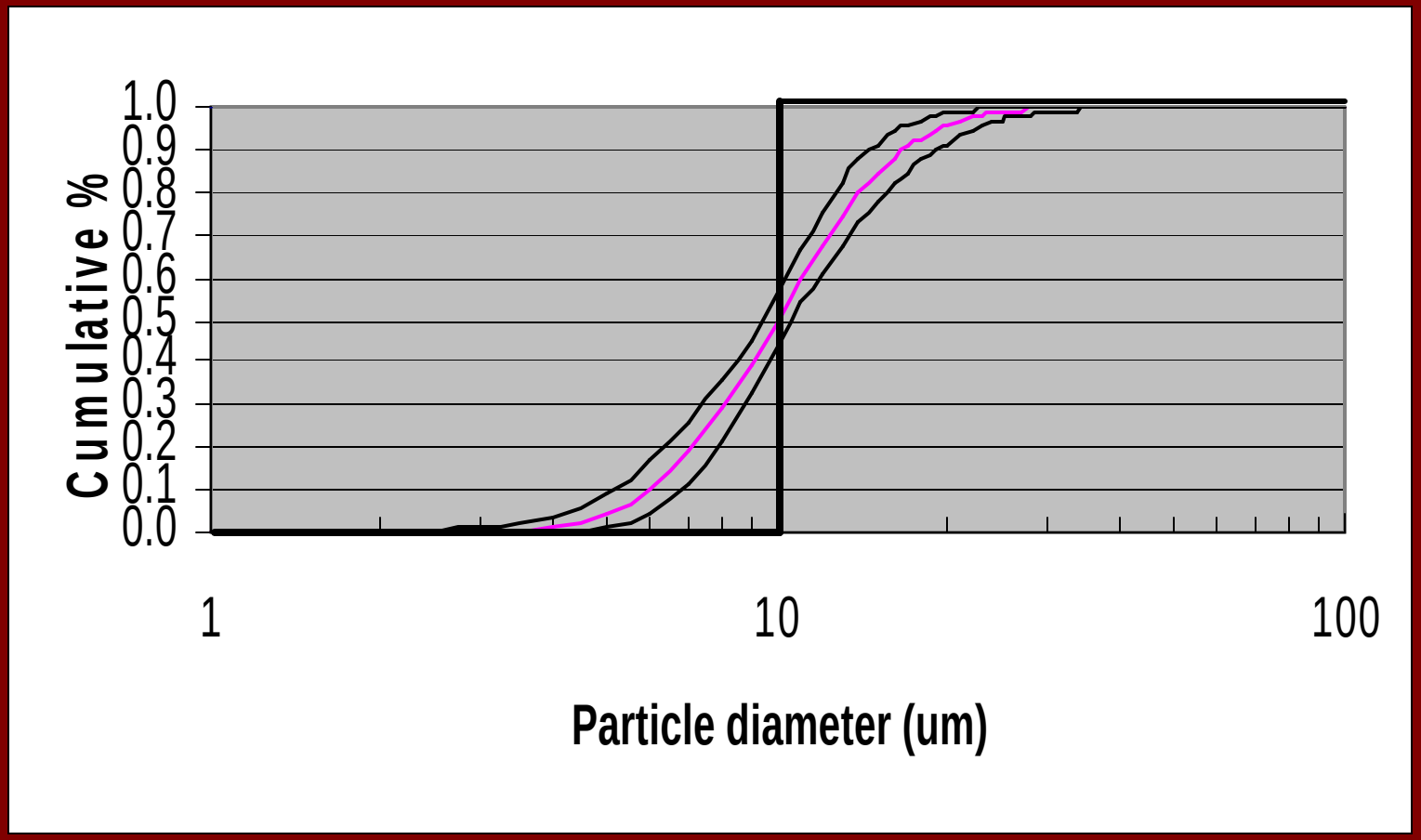


Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Center for Agricultural Air Quality Engineering & Science
CAAQES

Performance of FRM PM_{10} Samplers (EPA Criteria Document)

- Cut-off is 10 ± 0.5 µm (@50% efficiency)
- Slope is 1.5 ± 0.1 (Hinds, 1982)



Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

PM Size Distributions Used in Sampler Performance Evaluation

Scenario	Mode	MMD µm	GSD	TSP µg/m^3	PM_{10} µg/m^3	PM2.5 µg/m^3	PMcf µg/m^3
Urban 1	Coarse	10	1.6	124.29	62.14	0.20	61.95
	Fine	1	1.2	82.86	82.86	82.85	0.01
	TOTAL			207.14	145.00	83.04	61.96
Urban 2	Coarse	8	2.3	154.43	93.52	12.55	80.97
	Fine	0.3	2.05	51.48	51.48	51.40	0.08
	TOTAL			205.91	145.00	63.95	81.05
Urban 3	Coarse	14	2	225.00	70.58	1.46	69.12
	Fine	0.5	2	75.00	74.99	74.24	0.75
	TOTAL			300.00	145.57	75.70	69.87

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

PM Size Distributions Used in Sampler Performance Evaluation

Scenario	Mode	MMD μm	GSD	TSP μg/m^3	PM_{10} μg/m^3	PM2.5 μg/m^3	PMcf μg/m^3
Feedyard	Coarse	20	2.2	913.94	145.00	1.23	143.77
	Fine	0	0	0.00	0.00	0.00	0.00
	TOTAL			913.94	145.00	1.23	143.77
Broiler	Coarse	24	1.6	4639.51	145.00	0.00	145.00
	Fine	0	0	0.00	0.00	0.00	0.00
	TOTAL			4639.51	145.00	0.00	145.00
Dairy	Coarse	19	2.1	749.39	145.00	2.35	142.65
	Fine	0	0	0.00	0.00	0.00	0.00
	TOTAL			749.39	145.00	2.35	142.65
Cotton Gin	Coarse	23	1.8	1853.33	145.00	0.15	144.85
	Fine	0	0	0.00	0.00	0.00	0.00
	TOTAL			1853.33	145.00	0.15	144.85

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

$PM_{2.5}$ Sampler Performance for the Scenarios Evaluated[1]

Scenario	True $PM_{2.5}$ mg/m^3	Ideal Lower $PM_{2.5}$ mg/m^3	Ideal Upper $PM_{2.5}$ mg/m^3
Urban 1	83.04	83.02	83.40
Urban 2	63.95	62.34	66.95
Urban 3	75.70	75.06	76.70
Feedyard	1.23	1.12	2.30
Broiler	0.00	0.01	0.03
Dairy	2.35	2.08	3.89
Cotton Gin	0.15	0.16	0.43

[1] Ideal Lower and Ideal Upper refer to performance characteristics from 40 CFR parts 50 and 53.

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

PM_{10} Sampler Performance for the Scenarios Evaluated[1]

Scenario	True PM_{10} mg/m^3	Ideal Lower PM_{10} mg/m^3	Ideal Upper PM_{10} mg/m^3
Urban 1	145.00	141.17	148.65
Urban 2	145.00	139.70	145.98
Urban 3	145.57	147.36	157.25
Feedyard	145.00	170.91	201.84
Broiler	145.00	378.65	495.51
Dairy	145.00	161.12	187.17
Cotton Gin	145.00	222.44	275.65

[1] Ideal Lower and Ideal Upper refer to performance characteristics from 40 CFR parts 50 and 53.

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

PM_{CF} Measurement Range for the Samplers and Scenarios Evaluated

Scenario	True PM_{cf} mg/m^3	Lower PM_{cf} mg/m^3	Upper PM_{cf} mg/m^3
Urban 1	61.96	57.76	65.82
Urban 2	81.05	72.75	83.64
Urban 3	69.87	69.31	82.19
Feedyard	143.77	143.95	200.72
Broiler	145.00	159.74	495.51
Dairy	142.65	141.59	185.09
Cotton Gin	144.85	149.79	275.49

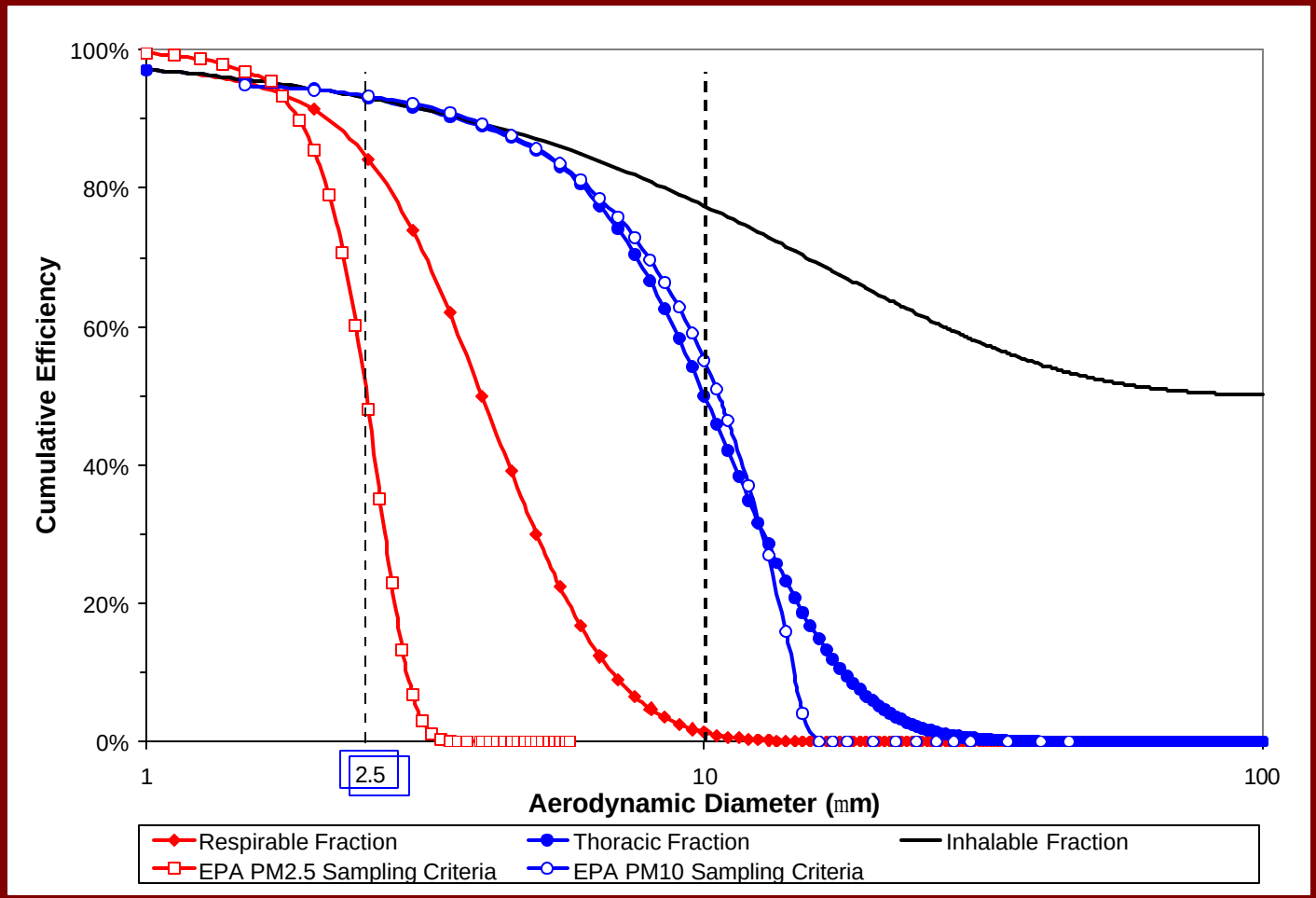
Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Concerns with NAAQS in Rural Environment

- **Basis for NAAQS development**
  - **Questionable association between PM_{CF} and health effects**
  - **Few epidemiological studies show association – those admit potential confounding…**
  - **No rural based epidemiological studies**
    - **Population limits statistical power**

Rationale for the Use of PM_{10} Samplers

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas



Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Concerns with NAAQS in Rural Environment

- **Basis for NAAQS development**
  - **Questionable association between PM_{CF} and health effects**
  - **Few epidemiological studies show association – those admit potential confounding…**
  - **No rural based epidemiological studies**
    - **Population limits statistical power**

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Concerns with NAAQS in Rural Environment

- **Basis for NAAQS development**
  - **Epidemiological study issues**
    - **Data confounded by measurement error**
    - **Data confounded by other pollutants**
    - **Single variable analysis**
    - **Lag time selection**

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Concerns with NAAQS in Rural Environment

- **Basis for NAAQS development**
  - **Questionable association between PM_{CF} and health effects**
  - **Few epidemiological studies show association – those admit potential confounding…**
  - **No rural based epidemiological studies**

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Conclusions

- Application of PM NAAQS in Rural/Agricultural environment is questionable at best
- Overestimation must be corrected
- Sampler performance in coarse particulate matter environment must be addressed
- Risk analysis approach needs improvement

Center for Agricultural Air Quality Engineering and Science
Texas A&M University
College Station, Texas

Conclusions

- **Failure to address these issues will result in:**
  - Inappropriate burden for sources of coarse particulate matter
  - Resources used to correct perceived environmental problems instead of more critical issues
  - Create distrust with the regulated industries

Center for Agricultural Air Quality Engineering and Science

Texas A&M University

College Station, Texas

Acknowledgements

We thank the Cotton Foundation, the CSREES, TAES, and Texas Cooperative Extension for the continued financial support for this research at The Center for Agricultural Air Quality Engineering and Science

Center for Agricultural Air Quality Engineering and Science

Texas A&M University

College Station, Texas