Assessment of Farmers' Exposure to Smoke from Agricultural Burning

L.-J. Sally Liu, Timothy Ting, Chris Simpson, Tim Gould, David Hardie

Department of Environ & Occu Health Sciences

University of Washington

For Ag Burning Task Force Meeting, Spokane, 6/10/04

Methods

- Nine subjects (one repeated) recruited in Oct 2003
- Monitored for exposure to
  - $PM_{2.5}$ (Harvard Personal Impactor and pDR)
  - NO_2 & SO_2 (Ogawa passive sampler)
  - CO (Langan CO monitor)
  - Aldehydes (UW passive sampler)
- Urine samples taken before and after burn; analyzed for methoxyphenols
- Other information
  - Time activity diary – 10 minute resolution and 6 micro-environments
  - Smoked foods diary
  - Burn characteristics – temperature, wind speed, burn type, etc

Analysis

- HPEM Filters
  - Mass gain
  - X-ray fluorescence
  - Light-absorbing carbon
  - Levoglucosan (LG) and methoxyphenols (MPs)
- Urine
  - Methoxyphenols

Summary of Monitored Agricultural Burns

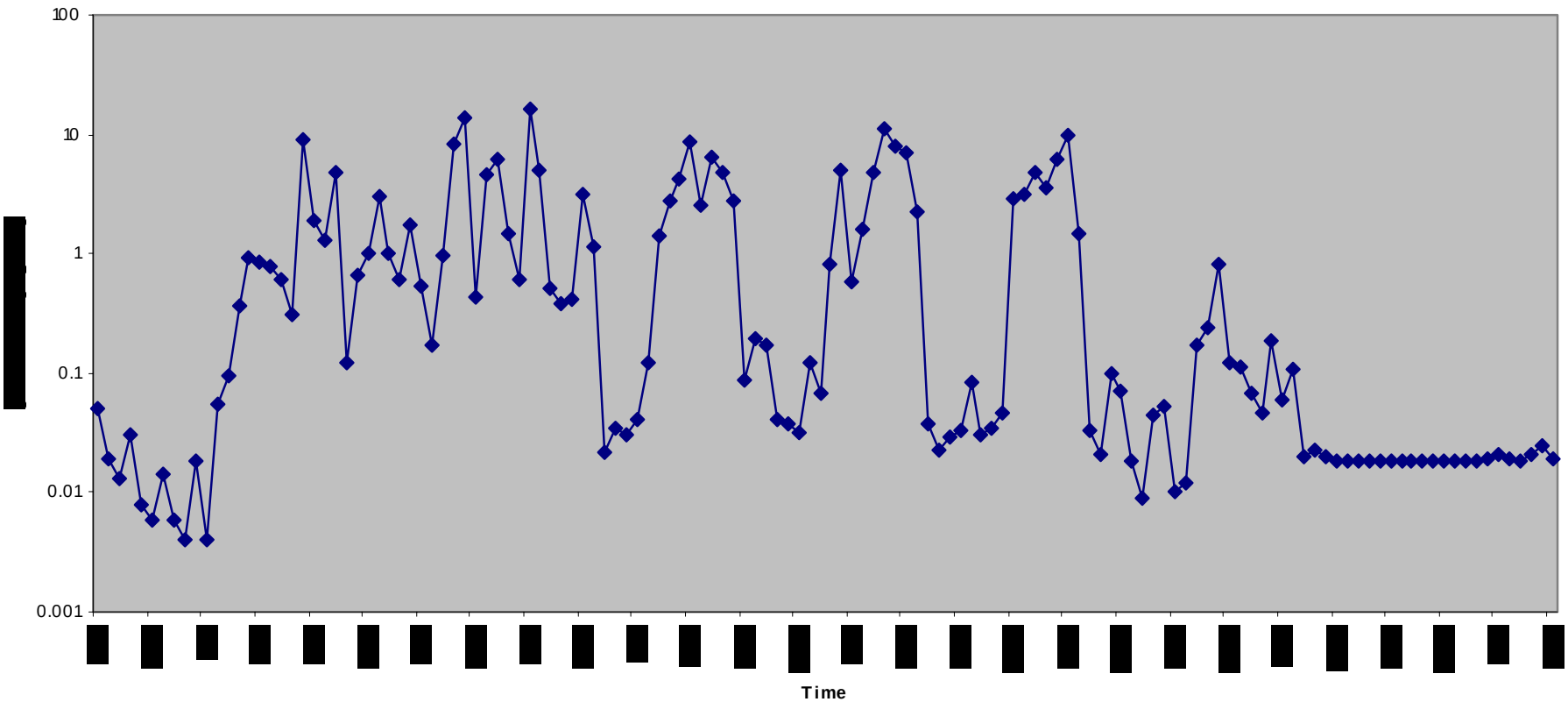
ID	DATE	DURATION (hrs)	INSTRUMENT RUN TIME	ACRES BURNED	MOISTURE CONTENT	BURN CONDITIONS	RESIDUAL LOAD (lbs)	VEHICLE MODEL
W01-01	10/15/2003	1.25	2.25	125	wet to dry	head fire	10000	Honda 300 4-trax
W01-02	10/22/2003	2.08	2.90	400	dry	backing fire, strip head fire		Honda 300 4-trax
W02	10/14/2003	0.62	1.12	1	wet	backing fire	10000	John Deere 3020 Tractor
W03	10/15/2003	1.00	1.13	25	very wet	backing fire, head fire	2000	Honda 400 ATV (4 wheel drive, small)
W04	10/20/2003	1.87	2.17	66	bone dry	backing fire	10000	Chevrolet 4wd pickup truck
W05	10/21/2003	2.27	2.77	154	dry	backing fire	7500	Yamaha 4x4 Kodiak
W06	10/21/2003	2.38	2.87	155	dry	backing fire, head fire, strip head fire, mass ignition	7500	Honda "Foreman" 400 Series (400 cc engine displacement)
W07	10/22/2003	2.98	3.82	71	dry	backing fire, head fire, strip head fire, mass ignition	4500	Honda "Fourtrax 300"
W08	10/22/2003	1.63	2.22	420	dry	backing fire	9000	Motorcycle - Honda Fatcat
W09	10/22/2003	2.98	3.28	71	dry	backing fire, head fire, strip head fire, mass ignition	4500	Ford F250 Lariet Diesel

Summary of time-activities

ID	In the field	Driving field truck	Resting in field	Outdoors away from field	Indoors	In a car	% time Nearby Smokers	% time Field burning
W01-01	16%	44%	0%	40%	0%	0%	7%	67%
W01-02	25%	75%	0%	0%	0%	0%	0%	76%
W02	0%	94%	0%	6%	0%	0%	0%	65%
W03	16%	84%	0%	0%	0%	0%	0%	100%
W04	10%	20%	0%	24%	19%	27%	0%	37%
W05	15%	35%	0%	31%	13%	6%	0%	32%
W06	8%	80%	12%	0%	0%	0%	0%	100%
W07	14%	86%	0%	0%	0%	0%	0%	96%
W08	32%	65%	0%	2%	0%	1%	0%	58%
W09	79%	18%	4%	0%	0%	0%	0%	96%

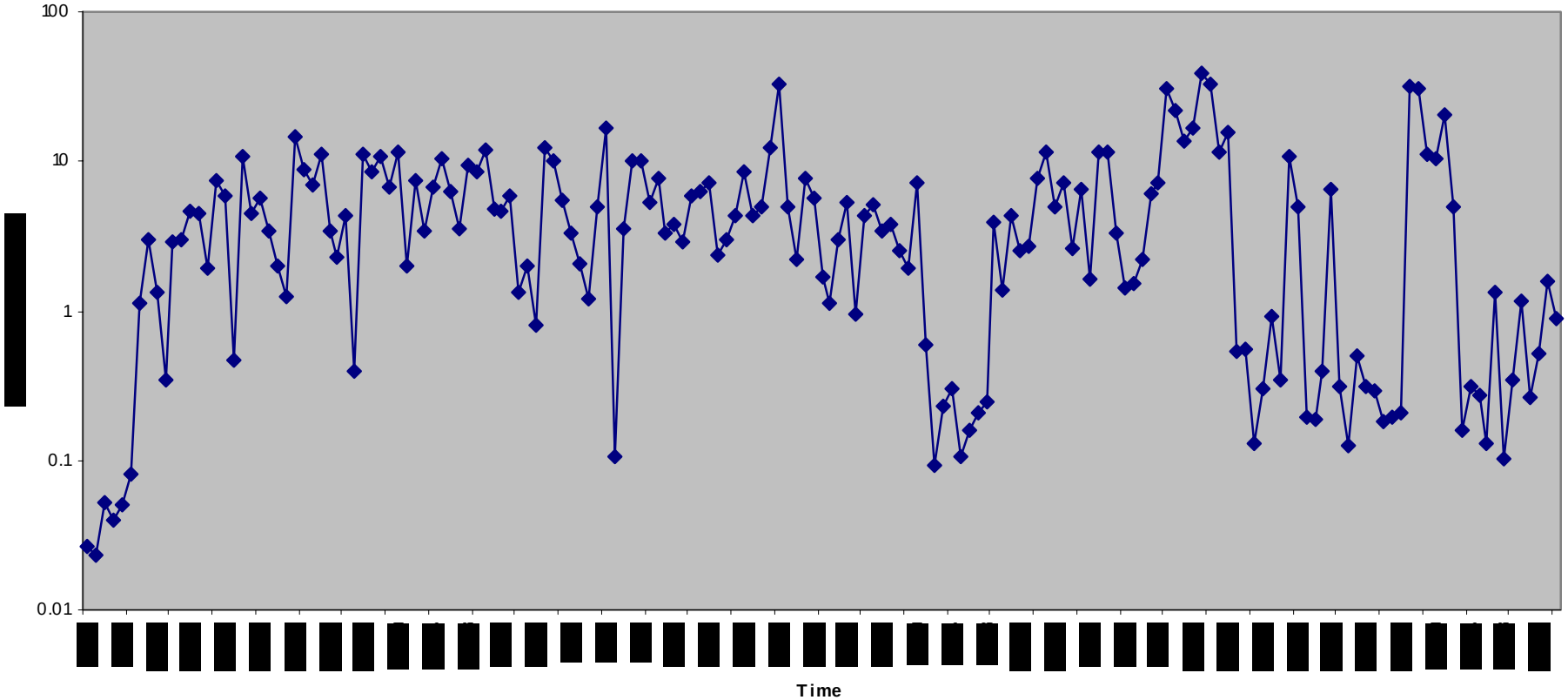
W01 (10/15)- igniting field, head fire

W01-01 (135 min, mean=1,505 μg/m³)



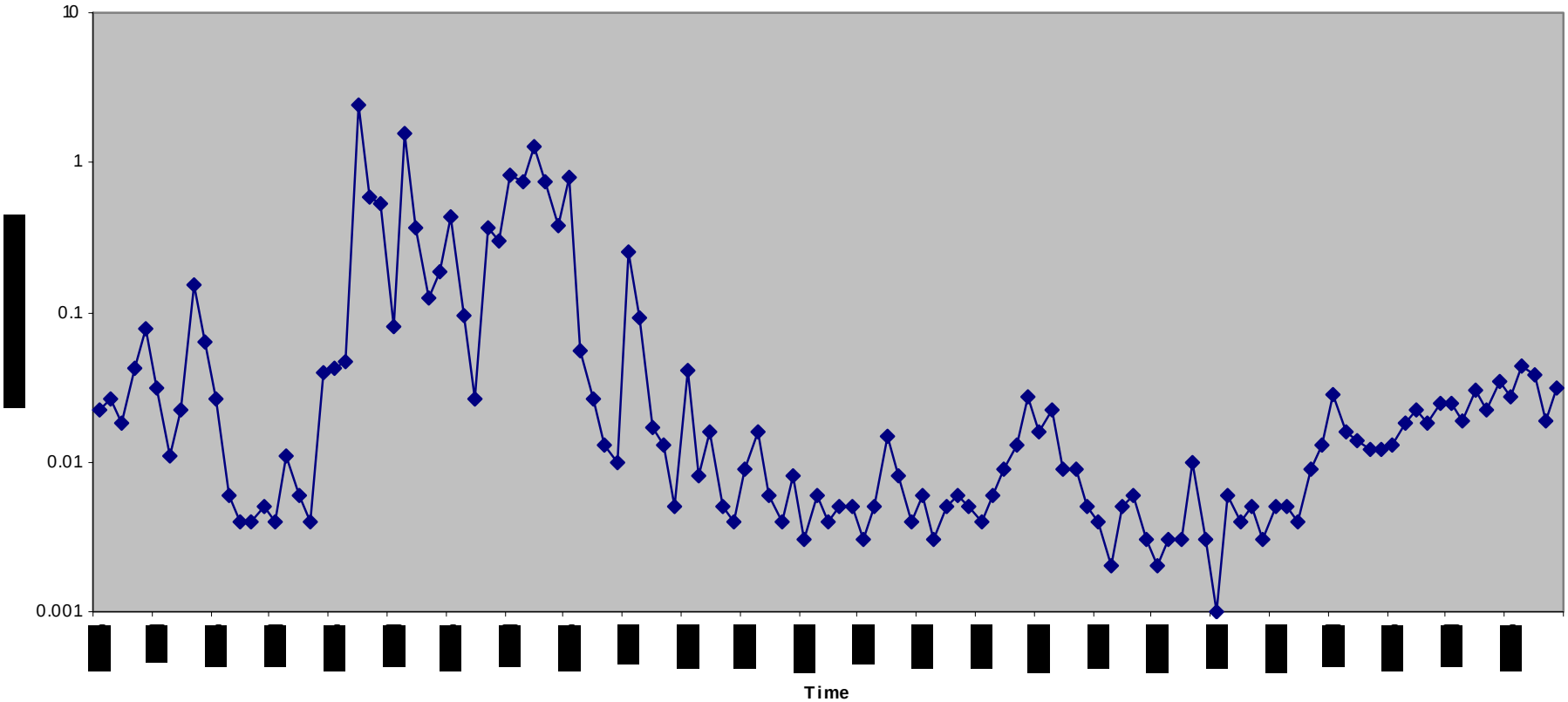
W01 (10/22) - igniting field, backing fire/strip head fire

W01-02 (174 min, mean=5,503 μg/m³)



W04 – backing fire

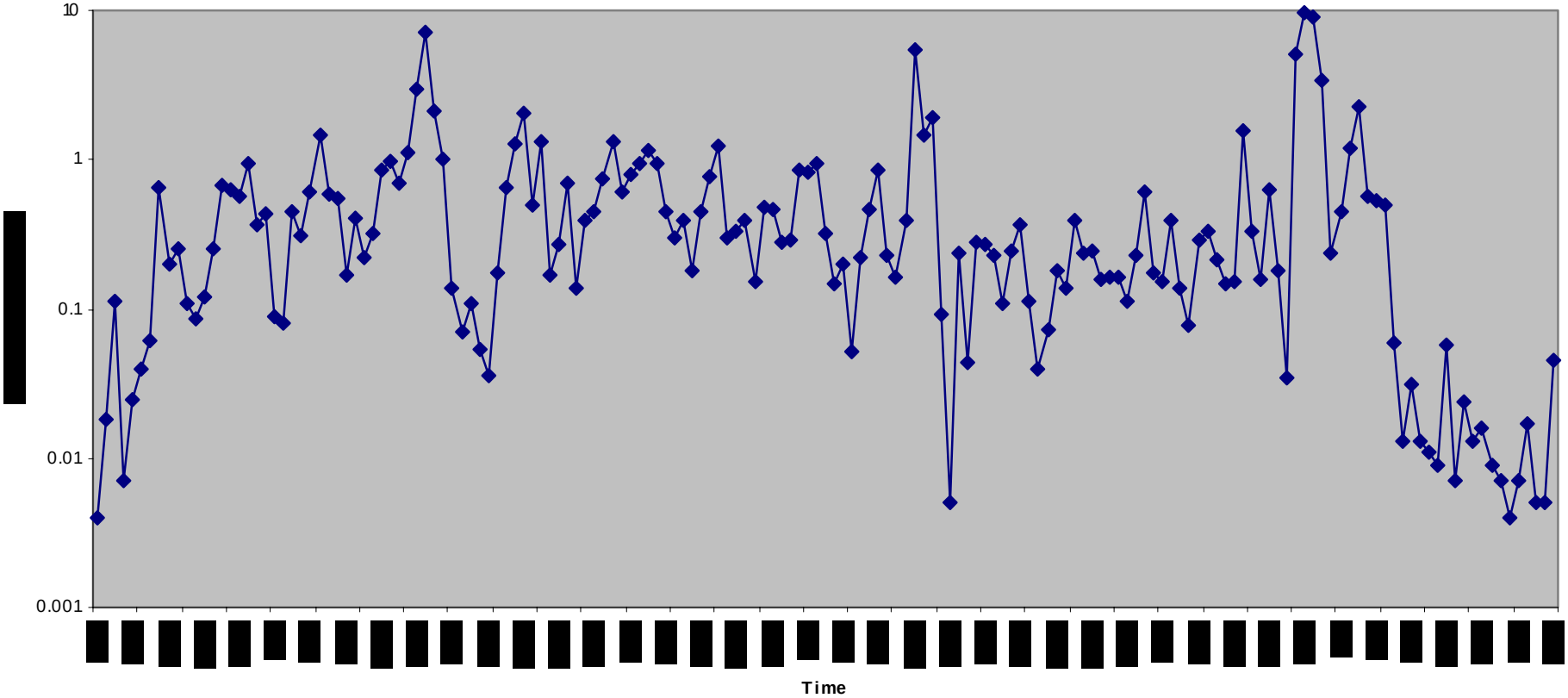
W04 (130 min, mean=111 μg/m^3)



W05 – backing fire , drag grate

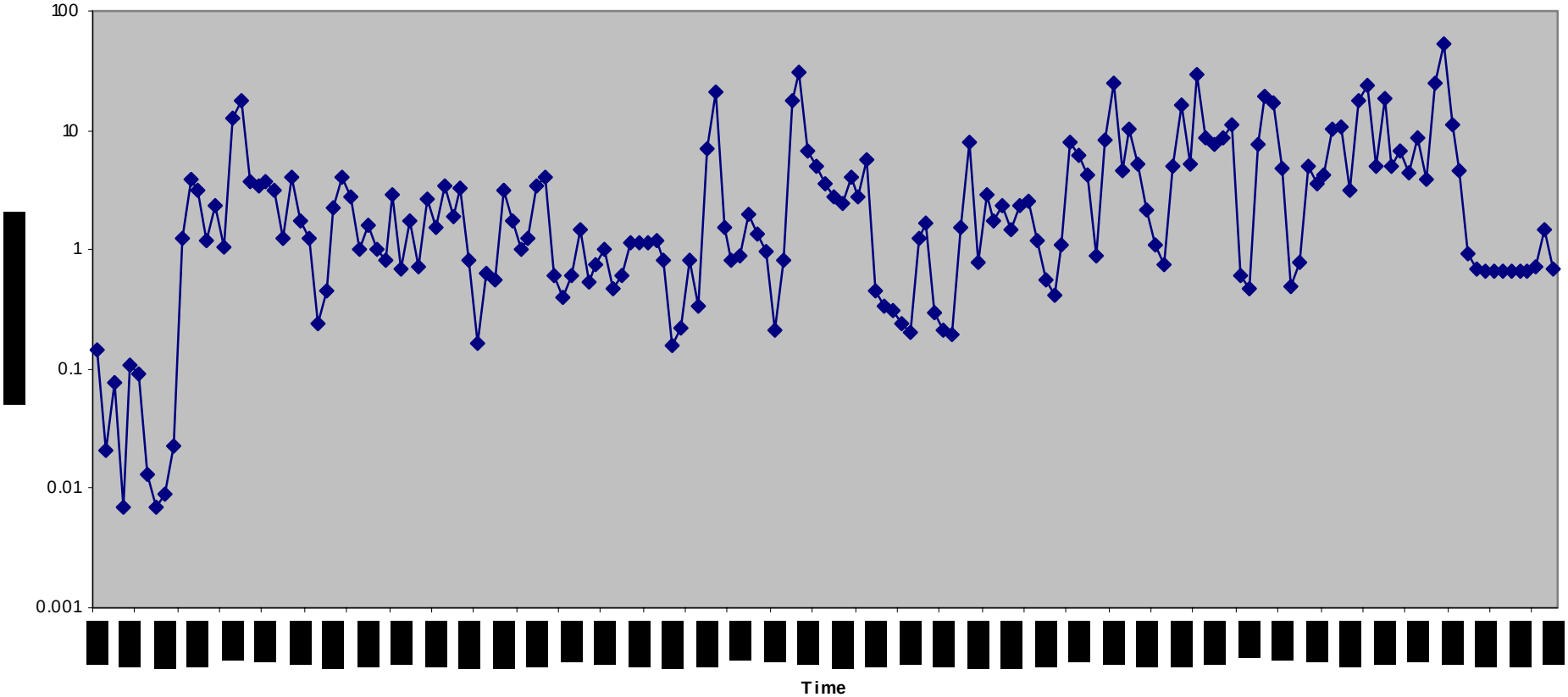
W05 – aethalometer

W05 (166 min, 647 μg/m³)



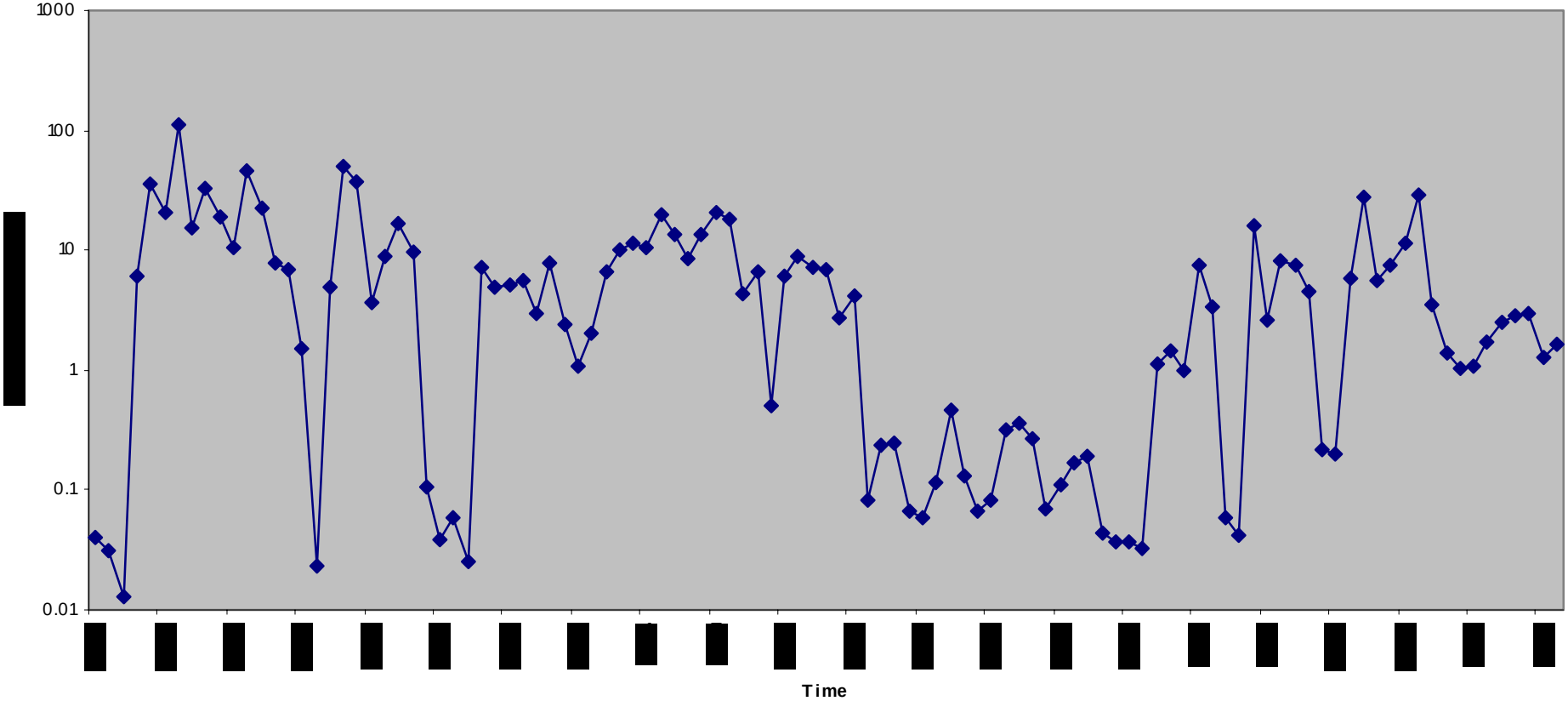
W06 – drip torch ignition

W06 (172 min, mean=4,239 μg/m³)



W08 – backing fire

W08 (133 min, mean=6,957 μg/m³)



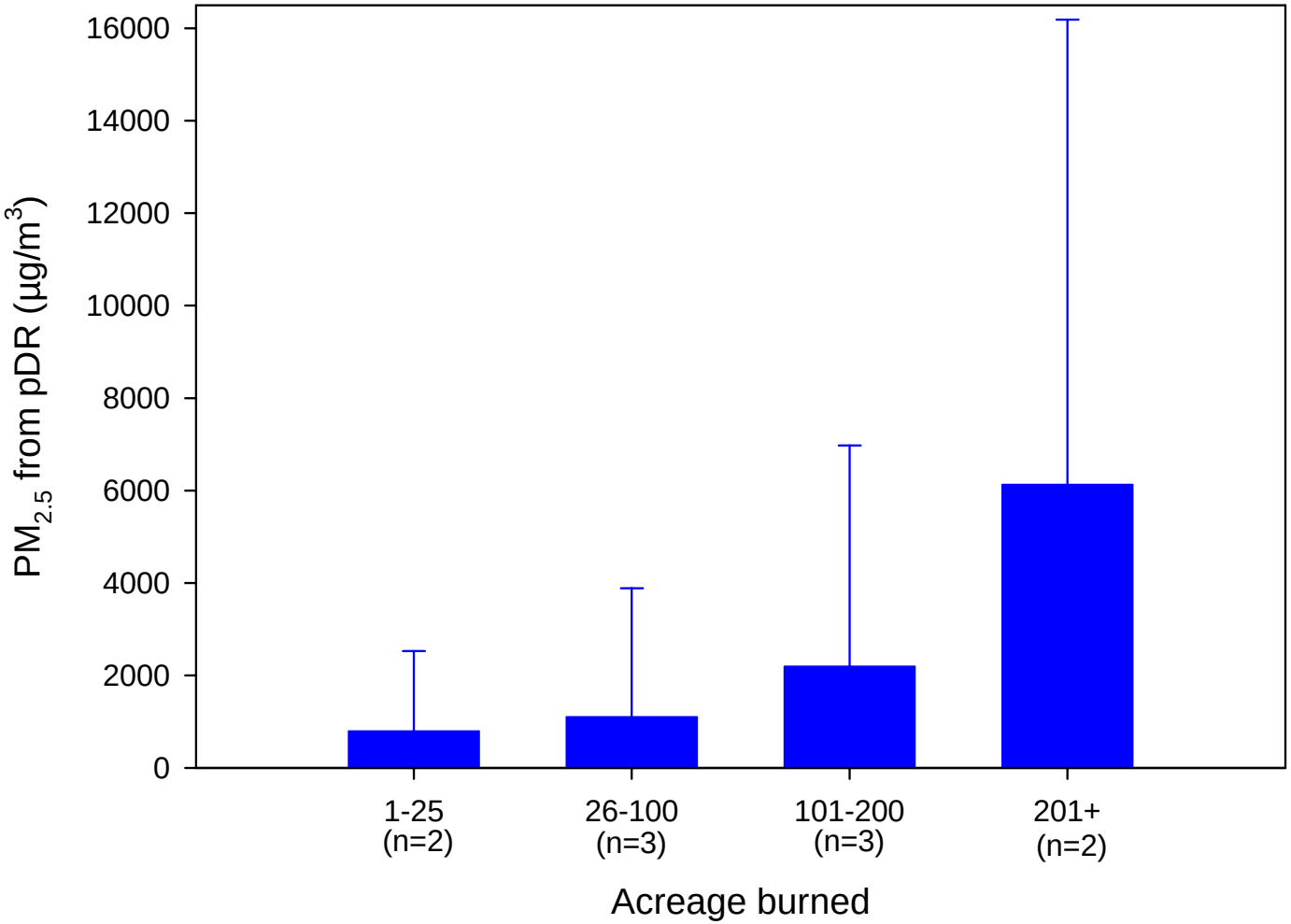
Summary of PM exposure as measured by pDR (1-min averages) and $HPEM_{2.5}$ (integrated over burn period) and environmental conditions.

	pDR ($\mu g/m^3$)						$HPEM_{2.5}$ Conc ($\mu g/m^3$)	T (°C)	RH (°C)
ID	N	MEAN	STD	MEDIAN	MIN	MAX		MEAN	MEAN
W01-01	135	1505	2874	110	4	16200	252	16	42
W01-02	174	5503	6865	3429	23	38380	3665	29	23
W02	67	168	388	56	3	2789	68	15	58
W03	68	1418	2250	354	3	12510	1378	14	55
W04	130	111	315	13	1	2430	628	24	36
W05	166	647	1336	269	4	9650	1157	35	27
W06	172	4239	6902	1542	7	52900	653	35	28
W07	229	2034	3929	717	0	27810	1807	30	31
W08	133	6957	13238	2065	13	109400	1034	29	30
W09	197	677	1378	268	5	16080	453	31	28

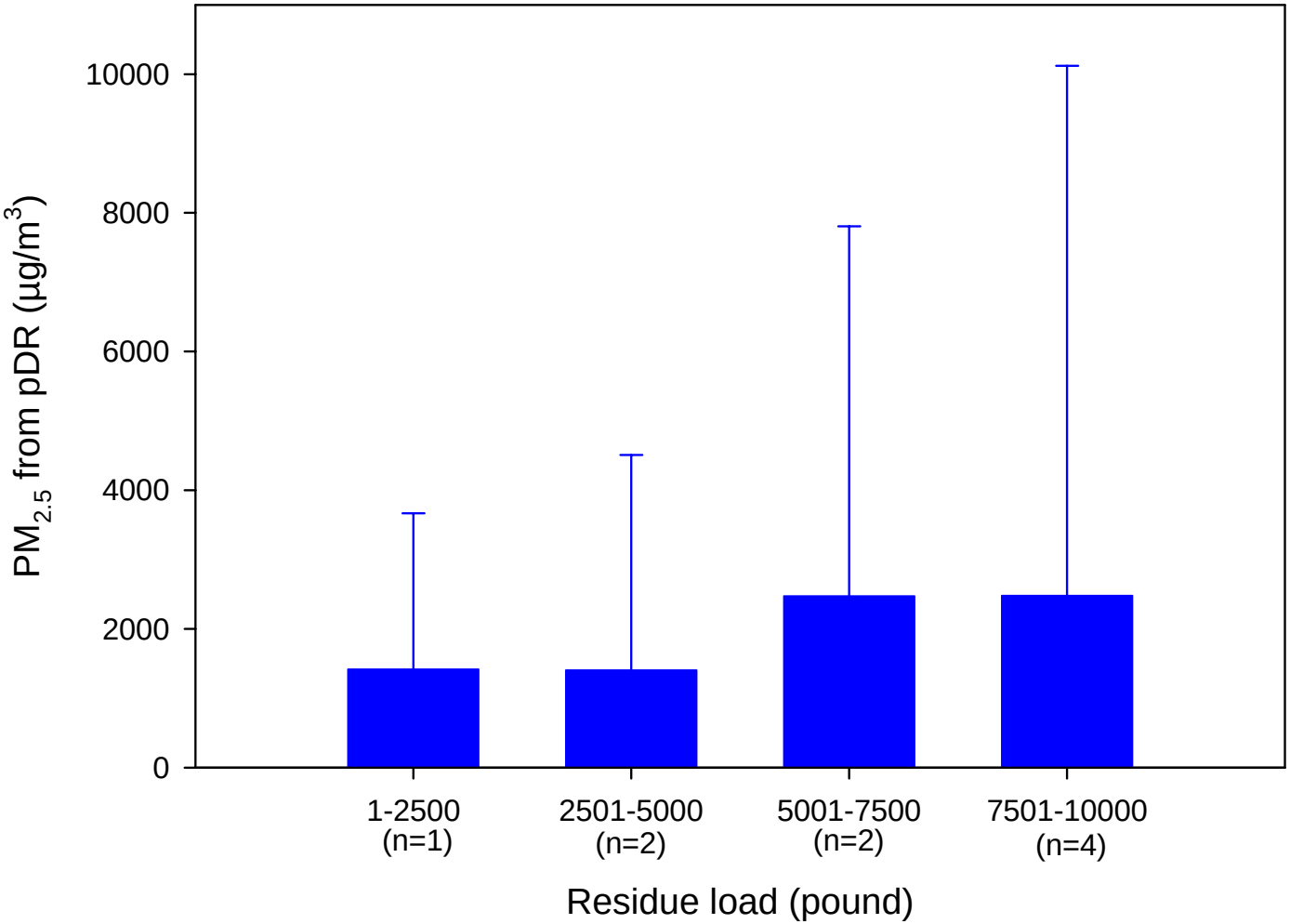
Summary of Trace Elements ($\mu g/m^3$)

	Mean	Median	Min	Max
Si	3.3712	3.6250	0.9520	4.7120
K	1.2086	1.3040	0.1540	1.8830
Fe	0.9050	0.8527	0.3420	1.4060
Al	0.7406	0.7661	0.1940	1.3460
Ca	0.7377	0.8415	0.1400	1.1950
Cl	0.3395	0.2924	0.0320	0.8086
Mg	0.1934	0.2608	0.0000	0.3802
S	0.1381	0.1347	0.0475	0.2363
Ti	0.0988	0.0934	0.0140	0.1732
Ba	0.0691	0.0376	0.0000	0.3680
Mn	0.0395	0.0390	0.0150	0.0772
Sn	0.0300	0.0084	0.0000	0.2220
P	0.0209	0.0185	0.0000	0.0741
Na	0.0146	0.0000	0.0000	0.1460
Sb	0.0146	0.0000	0.0000	0.1200
Sr	0.0105	0.0090	0.0023	0.0320
Ag	0.0089	0.0000	0.0000	0.0840
In	0.0087	0.0004	0.0000	0.0720
Cd	0.0071	0.0003	0.0000	0.0440
Zn	0.0070	0.0011	0.0000	0.0528

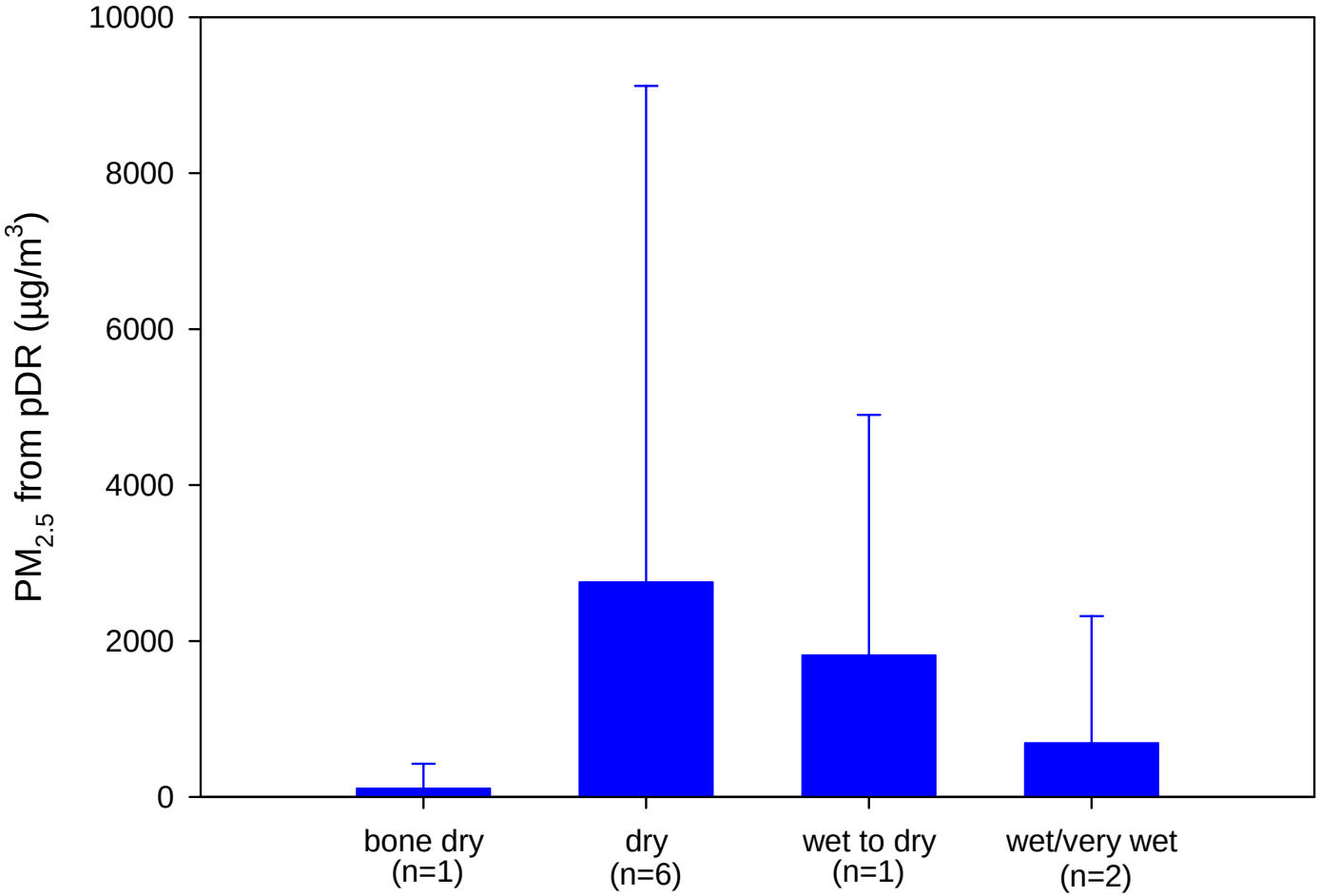
Personal exposure vs. acreage burned



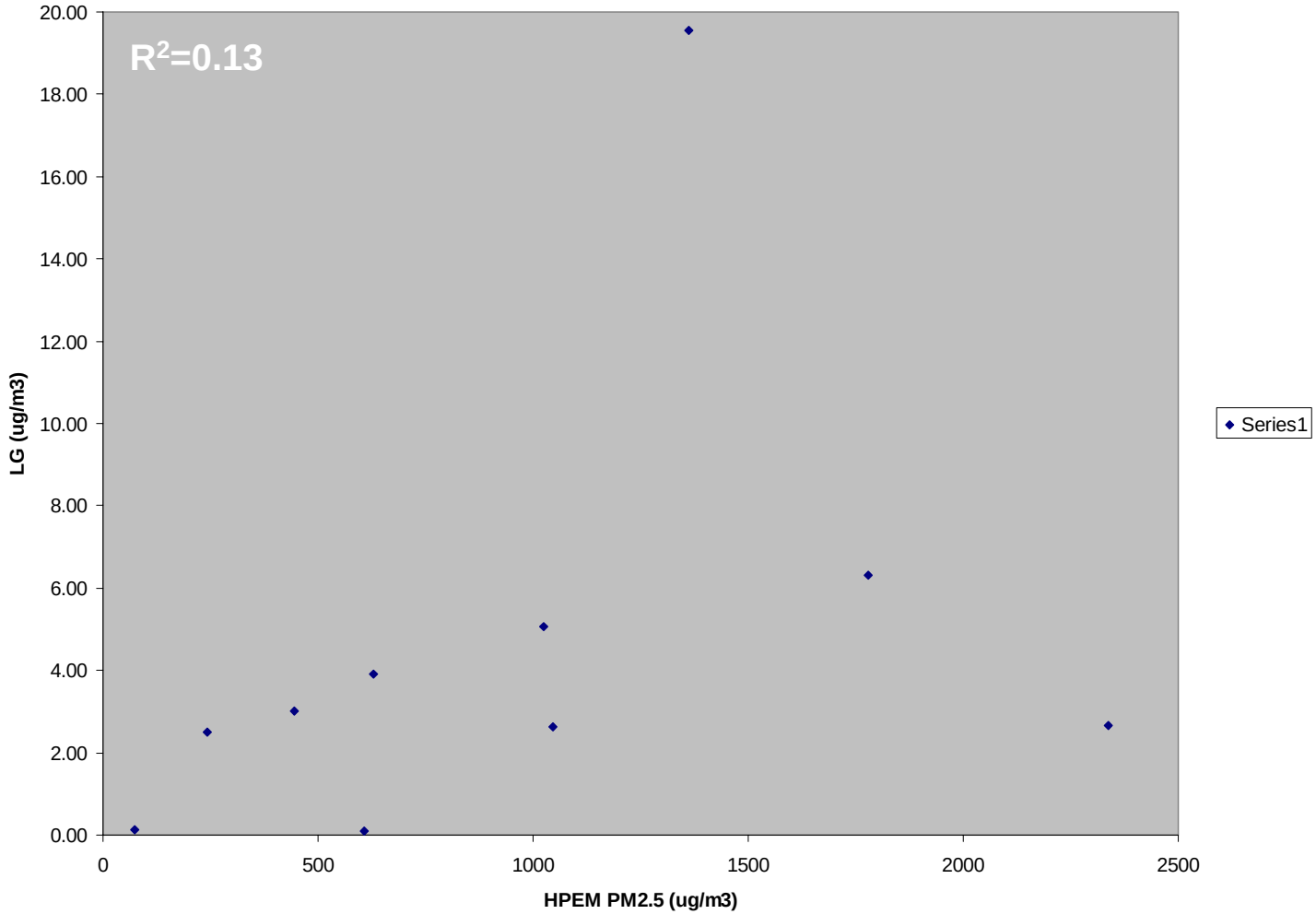
Personal exposure vs. residue load



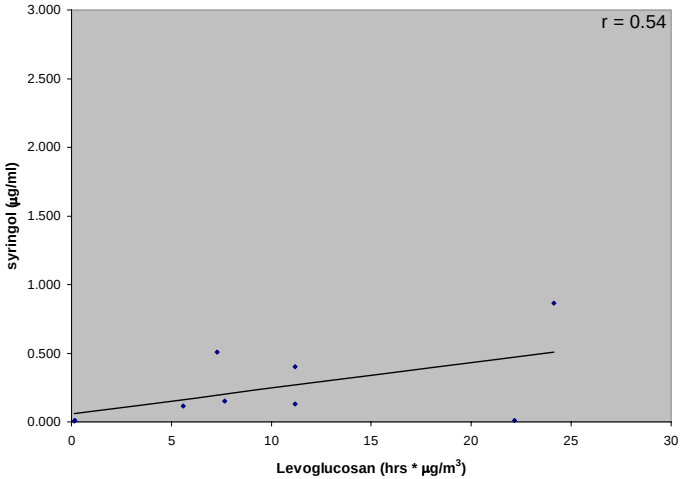
Personal exposure vs. moisture of residue

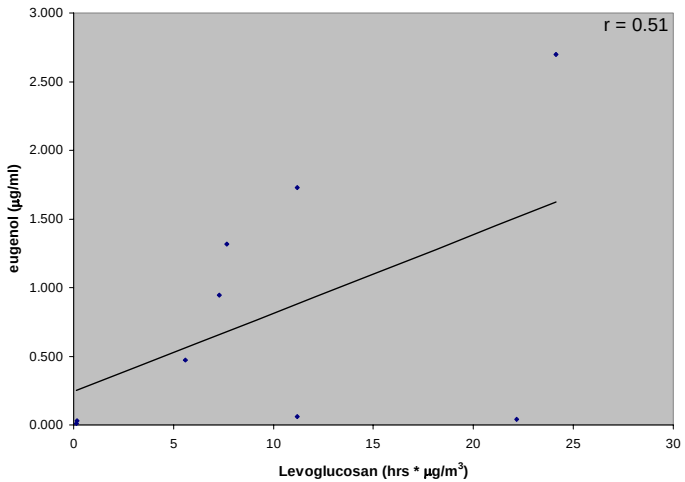


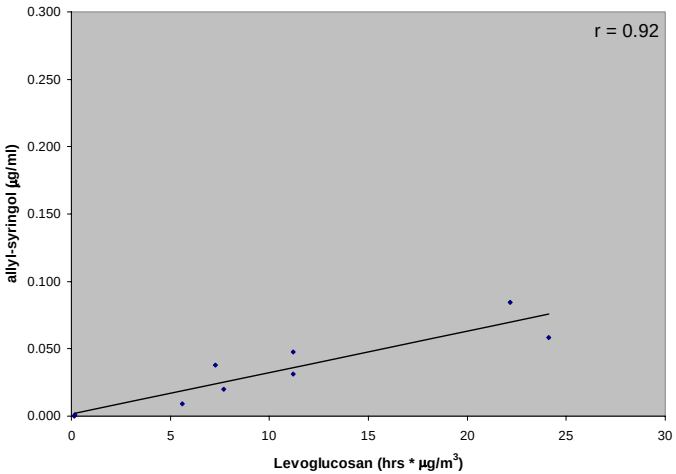
LG vs. $HPEM_{2.5}$

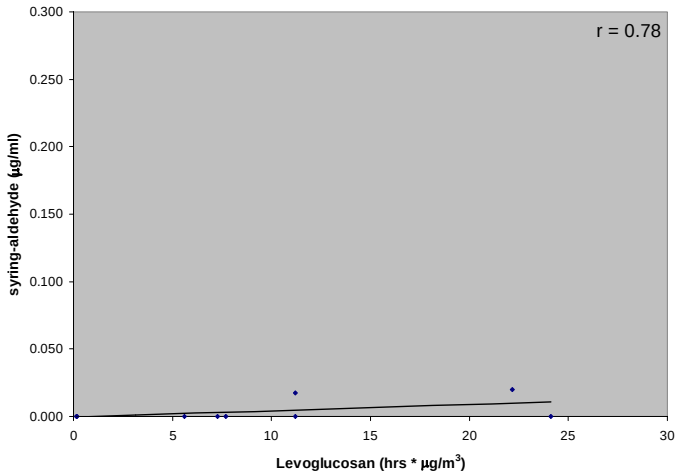

R2=0.13
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
LG (ug/m3)
0
500
1000
1500
2000
2500
HPEM PM2.5 (ug/m3)
Series1

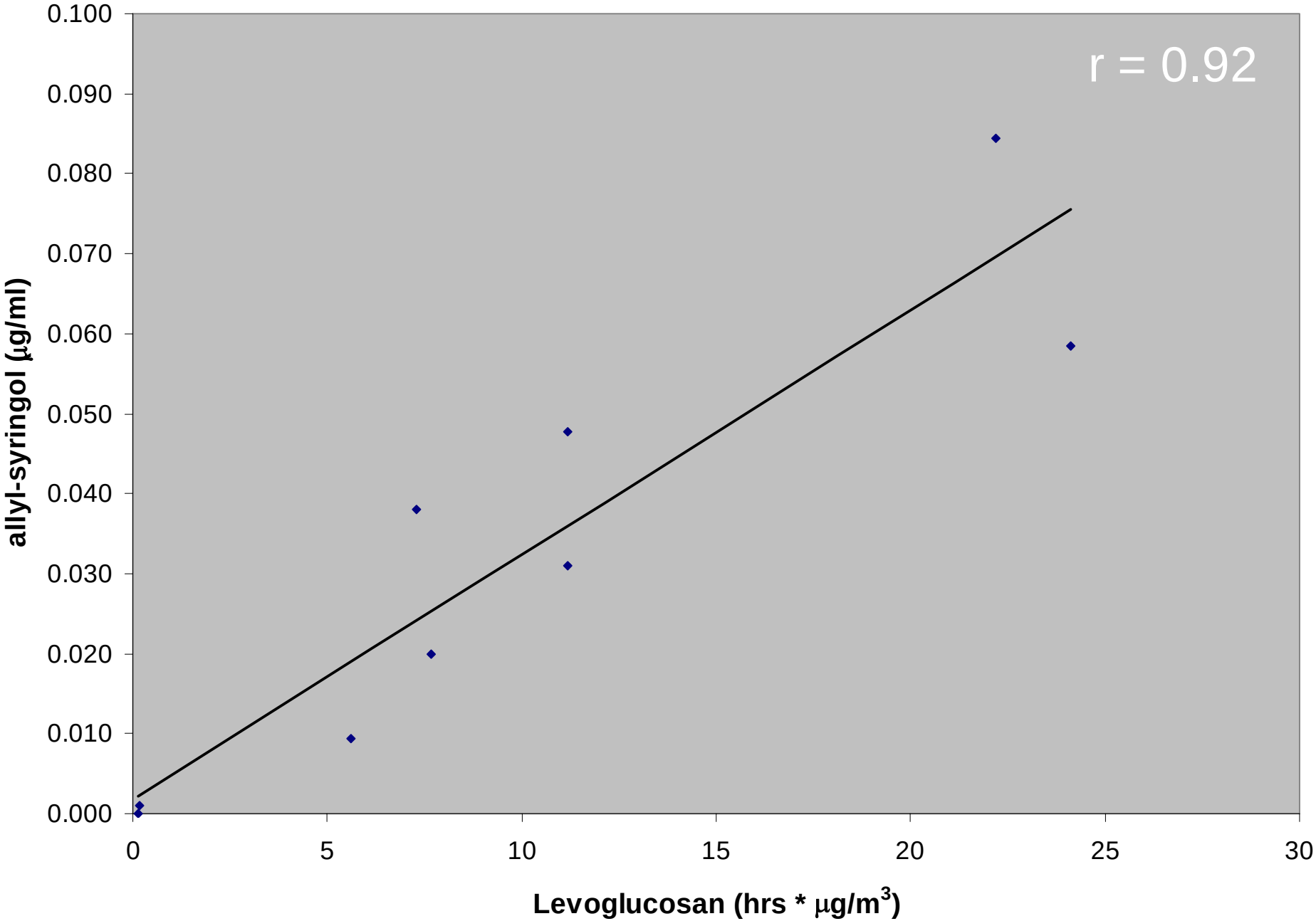
LG vs. methoxyphenols



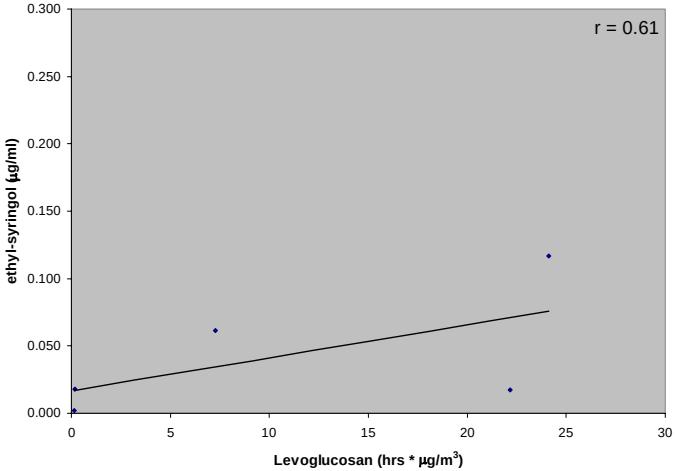


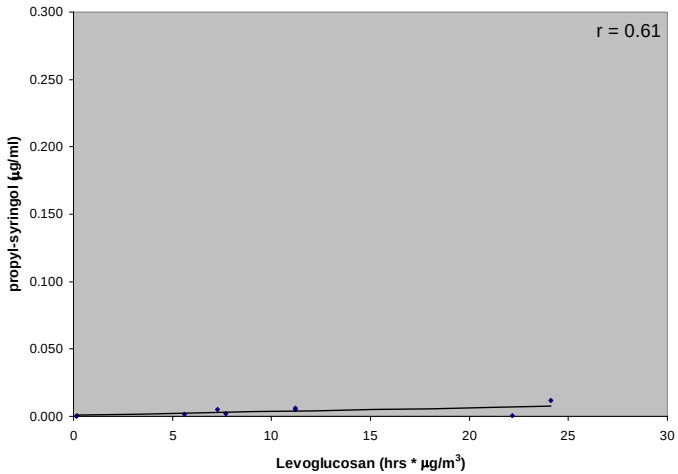


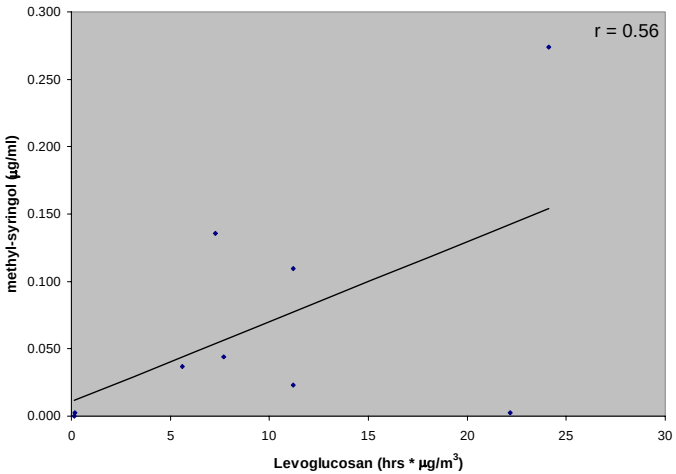


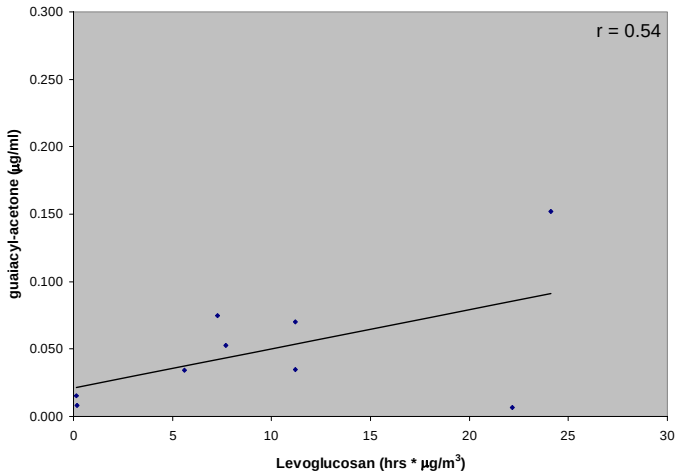

r = 0.92
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
allyl-syringol (µg/ml)
0
5
10
15
20
25
30
Levoglucosan (hrs * µg/m3)

LG vs. methoxyphenols









Summary

- Acute exposure to Ag burning related PM ranges between 111 and 7,949 $\mu g/m^3$, with a median of 2326 $\mu g/m^3$. These levels are higher than the EPA's National Ambient Air Quality Standard (65 $\mu g/m^3$, 24-h average). Two subjects had PM averages greater than the OSHA's standard for $PM_{2.5}$ (5000 $\mu g/m^3$, 8-h average).

- The $PM_{2.5}$ exposure levels are positively correlated with the residue loads of the wheat stubble and the acreage burned.

Summary (continued)

- Levoglucosan (LG) concentrations range between 0.13 and 19.5 $\mu g/m^3$, with an average of 4.58 $\mu g/m^3$.
- A good portion of $PM_{2.5}$ came from re-suspended dust based on the silica loading from the XRF analysis. However, substantial exposure is from Ag burning smoke based on LG loading, light absorbing carbon analysis, and urinary methoxyphenol (MP) results.
- LG concentrations correlate well with many urinary MPs, especially with syring-aldehyde and allyl-syringol.
- Farmers are exposed to substantial amount of $PM_{2.5}$ while conducting Ag burning.

Acknowledgements

- The Grower participants
- The Columbia Conservation District
- Karen Wood and the Ecology
- This study was funded by a grant from the Pacific Northwest Agricultural and Safety Health Center and the Northwest Center for Particulate Pollution and Health.