# Exploration of Emissions Factor Adjustments for Using Emissions Factors in Noninventory Applications

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# Overview

- Background
- Objective
- Technical Approach
- Results
- Next Steps

# Background

- Originally, Emissions Factors (EF) Used for Nationwide Inventories
- EF = Mean Value (Typically)
- Other Noninventory Applications, e.g.,
  - Permit Applicability Determination/Limits
  - Model inputs
  - Plant-wide Applicability Limits (PAL)

# Objective

- Explore adjustments to EFs to address uncertainty when using EFs for noninventory applications

# General Approach

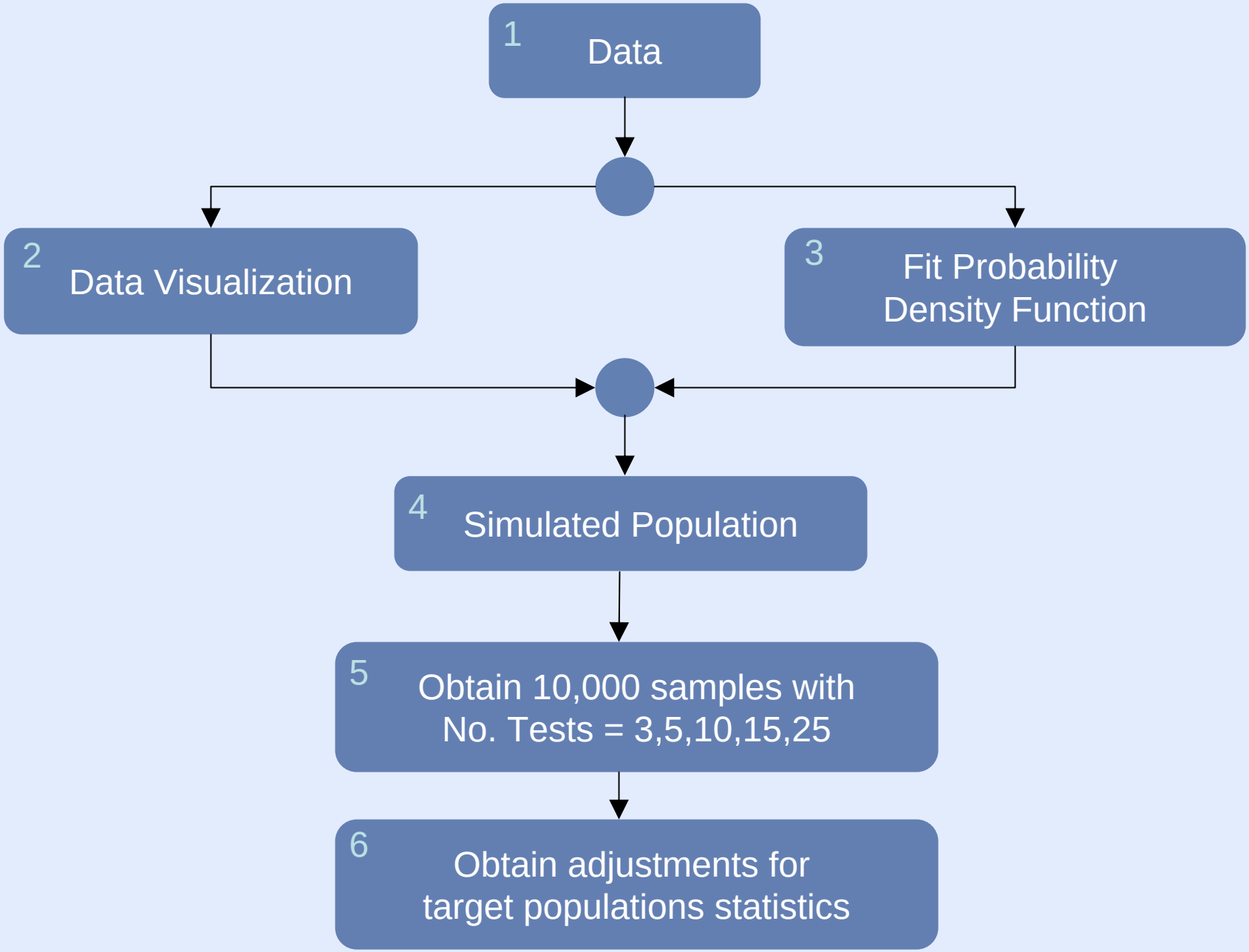
- Focus on single source:
  - Random sample from population
  - "Boundary statistics" of population distribution; e.g., 95th percentile
  - Variability of the sample provides estimates of uncertainty (between and within facility)
- Develop default adjustments
- Did not focus on uncertainty about the mean value

# Approach

- Select EF data sets for analysis
- Statistical procedure
  1. Visualize data
  2. Fit Probability Density Functions to model the data; Use Monte Carlo Techniques to simulate the hypothetical population
  3. Calculate statistics for each population: e.g., median, $90^{th}$ percentile, $95^{th}$ percentile

# Approach (continued)

4. Select 10,000 random samples from each population for sample size n=1, 3, 5 …25
5. For each of the 10,000 samples, calculate an adjustment to estimate the selected target statistic of the hypothetical population
6. Calculate composite adjustments by pollutant and sample size


1
Data
2
Data Visualization
3
Fit Probability
Density Function
4
Simulated Population
5
Obtain 10,000 samples with
No. Tests = 3,5,10,15,25
6
Obtain adjustments for
target populations statistics

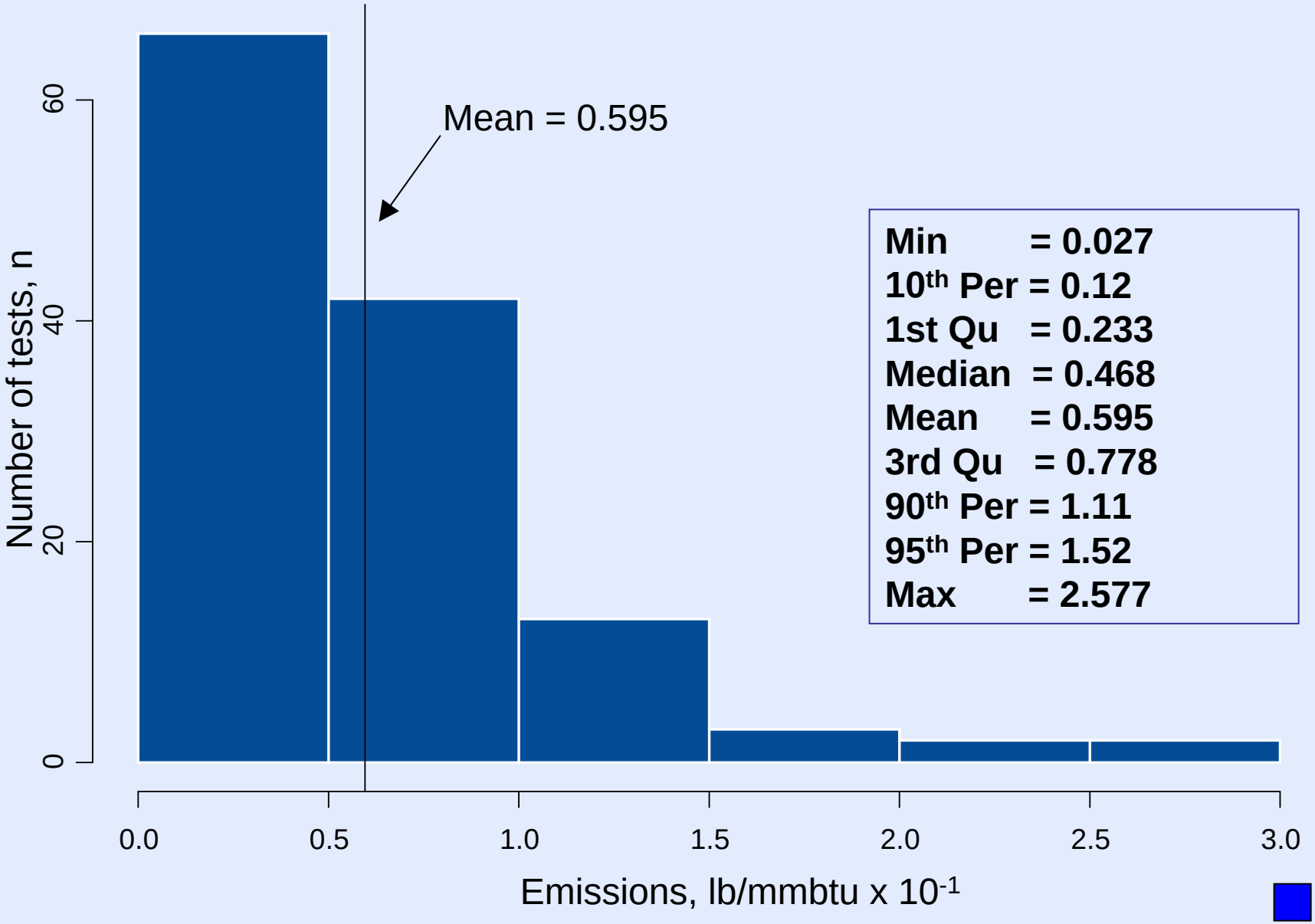
# Emissions Factor Data

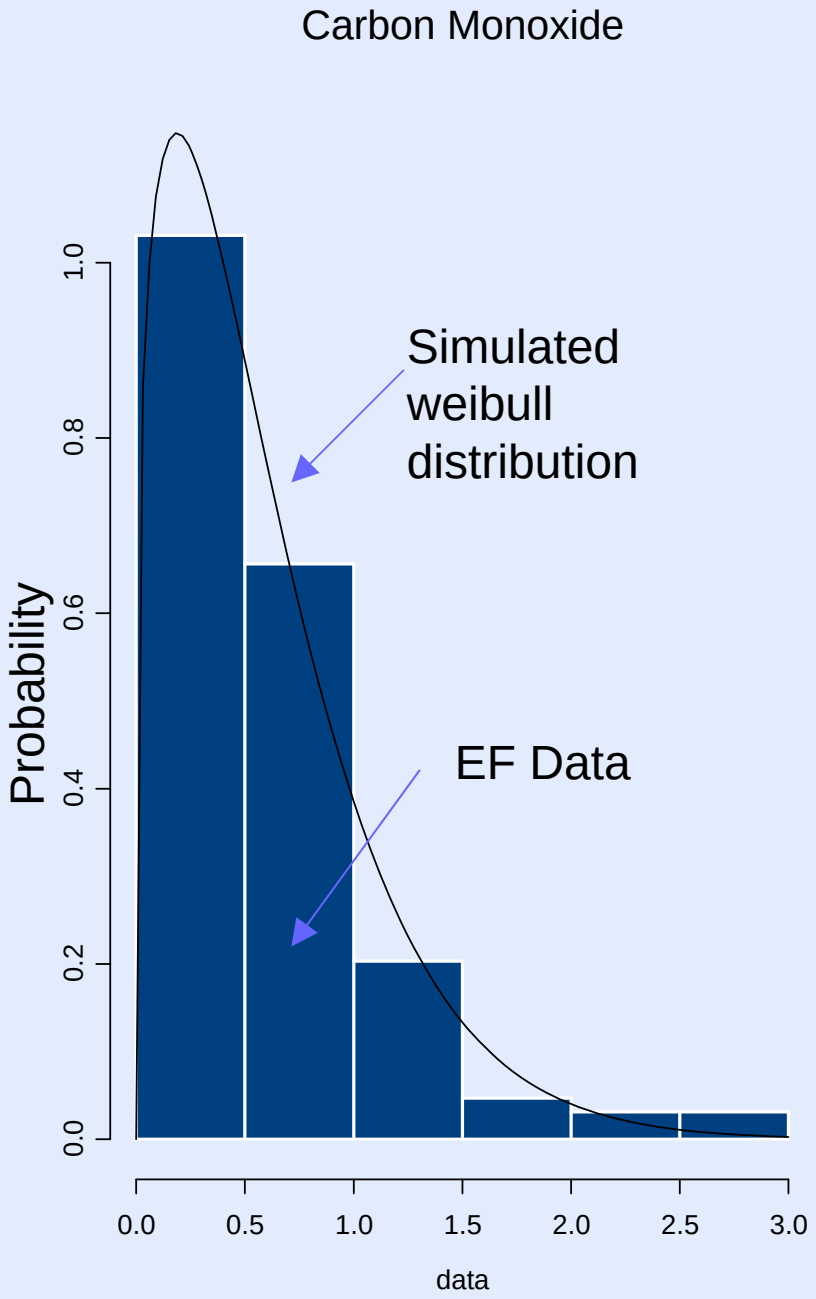
- Criteria for selection:
  - data quality (A-rated)
  - data quantity > 15 emissions tests
  - number/type of pollutants
  - accessibility of supporting emissions data

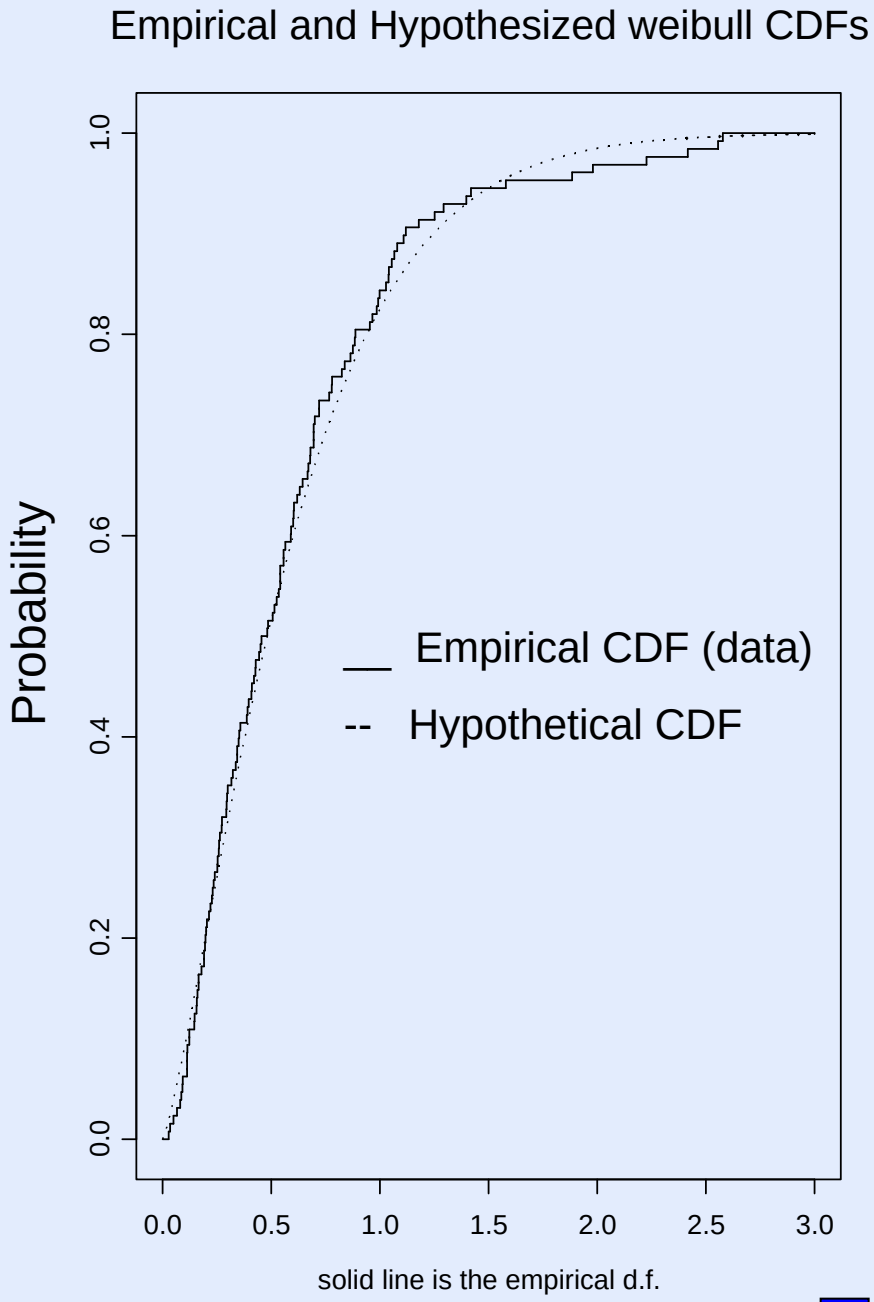
# Emissions Factor Data

- 44 A-rated Data Sets
- Wood Residue Combustion
- Refuse Combustion
- Waferboard/Oriented Strandboard
- Hot Mix Asphalt
- Particulate Matter, Sulfur Dioxide, Nitrogen Oxides, Carbon Monoxide, Hazardous Air Pollutants

# Distribution of AP-42 Carbon Monoxide EF Data

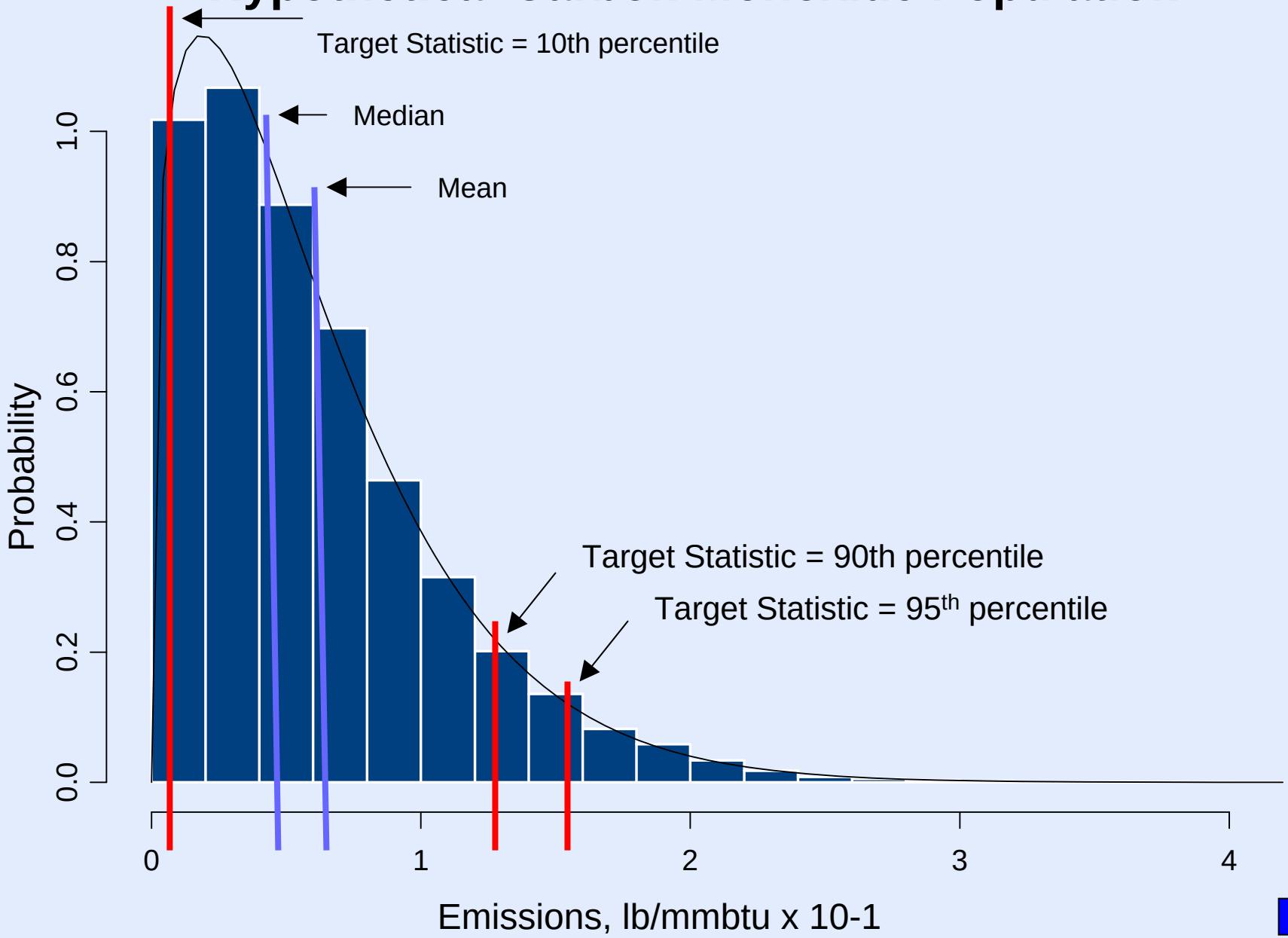




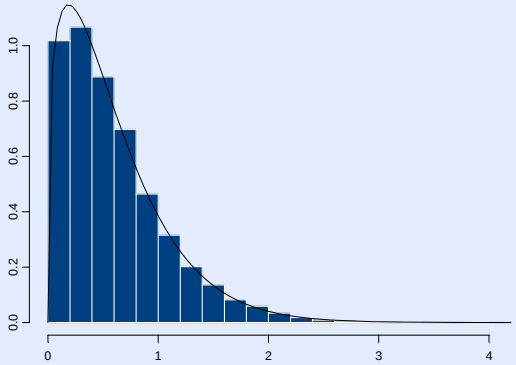



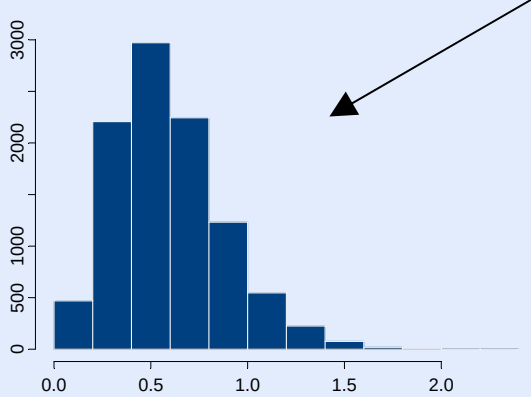

Emissions, lb/mmbtu x 10-1

# Hypothetical Carbon Monoxide Population

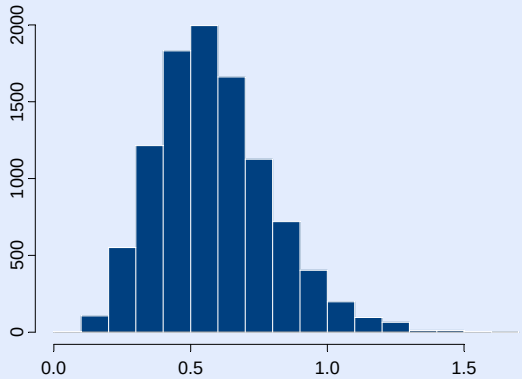


# Sample from Hypothetical Carbon Monoxide Population

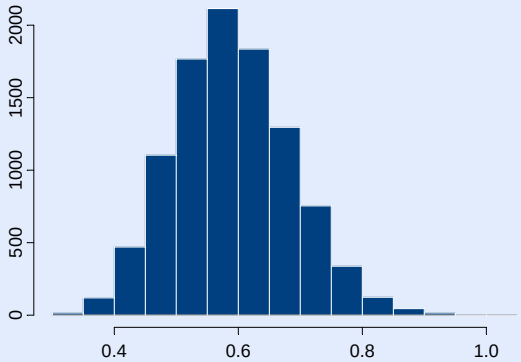



**n=3**
**10,000 samples**



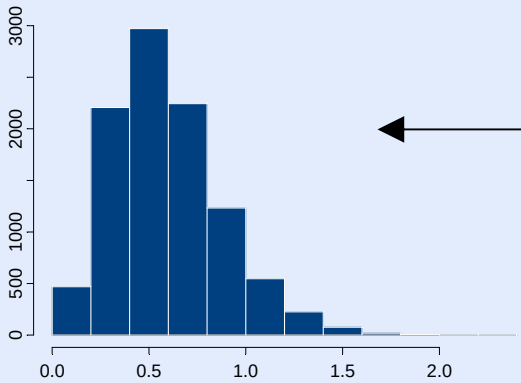

**n=5**
**10,000 samples**

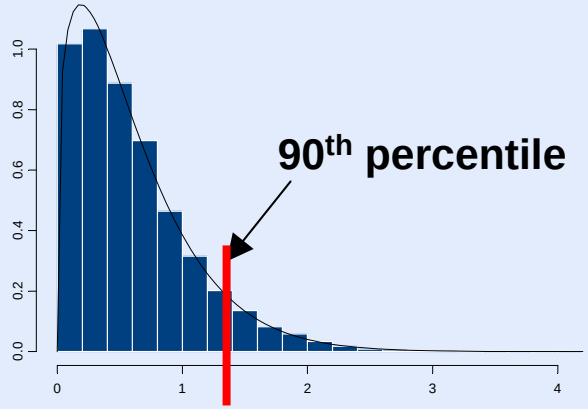



**n=25**
**10,000 samples**

# Distribution of Adjustments for Selected Target Statistics

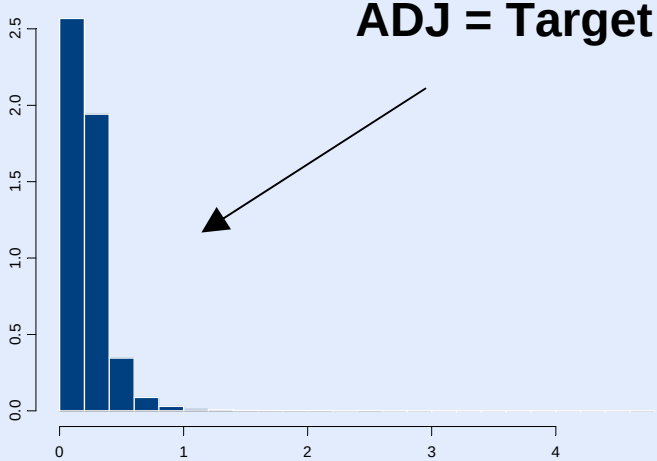
**EF Distribution**
**n =3**
**10,000 samples**

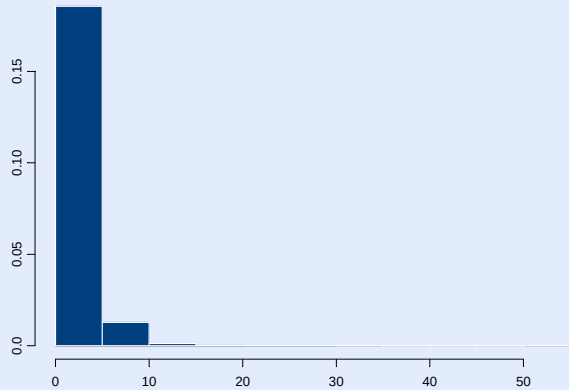



**10,000 calculations:**
**EF x ADJ = Target Statistic**
**ADJ = Target Statistic/EF**

**Hypothetical population**



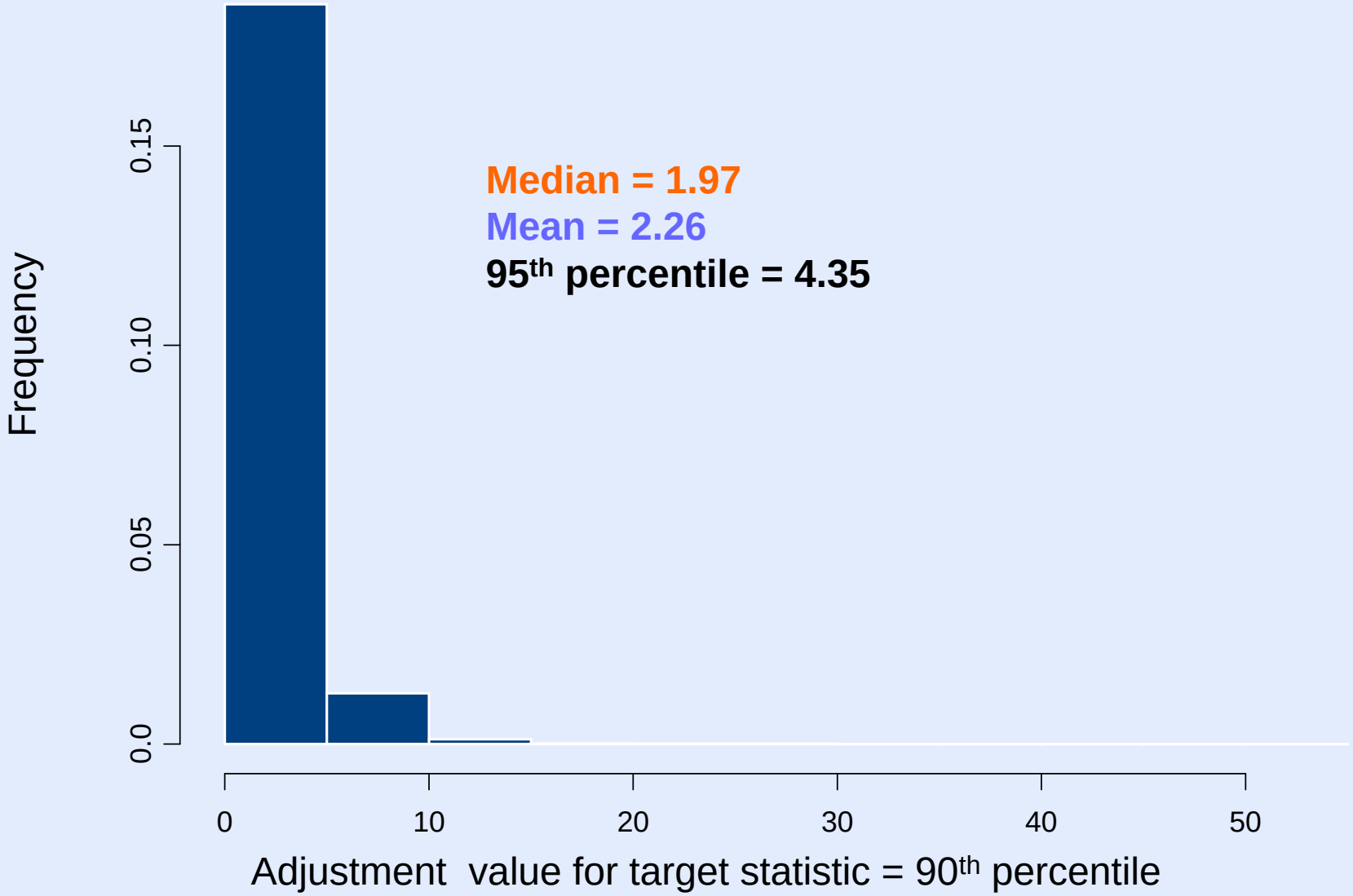

**Adjustment:**
**Target statistic = 10th percentile**

**Adjustment:**
**Target statistic = 90th percentile**

# Monte Carlo Distribution of Adjustments:

## Target Statistic = 90th percentile

## EF with n = 3 Tests



# Example of Adjustments

| *n* | Target Statistic | | | | |
|---|---|---|---|---|---|
| | Percentile | | Mean | Percentile | |
| | 5th | 10th | | 90th | 95th |
| 1 | 0.19 | 0.30 | 1.2 | 2.2 | 2.7 |
| 3 | 0.17 | 0.27 | 1.0 | 2.0 | 2.4 |
| 5 | 0.16 | 0.26 | 1.0 | 1.9 | 2.3 |
| 25 | 0.16 | 0.26 | 1.0 | 1.9 | 2.3 |

n= 3

Estimate 90$^{th}$ percentile of true population: EF x ADJ = 0.6 x **2.0** = 1.2

n= 25

Estimate 90$^{th}$ percentile of true population: EF x ADJ = 0.6 x **1.9** = 1.1

# Example of Adjustments

Wood Residue CO emission factor =0.6 lb/mmbtu
n=128

| *n* | Target Statistic | | | | |
|---|---|---|---|---|---|
| | Percentile | | Mean | Percentile | |
| | 5th | 10th | | 90th | 95th |
| 1 | 0.19 | 0.30 | 1.2 | 2.2 | 2.7 |
| 3 | 0.17 | 0.27 | 1.0 | 2.0 | 2.4 |
| 5 | 0.16 | 0.26 | 1.0 | 1.9 | 2.3 |
| 25 | 0.16 | 0.26 | 1.0 | 1.9 | 2.3 |

n=25

Estimate 90$^{th}$ percentile of true population: EF x ADJ = 0.6 x **1.9** = 1.1

Estimate 95$^{th}$ percentile of true population: EF x ADJ = 0.6 x **2.3** = 1.4

# Comparison of Selected Adjustments: PM-Filterable, uncontrolled Emissions Factors Target Statistic: 95th Percentile

| | n =1 | n =3 | n = 10 | n =25 |
|---|---|---|---|---|
| **Refuse Comb., RDF** | 1.8 | 1.7 | 1.7 | 1.7 |
| **Wood Comb., Dry Wood** | 1.9 | 1.9 | 1.8 | 1.8 |
| **Refuse Comb., Mass burn** | 2.3 | 2.1 | 2.0 | 2.0 |
| **Wood Comb., Wet Wood** | 2.5 | 2.3 | 2.2 | 2.2 |
| **OSB, Hot Press** | 5.1 | 3.8 | 3.4 | 3.2 |
| **Average (Comp, Default Adjustment)** | 2.7 | 2.3 | 2.2 | 2.2 |

# Composite Default Adjustments

- For n<3, 3<n<10, 10<n<25, n>25
- HAP, Controlled
- HAP, Uncontrolled
- PM-Condensible
- PM-filterable, controlled
- PM-filterable, uncontrolled
- Gaseous Criteria Pollutants

# Other Analyses

- Other analyses were conducted
- Estimates of uncertainty about the mean of the normalized distribution of emissions factors (n=1, n=3, n=5,…n=25)
  - confidence intervals about mean
  - yields smaller adjustment values
- See paper for discussion and results

# Summary and Conclusions

- All EF's examined are Weibull or log-normally distributed
- Adjustments decrease as n increases; begin to stabilize at n>10
- Uncontrolled HAPS have largest variability (and adjustments):
  - For $95^{th}$ percentile: 19 for n=1; 4.5 for n>25

# Additional Information

- Complete report is expected to be available for public review in June 2006
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