Source Apportionment of PM2.5 in North Carolina

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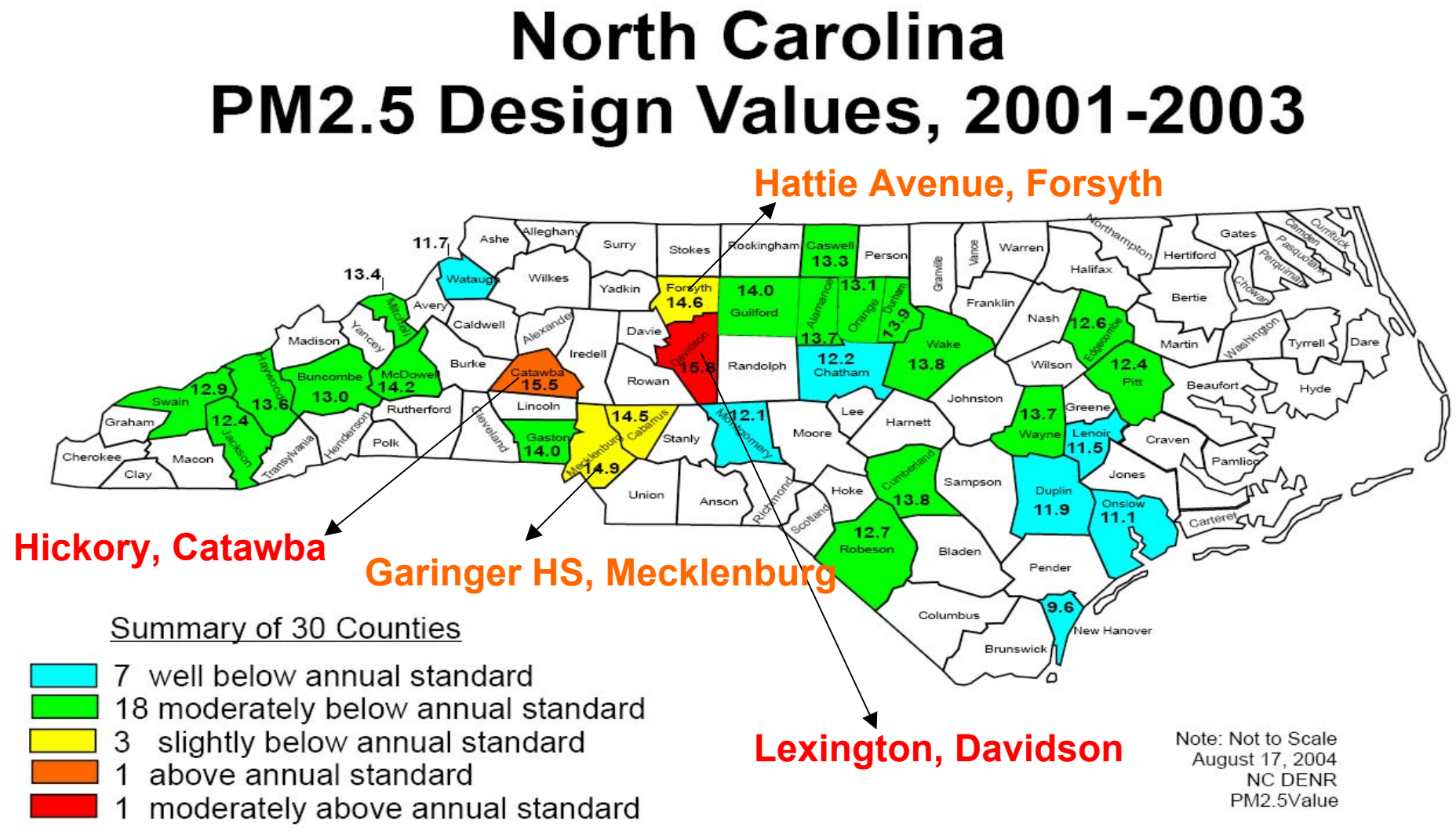
PM2.5 Monitoring Network in NC (30 Counties)



(Source: http://daq.state.nc.us/monitor/data/pm2pt5/pm25nc01-03.pdf)

Objective

Source Apportionment of PM2.5

Using Organic Tracers and Chemical Mass Balance (CMB) Method Developed by Schauer and Cass

Two Steps

- Step 1: Conduct source apportionment of fine organic carbon (OC) using organic tracers and CMB
- Step 2: Convert OC source apportionment results to PM2.5 source apportionment using the ratio of fine OC to PM2.5 mass (different ratios for different source types, obtained from source tests)

Sites and PM2.5 mass concentration

- Lexington, Davidson: 15.8 μg m^{-3}
- Hickory, Catawba: 15.5 μg m^{-3}
- Garinger High School, Mecklenburg : 14.9 μg m^{-3}
- Hattie Avenue, Forsyth: 14.6 μg m^{-3}

(Source: http://daq.state.nc.us/monitor/data/pm2pt5/pm25nc01-03.pdf)

Seasonal Composites for Solvent Extraction and Gas Chromatography/Mass Spectrometry (GC/MS) Analysis

County	Site	Sampling Period	Season	Number of Filters	Total OC (μg)
Mecklenburg	Garinger High School	Jan 3 to May 30, 2003	Spring	34	1237
	Garinger High School	Jan 1 to May 30, 2004	Spring	42	1545
	Garinger High School	Jun 5 to Oct 18, 2003	Summer	36	1264
	Garinger High School	Oct 21 to Dec 26, 2003	Winter	18	753
Forsyth	Hattie Avenue	Jan 3 to May 27, 2003	Spring	21	724
	Hattie Avenue	Jun 2 to Oct 18, 2003	Summer	20	649
	Hattie Avenue	Oct 24 to Dec 29, 2003	Winter	12	481
Catawba	Hickory	Jan 3 to May 27, 2003	Spring	23	866
	Hickory	Jan 4 to May 27, 2004	Spring	22	733
	Hickory	Jun 2 to Oct 18, 2003	Summer	23	809
	Hickory	Oct 24 to Dec 29, 2003	Winter	10	481
Davidson	Lexington	Jan 16 to May 27, 2004	Spring	22	805

CMB

- **Source apportionment of fine organic carbon using CMB Modeling:**

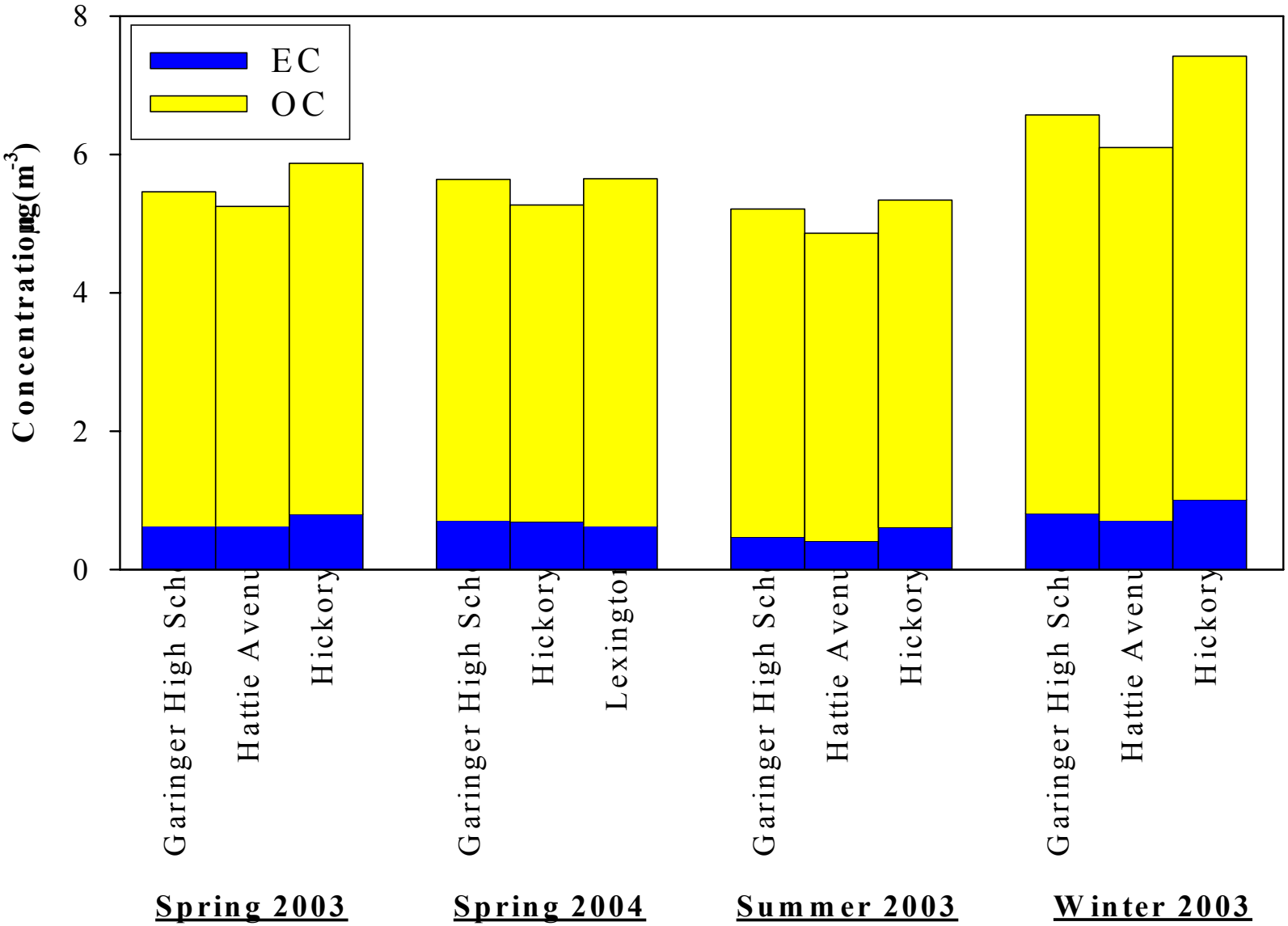
$$c_{ik} = \sum_{j=1}^{m} a_{ij} S_{jk}$$

- c_{ik} **is the concentration of chemical species** ***i*** **at ambient receptor site** ***k*****;**
- ***m*** **is the total number of emission sources;**
- a_{ij} **is the contribution of species** ***i*** **in the fine OC emissions from source** ***j*****;**
- s_{jk} **is the contribution of emission of source** ***j*** **to fine OC at receptor site** ***k*****.**

- ***Source Profiles***
  - **Diesel Exhaust** (Hildemann et al., 1991; Schauer et al., 1999a)
  - **Gasoline Exhaust** (Schauer et al., 2002)
  - **Wood Combustion** (Fine et al., 2002, 2004; Johnson and Brown, 2002)
  - **Paved Road Dust** (Schauer, 1998; Zheng et al., 2002)
  - **Meat Cooking** (Schauer et al., 1999b; McDonald et al., 2003)
  - **Vegetative Detritus** (Rogge et al., 1993)

- ***Fitting Species***
  - Elemental Carbon (EC)
  - Al, Si
  - *n*-Alkanes
  - Hopanes and steranes
  - PAHs
  - Levoglucosan
  - Cholesterol

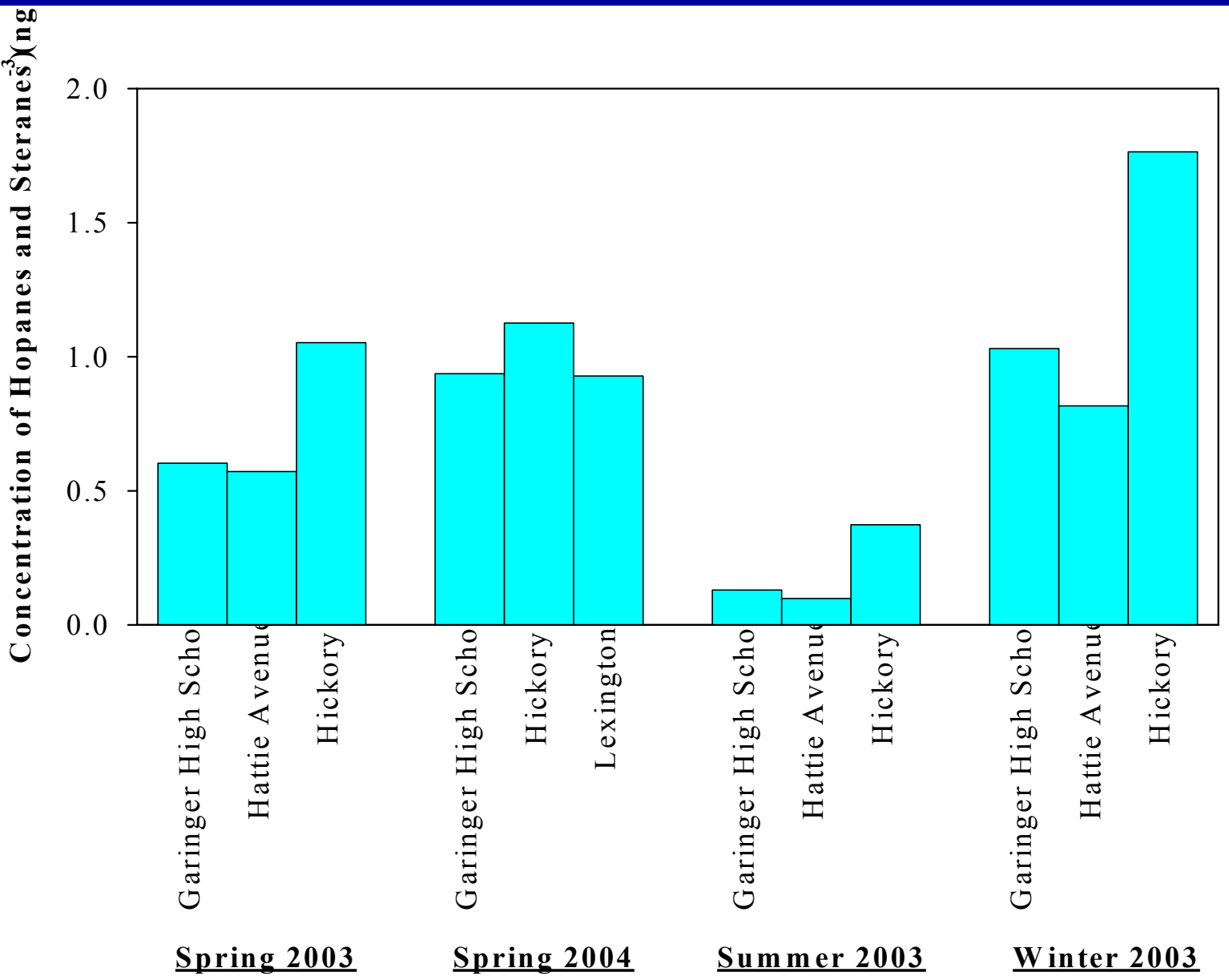
Spatial and seasonal distributions of OC and EC



Findings

- OC and EC concentrations were slightly higher in winter, followed by spring and summer.
- Both OC and EC concentrations were slightly higher at Hickory, followed by Garinger High School (GHS), and then Hattie Avenue.

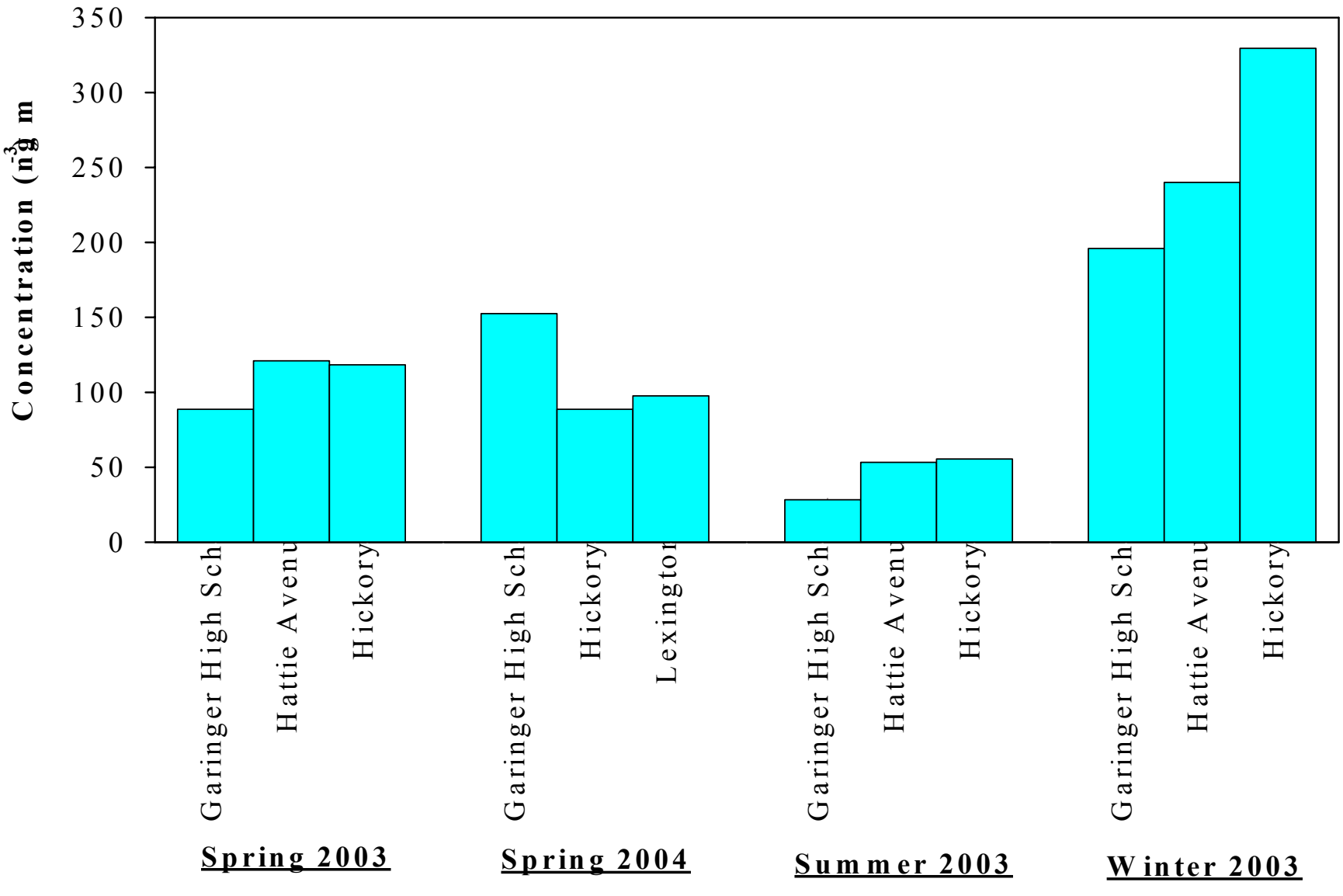
Spatial and seasonal distributions of hopanes and steranes (H+S)



Findings

- Hopanes and steranes are detected in fine particles emitted from both diesel and gasoline-powered vehicles.
- At all sites except Lexington, the highest concentration of hopanes and steranes (H+S) was found in winter, while the lowest level in summer.
- The highest H+S was at Hickory, not Lexington.

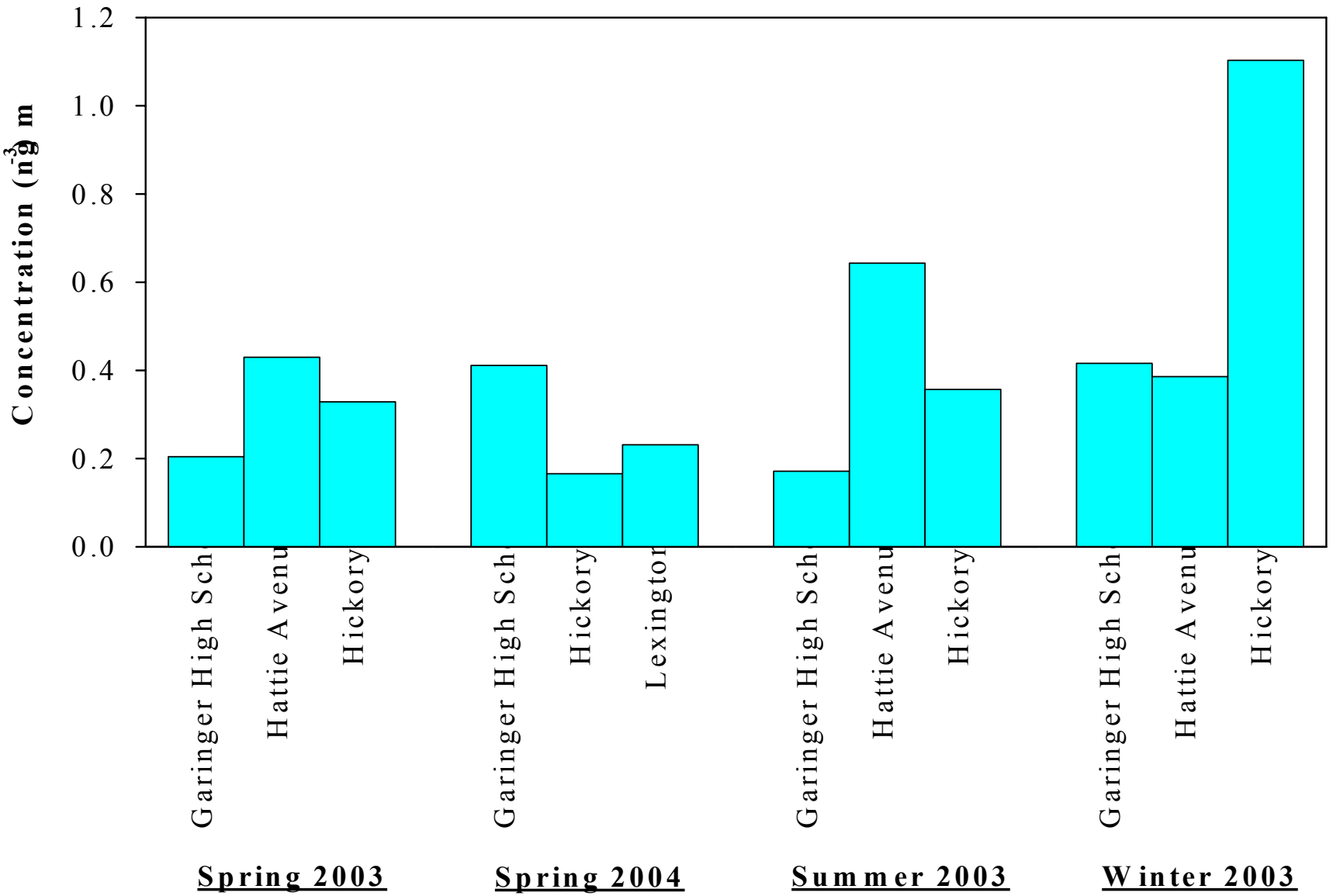
Spatial and seasonal distributions of levoglucosan



Findings

- Levoglucosan is an important tracer for wood combustion.
- Same seasonal variation pattern can be seen at all sites, with the highest levoglucosan concentration in winter and the lowest level in summer.
- In spring 2004, Levoglucosan concentration measured at Garinger High School was higher than at Hickory and Lexington.

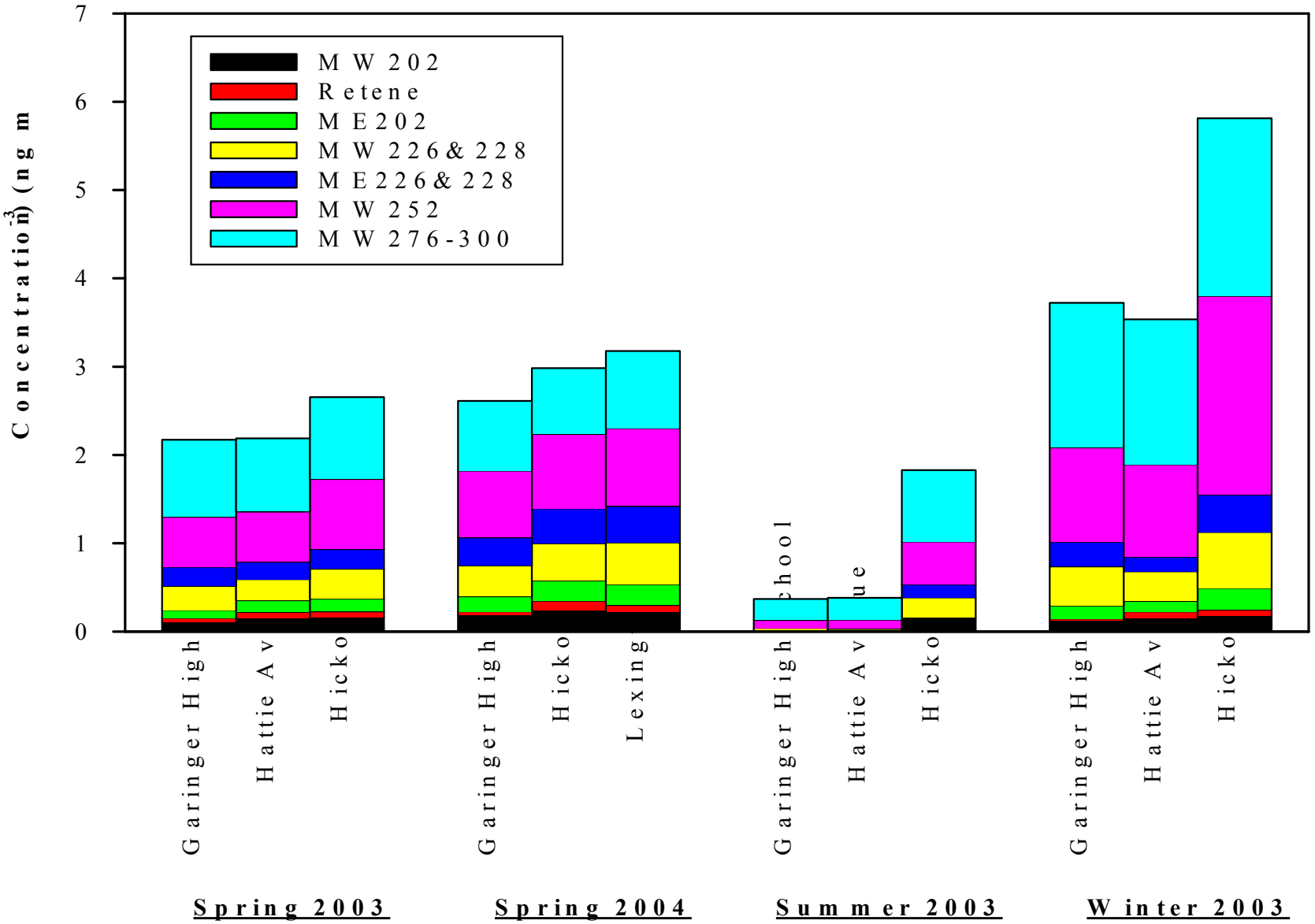
Spatial and seasonal distributions of cholesterol



Findings

- The seasonal distributions of cholesterol were different for different sites.
- Unlike other tracers, cholesterol concentration does not show a distinct low level in summer.

Spatial and seasonal distributions of PAHs

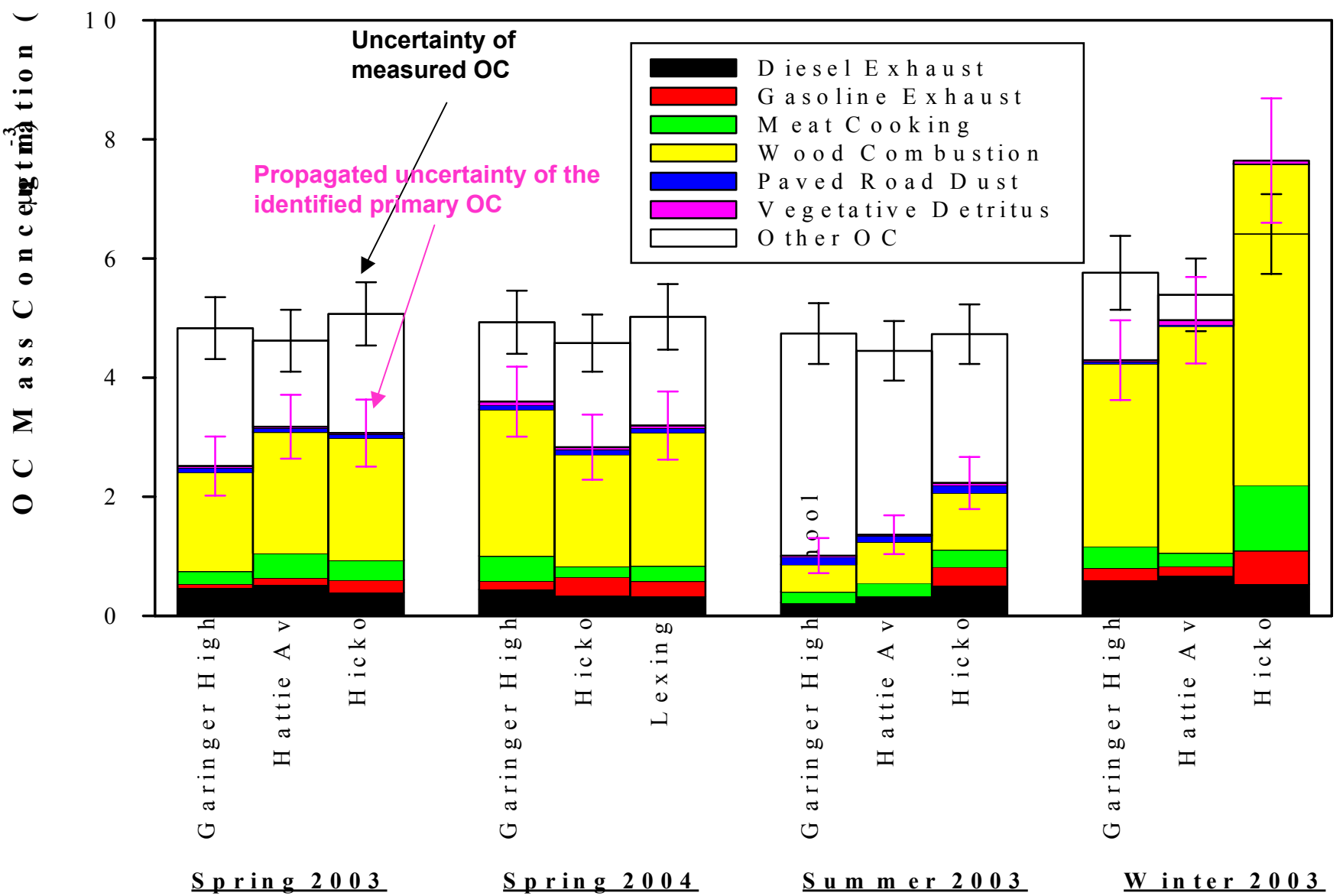


Findings

- Polycyclic aromatic hydrocarbons (PAHs) are mainly from incomplete combustion process.
- The highest level was found in winter at all sites.
- Among all sites except for Lexington, Hickory also had the highest level of PAHs.
- In summer 2003, PAH concentration measured at Hickory was much higher than at other sites.

Source Apportionment of Fine OC

Sources Contributions to Fine OC



Findings

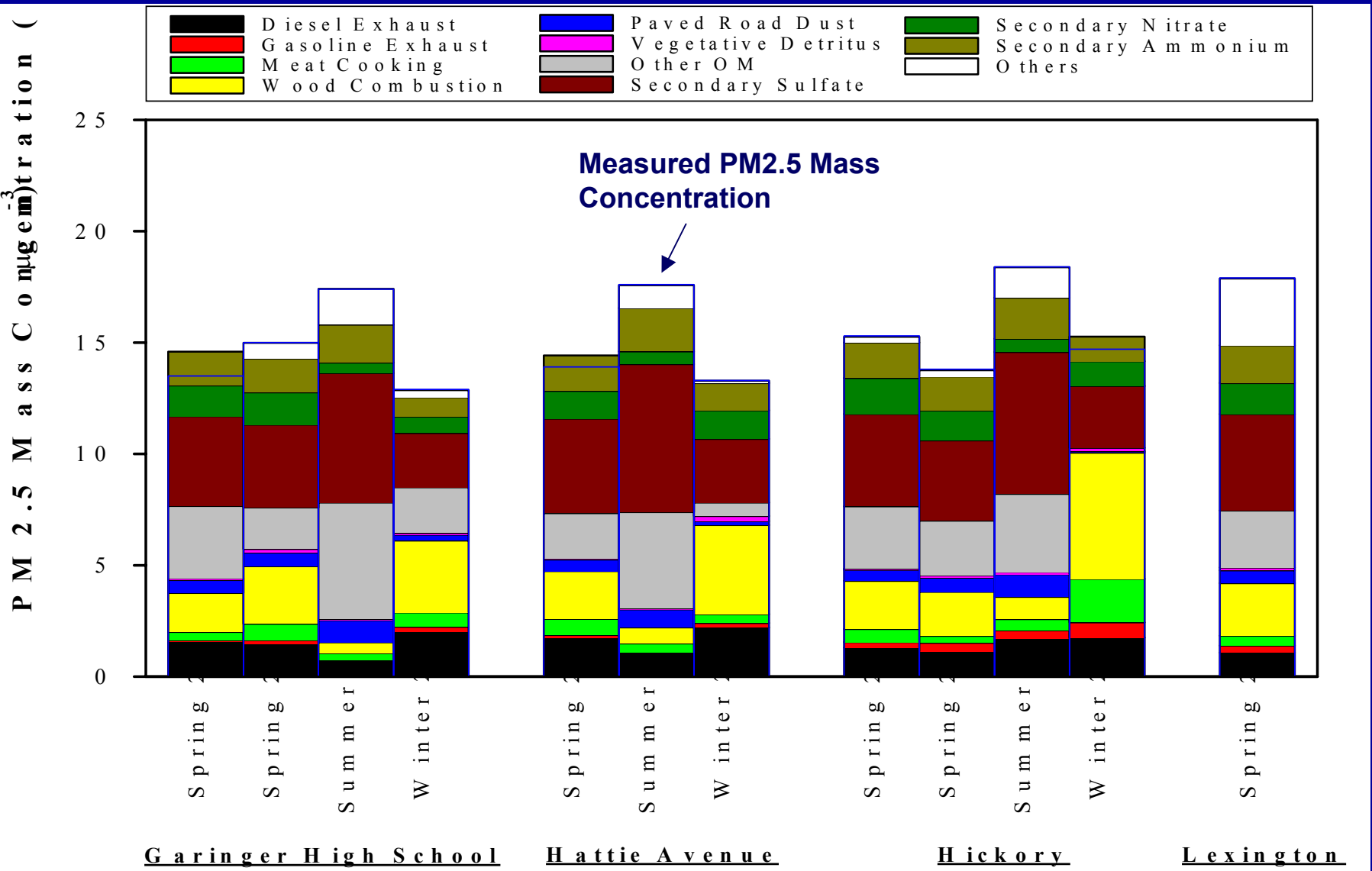
- Wood combustion, diesel exhaust, gasoline exhaust, and meat cooking are the major emission sources of fine OC at all sites.
- The highest “Other OC” or unexplained OC was always found in summer.
- Significant increase in wood combustion source can be seen in winter at all sites.

Source Apportionment of PM2.5

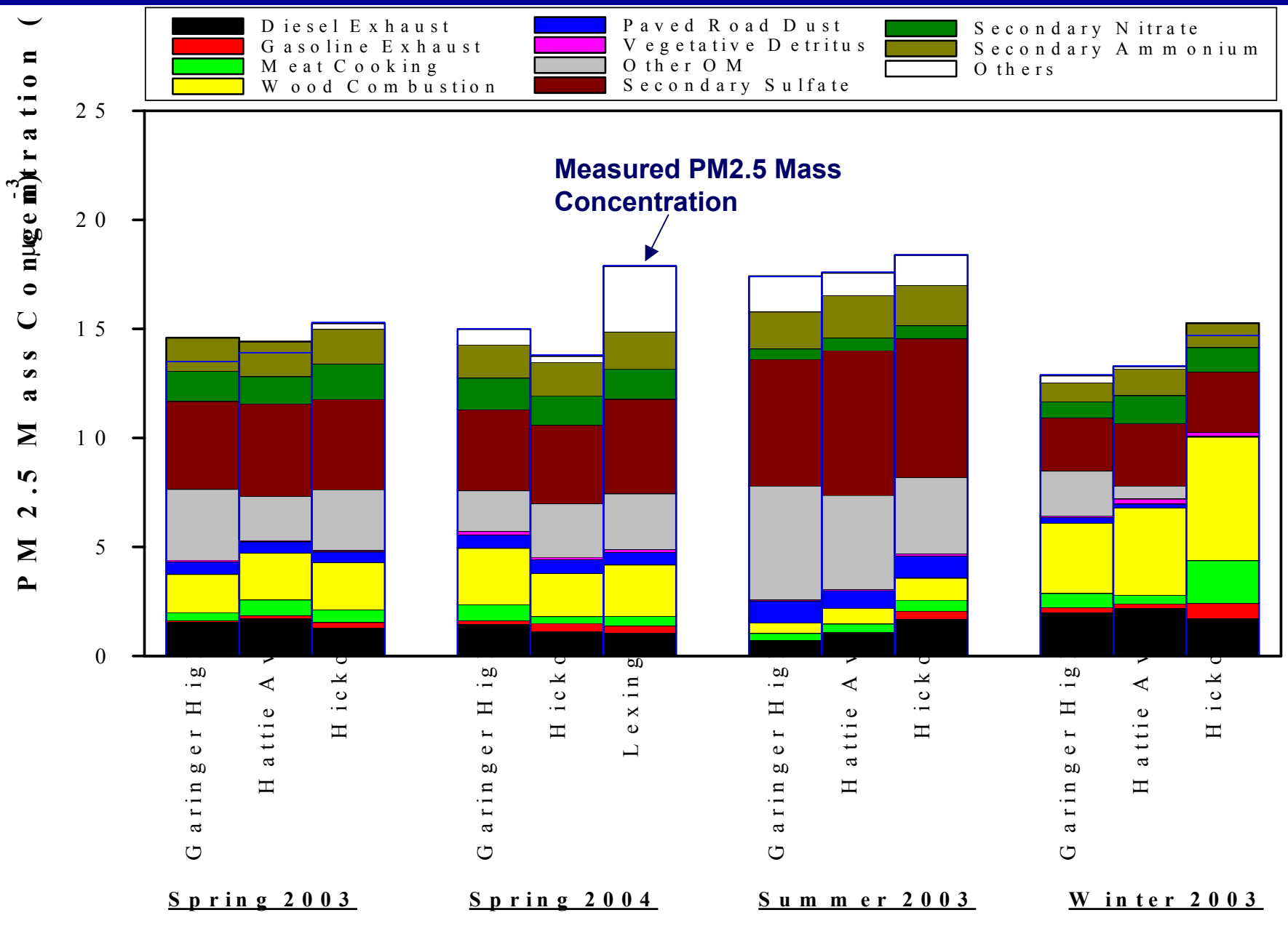
More Details of PM2.5 Source Apportionment

- **Contributions of the 6 primary emission sources to PM2.5 can be calculated based on OC source apportionment results since the ratios of OC to PM2.5 emitted from these sources are known from source tests.**
- **Secondary ions were estimated by subtracting the direct emissions of ions from these 6 primary sources from their measured ambient concentrations.**
- **"Other OM" was estimated by multiplying the "Other OC" by a factor of 1.4 to convert organic carbon to organic matter.**
- **"Others" represents the difference between the measured PM2.5 mass concentration and the sum of the identified primary sources and the secondary ions.**

Source Contributions to PM2.5



Source Contributions to PM2.5



Findings

- Secondary sulfate, wood combustion, diesel exhaust, secondary nitrate, secondary ammonium are the major sources of PM2.5.
- Both secondary sulfate and unexplained organic matter (Other OM) showed the highest level in summer.
- Though the measured PM2.5 concentration was the lowest in winter, primary emissions became more important, especially emissions from wood combustion.

Acknowledgements

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Thank You!