5.0 CORRELATIONS

Section 4 summarized the relationship between lead levels and various abatement, sampling and other factors by sample type. Here we discuss correlations of lead levels between the various sample types after correction for the estimated effects of the factors discussed in Section 4. Thus, these correlations should be interpreted as relationships between different sample types above and beyond that which are explained by things like abatement, age of house, cleanliness measures, and other factors included in the models.

This analysis involves examining correlation matrices and scatterplot matrices. The primary data used to examine these relationships are the estimated random house (house) effects and the estimated random location-within-house effects. Both of these random effects are estimated after controlling for the estimated fixed effects in the model for each sample type.

5.1 BETWEEN-HOUSE CORRELATIONS

The correlation matrix of random house-to-house differences in lead loading is presented in Table 5-1. To locate a correlation of interest, locate the row corresponding to the first sample type and the column corresponding to the second sample type. Correlation information for the two sample types is presented in the corresponding box. Within each box, three values are presented:

- **Top value:** Correlation coefficient between the logarithms of the geometric house means,

- **Middle value:** Degrees of freedom used in calculating the correlation coefficient, and

- **Bottom value:** Observed significance level of the test of the hypothesis of no correlation (correlation coefficient equal to zero).

Table 5-1. Correlations* Among Sample Types for Between-House Random Effects: Lead Loading

	Air Duct	Window Channel	Window Stool	Floor (Wipe)	Entryway Exterior (Dust)
Air Duct		.16 33 .37	.13 37 .43	.25 21 .26	.41 36 .01
Window Channel			.56 41 .00	-.08 25 .68	.12 40 .43
Window Stool				-.03 27 .87	.09 45 .55
Floor (Wipe)					.44 27 .02
Entryway Exterior (Dust)					

* Top number is estimated correlation; middle number is degrees of freedom; and bottom number is significance level.

Only the upper right-hand half of the matrix, above the shaded diagonal, is filled in since the lower left-hand half of the matrix would contain redundant information.

When controlling for the fixed effects, degrees of freedom for the estimation of correlation are specified to estimate the fixed effects. This was accounted for in the significance levels and the degrees of freedom displayed in the correlation tables.

The following method was used to calculate degrees of freedom for estimating the house-level correlation of two sample types, A and B:

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1. Let $m_{A,B}$ denote the number of houses from which samples of both types were taken, and

2. Let f_i denote the number of house-level fixed effects in the model fit for sample type i (i=A,B).

3. $df_{A,B} = m_{A,B} - \max(f_A, f_B) - 2$.

In most cases there were at least 30 degrees of freedom. Estimates of correlations with floor wipe samples had fewer degrees of freedom because the samples were only taken in the abated houses.

Some sample types are not represented in the house-level correlation analysis. This is because in some cases the restricted maximum likelihood (REML) estimates of the random house-to-house differences were negligible after controlling for the fixed effects. This happened in the case of interior entryway lead loadings, vacuum floor lead loadings and concentrations, air duct concentrations, and interior entryway dust loadings.

The lead loading random house effect estimates are presented graphically in Figure 5-1. This figure is a scatterplot matrix, or a collection of bivariate plots organized into matrix form. As with the correlation matrix, to locate a plot of interest,

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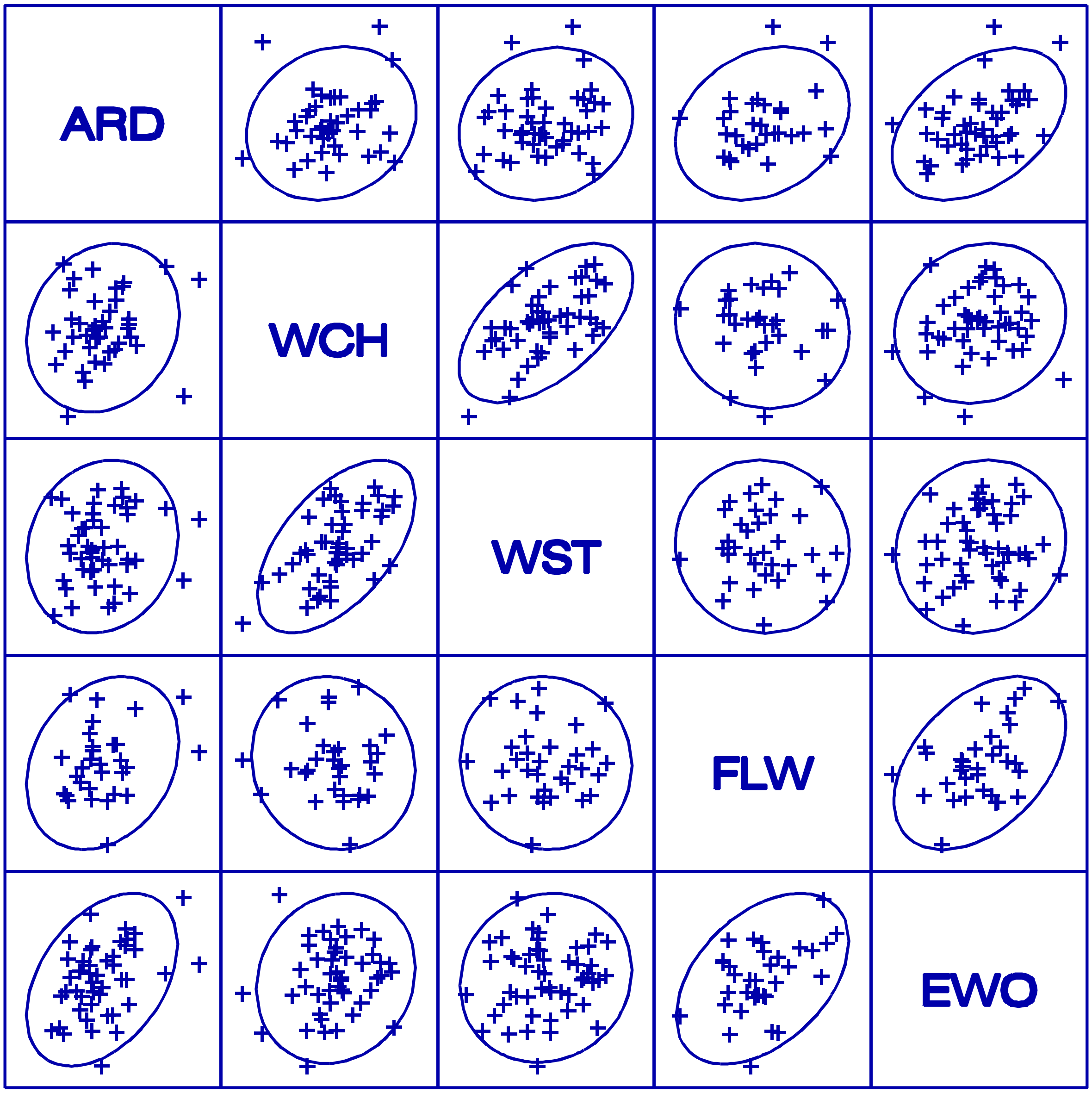

Figure 5-1. Scatterplot matrix of unit-level random effects for different sample types: lead loading ($\mu g/ft^2$).

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identify the row associated with one sample type and the column associated with the other sample type. The plot is presented in the corresponding box. Within each box, the horizontal axis represents increasing values of the column variable on a logarithmic scale. Similarly, the vertical axis represents increasing values of the row variable on a logarithmic scale. The abbreviations employed on the diagonal to identify the different sample types are defined in Table 1-4.

The ellipse plotted in each box of Figure 5-1 is the ellipse that contains 95% of the probability associated with the estimated bivariate normal distribution for the plotted data. The narrower the ellipse, the stronger the correlation between the two sample types. If the ellipse is oriented from the lower left-hand corner of the box to the upper right-hand corner of the box, the sample types are positively correlated. If, on the other hand, the ellipse is oriented from the upper left-hand corner of the box to the lower right-hand corner of the box, the sample types are negatively correlated.

Table 5-2 contains house-to-house correlation estimates for lead concentrations; Table 5-3 provides the same for dust loading. Figure 5-2 is the analog to Figure 5-1 for lead concentrations; Figure 5-3 provides the same information about dust loadings.

There were several indications of a positive house-level correlation between different sample types. No significant negative correlations were observed. Thus, unexplained (not accounted for by the models) differences between lead and dust levels in different houses appear to be similar for certain pairs of sample types.

The strongest correlation in lead loadings was observed between window channels and window stools. The estimated

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correlation was 0.56 with 41 degrees of freedom. This was highly significant. Examining Figures 5-2 and 5-3 reveals that this

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Table 5-2. Correlations* Among Sample Types for Between-House Random Effects: Lead Concentration

	Vacuum				Soil		
	Window Channel	Window Stool	Entryway Interior	Entryway Exterior	Entryway	Foundation	Boundary
Window Channel		.40 41 .01	.27 40 .08	.26 40 .10	.23 41 .13	.07 24 .72	.15 39 .35
Window Stool			.07 44 .63	-.06 45 .70	.18 46 .22	.12 29 .53	.38 44 .01
Entryway Interior				.25 43 .09	.29 44 .05	.26 28 .16	.22 43 .15
Entryway Exterior					.18 45 .22	.32 28 .08	-.12 43 .44
Entryway						.29 29 .11	.56 44 .00
Foundation							.09 29 .93
Boundary							

* Top number is estimated correlation; middle number is degrees of freedom; and bottom number is significance level.

Table 5-3. Correlations* Among Sample Types for Between-House Random Effects: Dust Loading

	Air Duct	Window Channel	Window Stool	Floor (Vacuum)	Entryway Exterior (Dust)
Air Duct		-.32 33 .06	.03 37 .88	.12 37 .45	.33 36 .04
Window Channel			.34 41 .02	.17 38 .28	.01 40 .96
Window Stool				.27 43 .07	.15 45 .30
Floor (Vacuum)					.33 42 .03
Entryway Exterior (Dust)					

* Top number is estimated correlation; middle number is degrees of freedom; and bottom number is significance level.

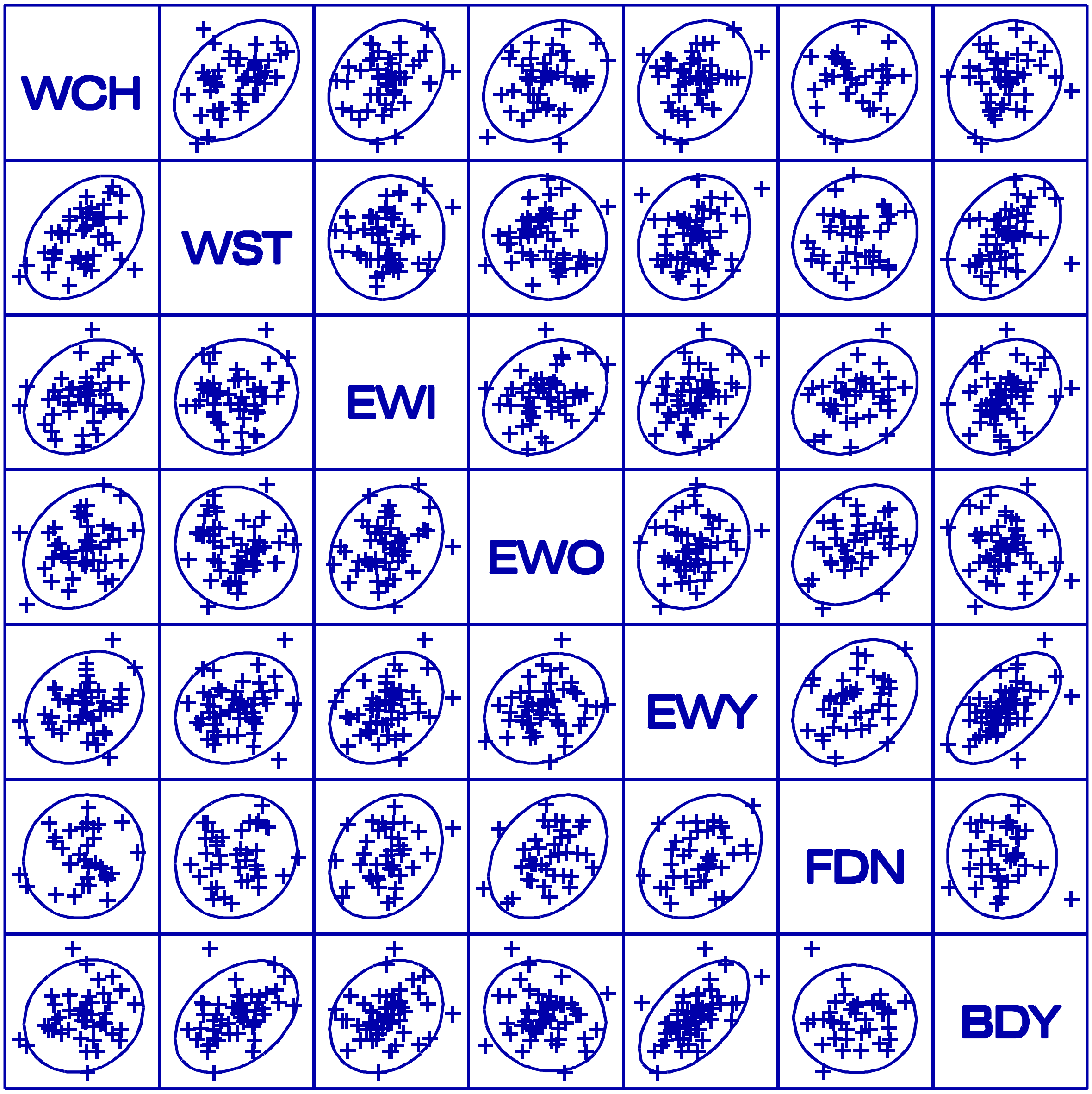

Figure 5-2. **Scatterplot matrix of unit-level random effects for different sample types: lead concentration (µg/g).**

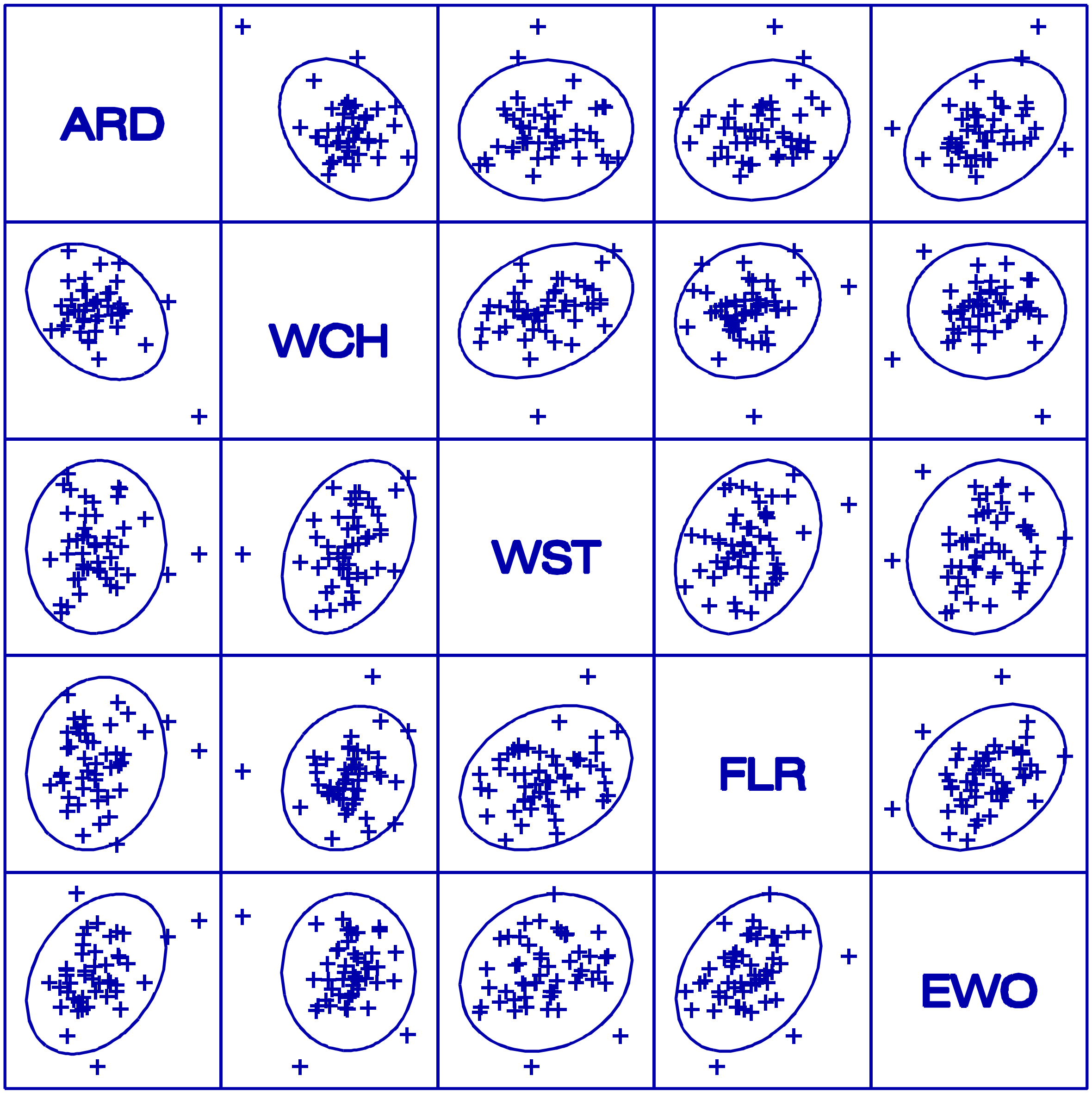

Figure 5-3. **Scatterplot matrix of unit-level random effects for different sample types: dust loading (µg/g).**

relationship is due to positive correlations in both lead concentrations and dust loading.

Significant correlation was observed for lead loadings between air duct and exterior entryway lead loadings. The house-to-house variation in air duct lead concentrations was negligible (refer to Table 4-5). However, there was significant correlation observed in dust loadings for these two sample types. That is, at houses where much dust was found at the exterior entryways, there was also much dust found in the air ducts. Exterior entryway dust lead loading was also significantly correlated with floor lead loading collected with wipes.

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There were also significant correlations observed in soil lead concentrations at different property locations (Table 5-2). Entryway soil lead concentrations were significantly correlated with boundary concentrations (.56, p < .005). The correlation between boundary and foundation lead concentrations was not significant. There were two indications of correlation between interior and exterior lead concentrations. Interior entryway dust lead concentrations were significantly correlated with entryway soil lead concentrations (.29, p=.05). Lead concentrations were also correlated for boundary soil and window stool dust (.38, p=.01).

There was significant correlation observed (Table 5-3) between dust loading on (interior) vacuum floors and exterior entryways (.33, p = .03). That is, houses with more dust outside the entryways tended to have more dust on the floors inside. There was also significant correlation between dust loadings in air ducts and dust loadings at the exterior entryways (.33, p=.04), and between window stools and window channels (.34, p=.02).

5.2 <u>WITHIN-HOUSE CORRELATIONS</u>

Whereas the previous section discussed house-to-house variations in lead and dust levels, this section discusses within-house correlations among sample types. Thus, the purpose of this analysis is to determine if there is significant co-variation in lead levels as one moves from room to room or side to side at a house.

For interior dust samples (except floor samples), there was typically only one sample taken per room. For these sample types, it was impossible to estimate random room effects apart from within-room variation. Residuals from the fit of the full model were used in the correlation calculations. Therefore, for these sample types, the correlations presented in this section are really those of room-to-room plus within-room variation among the different dust sample types. For some pairs of sample types (e.g., entryway interior and floor vacuum), there were insufficient data to estimate the room-level correlations after fitting the full model. In these instances, the relevant entry in Tables 5-4, 5-5, and 5-6 is blank.

For floor and soil samples, side-by-side samples were taken at several locations. Therefore, the model included a room/side level random effect term for each location sampled. For these sample types, residuals from this model were averaged and added to the estimates of the room/side levels random effect to estimate within-house correlations.

To calculate degrees of freedom for estimating the within-house correlation of two sample types, A and B, the following method was used:

1. Let $h_{A,B}$ denote the number of houses from which samples of both types were taken, and

2. Let $l_{A,B}$ denote the number of locations from which both sample types were taken, and

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3. Let f_i^r denote the number of room-level fixed effects in the model fit for sample type (i=A,B).

4. $df_{A,B} = l_{A,B} - h_{A,B} - \max(f_A^r, f_B^r) - 2$.

Table 5-4 presents these correlations for lead loading; Table 5-5 presents the correlations for lead concentrations; and Table 5-6 presents the correlations for dust loading. The format used in these tables is the same as that of Tables 5-1, 5-2, and 5-3. Figure 5-4 displays scatterplot matrices of within-house level differences in lead loadings; Figures 5-5 and 5-6 provide the same for lead concentrations and dust loadings.

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No significant correlations were found for lead loading. The only significant within-house level correlation in lead concentration was between interior and exterior entryway dust samples (.37, p=.03). Lead concentration for these two sample types were not at all correlated with lead concentrations in entryway soil samples, despite the fact that these estimates are based on many degrees of freedom. There were no significant correlations for dust loading.

Table 5-4. Correlations* Among Sample Types for Within-House Random Effects: Lead Loading

	Air Duct	Window Channel	Window Stool	Floor (Wipe)	Floor (Vacuum)	Entryway Interior	Entryway Exterior (Dust)
Air Duct		.06 8 .86	.17 23 .42		.02 27 .90		
Window Channel			.27 21 .22		.12 20 .60		
Window Stool					.17 49 .24		.05 2 .95
Floor (Wipe)							
Floor (Vacuum)							
Entryway Interior							.14 31 .44
Entryway Exterior (Dust)							

* Top number is estimated correlation; middle number is degrees of freedom; and bottom number is significance level.

Table 5-5. Correlations* Among Sample Types for Within-House Random Effects: Lead Concentration

	Air Duct	Window Channel	Window Stool	Floor (Vacuum)	Entryway Interior	Entryway Exterior (Dust)	Entryway** (Soil)
Air Duct		.06 4 .90	.38 23 .06	.09 27 .64			
Window Channel			.34 21 .11	.14 20 .54			
Window Stool				-.01 49 .94		.05 2 .95	.17 3 .78
Floor (Vacuum)							
Entryway Interior						.37 31 .03	-.04 38 .81
Entryway Exterior (Dust)							-.14 41 .38
Entryway (Soil)							

* Top number is estimated correlation; middle number is degrees of freedom; and bottom number is significance level.

** Foundation and boundary soil samples are not represented in this table because there is not a clear link between interior dust samples (e.g., the window stool of an interior room) and soil samples near the boundary or near the foundation, except at the entry. Even though a link can be made if the boundary or foundation soil sample was collected on the same side of the house as an entry, there were too few cases to warrant this.

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Table 5-6. Correlations* Among Sample Types for Within-House Random Effects: Dust Loading

	Air Duct	Window Channel	Window Stool	Floor (Vacuum)	Entryway Interior	Entryway Exterior (Dust)
Air Duct		-.20 8 .57	-.11 23 .64	.11 27 .55		
Window Channel			.15 21 .48	-.02 20 .93		
Window Stool				.26 49 .07		.156 2 .84
Floor (Vacuum)						
Entryway Interior						.04 31 .85
Entryway Exterior (Dust)						

* Top number is estimated correlation; middle number is degrees of freedom; and bottom number is significance level.

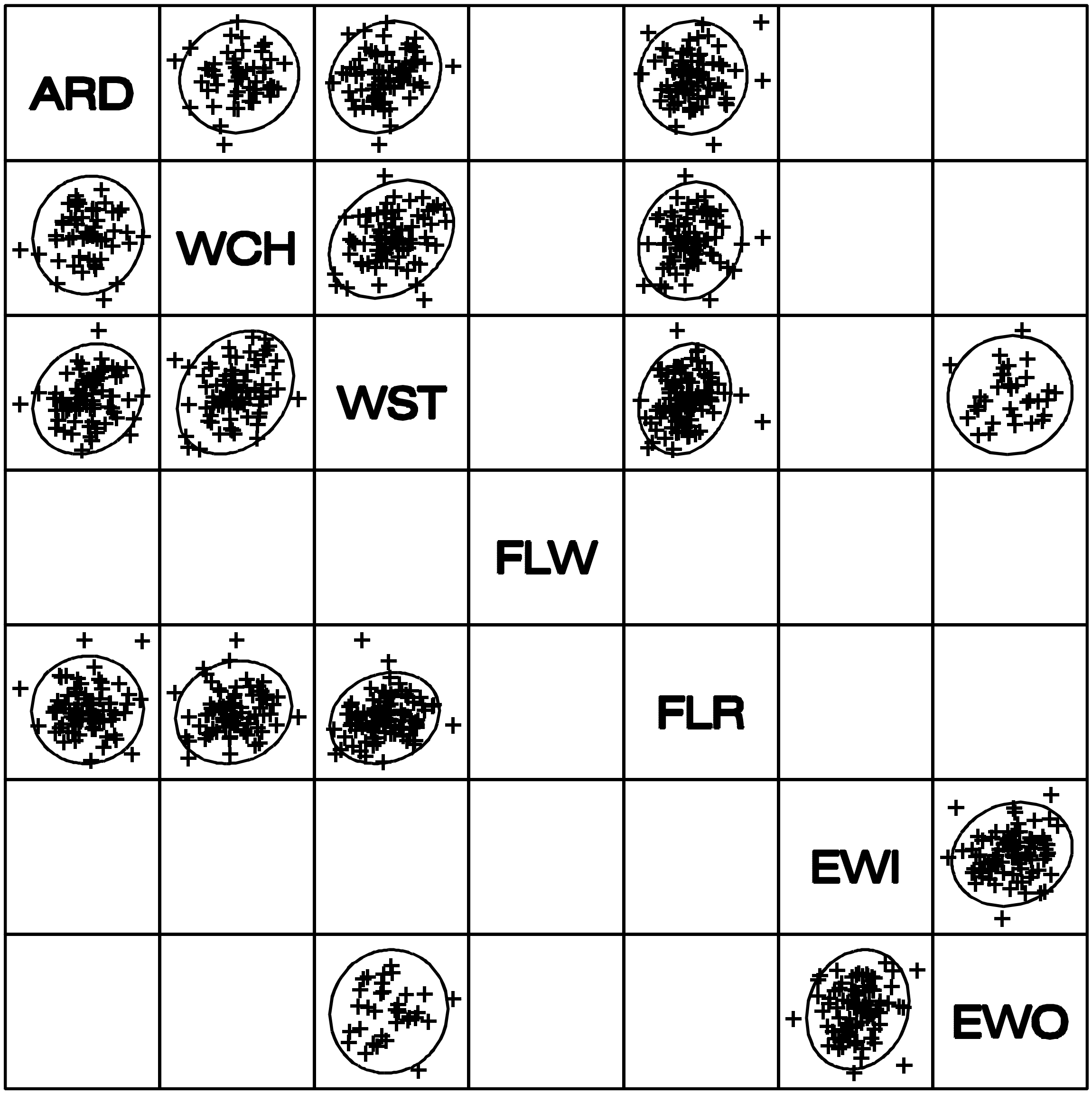

Figure 5-4. Scatterplot matrix of room-level random effects for different sample types: lead loading (μg/ft²).

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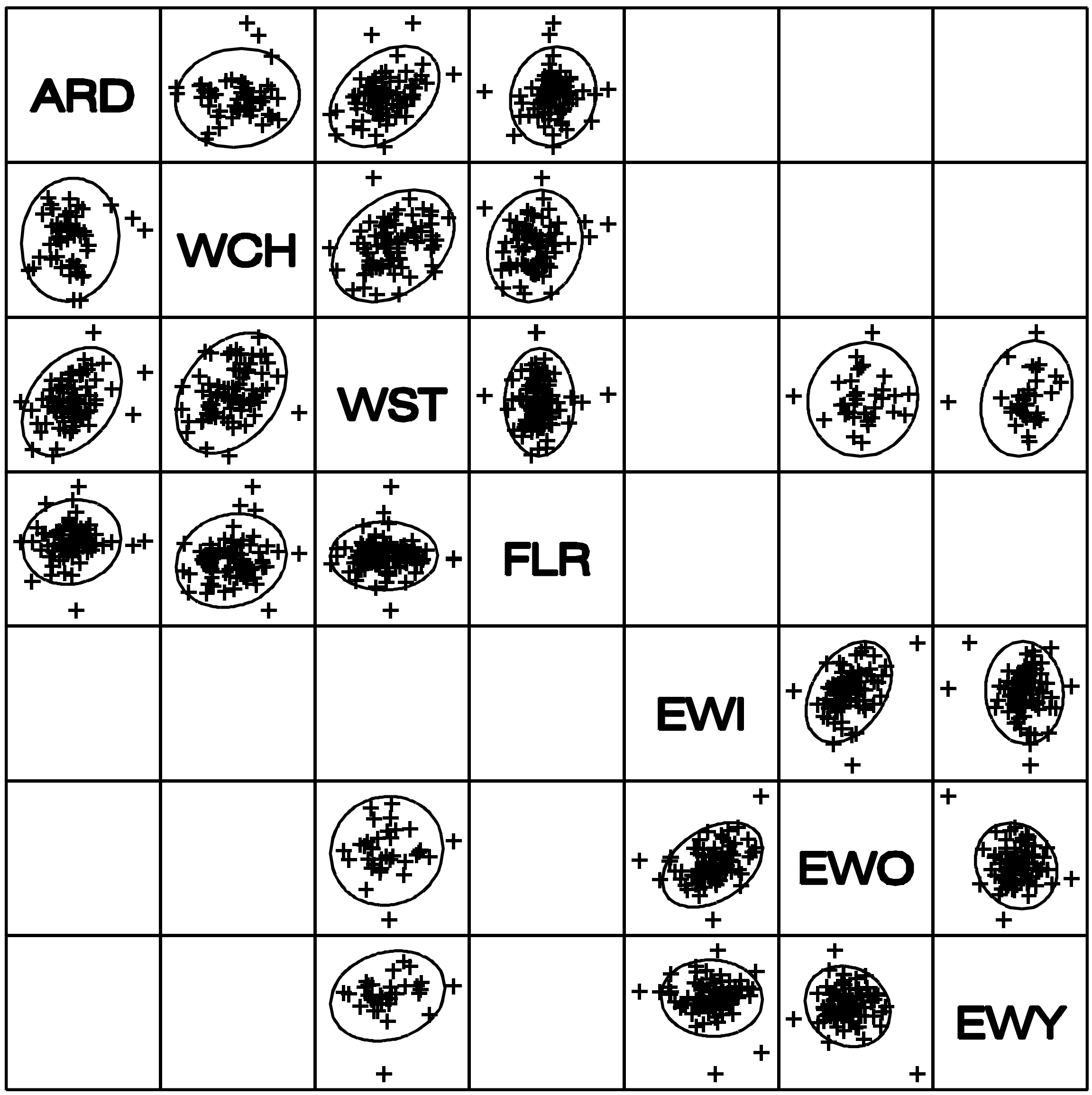

Figure 5-5. Scatterplot matrix of room-level random effects for different sample types: lead concentration (µg/g).

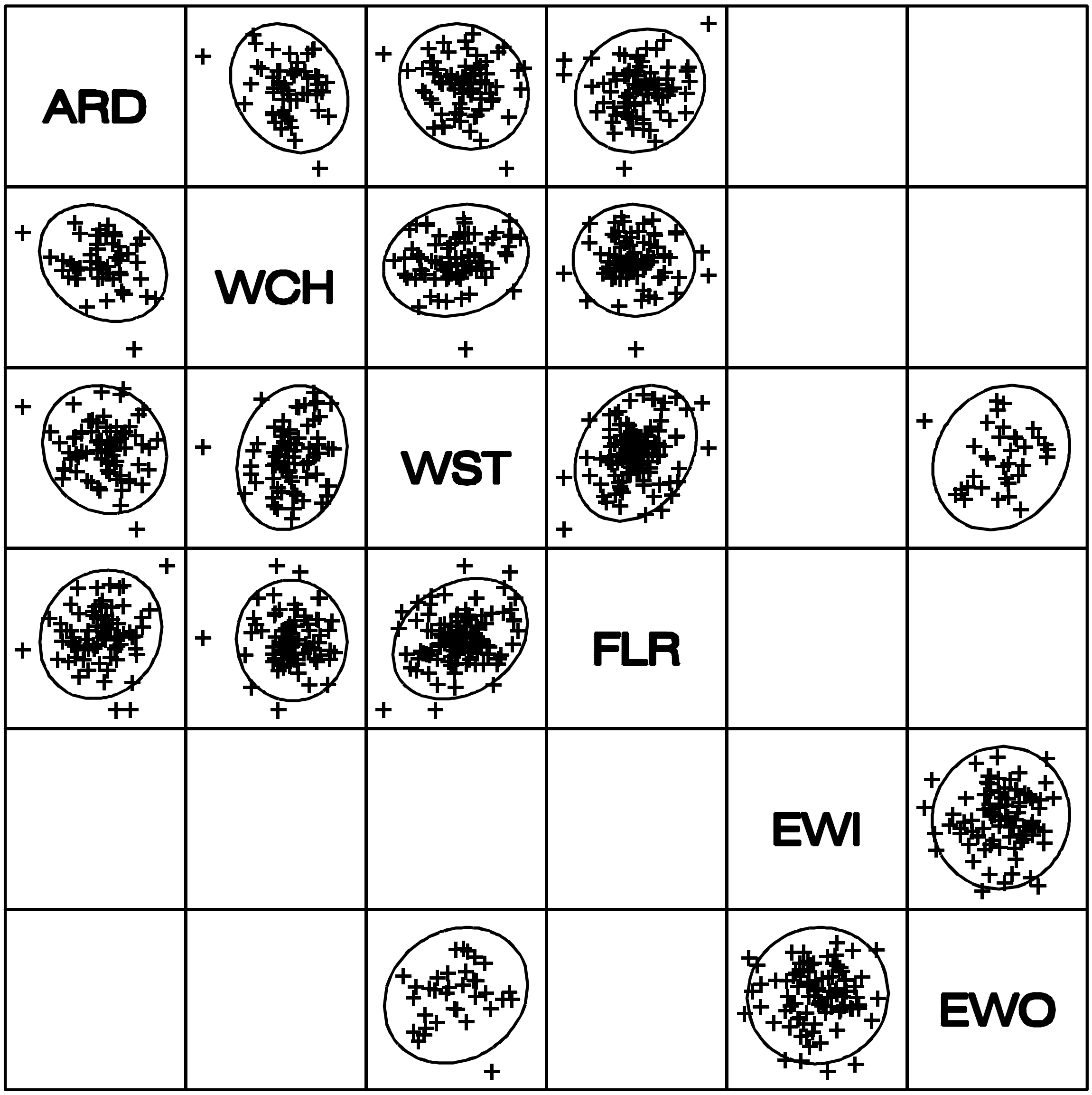

Figure 5-6. Scatterplot matrix of room-level random effects for different sample types: dust loading (µg/g).