APPENDIX F

STATISTICAL ANALYSES COMPLETED FOR THE OU 3 STUDY AREA

Appendix F: Statistical Analyses Completed for the OU 3 Study Area

Final Upland RI Report, Upper Columbia River, Washington

PREPARED FOR
Teck American Incorporated

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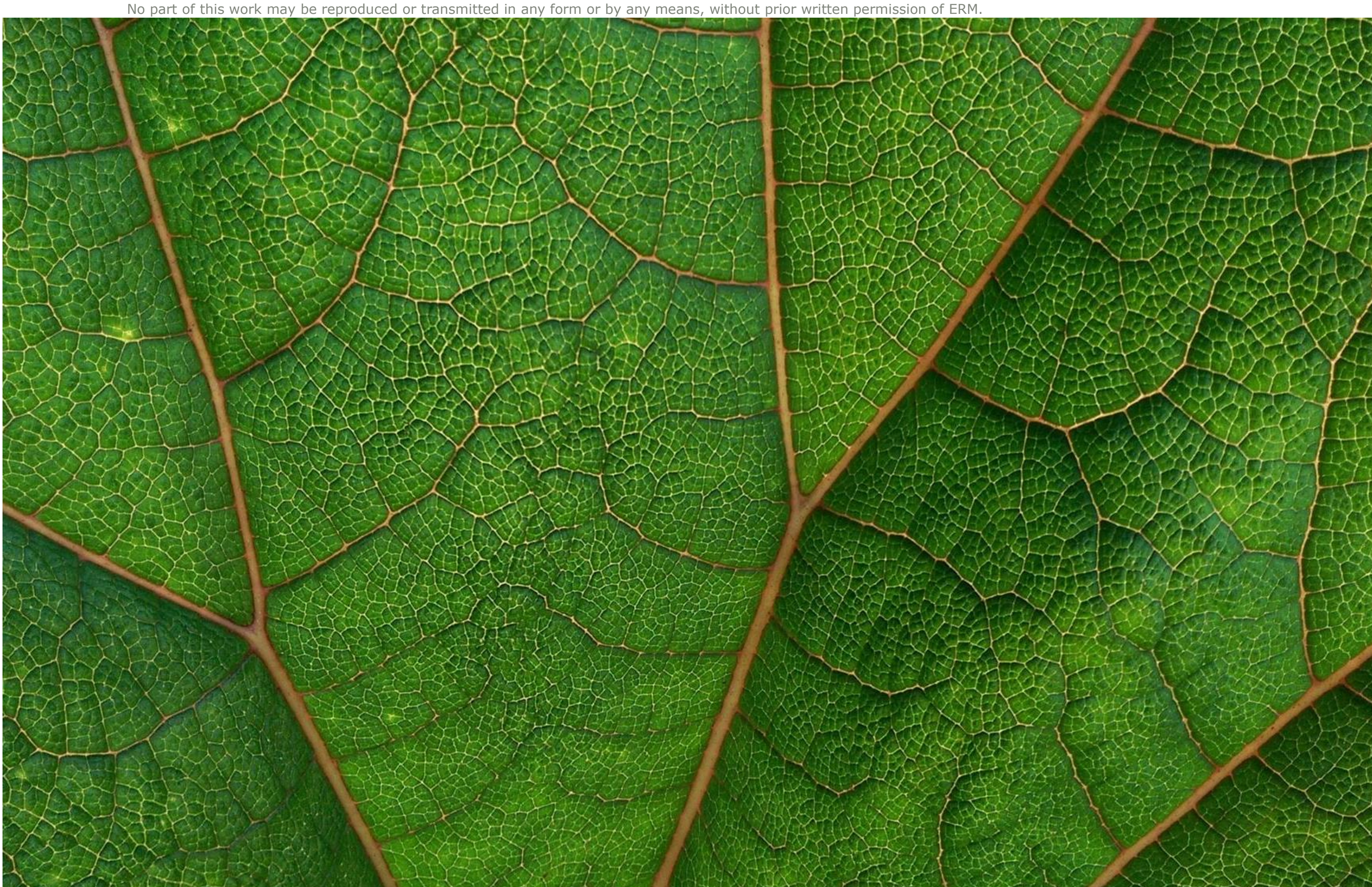

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ACRONYMS AND ABBREVIATIONS

Acronym	Description
µm	micrometer(s)
ADA	Aerial Deposition Area
amsl	above mean sea level
CI	confidence interval
COC	chemical of concern
DU	decision unit
EDA	exploratory data analysis
edf	estimated degrees of freedom
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ft	foot/feet
GAM	generalized additive model
HHRA	Final Site-Wide Human Health Risk Assessment: Upper Columbia River Site (USEPA 2021)
in.	inch
log10	log-transformed
m	meter(s)
mg/kg	milligram(s) per kilogram
mm	millimeter(s)
OU	operable unit
PA/SI	preliminary assessment/site investigation
PC	principal component
PCA	principal component analyses
Ref.df	Reference degrees of freedom
RI	remedial investigation
RI/FS	remedial investigation and feasibility study
SATES	Soil Amendment Technology Evaluation Study
Site	Upper Columbia River site
TAI	Teck American Incorporated
TAL	target analyte list
UCR	Upper Columbia River
UTM	Universal Transverse Mercator

1. INTRODUCTION

Teck American Incorporated (TAI) is performing a remedial investigation and feasibility study (RI/FS) for the Upper Columbia River site (UCR Site or Site) pursuant to the Settlement Agreement for Implementation of Remedial Investigation and Feasibility Study at the Upper Columbia River Site (USEPA 2006). Operable Unit (OU) 3 of the UCR Site is the terrestrial upland portion of the Site that may have been influenced by historical deposition of metals.

This appendix describes the statistical analyses performed to support the nature and extent evaluation of chemicals of concern (COCs) in the Remedial Investigation (RI) Report for OU 3 (hereafter, Upland RI report). The COCs being evaluated in the Upland RI report include arsenic, barium, cadmium, copper, lead, manganese, mercury, selenium, and zinc.

The statistical analyses described in this appendix include:

- Exploratory data analysis (EDA)
- Generalized additive models (GAMs)

Other statistical analyses were performed to support the nature and extent evaluation for the Upland RI report, namely an assessment of small-scale variability in surface soil metals concentrations and a geostatistical model for lead, cadmium, and zinc concentrations in surface soil. These other statistical analyses are described in Section 6 of the Upland RI report and the geostatistical model is described in Appendix G to the Upland RI report.

2. DATA SET PREPARATION

The statistical analyses described in this appendix were performed using the Upland RI data set, which is described in Section 6.1 of the Upland RI report. Soil metals concentration data were compiled from 30 separate studies conducted in northeastern Washington and southcentral British Columbia to create the Upland RI data set. Descriptions of these studies are provided in Section 3 and Table 3-1 of the Upland RI report. Soil metals concentration data for the studies were downloaded from the UCR project database[1]. Several basic data management steps, consistent with the RI/FS Data Management Plan (TAI 2019a), were applied to produce the Upland RI data set. Analytical results for field duplicate and replicate samples were averaged, nondetected values were substituted with the value in the measurement value field[2] in the database, and estimated ("J" qualified) values were used at their reported value.

Not all data in the Upland RI data set were appropriate for use in the statistical analyses described in the following sections. For example, some studies (e.g., Teck_2016_ResSoil [2016 Residential Soil Study]; TAI 2017) collected samples from beaches, which will be evaluated in the Aquatic RI report, instead of the Upland RI report. Other studies (e.g., Teck_2017_SATES_PIA [2017 SATES Test Plot Characterization]; TAI 2019b) collected multiple samples from decision units (DUs) that were sampled during a previous study, and inclusion of these samples had the potential to bias

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[1] Accessible to registered users at https://teck-ucr.equisonline.com/.

[2] Per the Data Management Plan (TAI 2019a), "For values flagged as nondetected values, the measurement value field will contain either the MDL [method detection limit], MRL [method reporting limit], or other value."

the statistical results. The general data selection and filtering criteria applied across all studies (where applicable) for developing the Upland RI data set are provided in Table F-1a. Table F-1b describes the data selection and filtering criteria that were applied on a study-by-study basis. Data included in the Upland RI data set are provided in Appendix D-2 to the Upland RI report, which includes columns to identify which sample results were used for each analysis.

The locations of samples in the Upland RI data set are shown on Map F-1. Table F-2 provides a list of the studies included in the EDA and GAM statistical analyses and the rationale for each study that was excluded from a given analysis.

The following sections describe the EDA and GAM statistical analyses performed to support nature and evaluations for the OU 3 study area. All of the target analyte list (TAL)[3] metals plus molybdenum were included in the EDA to the extent possible based on data availability and data quality, while the GAM was prepared for the nine COC metals. Table F-3 lists the metals included in each analysis.

3. EXPLORATORY DATA ANALYSIS

The EDA was conducted to examine the metals concentrations and physical variables for patterns, inconsistencies, and outliers. This involved an examination of relationships among variables, and it highlighted potential issues for regression modeling and multivariate analysis. EDA is an important preliminary step in a data analysis process that prevents application of incorrect methods and uncovers potential structure in the data and the shape of relationships among variables (Tukey 1977).

Outputs from the EDA included metal-metal correlation matrices, scatterplots of metals concentrations versus distance from the Trail Facility and elevation, and boxplots of metals concentrations by study. The field and laboratory methods for the studies used in the Upland RI are compared in Table F-4. Detection frequencies, detection limits, and reporting limits for data used in the EDA are provided in Table F-5, and summary statistics for data used in the EDA are provided in Table F-6. For studies where multiple grain size fractions were analyzed (2014 Soil Study [TAI 2015] and 2015 Bossburg Study [TAI 2016]), the data were filtered to include only the < 2 mm size fraction samples for the correlation analysis (Section 3.1) and scatterplots (Section 3.2). Grain size fractions for these studies are plotted separately in the boxplots of metals concentrations by study (Section 3.3).

The results of the EDA are summarized in the following subsections.

3.1 CORRELATIONS AMONG METALS

Correlations between metals concentrations were reviewed to identify patterns in the data set and pairwise relationships of metals. Tables F-7a and F-7b and Figures F-1a and F-1b show Spearman's rank correlation coefficients for all the TAL metals plus molybdenum and Figures F-1c and F-1d show Spearman's rank correlations for the nine COCs. These results include all pairwise

[3] TAL metals include aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

complete observations (i.e., any sample for which both analytes in a pair were measured were included in the calculations).

In the correlation coefficient matrices, blue squares indicate a positive correlation (i.e., concentrations of one metal increase when concentrations of the other increase), and red squares indicate a negative correlation (i.e., concentrations of one metal decrease when concentrations of the other increase). The shade of the square indicates the strength of the correlation, with darker squares indicating strong correlations and lighter squares indicating weak correlations. Correlation coefficients (rho) can be categorized into bins that are indicative of the strength of the relationship between the two variables. Rho of zero to ±0.20 is considered very low or none, rho of ±0.20 to ±0.40 is considered low, rho of ±0.40 to ±0.60 is considered moderate, rho of ±0.60 to ±0.80 is considered strong, and rho greater than or equal to ±0.8 is considered very strong.

The correlation coefficient matrices for the nine COCs (Figures F-1c and F-1d) show that arsenic, cadmium, copper, lead, mercury, and zinc have moderate to strong positive correlations with each other. Barium, manganese, and selenium exhibit variable correlation patterns with the other six COCs. However, barium and manganese have a strong positive correlation with each other, and selenium has a low positive correlation with barium and manganese. These patterns of covariation among COCs in the data set are useful when considering similarities and differences in the nature and extent of COC concentrations in surface soil within OU 3.

Pairwise correlations of detected-only concentrations were also calculated to determine the potential effects of nondetected values on metal-metal correlations. Correlations using detections only are provided in Figure F-1b for all metals, Figure F-1d for the nine COCs, and in Table F-7b. An examination of the differences between the two sets of correlations for the nine COCs suggests that the COCs where correlations are impacted by a large proportion of nondetected values are barium and selenium. There was very little or no change in the correlations when nondetected results were excluded for arsenic, cadmium, copper, lead, manganese, and zinc.

3.2 SCATTERPLOTS OF METALS BY PHYSICAL VARIABLES

Metal concentrations were plotted against the distance from the Trail Facility (as Universal Transverse Mercator [UTM] northing; Figure F-2) and elevation (Figure F-3) for the EDA to check for macro trends in metals concentrations as functions of physical (location) variables. These scatterplots were performed as a precursor to the GAM, described in Section 4, which also considered the sample physical variables plus others. The scatterplots include trend lines showing how the average concentration changes as a function of UTM northing (Figure F-2) or elevation (Figure F-3). These trend lines were added to the plots using a GAM; however, these are not the same GAMs that are described in Section 4 of this appendix.

The relationships between soil metals concentrations and UTM northing and elevation were complicated, nonlinear, and varied by metal. The COCs either tended to decrease in concentration with distance from Trail and then increase in concentration in the U.S. in the vicinity of Northport (arsenic, cadmium, lead, mercury), increase within the U.S. (barium, selenium, zinc), or show a flat trend (manganese). The scatterplots also illustrate a high frequency of nondetected results for selenium.

The scatterplots revealed that concentrations of some metals change near the U.S.-Canada border. Several potential methodological reasons for the observed shift were investigated, including field sampling methods, laboratory preparation methods (digestion preparation protocol, digestion acid, heating mechanism, digestion process, digestion time, digestion temperature), and laboratory analytical methods (Table F-4). For some metals (e.g., selenium), the difference could be attributable at least in part to a high proportion of nondetected values and different detection limits for studies conducted in the U.S. and Canada. The relationships between soil metals concentrations and elevation were generally nonlinear and dependent on the metal in question. Most metals showed an initial steep change (either positive or negative) in concentration at low elevations, likely due to very small sample numbers at lower elevations (less than 1,300 ft amsl), that made averages difficult to compute accurately. Only a small number of terrestrial areas are present within the UCR valley below 1,300 ft amsl (Map F-3). Assessments of trends in concentration by elevation for the GAM in Section 4 therefore focused on the portion of the figures where data are more abundant, which is at approximately 1,300 ft amsl and higher for most metals. The COCs arsenic, barium, cadmium, copper, lead, mercury, selenium, and zinc showed generally decreasing concentrations with increasing elevation. Manganese showed very little change in concentration with increasing elevation.

3.3 BOXPLOTS OF METALS BY STUDY

Boxplots of soil metals concentrations by study were prepared to illustrate the range of concentrations from each study and to investigate potential systematic differences due to different study protocols (Figures F-4 to F-27). These plots show heterogeneity of soil metals concentrations between studies, while also highlighting the large variances for some metals within and among studies. This heterogeneity within and among studies is especially apparent for arsenic, cadmium, mercury, lead, and zinc with orders of magnitude differences seen among samples within the same study. The boxplots for selenium (Figure F-23) illustrate a high proportion of nondetected results for this COC in multiple studies.

The boxplot results were also used to curate the data set for use in other RI analyses. For example, the boxplots showed that the USEPA2001Mines/Mills study data (2001 U.S. Environmental Protection Agency [EPA] Stevens County Mines and Mills Preliminary Assessment/Site Investigation [PA/SI]; USEPA 2002) contain extreme concentrations for several analytes. Samples from this study have the highest concentrations for soils in the Upland RI data set for some metals (e.g., lead, copper, calcium, magnesium), and the lowest concentrations for other metals (e.g., aluminum, cobalt, potassium), which makes the USEPA2001Mines/Mills study a distinctive data set. The extreme ranges of concentrations exhibited for the USEPA 2001 Mines/Mills study is one of the reasons that mines and mill data were not combined with other soil data used to develop the geostatistical model, which is provided in Appendix G to the Upland RI report.

4. GENERALIZED ADDITIVE MODEL

The extent to which physical attributes are associated with soil metals concentrations was evaluated using a GAM. The purpose of using a GAM was to answer the question: What is the statistical relationship between metals concentrations in soil and physical attributes?

The GAM was used to evaluate the relationship between metals concentrations in soil and physical parameters, including distance from the Trail Facility, as measured by UTM northing, elevation, slope, lateral distance from the river, side of river (i.e., east or west), and depth of sample. The GAM described in this appendix builds on work previously completed by EPA oversight contractors to analyze and interpret upland soil data from the Site, which included a linear regression analysis (SRC 2015). The linear regression analysis developed by EPA oversight contractors is summarized in Section 4.1.

Sections 4.2 and 4.3 present the methods, results, and uncertainties for the GAM. Summary statistics for data used in the GAM are provided in Table F-8.

4.1 PREVIOUS WORK—2015 LINEAR REGRESSION ANALYSIS

In 2015, EPA conducted regression analyses to investigate the relationships between river mile and concentrations of lead, arsenic, antimony, and thallium (SRC 2015), including both distance from the U.S.-Canada border and distance from Northport, Washington. The analyses used data from the USEPA_2014_ResSoil study (2014 Residential Soil Study; USEPA 2016) for lead, arsenic, antimony, and thallium and the Teck_2014_UplandSoil study (2014 Soil Study; TAI 2015) for lead and arsenic. See Table 3-1 of the Upland RI report for a summary of these studies. For the USEPA_2014_ResSoil study, the analyses excluded samples from beaches, driplines, and gardens, and included only samples with a starting depth of 0 in. and an ending depth of 1 in. Data analyzed for the Teck_2014_UplandSoil study included samples from Aerial Deposition Area (ADA) DUs only; samples from windblown sediment deposition areas and relict floodplain deposition areas were excluded. Regressions were conducted using data from each study separately and included side of river (east or west), elevation, and slope as potential covariates. Final linear regression models were produced including some or all covariates, and the relative contribution of different variables was assessed using standardized regression coefficients. The results of these models suggested log-linear decreases in lead, arsenic, antimony, and thallium concentrations with increasing river distance from the U.S.-Canada border, while controlling for other variables in the models. For data from the USEPA_2014_ResSoil study (USEPA 2016), river distance from the border was estimated to be the most influential variable in the models for all metals (largest standardized coefficients), while for data from the Teck_2014_UplandSoil study (TAI 2015), the most influential variable was elevation for lead and arsenic, which both showed decreasing concentrations with increasing elevation.

To determine if local mines showed similar concentration trends, EPA evaluated the relationships between distance to closest mine and lead and arsenic concentrations; no linear trends were observed in these regressions. However, the USEPA2001Mines/Mills study (USEPA 2002), discussed above, was not included in the analysis.

To assess whether there were similar trends with distance from the Le Roi/Northport Smelter, EPA applied the same model selection process and found an increasing trend in concentrations of lead and arsenic with increasing distance from the Le Roi/Northport Smelter. However, it should be noted that data from the LeRoi2005 study (2004 EPA Le Roi Smelter Removal Action; USEPA 2005) were not included in that evaluation.

While the models described above provide an assessment of how lead, arsenic, antimony, and thallium concentrations change with river distance from the U.S.-Canada border, controlling for elevation and/or slope, TAI concluded that the analysis is insufficient to support several of the findings presented in SRC (2015). Specific issues are summarized below:

- As discussed in Windward (2015), the underlying metals concentrations show nonlinear relationships with river distance. Linearity is a strict assumption of linear regression, suggesting that a nonlinear regression approach may be necessary to properly characterize the relationships between these variables.
- R^2 values for the multiple linear regressions are presented as proof of the strength of the relationships with river distance; however, the inclusion of additional variables in a model, by definition, increases the overall R^2 value. Therefore, a more useful metric would be a partial R^2 (or eta-squared) value that would estimate the partial effect of river distance after parsing out the effects of the covariates.
- Studies were modeled separately, thereby reducing both the power of the analysis and limiting the geographic span that could be simultaneously considered.

The previous linear regression models did not include data from many of the studies included in the Upland RI data set, most notably the LeRoi2005 study (USEPA 2005), which evaluated concentrations of four COCs (arsenic, cadmium, copper, and lead) in and around Northport, and the 2012 Ecology Upland Soil Study (Ecology 2013), which included samples within the OU 3 study area in the vicinity of the U.S.-Canada border, including samples at higher elevations. Therefore, the previous analyses omitted data and provided an incomplete analysis of trends in metals concentrations along the river in the vicinity of Northport and in the upland portion of the Site.

The GAM presented in Sections 4.2 and 4.3 of this appendix represents updates and refinements to the work previously completed by EPA.

4.2 GAM METHOD

A GAM was developed to build on the regression model conducted by EPA (SRC 2015) that assessed the relationships between metals concentrations and various physical variables such as distance from the Trail Facility[4]. A GAM is like a linear regression model, but instead of estimating

[4] Regression models conducted by EPA (SRC 2015) used data from either the 2014 Residential Soil Study or the 2014 Soil Study. The variables included in the multiple linear regression modeling varied by metal and data source (study) and included side of UCR, river mile, slope, elevation, and/or distance from the Le Roi/Northport Smelter. Metals evaluated using multiple linear regression modeling included lead, arsenic, antimony, and thallium. Regression modeling was also conducted to evaluate the relationships between lead concentrations and distance to nearest mine and between metals (lead or arsenic) concentrations and the footprint of injury to forest trees by sulfur dioxide from smelters in 1931 as described by Scheffer and Hedgcock (1955).

a linear slope relationship, a flexible smoothing function is used to allow for nonlinear relationships (e.g., curves). GAMs have the advantage of interpretability and flexibility, making them a high-performing alternative to traditional linear regression modeling techniques. The objective of the GAM was to evaluate the relationship between univariate metals concentrations in soil and the physical parameters UTM northing[5], elevation, slope, lateral distance to the river, side of river, and depth of sample.

There are many factors that can influence the spatial deposition patterns of particulate smelter emissions. For the deposition in the area of the Trail Facility, the prominent factors that control the seasonal and spatial distribution of metals deposition include physiography (terrain elevation and orientation of valleys), prevailing winds, precipitation, and emissions rates and chemical characteristics from smelter operations (Goodarzi et al. 2003). However, particulate diffusion theory describes that, in general, if metals originated from a single point source, the highest concentrations would be observed near that source with concentrations decreasing with increasing distance away from the source.

GAMs have several advantages over simple linear regression models, such as ordinary least squares regression. For one, GAMs do not have the same assumption of linearity and allow the dependent variable to have curvilinear relationships with the independent variables. The amount of nonlinearity in the GAM is estimated using thin-plate spline smoothers that are penalized to avoid overfitting. In a GAM, the relationship between the response variable and predictors is:

Equation F-1: $y=\alpha+s(x1)+s(x2)+...+\epsilon$,

where s(x) indicates a smoothing function.

The degree of smoothness of s(x) is derived using generalized cross-validation within the model-fitting procedure. If a straight line is the best fit for the data, the GAM will return the same results as a linear regression.

Compared to linear regression analysis, the GAM analysis conforms better to the data set characteristics by allowing for nonlinear trends in concentrations with UTM northing, as evident in plots of metals concentrations versus distance from the Trail Facility (Figure F-2). Linearity is a strict assumption of linear regression models (Freedman et al. 2007) that is violated in these data, suggesting that a more flexible approach is necessary. This is best illustrated by a plot of residuals from a linear model against fitted values, which is shown for lead in Figure F-28.

The GAM was performed using data from six studies from the OU 3 study area (wholly located in the U.S.) and the Trail Smelter Terrestrial Ecological Risk Assessment (ERA) study (Teck Metals Ltd. 2011) data set in Canada (Table F-2). The Trail ERA data set was used in the GAM to support a more complete evaluation of the trends in metals concentrations within the UCR valley and in upland areas. All soil samples that had a starting depth of 0 in. (i.e., surface samples) were included, regardless of bottom depth. The most common sample intervals were 0 to 1 in. and 0 to 3 in., and the maximum of bottom depth was 12 in. Data from the U.S. and Canada were

[5] UTM northing was used as a variable to capture distance from the Trail Facility.

evaluated together. Sample locations for the data used in the GAM are shown on Map F-2 and summary statistics for data used in the GAM are provided in Table F-8.

The GAM analysis used the U.S. and Canada combined data set for the COC metals. As described in Section 3, there was a large proportion of nondetected values in Canada for selenium. This may influence relationships observed in Canada and care needs to be taken when interpreting results. Molybdenum data in Canada had little to no variability in concentration and was not included. (See Section 3 of this appendix).

The GAM analysis was performed using the mgcv package (Wood 2004, 2011) in the R programming language (R Core Team 2024). This package also allows for an additional penalization that permits smooth terms to be shrunk to zero and effectively removed from the model, providing a form of variable selection that allows for an assessment of variable importance. Choice of the basis dimension (k), which controls the maximum possible degrees of freedom allowed for a smooth term in the model (k-1), is important when fitting GAMs. It is necessary to ensure that it is not restrictively small, while balancing the computational requirements for fitting more complicated nonlinear relationships. For each metal, the fit of the model was compared allowing k to be 3 (smallest possible)—allowing for at most a quadratic relationship, 10 and 15 for the UTM northing smooth term. The model with the highest R^2 value was chosen as the final representative model. Results were also assessed visually to ensure that the fitted relationships were smooth in general while still revealing underlying fluctuations in the data.

Most of the metals showed log-normal distributions of concentrations. Therefore, they were log-transformed (log10) prior to analysis to ease the interpretation of the modeling results and allow for the use of Gaussian (Normal) error distributions in the models. Side of river (east and west), elevation (ft), lateral distance to river (ft), average slope (degrees), and depth of sample were also considered as covariates in all models. A random effect for study ID was also considered in the model but there was no spatial overlap between samples collected in Canada versus studies in the U.S., and some studies were only conducted in a small range of UTM northings, therefore, variability from study ID may be captured by the spatial autocorrelation and UTM northing term in the model. Sample depth was also only variable for the residential soil studies and constant for all other studies. Inclusion of sample depth and study ID in the model tend to inflate the standard errors of the fitted relationships, which is a sign of overfitting, therefore, sample depth and study ID was not included in the model. UTM northing, side of river (east and west), elevation (ft), lateral distance to river (ft), and average slope (degrees) were included as covariates in all models, regardless of their significance as indicated by p-value, although shrinkage of smoothed terms was allowed as described above.

Continuous variables were fit with a smoothing function. Gaussian spatial autocorrelation among samples located near to each other was also incorporated to control for nonrandom correlation of residuals over space and among samples from the same study as samples from the same study tend to be within specific ranges of UTM northing.

Shown below is the R code for running the GAMs with k = 15 for the UTM northing (y_coord_utm) smooth:

```
gam(log_conc ~ s(y_coord_utm, k = 15) +
    s(elevation_ft) +
    s(average_slope) +
    s(distanceto_river_ft) +
    sideof_river,
    correlation = corGaus(1, form = ~ x_coord_utm + y_coord_utm),
    select = TRUE,
    data = data_frame)
```

4.3 RESULTS

Regression diagnostic plots for the GAM are presented in Figures F-29 to F-37 and the complete model outputs are provided in Attachment A. Investigation of residuals suggested only minimal deviations from the assumptions of the GAMs for most metals. The estimated degrees of freedom (edf) for each smooth fit in the model indicates the number of degrees of freedom used in the smoothing function, and the Reference degrees of freedom (Ref.df, from the chosen basis dimension (k) = the maximum possible degrees of freedom for the smooth) from the model with the highest R^2. Edf is estimated to be approximately 1 for linear relationships, while values > 1 and ≤ 2 are indicative of weakly nonlinear relationships, and > 2 are indicative of more strongly nonlinear relationships. Edf values < 1 indicate that the variable coefficient for a smooth has been shrunk toward 0 such that it contributes fewer than 1 degree of freedom to the model, which suggests lack of importance for the overall model fit. P-values for the test of whether a smooth term is significantly different from 0 are also presented. However, these p-values are generally too low and should be considered approximate especially when they are near to the alpha cutoff for the study (in this case 0.05) (Wood 2013). Therefore, a cutoff of 0.01 was used.

4.3.1 UTM NORTHING / DISTANCE FROM THE TRAIL FACILITY

GAM results for UTM northing versus metals concentrations as well as the full model outputs are available in Attachment A. The graphs of metals concentrations by UTM northing are presented in Figures F-38 to F-46. Figure F-47 plots the graphs for all nine COCs together to more easily compare the patterns and to identify shared relationships across metals with UTM northing more clearly.

All metals show variable (i.e., not consistently decreasing) relationships along the observed UTM northing range away from the Trail Facility. The relationships between COC metals and UTM northing exhibited the following patterns:

1. Arsenic, barium, cadmium, copper, lead, mercury, selenium, and zinc concentrations show a broad peak centered at or near the Trail Facility with concentrations that decline to the north and to the south toward the U.S.-Canada border (Figures F-38, F-39, F-40, F-41, F-42, F-43,

F-45, F-46, and F-47). Manganese concentrations show a relatively flat line in Canada with a small increase centered at the Trail Facility (Figure F-44).

2. Concentrations of arsenic, cadmium, lead, and zinc show a relatively steep decline after the initial peak south of the U.S.-Canada border, and copper shows a more moderate decline. Concentrations continue to decline to the south, with local peaks for cadmium, copper, and lead centered around Northport, Washington, and local peaks for arsenic, cadmium, lead, and zinc near Marble, Washington.
3. Concentrations of barium (Figure F-42) and manganese (Figure F-44) level off after the initial increase south of the U.S.-Canada border, followed by a decline south of Northport and a leveling off. Barium and manganese concentrations in the U.S. are elevated above concentrations in the vicinity of the Trail Facility.
4. Concentrations of mercury and selenium show a gradual decline after the initial increase south of the U.S.-Canada border followed by a leveling off. Because mercury was not analyzed in soil samples from the 2014 and 2016 Residential Soil Studies, there are less samples along the UCR valley for mercury than for other metals, which may contribute to the different pattern shown for mercury. For selenium, several studies included high frequencies on nondetected values and/or elevated detection limits, which complicate interpretations from the GAM for selenium.

The patterns described in the list above indicate that the nature and extent of the COCs arsenic, cadmium, copper, lead, mercury, and zinc exhibit relationships between soil concentrations and distance from the Trail Facility with other influences exhibited in the vicinity of Northport and/or Marble, Washington. Barium and manganese concentrations exhibit different relationships with distance from the Trail Facility than the other COC metals.

4.3.2 ELEVATION

After accounting for the other variables in the models, COC concentrations (except mercury) had a statistically significant relationship with elevation (Attachment A), although the shapes differed. Graphs of individual metals concentrations versus elevation are provided on Figures F-48 to F-56, and the results are summarized below. Figure F-57 plots the graphs for the COC metals together to more easily compare the patterns and to identify shared relationships across metals with elevation more clearly. To help interpret the GAM results for elevation, these figures show elevation bands that were selected by dividing the sample set into four categories (bands) based on the quartiles of elevations of samples. These elevation bands are shown on Map F-3 and include less than 1,500 ft amsl, 1,500 to 1,800 ft amsl, 1,800 to 2,700 ft amsl, and greater than or equal to 2,700 ft amsl.

There were three general relationships between elevation and metals exhibited in the GAM, which varied by COC. These relationships are as follows:

1. Lead, cadmium, and copper exhibit steeply decreasing concentrations with increasing elevation across the lowest elevation band (less than 1,500 ft amsl) and partway into the second elevation band (1,500 to 1,800 ft amsl). Above 1,800 ft amsl, there are variable patterns between increasing and decreasing concentrations. The decreasing trend across the lowest elevation band is driven at least in part by the many soil samples at lower elevations in

the Northport area that were analyzed for cadmium, copper, and lead as part of the 2004 EPA Le Roi Smelter Removal Action Study (USEPA 2005). Selenium also shows a gradual decrease in concentrations with increasing elevation across the lowest elevation band (less than 1,500 ft amsl); but above 1,800 ft amsl, selenium concentrations tend to increase. As noted above, interpretations for selenium are limited due to the high frequency of nondetected values and elevated detection limits for several studies.

2. Arsenic and zinc do not exhibit a strong relationship with elevation. As such, these COCs do not show a decrease in concentration with increasing elevation across the lowest elevation bin (less than 1,500 ft amsl).
3. Barium, manganese, and mercury show a gradual increase in concentrations with increasing elevation beginning in the lowest elevation band (less than 1,500 ft amsl) and extending to 2,700 ft amsl for mercury and above 2,700 ft amsl for barium and manganese.

4.3.3 SLOPE

Graphs of COC metals concentrations versus slope are provided on Figures F-58 to F-66. None of the COC metals showed a statistically significant relationships with slope (after accounting for the other variables in the models). All COC metals showed generally flat trends with slope, which suggests that changes in slope do not affect metal concentration. This is consistent with how slope is not strongly correlated with elevation.

4.3.4 LATERAL DISTANCE TO RIVER

Graphs of metals concentrations versus lateral distance to the river are provided on Figures F-67 through F-75, and the results are summarized below. All COC metals concentrations had a statistically significant relationship with lateral distance to the river (after accounting for the other variables in the models), although the patterns differed. In general, metals showed decreasing concentrations with increasing distance to the river with varying magnitude of peaks and valleys. Manganese showed flatter trends compared to the other metals (Figure F-73). These overall trends are similar to the relationship between metals concentration and elevation where concentration also tends to decrease with increasing elevation. This is in line with the fact that lateral distance is strongly correlated with elevation.

4.3.5 SIDE OF RIVER

After controlling for the other variables in the model, there was a significant relationship between side of river and concentration for arsenic, lead, mercury, and selenium with all showing higher average concentrations on the western side of the river compared to the eastern side. However, while these are statistically significant, the coefficient estimates in the model are close to 0 suggesting only a small difference between the sides in average concentration (Attachment A). Given these very small differences, plots of the estimates for each side of the river are nearly identical and thus not shown.

4.3.6 UNCERTAINTIES

There are several factors that contribute to the uncertainty of the GAMs:

- **Combining disparate data sets.** There is potentially some confounding of variables in the models by study ID, as some studies were only conducted in a small range of UTM northings or with no overlap in UTM northing, covered only a small range in elevation, and several studies had different detection limits and analyzed for different metals. Together, these differences could influence the variation in concentrations over space depicted in the models. The incorporation of variables that differ among studies with good coverage (e.g., elevation, average slope) helps mitigate the effects of merging data from different studies.
- **Potential for overfitting.** When a nonlinear relationship or multivariable model is applied to data, there is a potential for overfitting. However, several techniques were used to mitigate this problem: 1) the algorithm in the "mgcv" package to determine the optimal number of degrees of freedom for the spline uses a cross-validation method to reduce the potential for overfitting; 2) reduction in the estimates for smooths was allowed by applying a "shrinkage" effect (select = TRUE in the GAM function), allowing them to be effectively removed from the models; and 3) the models were fit allowing for increasing complexity in the smooth for river distance (k values of 3, 10, and 15), and used model-fitting metrics to select the model that best fit the data.
- **Detection limits and missing analytes.** As illustrated by the EDA, some COC metals had high frequencies of nondetected results in one or more studies. Most notably, selenium was only detected in 10 out of 119 samples in the 2012 Ecology Upland Soil Study (HARTC13A) and in 283 out of 404 samples in the Trail ERA study (Table F-5). In addition, some studies did not include all COC as analytes. These included the 2014 and 2016 Residential Soil Studies that did not analyze for mercury, and the 2004 EPA Le Roi Smelter Removal Action Study where, of the 242 total samples collected, all were analyzed for arsenic, cadmium, copper, and lead, but only 11 samples were only analyzed for the full list of COCs. Both of these issues should be taken into consideration when interpreting GAM results.

5. SUMMARY AND CONCLUSIONS

This appendix presents the methods and results for statistical analyses that were completed to support the nature and extent evaluation for the Upland RI. The data sets used for these analyses were compiled from 30 different studies in Washington and British Columbia, Canada. Some of these studies were conducted as part of the UCR RI/FS, while several were conducted independent of the UCR RI/FS for similar or other purposes.

The statistical analyses included EDA and GAMs. The results from these statistical analyses are presented and synthesized in the nature and extent evaluation in the Upland RI report.

The overall conclusions from these analyses are as follows:

- The correlation coefficient matrices for the nine COCs show that arsenic, cadmium, copper, lead, mercury, and zinc have moderate to strong positive correlations with each other.
- The parameters exhibiting the most pronounced relationship with COC concentrations in the GAMs are UTM northing (as a proxy for distance from the Trail Facility), lateral distance from

the river, and elevation. Of these parameters, elevation and lateral distance from the river are correlated with each other.

- Relationships between metals concentrations and UTM northing in the GAMs suggest that the nature and extent of the COCs arsenic, cadmium, copper, lead, mercury, and zinc are consistent with aerial deposition from smelter emissions. Barium and manganese exhibit different north-south patterns than the other COC metals.

The data sets used for these analyses were intentionally developed to be as inclusive as possible with respect to the studies included, even though the studies used different sampling designs and included a variety of sample types, sample depths, grain sizes, and analytical methods. This data-inclusive approach was adopted to maximize the spatial coverage and to help ensure that no important data were inadvertently excluded. However, the spatial coverage (density) of samples is variable, and combining different sample types likely introduces uncertainty to the analyses. Analyses performed using a more focused data set (limited in spatial extent or limited by study) could also be useful for evaluating patterns, depending on the specific question being addressed.

6. REFERENCES

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TABLES

Table F-1a
Data Selection for the Upland RI Data Set
Final Upland RI Report
Upper Columbia River, Washington

Selection Criterion	Selection Criteria Applied?	Rationale
Exclude nonmetals. [a]	yes	COPCs identified for upland soil are metals.
Exclude sediment, surface water, and groundwater samples.	yes [b]	Sediment, surface water, and groundwater are not media of concern.
Exclude results with units of % or mg/L.	yes	Only data reported in mg/kg are used for comparability.
Exclude results that were qualified as rejected during data validation.	yes	Rejected values are not appropriate for use in decision making.
Exclude samples without spatial coordinates. [c]	yes	Spatial coordinates are necessary for mapping and spatial analyses.
Exclude laboratory quality control samples, including laboratory replicates.	yes	These samples are not investigative samples.
Exclude samples collected below the pre-1973 flood extent maximum (i.e., floodplain samples). [d]	yes	These samples will be evaluated in the Aquatic RI report.
Exclude field-screening results obtained through XRF analysis.	yes	XRF is a screening method; only laboratory-analyzed data are used for comparability.
Exclude samples with unknown analytical methods.	yes	The data set includes multiple methods for some samples, but only results from known analytical methods are used in the analyses and only one result per sample location is used.
Exclude waste rock, soil tailings, crushed ore, and tailings.	varies	Waste rock, tailings, and crushed ore data are included in the data set but are not considered soil. Only soil samples are retained for comparability in the analyses, with the exception of the exploratory data analysis.
Exclude subsurface samples.	varies [b]	Subsurface results are evaluated separately in some analyses.
Exclude samples outside the boundaries of Stevens, Ferry, and Lincoln Counties.	varies [b]	The tri-county area represents regional conditions. Data outside the tri-county area are included in the data set but are not used in the analyses.
Exclude samples prepared using a total digestion method.	varies	Total digestion results are evaluated separately in some analyses.
Exclude samples prepared using an IVBA method.	varies	IVBA results are evaluated separately in some analyses.
Include multiple size fractions for the same sample when analyzed.	varies	Different size fractions were used for some analyses.
Include triplicate samples from the same DU when collected.	varies	Triplicate results were used for some analyses.

Table F-1a
Data Selection for the Upland RI Data Set
Final Upland RI Report
Upper Columbia River, Washington

Selection Criterion	Selection Criteria Applied?	Rationale
Include discrete and composite samples from the same DU when collected.	varies	Different sample types were used for some analyses.

Notes:

[a] Antimony, arsenic, and selenium are classified as metals/metalloids in the database and were retained.

[b] This filter was not applied to background threshold value (BTV) samples.

[c] The 2015 TCRA Memorandum samples and the pre-removal 2017–2018 VRA samples do not have spatial coordinates. These coordinates were not provided in the reports; therefore, these samples are not included in mapping or spatial analyses.

[d] This filter removes ADA-140, which was sampled during the 2014 Soil Study. This DU will be evaluated in the Aquatic RI report.

COPC - chemical of potential concern
DU - decision unit
IVBA - in vitro bioaccessibility
mg/kg - milligram per kilogram
mg/L - milligram per liter
RI - remedial investigation
XRF - x-ray fluorescence

Table F-1b
Study-Specific Data Selection for the Upland RI Data Set
Final Upland RI Report
Upper Columbia River, Washington

Abbreviated Study Name Used in Upland RI Report	Selection Criteria	Selection Criteria Applied?	Rationale
2014 Soil Study	Exclude RFDA and WSDA samples.	yes [a]	These samples will be evaluated in the Aquatic RI report.
2016 Residential Soil Study	Exclude beach DU samples. Exclude dripline DU samples.	yes	Beach samples will be evaluated in the Aquatic RI report. Dripline samples were excluded from the HHRA.
2014 Residential Soil Study			
2017 SATES Test Plot Characterization	For replicate samples, retain only samples analyzed by ALS-Kelso.	yes	ALS-Kelso was the primary analytical laboratory for soil metals analysis.
Trail Smelter Terrestrial ERA	Retain only SALM analyses; exclude other analytical methods.	yes	This method is most consistent with U.S. analytical methods.
2001 EPA Stevens County Mines and Mills PA/SI	Exclude samples collected in Pend Oreille County.	yes	These samples were erroneously included in this study in the database.
2004 EPA Le Roi Smelter Removal Action	Exclude driveway DU samples. [b]	yes	Driveway DU samples likely represent non-native material.
	Exclude the following locations: 092-BY, 092-DW, 092-FY, 118-DW, 118-GA, 118-PA, 138-FY, and 162-SY.		Reported sample coordinates for listed locations did not match property descriptions.

Notes:
[a] This filter was not applied to background threshold value (BTV) samples.
[b] Driveway samples had lower metals concentrations than samples from other area types (front yard, side yard, back yard, garden area, and play area). Driveway samples likely represent non-native material and therefore are not representative of local soil conditions.
DU - decision unit
HHRA - Final Human Health Risk Assessment: Upper Columbia River Site (USEPA 2021)
RFDA - relict floodplain deposition area
RI - remedial investigation
SALM - strong acid leaching method
WSDA - windblown sediment deposition area

Table F-2
Data Used for the Statistical and Nature and Extent Evaluations
Final Upland RI Report
Upper Columbia River, Washington

Abbreviated Study Name for Upland RI Report	UCR RI/FS Database Study ID	Grain Size(s)	Sample Preparation Method Type	Exploratory Data Analysis [a]	GAM [a,b]
United States Studies					
USGS Midnite Mine Sediment Study	CHURC08A	< 150 µm	total recoverable (per UCR database)	included	not included (spatially removed from OU 3 study area)
Ecology Natural Background Soil Study	ECOLO94A	< 2 mm	total recoverable	not included (no surface samples)	not included (spatially removed from OU 3 study area)
2012 Ecology Upland Soil Study	HARTC13A	< 2 mm	total recoverable [c]	included	included
2014 Soil Study	Teck_2014_UplandSoil	< 2 mm, < 150 µm	total recoverable, partial extraction (IVBA)	included	included
2016 Residential Soil Study	Teck_2016_ResSoil	< 150 µm	total recoverable, partial extraction (IVBA)	included	included
2014 Residential Soil Study	USEPA_2014_ResSoil	< 150 µm	total recoverable, partial extraction (IVBA)	included	included
2007 Brooks Road/Bonanza Mine Roadbed Voluntary Cleanup	WADOE_2007b	unknown	total recoverable [c]	included	not included (study design/sample type)
2007 Peterson Swamp/Bonanza Mine Roadbed Voluntary Cleanup	WADOE_2007c	unknown	total recoverable [c]	included	not included (study design/sample type)
2018 Plant Tissue Study	Teck_2017_PlantTissue	< 150 µm	total recoverable	included	not included (resampling of DUs from previous study[ies])

Table F-2
Data Used for the Statistical and Nature and Extent Evaluations
Final Upland RI Report
Upper Columbia River, Washington

Abbreviated Study Name for Upland RI Report	UCR RI/FS Database Study ID	Grain Size(s)	Sample Preparation Method Type	Exploratory Data Analysis [a]	GAM [a,b]
2017 SATES Test Plot Characterization	Teck_2017_SATES_PIA	< 2 mm and < 150 µm	total recoverable, partial extraction (multiple types)	included	not included (resampling of DUs from previous study[ies])
2017–2018 VRA	Teck_2017-18_VRA	unknown	total recoverable	included	not included (pre-removal resampling of DUs from previous studies; post removal)
2015 TCRA Memorandum	USEPA_2015_TCRASoil	unknown	total recoverable	included	not included (pre-removal resampling of DUs from previous studies; post removal)
2015 TCRA		< 2 mm (per UCR database)	total recoverable [c]		
2011 Port of Entry Soil Remediation	SHANN11A	unknown	total recoverable [c]	included	not included (post removal)
2003–2004 EPA Anderson Calhoun EE/CA	ACMINESITE2007	unknown	unknown	included	not included (non smelter source)
2014–2015 Ecology Van Stone FS	FS1554858	< 2 mm	total recoverable [c]	not included (no surface samples)	not included (non smelter source)
2011–2012 Ecology Van Stone RI	HARTC13C	< 2 mm	total recoverable [c]	included	not included (non smelter source)
2004 EPA Le Roi Smelter Removal Action	LeRoi2005	unknown	total recoverable [c]	included	included
2015 Bossburg Study	Teck_2015_Bossburg	< 2 mm, < 150 µm	total recoverable, partial extraction (IVBA)	included	not included (non smelter source)

Table F-2
Data Used for the Statistical and Nature and Extent Evaluations
Final Upland RI Report
Upper Columbia River, Washington

Abbreviated Study Name for Upland RI Report	UCR RI/FS Database Study ID	Grain Size(s)	Sample Preparation Method Type	Exploratory Data Analysis [a]	GAM [a,b]
WDNR Young America Mine Site Characterization	WADNR2008	unknown	total recoverable [c]	not included (sample depths not specified)	not included (non smelter source)
2011 EPA Young America Mine Removal Assessment	USEPA_2012_YAM	unknown	total recoverable	not included (sample depths not specified)	not included (non smelter source)
2001 EPA Stevens County Mines and Mills PA/SI	USEPA2001Mines_Mills	unknown	total recoverable [c]	included	included [d]
USGS NURE Sample Reanalysis	geochem-fU53	< 150 µm [e]	other	included	not included (total digestion)
USGS Reformatted NURE-HSSR Program	NURE Seds Soil Only	< 150 µm	total digestion, INAA	included	not included (total digestion)
2007–2010 USGS Soil Study	SMITH13A	sieved to < 2 mm, crushed to < 150 µm (lab)	total digestion	included	not included (total digestion)
Wells Lichen Study	WELLS15A	< 2 mm	other (loss on ignition before total recoverable digestion)	included	not included (total digestion)
Canada Studies					
2001 Trail Area Soil Background Assessment	GOOD01A	< 2 mm (lab)	total recoverable	included	not included (spatially removed from river)
2001 Trail Area Moss Bag Study	GOODA02A	< 2 mm	total digestion	included	not included (total digestion)
Trail Smelter Terrestrial ERA	Trail ERA	< 2 mm (field)	total recoverable	included	included
2005 Waneta Expansion Project	Waneta2005	< 2 mm	total recoverable	included	not included (study design/sample type)

Table F-2
Data Used for the Statistical and Nature and Extent Evaluations
Final Upland RI Report
Upper Columbia River, Washington

Abbreviated Study Name for Upland RI Report	UCR RI/FS Database Study ID	Grain Size(s)	Sample Preparation Method Type	Exploratory Data Analysis [a]	GAM [a,b]
Lead Isotope Studies [f]					
2010 Vlassopoulos Expert Report	VLASSOPOULOS2010	NA	NA	not included (sediment)	not included (sediment)
2014 Vlassopoulos Expert Report	NA	NA	NA	not included (sediment)	not included (sediment)
2010 Riese Expert Report	RIESE2011	NA	NA	not included (sediment)	not included (sediment)
2018 Child et al. Isotope Study	NA	NA	NA	not included (sediment)	not included (sediment)

Notes:

For data sets that were not included, reasons are provided in parentheses. For data sets that were included, additional information regarding what data or how the data were used is provided in parentheses.

Green shaded cells indicate the study was included in the analysis/map.

[a] Only surface samples were used (i.e., samples with upper depth of 0).

[b] Only samples prepared using a total recoverable method were included.

[c] Sample preparation method type is assumed.

[d] Only three background soil samples from this study were used in the model.

[e] The UCR database reports National Uranium Resource Evaluation (NURE) samples with < 150 micrometer (µm) grain size. The U.S. Geological Survey (USGS) does not have a specific report confirming the grain size; however, they note that a subset of the NURE samples was sieved at < 150 µm and geochem-fU53 samples in the UCR are included in this data set (USGS 2025).

[f] Lead isotope studies did not collect soil samples.

ADA - aerial deposition area
DU - decision unit
GAM - generalized additive model
IC - incremental composite
INAA - instrumental neutron activation analysis
IVBA - in vitro bioaccessibility
mm - millimeter
NA - not applicable
RI - remedial investigation
RBA - relative bioavailability

Table F-3
Metals Included in the Statistical and Nature and Extent Evaluations
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Upper Columbia River, Washington

Metal	Human Health COC [a]	Ecological COC [b]	Exploratory Data Analysis	GAM [c]
Aluminum	no	no	yes	no
Antimony	no	no	yes	no
Arsenic	yes	yes	yes	yes
Barium	no	yes	yes	yes
Beryllium	no	no	yes	no
Cadmium	no	yes	yes	yes
Calcium	no	no	yes	no
Chromium	no	no	yes	no
Cobalt	no	no	yes	no
Copper	no	yes	yes	yes
Iron	no	no	yes	no
Lead	yes	yes	yes	yes
Magnesium	no	no	yes	no
Manganese	no	yes	yes	yes
Mercury	no	yes	yes	yes
Molybdenum	no	no	yes	no
Nickel	no	no	yes	no
Potassium	no	no	yes	no
Selenium	no	yes	yes	yes [d]
Silver	no	no	yes	no
Sodium	no	no	yes	no
Thallium	no	no	yes	no
Vanadium	no	no	yes	no
Zinc	no	yes	yes	yes

Notes:

[a] Human health chemicals of concern (COCs) for upland soil were identified based on the results of the Final Site-Wide Human Health Risk Assessment: Upper Columbia River Site (USEPA 2021) (HHRA) and the Human Health Remedial Action Objectives for the Upper Columbia River Site (RAOs) (USEPA 2023).

[b] Ecological COCs were identified in the Upland BERA.

[c] Generalized additive model (GAM) run for the nine COCs (arsenic, barium, cadmium, copper, lead, manganese, mercury, selenium, and zinc).

[d] Low detection frequency in Canada.

Table F-4
Comparison of Field and Laboratory Methods for U.S. and Canada Studies
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UCR RI/FS Database Study ID	Lab and Analytical Method	Field Sampling	Initial Preparation	Digestion Acid	Heating Mechanism	Digestion Process	Digestion Time	Digestion Temp	Instrument	ICP-MS analytes	ICP-AES Analytes
Teck_2014_UplandSoil	ALS: 3050B/EPA 6010C; method scaled to 2-gram digestion rather than 1 gram	30-point IC sample, collected 0 to 3 in. using 5-cm diameter AMS sampler (soil punch) across approximately 25 ha. Samples were collected below leaf litter.	Homogenized, air dried, and sieved prior to analysis; Sieved into < 2 mm and < 149 um	HNO_3, H_2O_2 (30%), HCl	Block digester, hot plates	Dry weight is digested with repeated additions of HNO_3 and H_2O_2. When reactions with HNO_3 and H_2O_2 are complete, add 10 mL HCl, then refluxed and cooled. Digestate is then diluted to 100 mL.	15 minutes HNO_3 + 30 minutes HNO_3 + 120 minutes HNO_3 + 120 minutes H_2O_2 + 15 minutes HCl	95 degrees C	ICP-AES	Aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), vanadium (V), and zinc (Zn); molybdenum	Calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), and sodium (Na)
Teck_2014_UplandSoil	ALS: 3050B/EPA 6020A; method scaled to 2-gram digestion rather than 1 gram	30-point IC sample, collected 0 to 3 in. using 5-cm diameter AMS sampler (soil punch) across approximately 25 ha. Samples were collected below leaf litter.	Homogenized, air dried, and sieved prior to analysis; Sieved into < 2 mm and < 149 um	1:1 HNO_3, H_2O_2 (30%)	Block digester, hot plates	Dry weight is digested with repeated additions of HNO_3 and H_2O_2. When reactions with HNO_3 and H_2O_2 are complete, then refluxed and cooled. Digestate is then diluted to 100 mL.	15 minutes HNO_3 + 30 minutes HNO_3 + 120 minutes HNO_3 + 120 minutes H_2O_2	95 degrees C	ICP-MS	Aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), vanadium (V), and zinc (Zn); molybdenum	Calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), and sodium (Na)
Teck_2014_UplandSoil	ALS: 7471 Mercury - No analytical SOP - referenced EPA method - not lab specific	30-point IC sample, collected 0 to 3 in. using 5-cm diameter AMS sampler (soil punch) across approximately 25 ha. Samples were collected below leaf litter.	Homogenized, air dried, and sieved prior to analysis; Sieved into < 2 mm and < 149 um	Water, aqua regia, potassium permanganate, sodium chloride hydroxylamine sulfate	Block digester, hot plates	Add 5 mL of reagent water and 5 mL of aqua regia. Heat. Cool; then add 50 mL of reagent water and 15 mL of potassium permanganate solution to each sample until the purple color persists for at least 15 min. Mix thoroughly, then heat. Cool and add 6 mL of sodium chloride hydroxylamine sulfate to reduce the excess permanganate. Alternate digestion using autoclave: 5 mL H_2SO_4 + 2 mL HNO_3 added to sample. Add 5 mL of saturated $KMnO_4$ solution and cover bottle with a piece of aluminum foil. Autoclave samples at 121 degrees C and 15 lb for 15 min. Cool, dilute to a volume of 100 mL with reagent water, and add 6 mL of sodium chloride-hydroxylamine sulfate solution to reduce the excess permanganate.	2 minutes aqua regia + 30 minutes $KMnO_4$	95 degrees C	CVAA	--	--

Table F-4
Comparison of Field and Laboratory Methods for U.S. and Canada Studies
Final Upland RI Report
Upper Columbia River, Washington

UCR RI/FS Database Study ID	Lab and Analytical Method	Field Sampling	Initial Preparation	Digestion Acid	Heating Mechanism	Digestion Process	Digestion Time	Digestion Temp	Instrument	ICP-MS analytes	ICP-AES Analytes
HARTC13A	Analytical Resources, Incorporated: 3050B/EPA 6010C/200.8/ 7471- Mercury	4-point composite samples of grabs obtained from within 20 feet radius of a fixed point, collected from 0 to 3 in. below non-decomposed surface litter using a precleaned stainless steel spoon, trowel, bulb planter, or other coring device. In addition, a shallow borehole up to 2 feet was hand excavated for discrete samples 0 to 3 in., 3 to 6 in., 6 to 12 in., 12 to 24 in.	Samples should be dried (without elevated temps) before 2 mm sieve	--	--	Did not have analytical SOP but method 3050B should be similar to that of Teck_2014_UplandSoil.	--	--	ICP-AES or ICP-MS	Antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, manganese, nickel, selenium, silver, thallium, vanadium, zinc	Aluminum, calcium, iron, magnesium, potassium, sodium
Teck_2016_ResSoil	ALS: 3050/6020/6010; No mercury analyzed	Leaf litter and surface debris was cleared prior to sampling. 30-point ICS collected at various depths using multi-incremental sampling tool, EZ-Probe device or stainless-steel trowel. Soil depth measured below thatch or root zone. Discrete samples collected from 0 to 1 in. and 1 to 6 in. at five locations.	Homogenized, air dried, and sieved prior to analysis; Sieved into < 2 mm and < 149 um	--	--	Same as Teck_2014_UplandSoil.	--	--	ICP-AES or ICP-MS	Aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), vanadium (V), and zinc (Zn)	Calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), and sodium (Na)
USEPA_2014_ResSoil	ALS: 3050/6020/6010; No mercury analyzed	Leaf litter and surface debris was cleared prior to sampling. 30-point ICS collected at various depts 0 to 3 in., 0 to 6 in., and 0 to 12 in. using multi-incremental sampling tool or trowel. Soil depth measured below thatch or root zone.	Homogenized, air dried, and sieved prior to analysis; Sieved into < 2 mm and < 149 um	--	--	Same as Teck_2014_UplandSoil.	--	--	ICP-AES or ICP-MS	Aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), manganese (Mn), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), vanadium (V), and zinc (Zn)	Calcium (Ca), iron (Fe), magnesium (Mg), potassium (K), and sodium (Na)
TrailERA	BC ALS: BC CSR SALM and procedures adapted from SW846 3050B or 3051 (SALM 10)	Prior to sampling, litter, fiber, and humus layer was removed, photographed, and refrigerated. Samples collected from stainless-steel corer at the main rooting medium of the site vegetation. 5-point composite samples from a center point and 10 m from the center point in cardinal directions from 0 to 6 in.	Homogenized, dried at 60 degrees C, sieved through 2 mm sieve, weigh 1.0 gram subsample of dry material	Minimum 2.5 mL HNO_3, 2.5 mL HCl; 1:1 HNO_3 and HCl	Hot plate or block digester	Allow sample to sit at room temperature 1 hour before heating. Digest at 90 degrees C for 2 hours by hot plate or block digester in 1:1 nitric/HCL, dilute as needed for analysis. For ICP-MS metals, a portion of the dry, ground sample (0.5 gram) was digested in a sealed Teflon vessel using microwave heating (EPA Method 3051).	120 minutes	90 degrees C	ICP-OES or ICP-MS	ICP-MS-silver, arsenic, cadmium, selenium, thallium, uncertain about which others	Unknown

Table F-4
Comparison of Field and Laboratory Methods for U.S. and Canada Studies
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Upper Columbia River, Washington

UCR RI/FS Database Study ID	Lab and Analytical Method	Field Sampling	Initial Preparation	Digestion Acid	Heating Mechanism	Digestion Process	Digestion Time	Digestion Temp	Instrument	ICP-MS analytes	ICP-AES Analytes
TrailERA	BC ALS: Mercury	Prior to sampling, litter, fiber, and humus layer was removed, photographed, and refrigerated. Samples collected from stainless-steel corer at the main rooting medium of the site vegetation. 5-point composite samples from a center point and 10 m from the center point in cardinal directions from 0 to 6 in.	Homogenized, dried at 60 degrees C, sieved through 2 mm sieve, weigh 1.0 gram subsample of dry material	--	--	CVAA - non-heated soil was subjected to an oxidative digestion, followed by reduction, aeration, and measurement of mercury flame fluorescence at 253.7 nm.	--	--	CVAA	--	--
TrailERA	BC ALS: BC CSR SALM and procedures adapted from SW846 3050B or 3051 (SALM 10)	Prior to sampling, litter, fiber, and humus layer was removed, photographed, and refrigerated. Samples collected from stainless-steel corer at the main rooting medium of the site vegetation. 5-point composite samples from a center point and 10 m from the center point in cardinal directions from 0 to 6 in.	Homogenized, dried at 60 degrees C, sieved through 180 um sieve, weigh 1.0 gram subsample of dry material	Minimum 2.5 mL HNO_3, 2.5 mL HCl; 1:1 HNO_3 and HCl	Hot plate or block digester	Allow sample to sit at room temperature 1 hour before heating. Digest at 90 degrees C for 2 hours by hot plate or block digester in 1:1 nitric/HCL, dilute as needed for analysis. For ICP-MS metals, a portion of the dry, ground sample (0.5 gram) was digested in a sealed Teflon vessel using microwave heating (EPA Method 3051).	120 minutes	90 degrees C	ICP-OES or ICP-MS	ICP-MS-silver, arsenic, cadmium, selenium, thallium, uncertain about which others	Unknown

Notes:
All results were reported in dry-weight basis.
"--" - unknown
um - micrometer
cm - centimeter
CVAA - cold vapor atomic absorption
H2O2 - hydrogen peroxide
ha - hectare
HCI - hydrochloric acid
HNO3 - nitric acid
IC - incremental composite
ICP-AES - inductively coupled plasma atomic emission spectroscopy
ICP-MS - inductively coupled plasma mass spectrometry
ICP-OES - inductively coupled plasma optical emission spectroscopy
in. - inch
lb - pound
m - meter
min - minute
mL - milliliter
mm - millimeter
nm - nanometer
RI/FS - remedial investigation and feasibility study
SALM - strong acid leaching procedure
SOP - standard operating procedure

Table F-5
Detection Frequencies, Detection Limits, and Reporting Limits for Data Used in the Exploratory Data Analysis
Final Upland RI Report
Upper Columbia River, Washington

Material Analyzed	Sample Material	Country	Metal	Number of Samples	Number of Samples with Detected Values	Number of Unique Detection Limits	Minimum Detection Limit Concentration (mg/kg)	Maximum Detection Limit Concentration (mg/kg)	Number of Unique Reporting Limits	Minimum Reporting Limit Concentration (mg/kg)	Maximum Reporting Limit Concentration (mg/kg)
Sediment<150um	CHURC08A	USA	Aluminum	41	41	na	na	na	na	na	na
Soil	GOODA01A	USA	Aluminum	37	37	1	0.01	0.01	na	na	na
Soil	Teck_2015_Bossburg	USA	Aluminum	48	48	3	0.4	0.6	7	1.5	2.3
Soil	Trail ERA	Canada	Aluminum	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Aluminum	98	98	na	na	na	na	na	na
Soil	Waneta2005	USA	Aluminum	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Aluminum	173	173	3	0.4	0.6	10	1.9	6
Soil<150um	CHURC08A	USA	Aluminum	2	2	na	na	na	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Aluminum	807	807	7	0.3	0.6	37	1.5	4.5
Soil<150um	Teck_2017_PlantTissue	USA	Aluminum	160	160	4	1.2	30	13	3.8	110
Soil<150um	Teck_2017_SATES_PIA	USA	Aluminum	16	16	1	0.18	0.18	1	5	5
Soil<150um	USEPA_2014_ResSoil	USA	Aluminum	384	384	4	0.3	0.6	15	1.6	4
Soil<2mm	HARTC13A	USA	Aluminum	119	119	34	3.3	9.8	4	5	10
Soil<2mm	SMITH13A	USA	Aluminum	118	118	1	0.01	0.01	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Aluminum	173	173	3	0.4	0.6	20	1.8	6.2
Soil<2mm	Teck_2017_SATES_PIA	USA	Aluminum	32	32	1	0.18	0.18	1	5	5
Soil<2mm	WELLS15A	USA	Aluminum	23	23	1	0.08	0.08	na	na	na
Soil	GOODA01A	USA	Antimony	37	37	1	0.1	0.1	na	na	na
Soil	HARTC13C	USA	Antimony	176	175	na	na	na	na	na	na
Soil	LeRoi2005	USA	Antimony	2	1	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Antimony	48	48	4	0.007	0.011	11	0.037	0.057
Soil	Trail ERA	Canada	Antimony	404	102	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Antimony	98	70	na	na	na	na	na	na
Soil	Waneta2005	USA	Antimony	28	2	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Antimony	173	173	2	0.009	0.01	4	0.04	0.1
Soil<150um	Teck_2016_ResSoil	USA	Antimony	807	807	10	0.007	0.012	64	0.037	0.105
Soil<150um	Teck_2017_PlantTissue	USA	Antimony	160	160	5	0.01	0.04	15	0.025	0.13
Soil<150um	Teck_2017_SATES_PIA	USA	Antimony	16	16	1	0.46	0.46	1	5	5
Soil<150um	USEPA_2014_ResSoil	USA	Antimony	384	384	5	0.008	0.021	25	0.041	0.103
Soil<2mm	HARTC13A	USA	Antimony	119	65	6	0.012	0.015	1	0.2	0.2
Soil<2mm	SMITH13A	USA	Antimony	118	118	1	0.05	0.05	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Antimony	173	173	2	0.009	0.01	6	0.04	0.11
Soil<2mm	Teck_2017_SATES_PIA	USA	Antimony	32	32	1	0.46	0.46	1	5	5
Sediment<150um	CHURC08A	USA	Arsenic	41	41	1	1	1	na	na	na
Soil	GOODA01A	USA	Arsenic	37	37	1	0.1	0.1	na	na	na
Soil	GOODA02A	USA	Arsenic	20	20	1	0.5	0.5	na	na	na
Soil	HARTC13C	USA	Arsenic	182	182	na	na	na	na	na	na
Soil	LeRoi2005	USA	Arsenic	242	230	na	na	na	na	na	na

Table F-5
Detection Frequencies, Detection Limits, and Reporting Limits for Data Used in the Exploratory Data Analysis
Final Upland RI Report
Upper Columbia River, Washington

Material Analyzed	Sample Material	Country	Metal	Number of Samples	Number of Samples with Detected Values	Number of Unique Detection Limits	Minimum Detection Limit Concentration (mg/kg)	Maximum Detection Limit Concentration (mg/kg)	Number of Unique Reporting Limits	Minimum Reporting Limit Concentration (mg/kg)	Maximum Reporting Limit Concentration (mg/kg)
Soil	NURE Seds	USA	Arsenic	399	399	na	na	na	na	na	na
Soil	SHANN11A	USA	Arsenic	48	48	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Arsenic	48	48	3	0.03	0.05	11	0.37	0.57
Soil	Teck_2017-18_VRA	USA	Arsenic	219	205	na	na	na	na	na	na
Soil	Trail ERA	Canada	Arsenic	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Arsenic	98	90	na	na	na	na	na	na
Soil	USEPA_2015_TCRASoil	USA	Arsenic	93	93	na	na	na	na	na	na
Soil	WADOE_2007b	USA	Arsenic	5	5	na	na	na	3	2.96	3.7
Soil	WADOE_2007c	USA	Arsenic	15	12	na	na	na	13	2.63	17.1
Soil	Waneta2005	USA	Arsenic	28	6	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Arsenic	173	173	1	0.04	0.04	10	0.46	0.55
Soil<150um	CHURC08A	USA	Arsenic	2	2	1	1	1	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Arsenic	807	807	4	0.03	0.05	38	0.37	0.6
Soil<150um	Teck_2017_PlantTissue	USA	Arsenic	160	160	3	0.02	0.09	10	0.24	1.1
Soil<150um	Teck_2017_SATES_PIA	USA	Arsenic	16	16	1	0.39	0.39	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Arsenic	385	385	3	0.03	0.05	17	0.41	0.57
Soil<150um	geochem-fU53	USA	Arsenic	26	17	na	na	na	2	10	10
Soil<2mm	HARTC13A	USA	Arsenic	119	119	27	0.081	0.098	3	0.2	0.6
Soil<2mm	SMITH13A	USA	Arsenic	118	118	1	0.6	0.6	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Arsenic	173	173	2	0.04	0.05	16	0.45	0.61
Soil<2mm	Teck_2017_SATES_PIA	USA	Arsenic	631	631	15	0.39	2.2	30	1	4.8
CrushedOre	ACMINESITE2007	USA	Barium	1	1	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Barium	41	41	1	0.2	0.2	na	na	na
Soil	ACMINESITE2007	USA	Barium	17	17	na	na	na	na	na	na
Soil	GOODA01A	USA	Barium	37	37	1	0.2	0.2	na	na	na
Soil	NURE Seds	USA	Barium	380	380	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Barium	48	48	1	0.02	0.02	5	0.05	0.11
Soil	Trail ERA	Canada	Barium	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Barium	98	97	na	na	na	na	na	na
Soil	Waneta2005	USA	Barium	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Barium	173	173	1	0.02	0.02	5	0.05	0.21
Soil<150um	CHURC08A	USA	Barium	2	2	1	0.2	0.2	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Barium	807	807	2	0.02	1.97	24	0.04	4.93
Soil<150um	Teck_2017_PlantTissue	USA	Barium	160	160	4	0.01	0.04	10	0.096	0.27
Soil<150um	Teck_2017_SATES_PIA	USA	Barium	16	16	1	0	0	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Barium	384	384	1	0.02	0.02	6	0.04	0.21
Soil<150um	geochem-fU53	USA	Barium	13	13	na	na	na	1	1	1
Soil<2mm	HARTC13A	USA	Barium	119	119	16	0.056	0.17	6	0.3	0.8

Table F-5
Detection Frequencies, Detection Limits, and Reporting Limits for Data Used in the Exploratory Data Analysis
Final Upland RI Report
Upper Columbia River, Washington

Material Analyzed	Sample Material	Country	Metal	Number of Samples	Number of Samples with Detected Values	Number of Unique Detection Limits	Minimum Detection Limit Concentration (mg/kg)	Maximum Detection Limit Concentration (mg/kg)	Number of Unique Reporting Limits	Minimum Reporting Limit Concentration (mg/kg)	Maximum Reporting Limit Concentration (mg/kg)
Soil<2mm	SMITH13A	USA	Barium	118	118	1	5	5	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Barium	173	173	2	0.02	0.2	8	0.05	0.51
Soil<2mm	Teck_2017_SATES_PIA	USA	Barium	32	32	1	0	0	1	1	1
Tailings	ACMINESITE2007	USA	Barium	7	7	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Beryllium	41	41	1	0.03	0.03	na	na	na
Soil	GOODA01A	USA	Beryllium	37	37	1	0.05	0.05	na	na	na
Soil	HARTC13C	USA	Beryllium	176	119	na	na	na	na	na	na
Soil	LeRoi2005	USA	Beryllium	11	11	na	na	na	na	na	na
Soil	NURE Seds	USA	Beryllium	380	376	2	0.5	0.5	na	na	na
Soil	Teck_2015_Bossburg	USA	Beryllium	48	48	3	0.004	0.006	7	0.015	0.023
Soil	Trail ERA	Canada	Beryllium	404	70	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Beryllium	98	80	na	na	na	na	na	na
Soil	Waneta2005	USA	Beryllium	28	0	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Beryllium	173	173	2	0.005	0.006	2	0.01	0.02
Soil<150um	CHURC08A	USA	Beryllium	2	2	1	0.03	0.03	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Beryllium	807	807	5	0.004	0.006	20	0.015	0.024
Soil<150um	Teck_2017_PlantTissue	USA	Beryllium	160	160	6	0.002	0.011	13	0.0096	0.044
Soil<150um	Teck_2017_SATES_PIA	USA	Beryllium	16	16	1	0	0	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Beryllium	384	384	3	0.004	0.006	8	0.016	0.023
Soil<150um	geochem-fU53	USA	Beryllium	13	13	na	na	na	1	1	1
Soil<2mm	HARTC13A	USA	Beryllium	119	119	9	0.017	0.02	1	0.2	0.2
Soil<2mm	SMITH13A	USA	Beryllium	118	118	1	0.1	0.1	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Beryllium	173	173	3	0.004	0.006	2	0.01	0.02
Soil<2mm	Teck_2017_SATES_PIA	USA	Beryllium	32	19	1	0.0036	0.0036	1	1	1
CrushedOre	ACMINESITE2007	USA	Cadmium	1	1	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Cadmium	41	41	1	0.007	0.007	na	na	na
Soil	ACMINESITE2007	USA	Cadmium	17	9	na	na	na	na	na	na
Soil	GOODA01A	USA	Cadmium	37	37	1	0.01	0.01	na	na	na
Soil	GOODA02A	USA	Cadmium	20	20	1	0.2	0.2	na	na	na
Soil	HARTC13C	USA	Cadmium	182	182	na	na	na	na	na	na
Soil	LeRoi2005	USA	Cadmium	242	229	na	na	na	na	na	na
Soil	SHANN11A	USA	Cadmium	51	42	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Cadmium	48	48	4	0.005	0.008	7	0.015	0.023
Soil	Trail ERA	Canada	Cadmium	404	398	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Cadmium	98	95	na	na	na	na	na	na
Soil	WADOE_2007b	USA	Cadmium	5	5	na	na	na	4	0.237	0.296
Soil	WADOE_2007c	USA	Cadmium	15	15	na	na	na	14	0.21	1.37
Soil	Waneta2005	USA	Cadmium	28	23	na	na	na	na	na	na

Table F-5
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Material Analyzed	Sample Material	Country	Metal	Number of Samples	Number of Samples with Detected Values	Number of Unique Detection Limits	Minimum Detection Limit Concentration (mg/kg)	Maximum Detection Limit Concentration (mg/kg)	Number of Unique Reporting Limits	Minimum Reporting Limit Concentration (mg/kg)	Maximum Reporting Limit Concentration (mg/kg)
Soil<149um	Teck_2014_UplandSoil	USA	Cadmium	173	173	3	0.006	0.008	2	0.01	0.02
Soil<150um	CHURC08A	USA	Cadmium	2	2	1	0.007	0.007	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Cadmium	807	807	6	0.005	0.008	20	0.015	0.024
Soil<150um	Teck_2017_PlantTissue	USA	Cadmium	160	160	7	0.003	0.015	13	0.0096	0.044
Soil<150um	Teck_2017_SATES_PIA	USA	Cadmium	16	16	1	0.02	0.02	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Cadmium	384	384	3	0.006	0.008	8	0.016	0.023
Soil<150um	geochem-fU53	USA	Cadmium	13	0	na	na	na	1	2	2
Soil<2mm	HARTC13A	USA	Cadmium	119	119	6	0.011	0.014	3	0.09	0.1
Soil<2mm	SMITH13A	USA	Cadmium	118	115	1	0.1	0.1	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Cadmium	173	173	4	0.006	0.009	2	0.01	0.02
Soil<2mm	Teck_2017_SATES_PIA	USA	Cadmium	32	32	1	0.02	0.02	1	1	1
Soil<2mm	WELLS15A	USA	Cadmium	23	22	1	0.01	0.01	na	na	na
Tailings	ACMINESITE2007	USA	Cadmium	7	7	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Calcium	41	41	1	100	100	na	na	na
Soil	GOODA01A	USA	Calcium	37	37	1	0.01	0.01	na	na	na
Soil	Teck_2015_Bossburg	USA	Calcium	48	48	5	0.7	1.1	10	3	4.5
Soil	Trail ERA	Canada	Calcium	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Calcium	98	98	na	na	na	na	na	na
Soil	Waneta2005	USA	Calcium	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Calcium	173	173	8	0.8	3.2	14	3.7	8.2
Soil<150um	CHURC08A	USA	Calcium	2	2	1	100	100	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Calcium	807	807	14	0.7	6	47	2.9	24.1
Soil<150um	Teck_2017_SATES_PIA	USA	Calcium	16	16	1	0.37	0.37	1	10	10
Soil<150um	USEPA_2014_ResSoil	USA	Calcium	384	384	14	0.8	29.9	20	3.3	39.9
Soil<2mm	HARTC13A	USA	Calcium	119	119	21	1.8	5.2	4	5	10
Soil<2mm	SMITH13A	USA	Calcium	118	118	1	0.01	0.01	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Calcium	173	173	11	0.8	3.3	21	3.6	8.6
Soil<2mm	Teck_2017_SATES_PIA	USA	Calcium	32	32	1	0.37	0.37	1	10	10
Soil<2mm	WELLS15A	USA	Calcium	23	23	1	0.43	0.43	na	na	na
WasteRock	ACMINESITE2007	USA	Calcium	3	3	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Chromium	41	41	1	0.5	0.5	na	na	na
Soil	GOODA01A	USA	Chromium	37	37	1	1	1	na	na	na
Soil	HARTC13C	USA	Chromium	176	143	na	na	na	na	na	na
Soil	LeRoi2005	USA	Chromium	11	11	na	na	na	na	na	na
Soil	NURE Seds	USA	Chromium	436	436	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Chromium	48	48	3	0.05	0.07	7	0.15	0.23
Soil	Trail ERA	Canada	Chromium	404	403	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Chromium	98	96	na	na	na	na	na	na

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Material Analyzed	Sample Material	Country	Metal	Number of Samples	Number of Samples with Detected Values	Number of Unique Detection Limits	Minimum Detection Limit Concentration (mg/kg)	Maximum Detection Limit Concentration (mg/kg)	Number of Unique Reporting Limits	Minimum Reporting Limit Concentration (mg/kg)	Maximum Reporting Limit Concentration (mg/kg)
Soil	Waneta2005	USA	Chromium	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Chromium	173	173	2	0.06	0.07	4	0.19	0.22
Soil<150um	CHURC08A	USA	Chromium	2	2	1	0.5	0.5	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Chromium	807	807	6	0.04	0.07	19	0.15	0.24
Soil<150um	Teck_2017_PlantTissue	USA	Chromium	160	160	4	0.029	0.13	13	0.096	0.44
Soil<150um	Teck_2017_SATES_PIA	USA	Chromium	16	16	1	0.03	0.03	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Chromium	384	384	3	0.05	0.07	8	0.16	0.23
Soil<150um	geochem-fU53	USA	Chromium	13	13	na	na	na	1	2	2
Soil<2mm	HARTC13A	USA	Chromium	119	119	23	0.035	0.2	6	0.5	3
Soil<2mm	SMITH13A	USA	Chromium	118	118	1	1	1	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Chromium	173	173	3	0.05	0.07	7	0.18	0.24
Soil<2mm	Teck_2017_SATES_PIA	USA	Chromium	32	32	1	0.03	0.03	1	1	1
Soil<2mm	WELLS15A	USA	Chromium	23	23	1	0.01	0.01	na	na	na
Sediment<150um	CHURC08A	USA	Cobalt	41	41	1	0.03	0.03	na	na	na
Soil	GOODA01A	USA	Cobalt	37	37	1	0.1	0.1	na	na	na
Soil	NURE Seds	USA	Cobalt	381	343	2	5	5	na	na	na
Soil	Teck_2015_Bossburg	USA	Cobalt	48	48	4	0.004	0.007	7	0.015	0.023
Soil	Trail ERA	Canada	Cobalt	404	255	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Cobalt	98	73	na	na	na	na	na	na
Soil	Waneta2005	USA	Cobalt	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Cobalt	173	173	2	0.006	0.007	2	0.01	0.02
Soil<150um	CHURC08A	USA	Cobalt	2	2	1	0.03	0.03	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Cobalt	807	807	6	0.004	0.007	20	0.015	0.024
Soil<150um	Teck_2017_PlantTissue	USA	Cobalt	160	160	4	0.0029	0.013	13	0.0096	0.044
Soil<150um	Teck_2017_SATES_PIA	USA	Cobalt	16	16	1	0.04	0.04	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Cobalt	384	384	3	0.005	0.007	8	0.016	0.023
Soil<150um	geochem-fU53	USA	Cobalt	13	13	na	na	na	1	2	2
Soil<2mm	HARTC13A	USA	Cobalt	119	119	17	0.03	0.17	4	0.2	1
Soil<2mm	SMITH13A	USA	Cobalt	118	118	1	0.1	0.1	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Cobalt	173	173	3	0.005	0.007	2	0.01	0.02
Soil<2mm	Teck_2017_SATES_PIA	USA	Cobalt	32	32	1	0.04	0.04	1	1	1
CrushedOre	ACMINESITE2007	USA	Copper	1	1	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Copper	41	41	1	2	2	na	na	na
Soil	ACMINESITE2007	USA	Copper	17	17	na	na	na	na	na	na
Soil	GOODA01A	USA	Copper	37	37	1	0.2	0.2	na	na	na
Soil	GOODA02A	USA	Copper	20	20	1	1	1	na	na	na
Soil	HARTC13C	USA	Copper	182	151	na	na	na	na	na	na
Soil	LeRoi2005	USA	Copper	242	232	na	na	na	na	na	na

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Material Analyzed	Sample Material	Country	Metal	Number of Samples	Number of Samples with Detected Values	Number of Unique Detection Limits	Minimum Detection Limit Concentration (mg/kg)	Maximum Detection Limit Concentration (mg/kg)	Number of Unique Reporting Limits	Minimum Reporting Limit Concentration (mg/kg)	Maximum Reporting Limit Concentration (mg/kg)
Soil	NURE Seds	USA	Copper	376	376	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Copper	48	48	3	0.03	0.05	7	0.07	0.22
Soil	Trail ERA	Canada	Copper	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Copper	98	98	na	na	na	na	na	na
Soil	WADOE_2007b	USA	Copper	5	5	na	na	na	5	0.592	0.741
Soil	WADOE_2007c	USA	Copper	15	15	na	na	na	14	0.526	3.42
Soil	Waneta2005	USA	Copper	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Copper	173	173	1	0.04	0.04	5	0.09	0.2
Soil<150um	CHURC08A	USA	Copper	2	2	1	2	2	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Copper	807	807	4	0.03	0.05	16	0.07	0.21
Soil<150um	Teck_2017_PlantTissue	USA	Copper	160	160	4	0.02	0.09	11	0.05	0.27
Soil<150um	Teck_2017_SATES_PIA	USA	Copper	16	16	1	0.06	0.06	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Copper	384	384	3	0.03	0.05	6	0.08	0.2
Soil<150um	geochem-fU53	USA	Copper	13	13	na	na	na	1	2	2
Soil<2mm	HARTC13A	USA	Copper	119	119	16	0.034	0.041	2	0.5	0.6
Soil<2mm	SMITH13A	USA	Copper	118	118	1	0.5	0.5	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Copper	173	173	2	0.04	0.05	7	0.09	0.21
Soil<2mm	Teck_2017_SATES_PIA	USA	Copper	32	32	1	0.06	0.06	1	1	1
Soil<2mm	WELLS15A	USA	Copper	23	23	1	0.02	0.02	na	na	na
Tailings	ACMINESITE2007	USA	Copper	7	7	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Iron	41	41	1	50	50	na	na	na
Soil	GOODA01A	USA	Iron	37	37	1	0.01	0.01	na	na	na
Soil	Teck_2015_Bossburg	USA	Iron	48	48	9	0.9	2.3	10	3	4.5
Soil	Trail ERA	Canada	Iron	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Iron	98	98	na	na	na	na	na	na
Soil	Waneta2005	USA	Iron	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Iron	173	173	6	0.8	2.2	8	3.7	4.4
Soil<150um	CHURC08A	USA	Iron	2	2	1	50	50	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Iron	807	807	19	0.6	2.2	59	2.9	9.3
Soil<150um	Teck_2017_PlantTissue	USA	Iron	160	160	6	0.6	16	16	1.9	55
Soil<150um	Teck_2017_SATES_PIA	USA	Iron	16	16	1	0.11	0.11	1	5	5
Soil<150um	USEPA_2014_ResSoil	USA	Iron	384	384	10	0.7	2.2	24	3.3	8.1
Soil<2mm	HARTC13A	USA	Iron	119	119	19	0.7	2.1	4	5	10
Soil<2mm	SMITH13A	USA	Iron	118	118	1	0.01	0.01	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Iron	173	173	10	0.8	2.4	12	3.6	4.9
Soil<2mm	Teck_2017_SATES_PIA	USA	Iron	32	32	1	0.11	0.11	1	5	5
Soil<2mm	WELLS15A	USA	Iron	23	23	1	0.02	0.02	na	na	na
CrushedOre	ACMINESITE2007	USA	Lead	1	1	na	na	na	na	na	na

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Sediment<150um	CHURC08A	USA	Lead	41	41	1	0.4	0.4	na	na	na
Soil	ACMINESITE2007	USA	Lead	17	17	na	na	na	na	na	na
Soil	GOODA01A	USA	Lead	37	37	1	0.2	0.2	na	na	na
Soil	GOODA02A	USA	Lead	20	20	1	0.5	0.5	na	na	na
Soil	HARTC13C	USA	Lead	182	182	na	na	na	na	na	na
Soil	LeRoi2005	USA	Lead	242	232	na	na	na	na	na	na
Soil	NURE Seds	USA	Lead	380	264	2	10	10	na	na	na
Soil	SHANN11A	USA	Lead	48	48	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Lead	58	58	4	0.02	0.2	15	0.05	4.84
Soil	Teck_2017-18_VRA	USA	Lead	219	213	na	na	na	na	na	na
Soil	Trail ERA	Canada	Lead	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Lead	98	98	na	na	na	na	na	na
Soil	USEPA_2015_TCRASoil	USA	Lead	94	94	na	na	na	na	na	na
Soil	WADOE_2007b	USA	Lead	5	5	na	na	na	3	1.78	2.22
Soil	WADOE_2007c	USA	Lead	15	15	na	na	na	13	1.58	10.3
Soil	Waneta2005	USA	Lead	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Lead	173	173	3	0.02	0.2	23	0.19	2.01
Soil<150um	CHURC08A	USA	Lead	2	2	1	0.4	0.4	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Lead	807	807	3	0.02	2.1	46	0.04	52.4
Soil<150um	Teck_2017_PlantTissue	USA	Lead	160	160	10	0.038	2	20	0.096	5.3
Soil<150um	Teck_2017_SATES_PIA	USA	Lead	16	16	1	0.33	0.33	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Lead	385	385	4	0.02	0.2	27	0.16	5.05
Soil<150um	geochem-fU53	USA	Lead	13	13	na	na	na	1	4	4
Soil<2mm	HARTC13A	USA	Lead	119	119	24	0.044	1.3	8	0.09	3
Soil<2mm	SMITH13A	USA	Lead	118	118	1	0.5	0.5	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Lead	173	173	4	0.02	0.2	29	0.18	1.96
Soil<2mm	Teck_2017_SATES_PIA	USA	Lead	631	631	8	0.3	0.8	16	1	2.4
Soil<2mm	WELLS15A	USA	Lead	23	23	1	0.18	0.18	na	na	na
Tailings	ACMINESITE2007	USA	Lead	7	6	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Magnesium	41	41	1	6	6	na	na	na
Soil	GOODA01A	USA	Magnesium	37	37	1	0.01	0.01	na	na	na
Soil	Teck_2015_Bossburg	USA	Magnesium	48	48	9	0.06	0.23	23	1.49	2.26
Soil	Trail ERA	Canada	Magnesium	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Magnesium	98	98	na	na	na	na	na	na
Soil	Waneta2005	USA	Magnesium	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Magnesium	173	173	5	0.06	0.22	35	1.85	4.18
Soil<150um	CHURC08A	USA	Magnesium	2	2	1	6	6	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Magnesium	807	807	18	0.04	0.22	108	1.43	4.12

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Soil<150um	Teck_2017_SATES_PIA	USA	Magnesium	16	16	1	0	0	1	5	5
Soil<150um	USEPA_2014_ResSoil	USA	Magnesium	384	384	9	0.05	0.22	77	1.63	4.04
Soil<2mm	HARTC13A	USA	Magnesium	119	119	16	1.3	3.8	4	5	10
Soil<2mm	SMITH13A	USA	Magnesium	118	118	1	0.01	0.01	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Magnesium	173	173	10	0.05	0.24	51	1.78	4.34
Soil<2mm	Teck_2017_SATES_PIA	USA	Magnesium	32	32	1	0	0	1	5	5
Soil<2mm	WELLS15A	USA	Magnesium	23	23	1	0.18	0.18	na	na	na
WasteRock	ACMINESITE2007	USA	Magnesium	3	3	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Manganese	41	41	1	0.7	0.7	na	na	na
Soil	GOODA01A	USA	Manganese	37	37	1	5	5	na	na	na
Soil	NURE Seds	USA	Manganese	1822	1809	2	20	20	na	na	na
Soil	Teck_2015_Bossburg	USA	Manganese	48	48	2	0.02	0.04	7	0.15	0.23
Soil	Trail ERA	Canada	Manganese	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Manganese	98	98	na	na	na	na	na	na
Soil	Waneta2005	USA	Manganese	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Manganese	173	173	2	0.02	0.04	5	0.19	0.39
Soil<150um	CHURC08A	USA	Manganese	2	2	1	0.7	0.7	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Manganese	807	807	5	0.02	0.05	28	0.14	0.42
Soil<150um	Teck_2017_PlantTissue	USA	Manganese	160	160	9	0.039	2	22	0.097	5.1
Soil<150um	Teck_2017_SATES_PIA	USA	Manganese	16	16	1	0.03	0.03	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Manganese	384	384	4	0.02	0.05	15	0.16	0.45
Soil<150um	geochem-fU53	USA	Manganese	13	13	na	na	na	1	4	4
Soil<2mm	HARTC13A	USA	Manganese	119	119	20	0.038	0.11	8	0.09	0.3
Soil<2mm	SMITH13A	USA	Manganese	118	118	1	5	5	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Manganese	173	173	5	0.02	0.31	8	0.18	0.39
Soil<2mm	Teck_2017_SATES_PIA	USA	Manganese	32	32	1	0.03	0.03	1	1	1
Soil<2mm	WELLS15A	USA	Manganese	23	23	1	0.01	0.01	na	na	na
Soil	GOODA01A	USA	Mercury	36	36	1	0.02	0.02	na	na	na
Soil	GOODA02A	USA	Mercury	20	20	1	0.02	0.02	na	na	na
Soil	HARTC13C	USA	Mercury	176	168	na	na	na	na	na	na
Soil	LeRoi2005	USA	Mercury	11	9	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Mercury	48	48	3	0.002	0.004	8	0.017	0.04
Soil	Trail ERA	Canada	Mercury	403	399	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Mercury	98	78	na	na	na	na	na	na
Soil	WADOE_2007b	USA	Mercury	5	2	na	na	na	1	0.05	0.05
Soil	WADOE_2007c	USA	Mercury	15	10	na	na	na	1	0.05	0.05
Soil	Waneta2005	USA	Mercury	28	27	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Mercury	173	173	1	0.002	0.002	1	0.02	0.02

Table F-5
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Material Analyzed	Sample Material	Country	Metal	Number of Samples	Number of Samples with Detected Values	Number of Unique Detection Limits	Minimum Detection Limit Concentration (mg/kg)	Maximum Detection Limit Concentration (mg/kg)	Number of Unique Reporting Limits	Minimum Reporting Limit Concentration (mg/kg)	Maximum Reporting Limit Concentration (mg/kg)
Soil<150um	Teck_2017_PlantTissue	USA	Mercury	49	49	13	0.08	0.49	13	0.0009	0.0054
Soil<150um	geochem-fU53	USA	Mercury	13	7	na	na	na	na	na	na
Soil<2mm	HARTC13A	USA	Mercury	119	119	2	0.0003	0.0004	2	0.007	0.008
Soil<2mm	SMITH13A	USA	Mercury	118	110	1	0.01	0.01	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Mercury	173	173	2	0.002	0.003	1	0.02	0.02
Sediment<150um	CHURC08A	USA	Molybdenum	41	41	1	0.05	0.05	na	na	na
Soil	GOODA01A	USA	Molybdenum	37	37	1	0.05	0.05	na	na	na
Soil	NURE Seds	USA	Molybdenum	436	186	2	2	2	na	na	na
Soil	Trail ERA	Canada	Molybdenum	404	7	na	na	na	na	na	na
Soil	Waneta2005	USA	Molybdenum	28	1	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Molybdenum	173	173	1	0.02	0.02	2	0.05	0.06
Soil<150um	CHURC08A	USA	Molybdenum	2	2	1	0.05	0.05	na	na	na
Soil<150um	geochem-fU53	USA	Molybdenum	13	13	na	na	na	1	2	2
Soil<2mm	SMITH13A	USA	Molybdenum	118	118	1	0.05	0.05	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Molybdenum	173	173	1	0.02	0.02	2	0.05	0.06
Sediment<150um	CHURC08A	USA	Nickel	41	41	1	0.3	0.3	na	na	na
Soil	GOODA01A	USA	Nickel	37	37	1	0.2	0.2	na	na	na
Soil	HARTC13C	USA	Nickel	176	151	na	na	na	na	na	na
Soil	LeRoi2005	USA	Nickel	11	11	na	na	na	na	na	na
Soil	NURE Seds	USA	Nickel	381	370	2	5	5	na	na	na
Soil	Teck_2015_Bossburg	USA	Nickel	48	48	2	0.02	0.03	11	0.18	0.45
Soil	Trail ERA	Canada	Nickel	404	402	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Nickel	98	98	na	na	na	na	na	na
Soil	Waneta2005	USA	Nickel	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Nickel	173	173	1	0.03	0.03	4	0.19	0.22
Soil<150um	CHURC08A	USA	Nickel	2	2	1	0.3	0.3	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Nickel	807	807	3	0.02	0.04	19	0.15	0.24
Soil<150um	Teck_2017_PlantTissue	USA	Nickel	160	160	5	0.01	0.07	13	0.098	0.44
Soil<150um	Teck_2017_SATES_PIA	USA	Nickel	16	16	1	0.09	0.09	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Nickel	384	384	2	0.02	0.03	13	0.16	0.56
Soil<150um	geochem-fU53	USA	Nickel	13	12	na	na	na	1	3	3
Soil<2mm	HARTC13A	USA	Nickel	119	119	20	0.046	0.055	2	0.5	0.6
Soil<2mm	SMITH13A	USA	Nickel	118	118	1	0.5	0.5	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Nickel	173	173	2	0.03	0.04	7	0.18	0.24
Soil<2mm	Teck_2017_SATES_PIA	USA	Nickel	32	32	1	0.09	0.09	1	1	1
Soil<2mm	WELLS15A	USA	Nickel	23	23	1	0.02	0.02	na	na	na
Sediment<150um	CHURC08A	USA	Potassium	41	41	1	20	20	na	na	na
Soil	GOODA01A	USA	Potassium	37	37	1	0.01	0.01	na	na	na

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Material Analyzed	Sample Material	Country	Metal	Number of Samples	Number of Samples with Detected Values	Number of Unique Detection Limits	Minimum Detection Limit Concentration (mg/kg)	Maximum Detection Limit Concentration (mg/kg)	Number of Unique Reporting Limits	Minimum Reporting Limit Concentration (mg/kg)	Maximum Reporting Limit Concentration (mg/kg)
Soil	Teck_2015_Bossburg	USA	Potassium	48	48	15	6.7	10.9	29	29.7	45.3
Soil	Trail ERA	Canada	Potassium	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Potassium	98	98	na	na	na	na	na	na
Soil	Waneta2005	USA	Potassium	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Potassium	173	173	20	8.5	10.5	57	37	83.7
Soil<150um	CHURC08A	USA	Potassium	2	2	1	20	20	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Potassium	807	807	66	6.8	12.1	247	29.3	89.7
Soil<150um	Teck_2017_SATES_PIA	USA	Potassium	16	16	1	0.7	0.7	1	10	10
Soil<150um	USEPA_2014_ResSoil	USA	Potassium	384	384	29	7.5	11.4	118	32.6	89.3
Soil<2mm	HARTC13A	USA	Potassium	119	119	21	16	48	8	50	140
Soil<2mm	SMITH13A	USA	Potassium	118	118	1	0.01	0.01	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Potassium	173	173	28	8.2	11	75	35.6	86.9
Soil<2mm	Teck_2017_SATES_PIA	USA	Potassium	32	32	1	0.7	0.7	1	10	10
Soil<2mm	WELLS15A	USA	Potassium	23	23	1	0.3	0.3	na	na	na
WasteRock	ACMINESITE2007	USA	Potassium	3	2	na	na	na	na	na	na
CrushedOre	ACMINESITE2007	USA	Selenium	1	1	na	na	na	na	na	na
Soil	ACMINESITE2007	USA	Selenium	17	7	na	na	na	na	na	na
Soil	GOODA01A	USA	Selenium	37	34	1	2	2	na	na	na
Soil	HARTC13C	USA	Selenium	176	143	na	na	na	na	na	na
Soil	LeRoi2005	USA	Selenium	11	10	na	na	na	na	na	na
Soil	NURE Seds	USA	Selenium	436	115	2	1	1	na	na	na
Soil	Teck_2015_Bossburg	USA	Selenium	48	48	4	0.05	0.08	7	0.15	0.23
Soil	Trail ERA	Canada	Selenium	404	283	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Selenium	87	17	na	na	na	na	na	na
Soil	Waneta2005	USA	Selenium	28	14	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Selenium	173	173	2	0.07	0.08	4	0.19	0.22
Soil<150um	Teck_2016_ResSoil	USA	Selenium	807	807	8	0.05	0.09	62	0.73	1.21
Soil<150um	Teck_2017_PlantTissue	USA	Selenium	160	160	4	0.03	0.2	11	0.48	2.2
Soil<150um	Teck_2017_SATES_PIA	USA	Selenium	16	16	1	0.7	0.7	1	50	50
Soil<150um	USEPA_2014_ResSoil	USA	Selenium	384	384	3	0.06	0.08	8	0.16	0.23
Soil<150um	geochem-fU53	USA	Selenium	13	3	na	na	na	na	na	na
Soil<2mm	HARTC13A	USA	Selenium	119	10	22	0.092	0.11	3	0.5	2
Soil<2mm	SMITH13A	USA	Selenium	118	9	1	0.2	0.2	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Selenium	173	173	4	0.06	0.09	7	0.18	0.24
Soil<2mm	Teck_2017_SATES_PIA	USA	Selenium	32	27	2	0.6978	0.7	1	50	50
Tailings	ACMINESITE2007	USA	Selenium	7	5	na	na	na	na	na	na
Soil	GOODA01A	USA	Silver	37	37	1	0.01	0.01	na	na	na
Soil	HARTC13C	USA	Silver	176	173	na	na	na	na	na	na

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Material Analyzed	Sample Material	Country	Metal	Number of Samples	Number of Samples with Detected Values	Number of Unique Detection Limits	Minimum Detection Limit Concentration (mg/kg)	Maximum Detection Limit Concentration (mg/kg)	Number of Unique Reporting Limits	Minimum Reporting Limit Concentration (mg/kg)	Maximum Reporting Limit Concentration (mg/kg)
Soil	LeRoi2005	USA	Silver	11	2	na	na	na	na	na	na
Soil	NURE Seds	USA	Silver	380	380	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Silver	48	48	3	0.003	0.005	16	0.015	0.105
Soil	Trail ERA	Canada	Silver	404	275	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Silver	98	88	na	na	na	na	na	na
Soil	Waneta2005	USA	Silver	28	1	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Silver	173	173	1	0.004	0.004	2	0.01	0.02
Soil<150um	Teck_2016_ResSoil	USA	Silver	807	807	5	0.003	0.005	20	0.015	0.024
Soil<150um	Teck_2017_PlantTissue	USA	Silver	160	160	4	0.0019	0.009	13	0.0096	0.044
Soil<150um	Teck_2017_SATES_PIA	USA	Silver	16	0	1	0.2	0.2	1	5	5
Soil<150um	USEPA_2014_ResSoil	USA	Silver	384	384	3	0.003	0.005	8	0.016	0.023
Soil<150um	geochem-fU53	USA	Silver	13	0	na	na	na	1	2	2
Soil<2mm	HARTC13A	USA	Silver	119	77	26	0.0075	0.045	2	0.2	1
Soil<2mm	SMITH13A	USA	Silver	118	0	1	1	1	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Silver	173	173	2	0.004	0.005	2	0.01	0.02
Soil<2mm	Teck_2017_SATES_PIA	USA	Silver	32	0	1	0.2	0.2	1	5	5
Sediment<150um	CHURC08A	USA	Sodium	41	41	1	20	20	na	na	na
Soil	GOODA01A	USA	Sodium	37	37	1	0.01	0.01	na	na	na
Soil	Teck_2015_Bossburg	USA	Sodium	48	48	12	3	5.5	29	29.7	45.3
Soil	Trail ERA	Canada	Sodium	404	396	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Sodium	98	92	na	na	na	na	na	na
Soil	Waneta2005	USA	Sodium	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Sodium	173	163	27	3.8	127	55	37	127
Soil<150um	CHURC08A	USA	Sodium	2	2	1	20	20	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Sodium	807	807	46	3	6	152	28.6	48.3
Soil<150um	Teck_2017_SATES_PIA	USA	Sodium	16	16	1	0.07	0.07	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Sodium	384	383	25	3.4	145	108	32.6	145
Soil<2mm	HARTC13A	USA	Sodium	119	95	14	1	2.9	8	50	140
Soil<2mm	SMITH13A	USA	Sodium	118	118	1	0.01	0.01	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Sodium	173	158	39	3.6	125	73	35.6	125
Soil<2mm	Teck_2017_SATES_PIA	USA	Sodium	32	32	1	0.07	0.07	1	1	1
Soil<2mm	WELLS15A	USA	Sodium	23	23	1	0.13	0.13	na	na	na
WasteRock	ACMINESITE2007	USA	Sodium	3	2	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Thallium	41	41	1	0.08	0.08	na	na	na
Soil	GOODA01A	USA	Thallium	37	37	1	0.02	0.02	na	na	na
Soil	HARTC13C	USA	Thallium	176	80	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Thallium	48	48	2	0.001	0.002	7	0.015	0.023
Soil	Trail ERA	Canada	Thallium	350	297	na	na	na	na	na	na

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Soil	USEPA2001Mines/Mills	USA	Thallium	98	20	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Thallium	173	173	1	0.002	0.002	2	0.01	0.02
Soil<150um	CHURC08A	USA	Thallium	2	2	1	0.08	0.08	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Thallium	807	807	2	0.001	0.002	20	0.015	0.024
Soil<150um	Teck_2017_PlantTissue	USA	Thallium	160	144	19	0.001	0.123	30	0.0096	0.123
Soil<150um	Teck_2017_SATES_PIA	USA	Thallium	16	16	1	0.26	0.26	1	5	5
Soil<150um	USEPA_2014_ResSoil	USA	Thallium	384	384	1	0.002	0.002	8	0.016	0.023
Soil<2mm	HARTC13A	USA	Thallium	119	92	14	0.0028	0.0034	1	0.2	0.2
Soil<2mm	SMITH13A	USA	Thallium	118	118	1	0.1	0.1	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Thallium	173	173	1	0.002	0.002	2	0.01	0.02
Soil<2mm	Teck_2017_SATES_PIA	USA	Thallium	32	32	1	0.26	0.26	1	5	5
Sediment<150um	CHURC08A	USA	Vanadium	41	41	1	0.2	0.2	na	na	na
Soil	GOODA01A	USA	Vanadium	37	37	1	1	1	na	na	na
Soil	NURE Seds	USA	Vanadium	1813	1782	2	10	10	na	na	na
Soil	Teck_2015_Bossburg	USA	Vanadium	48	48	1	0.02	0.02	7	0.15	0.23
Soil	Trail ERA	Canada	Vanadium	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Vanadium	98	98	na	na	na	na	na	na
Soil	Waneta2005	USA	Vanadium	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Vanadium	173	173	1	0.02	0.02	4	0.19	0.22
Soil<150um	CHURC08A	USA	Vanadium	2	2	1	0.2	0.2	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Vanadium	807	807	1	0.02	0.02	19	0.15	0.24
Soil<150um	Teck_2017_PlantTissue	USA	Vanadium	160	160	2	0.01	0.04	13	0.096	0.44
Soil<150um	Teck_2017_SATES_PIA	USA	Vanadium	16	16	1	0.03	0.03	1	5	5
Soil<150um	USEPA_2014_ResSoil	USA	Vanadium	384	384	1	0.02	0.02	8	0.16	0.23
Soil<150um	geochem-fU53	USA	Vanadium	13	13	na	na	na	1	2	2
Soil<2mm	HARTC13A	USA	Vanadium	119	119	15	0.016	0.088	4	0.2	1
Soil<2mm	SMITH13A	USA	Vanadium	118	118	1	1	1	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Vanadium	173	173	1	0.02	0.02	7	0.18	0.24
Soil<2mm	Teck_2017_SATES_PIA	USA	Vanadium	32	32	1	0.03	0.03	1	5	5
CrushedOre	ACMINESITE2007	USA	Zinc	1	1	na	na	na	na	na	na
Sediment<150um	CHURC08A	USA	Zinc	41	41	1	3	3	na	na	na
Soil	ACMINESITE2007	USA	Zinc	17	17	na	na	na	na	na	na
Soil	GOODA01A	USA	Zinc	37	37	1	2	2	na	na	na
Soil	GOODA02A	USA	Zinc	20	20	1	2	2	na	na	na
Soil	HARTC13C	USA	Zinc	182	174	na	na	na	na	na	na
Soil	LeRoi2005	USA	Zinc	11	11	na	na	na	na	na	na
Soil	NURE Seds	USA	Zinc	381	381	na	na	na	na	na	na
Soil	Teck_2015_Bossburg	USA	Zinc	48	48	2	0.1	0.2	4	0.5	1.1

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Material Analyzed	Sample Material	Country	Metal	Number of Samples	Number of Samples with Detected Values	Number of Unique Detection Limits	Minimum Detection Limit Concentration (mg/kg)	Maximum Detection Limit Concentration (mg/kg)	Number of Unique Reporting Limits	Minimum Reporting Limit Concentration (mg/kg)	Maximum Reporting Limit Concentration (mg/kg)
Soil	Trail ERA	Canada	Zinc	404	404	na	na	na	na	na	na
Soil	USEPA2001Mines/Mills	USA	Zinc	98	98	na	na	na	na	na	na
Soil	WADOE_2007b	USA	Zinc	5	5	na	na	na	5	0.592	0.741
Soil	WADOE_2007c	USA	Zinc	15	15	na	na	na	14	0.526	3.42
Soil	Waneta2005	USA	Zinc	28	28	na	na	na	na	na	na
Soil<149um	Teck_2014_UplandSoil	USA	Zinc	173	173	2	0.2	1.9	3	0.5	4.9
Soil<150um	CHURC08A	USA	Zinc	2	2	1	3	3	na	na	na
Soil<150um	Teck_2016_ResSoil	USA	Zinc	807	807	2	0.1	0.2	11	0.4	1.1
Soil<150um	Teck_2017_PlantTissue	USA	Zinc	160	160	8	0.39	11	18	0.97	27
Soil<150um	Teck_2017_SATES_PIA	USA	Zinc	16	16	1	0.03	0.03	1	1	1
Soil<150um	USEPA_2014_ResSoil	USA	Zinc	384	384	3	0.2	2	6	0.4	5
Soil<150um	geochem-fU53	USA	Zinc	13	13	na	na	na	1	2	2
Soil<2mm	HARTC13A	USA	Zinc	119	119	17	0.32	6.5	6	4	80
Soil<2mm	SMITH13A	USA	Zinc	118	118	1	1	1	na	na	na
Soil<2mm	Teck_2014_UplandSoil	USA	Zinc	173	173	2	0.2	2	4	0.4	4.9
Soil<2mm	Teck_2017_SATES_PIA	USA	Zinc	32	32	1	0.03	0.03	1	1	1
Soil<2mm	WELLS15A	USA	Zinc	23	23	1	0.02	0.02	na	na	na
Tailings	ACMINESITE2007	USA	Zinc	7	7	na	na	na	na	na	na

Notes:
Several basic data management steps, consistent with the RI/FS Data Management Plan (TAI 2019a), were applied to produce the Upland RI data set. Analytical results for field duplicate and replicate samples were averaged, nondetected values were substituted with the value in the measurement value field in the database, and estimated ("J" qualified) values were used at their reported value (TAI 2019a).

um - micrometer
mg/kg - milligram per kilogram
mm - millimeter
na - not available

Table F-6
Summary Statistics for Data Used in the Exploratory Data Analysis
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Analyte	Number of Samples	Percent of Samples with Detected Values	Minimum Concentration (mg/kg)	Mean Concentration (mg/kg)	Standard Deviation	Median Concentration (mg/kg)	Maximum Concentration (mg/kg)
Arsenic	4490	98	0.5	15.3	17.7	10.6	334
Barium	3060	100	1.4	561	5330	200	122000
Cadmium	3220	98	0.01	7.75	38.1	2.7	1090
Copper	3540	99	0.78	37.9	269	20.4	14700
Lead	4520	97	2	564	5460	108	181000
Manganese	4500	100	6	706	511	630	14800
Mercury	1480	96	-0.001	0.174	0.916	0.061	26.4
Selenium	3250	75	0.08	0.658	1.36	0.36	35
Zinc	3320	100	7	1170	10900	162	431000

Notes:
The 2001 Trail Area Soil Background Assessment (GOODA01A) reported one sample with a negative soil mercury concentration of -0.001 mg/kg.
mg/kg - milligram per kilogram

Table F-7a
Spearman's Rank Correlation Coefficients for Pairwise Complete Observations Between Metals (nondetects included)
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	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
Aluminum	1	-0.539	-0.348	0.673	0.309	-0.411	0.569	0.482	0.579	0.314	0.81	-0.471
Antimony	-0.539	1	0.462	-0.556	0.149	0.359	-0.684	-0.368	-0.681	-0.139	-0.546	0.455
Arsenic	-0.348	0.462	1	-0.134	-0.339	0.787	-0.225	-0.188	-0.156	0.386	-0.275	0.804
Barium	0.673	-0.556	-0.134	1	0.0345	-0.0508	0.739	0.35	0.682	0.393	0.617	-0.134
Beryllium	0.309	0.149	-0.339	0.0345	1	-0.55	-0.0885	0.149	-0.127	-0.147	0.224	-0.455
Cadmium	-0.411	0.359	0.787	-0.0508	-0.55	1	-0.0937	-0.24	-0.117	0.341	-0.346	0.842
Calcium	0.569	-0.684	-0.225	0.739	-0.0885	-0.0937	1	0.456	0.795	0.452	0.657	-0.165
Chromium	0.482	-0.368	-0.188	0.35	0.149	-0.24	0.456	1	0.56	0.329	0.681	-0.262
Cobalt	0.579	-0.681	-0.156	0.682	-0.127	-0.117	0.795	0.56	1	0.435	0.661	-0.187
Copper	0.314	-0.139	0.386	0.393	-0.147	0.341	0.452	0.329	0.435	1	0.473	0.322
Iron	0.81	-0.546	-0.275	0.617	0.224	-0.346	0.657	0.681	0.661	0.473	1	-0.393
Lead	-0.471	0.455	0.804	-0.134	-0.455	0.842	-0.165	-0.262	-0.187	0.322	-0.393	1
Magnesium	0.652	-0.503	-0.165	0.626	0.105	-0.183	0.772	0.662	0.739	0.512	0.795	-0.204
Manganese	0.524	-0.379	0.0508	0.682	-0.11	0.141	0.559	0.287	0.577	0.324	0.515	0.013
Mercury	-0.308	0.456	0.676	-0.17	-0.298	0.661	-0.216	-0.152	-0.221	0.273	-0.298	0.747
Molybdenum	-0.221	0.627	0.0852	-0.374	0.434	-0.0202	-0.604	-0.241	-0.555	-0.155	-0.225	-0.0625
Nickel	0.465	-0.34	0.0542	0.583	-0.163	0.137	0.507	0.484	0.588	0.452	0.594	-0.033
Potassium	0.55	-0.622	-0.117	0.735	-0.0671	-0.0565	0.839	0.52	0.744	0.558	0.681	-0.0838
Selenium	-0.134	0.285	0.5	-0.0186	-0.134	0.551	-0.0805	-0.00582	-0.115	0.434	-0.0567	0.435
Silver	0.323	-0.195	0.138	0.465	0.184	0.0957	0.454	0.2	0.345	0.598	0.348	0.137
Sodium	0.799	-0.583	-0.341	0.628	0.168	-0.349	0.687	0.489	0.585	0.345	0.753	-0.393
Thallium	0.144	-0.0348	0.45	0.408	-0.00282	0.377	0.355	0.119	0.309	0.572	0.17	0.477
Vanadium	0.764	-0.573	-0.308	0.596	0.162	-0.33	0.684	0.639	0.689	0.456	0.868	-0.401
Zinc	-0.106	0.0844	0.683	0.254	-0.558	0.84	0.207	-0.0859	0.168	0.567	-0.0316	0.748

Table F-7a
Spearman's Rank Correlation Coefficients for Pairwise Complete Observations Between Metals (nondetects included)
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	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
Aluminum	0.652	0.524	-0.308	-0.221	0.465	0.55	-0.134	0.323	0.799	0.144	0.764	-0.106
Antimony	-0.503	-0.379	0.456	0.627	-0.34	-0.622	0.285	-0.195	-0.583	-0.0348	-0.573	0.0844
Arsenic	-0.165	0.0508	0.676	0.0852	0.0542	-0.117	0.5	0.138	-0.341	0.45	-0.308	0.683
Barium	0.626	0.682	-0.17	-0.374	0.583	0.735	-0.0186	0.465	0.628	0.408	0.596	0.254
Beryllium	0.105	-0.11	-0.298	0.434	-0.163	-0.0671	-0.134	0.184	0.168	-0.00282	0.162	-0.558
Cadmium	-0.183	0.141	0.661	-0.0202	0.137	-0.0565	0.551	0.0957	-0.349	0.377	-0.33	0.84
Calcium	0.772	0.559	-0.216	-0.604	0.507	0.839	-0.0805	0.454	0.687	0.355	0.684	0.207
Chromium	0.662	0.287	-0.152	-0.241	0.484	0.52	-0.00582	0.2	0.489	0.119	0.639	-0.0859
Cobalt	0.739	0.577	-0.221	-0.555	0.588	0.744	-0.115	0.345	0.585	0.309	0.689	0.168
Copper	0.512	0.324	0.273	-0.155	0.452	0.558	0.434	0.598	0.345	0.572	0.456	0.567
Iron	0.795	0.515	-0.298	-0.225	0.594	0.681	-0.0567	0.348	0.753	0.17	0.868	-0.0316
Lead	-0.204	0.013	0.747	-0.0625	-0.033	-0.0838	0.435	0.137	-0.393	0.477	-0.401	0.748
Magnesium	1	0.459	-0.245	-0.411	0.598	0.826	-0.134	0.37	0.692	0.36	0.809	0.13
Manganese	0.459	1	0.0492	-0.3	0.517	0.456	0.0419	0.168	0.393	0.211	0.394	0.336
Mercury	-0.245	0.0492	1	0.115	-0.0424	-0.236	0.549	0.124	-0.349	0.308	-0.334	0.557
Molybdenum	-0.411	-0.3	0.115	1	-0.126	-0.571	0.306	-0.16	-0.332	-0.283	-0.261	-0.188
Nickel	0.598	0.517	-0.0424	-0.126	1	0.483	0.158	0.147	0.452	0.159	0.525	0.361
Potassium	0.826	0.456	-0.236	-0.571	0.483	1	-0.0946	0.508	0.679	0.513	0.715	0.256
Selenium	-0.134	0.0419	0.549	0.306	0.158	-0.0946	1	0.322	-0.145	0.275	-0.0781	0.467
Silver	0.37	0.168	0.124	-0.16	0.147	0.508	0.322	1	0.396	0.673	0.415	0.301
Sodium	0.692	0.393	-0.349	-0.332	0.452	0.679	-0.145	0.396	1	0.207	0.791	-0.0379
Thallium	0.36	0.211	0.308	-0.283	0.159	0.513	0.275	0.673	0.207	1	0.228	0.504
Vanadium	0.809	0.394	-0.334	-0.261	0.525	0.715	-0.0781	0.415	0.791	0.228	1	-0.0121
Zinc	0.13	0.336	0.557	-0.188	0.361	0.256	0.467	0.301	-0.0379	0.504	-0.0121	1

Table F-7b
Spearman's Rank Correlation Coefficients for Pairwise Complete Observations Between Metals (nondetects removed)
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	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead
Aluminum	1	0.0286	0.166	0.688	0.77	-0.0801	0.176	0.405	0.607	0.284	0.657	-0.118
Antimony	0.0286	1	0.806	0.115	0.0967	0.792	-0.158	-0.00778	-0.0508	0.558	-0.0842	0.809
Arsenic	0.166	0.806	1	0.0446	-0.0547	0.765	-0.082	-0.117	-0.0328	0.622	0.131	0.82
Barium	0.688	0.115	0.0446	1	0.529	0.143	0.347	0.416	0.592	0.262	0.493	-0.0559
Beryllium	0.77	0.0967	-0.0547	0.529	1	-0.0429	0.135	0.541	0.633	0.0488	0.593	-0.257
Cadmium	-0.0801	0.792	0.765	0.143	-0.0429	1	0.101	-0.0493	-0.0143	0.593	-0.0705	0.897
Calcium	0.176	-0.158	-0.082	0.347	0.135	0.101	1	0.266	0.443	0.411	0.36	0.00476
Chromium	0.405	-0.00778	-0.117	0.416	0.541	-0.0493	0.266	1	0.68	0.174	0.674	-0.202
Cobalt	0.607	-0.0508	-0.0328	0.592	0.633	-0.0143	0.443	0.68	1	0.287	0.769	-0.217
Copper	0.284	0.558	0.622	0.262	0.0488	0.593	0.411	0.174	0.287	1	0.36	0.568
Iron	0.657	-0.0842	0.131	0.493	0.593	-0.0705	0.36	0.674	0.769	0.36	1	-0.107
Lead	-0.118	0.809	0.82	-0.0559	-0.257	0.897	0.00476	-0.202	-0.217	0.568	-0.107	1
Magnesium	0.321	-0.171	-0.014	0.378	0.268	0.00803	0.682	0.553	0.655	0.429	0.634	-0.0465
Manganese	0.667	0.214	0.196	0.68	0.548	0.226	0.213	0.342	0.577	0.214	0.566	0.0689
Mercury	-0.316	0.63	0.596	-0.194	-0.281	0.725	0.0579	-0.121	-0.285	0.42	-0.179	0.807
Molybdenum	0.155	-0.0505	-0.305	0.171	0.269	0.133	0.0777	0.336	0.223	-0.0493	0.204	-0.277
Nickel	0.455	0.0343	0.317	0.411	0.148	0.0549	0.367	0.462	0.547	0.456	0.675	0.068
Potassium	0.37	-0.313	-0.153	0.423	0.288	-0.191	0.5	0.531	0.605	0.269	0.504	-0.24
Selenium	0.261	0.517	0.336	0.358	0.415	0.51	0.26	0.198	0.281	0.507	0.211	0.267
Silver	0.176	0.712	0.556	0.235	0.21	0.743	0.177	0.054	0.156	0.614	0.153	0.585
Sodium	0.469	-0.235	-0.157	0.345	0.274	-0.13	0.595	0.268	0.398	0.282	0.486	-0.201
Thallium	0.262	0.672	0.675	0.363	0.358	0.68	0.113	0.114	0.211	0.574	0.204	0.675
Vanadium	0.582	-0.0184	-0.238	0.507	0.657	-0.0849	0.314	0.765	0.748	0.144	0.762	-0.342
Zinc	0.0405	0.735	0.735	0.0887	-0.291	0.9	0.246	-0.209	-0.0734	0.641	0.072	0.847

Table F-7b
Spearman's Rank Correlation Coefficients for Pairwise Complete Observations Between Metals (nondetects removed)
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	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
Aluminum	0.321	0.667	-0.316	0.155	0.455	0.37	0.261	0.176	0.469	0.262	0.582	0.0405
Antimony	-0.171	0.214	0.63	-0.0505	0.0343	-0.313	0.517	0.712	-0.235	0.672	-0.0184	0.735
Arsenic	-0.014	0.196	0.596	-0.305	0.317	-0.153	0.336	0.556	-0.157	0.675	-0.238	0.735
Barium	0.378	0.68	-0.194	0.171	0.411	0.423	0.358	0.235	0.345	0.363	0.507	0.0887
Beryllium	0.268	0.548	-0.281	0.269	0.148	0.288	0.415	0.21	0.274	0.358	0.657	-0.291
Cadmium	0.00803	0.226	0.725	0.133	0.0549	-0.191	0.51	0.743	-0.13	0.68	-0.0849	0.9
Calcium	0.682	0.213	0.0579	0.0777	0.367	0.5	0.26	0.177	0.595	0.113	0.314	0.246
Chromium	0.553	0.342	-0.121	0.336	0.462	0.531	0.198	0.054	0.268	0.114	0.765	-0.209
Cobalt	0.655	0.577	-0.285	0.223	0.547	0.605	0.281	0.156	0.398	0.211	0.748	-0.0734
Copper	0.429	0.214	0.42	-0.0493	0.456	0.269	0.507	0.614	0.282	0.574	0.144	0.641
Iron	0.634	0.566	-0.179	0.204	0.675	0.504	0.211	0.153	0.486	0.204	0.762	0.072
Lead	-0.0465	0.0689	0.807	-0.277	0.068	-0.24	0.267	0.585	-0.201	0.675	-0.342	0.847
Magnesium	1	0.285	-0.00503	-0.0148	0.576	0.582	0.12	0.175	0.521	0.202	0.557	0.186
Manganese	0.285	1	-0.0391	0.0545	0.361	0.264	0.281	0.246	0.212	0.4	0.485	0.16
Mercury	-0.00503	-0.0391	1	-0.036	-0.0435	-0.266	0.293	0.718	-0.15	0.396	-0.31	0.669
Molybdenum	-0.0148	0.0545	-0.036	1	0.0103	-0.0546	0.641	0.314	0.0856	-0.0774	0.445	-0.262
Nickel	0.576	0.361	-0.0435	0.0103	1	0.477	0.11	0.174	0.27	0.0901	0.315	0.26
Potassium	0.582	0.264	-0.266	-0.0546	0.477	1	-0.0293	-0.131	0.448	0.0948	0.538	-0.0564
Selenium	0.12	0.281	0.293	0.641	0.11	-0.0293	1	0.583	0.227	0.549	0.339	0.369
Silver	0.175	0.246	0.718	0.314	0.174	-0.131	0.583	1	0.126	0.707	0.11	0.544
Sodium	0.521	0.212	-0.15	0.0856	0.27	0.448	0.227	0.126	1	0.0848	0.418	0.0234
Thallium	0.202	0.4	0.396	-0.0774	0.0901	0.0948	0.549	0.707	0.0848	1	0.241	0.669
Vanadium	0.557	0.485	-0.31	0.445	0.315	0.538	0.339	0.11	0.418	0.241	1	-0.253
Zinc	0.186	0.16	0.669	-0.262	0.26	-0.0564	0.369	0.544	0.0234	0.669	-0.253	1

Table F-8
Summary Statistics for Data Used in the Generalized Additive Model
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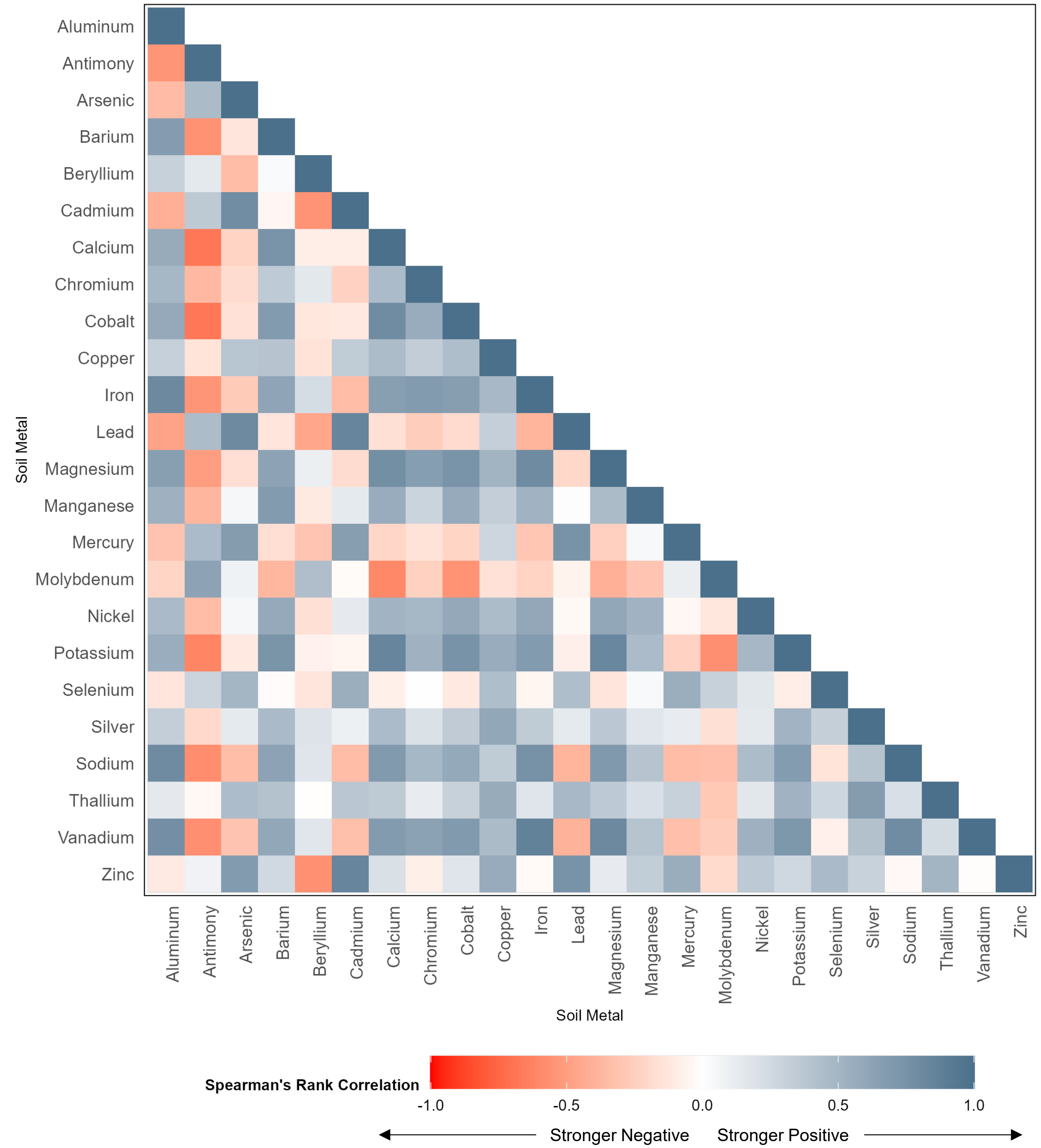
Analyte	Number of Samples	Percent of Samples with Detected Values	Minimum Concentration (mg/kg)	Mean Concentration (mg/kg)	Standard Deviation	Median Concentration (mg/kg)	Maximum Concentration (mg/kg)
Arsenic	2133	99	1.2	15.2	15.4	11.4	334
Barium	1890	100	14	207	175	178	4690
Cadmium	2132	99	0.2	4.18	4.5	2.78	59.3
Copper	2132	100	2	31.1	44	21.3	1400
Lead	2133	100	2	218	318	115	5700
Manganese	1890	100	6	595	389	506	5920
Mercury	709	99	0.001	0.106	0.182	0.069	2.44
Selenium	1901	88	0.08	0.42	0.578	0.3	13.5
Zinc	1901	100	14	231	193	175	1960

Note:
mg/kg - milligram per kilogram

FIGURES



Correlation
Darker Squares = Stronger Correlation
Blue = Positive Correlation
Red = Negative Correlation

Figure F-1a. Spearman's Rank Correlation Coefficients of Soil Metals Concentrations for Detected and Nondetected Concentrations
Final Upland RI Report
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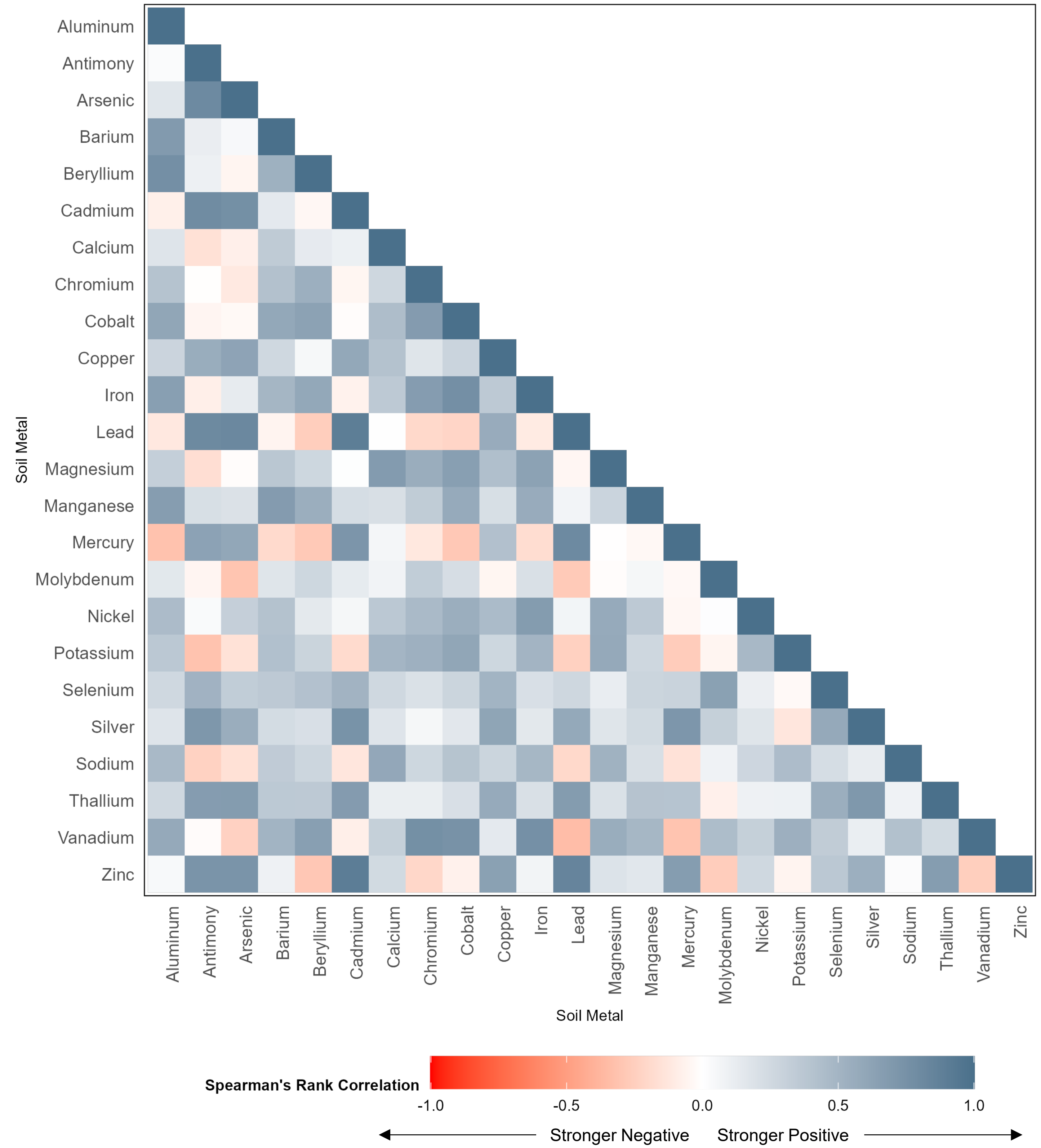


<u>Correlation</u>
Darker Squares = Stronger Correlation
Blue = Positive Correlation
Red = Negative Correlation

Figure F-1b. Spearman's Rank Correlation Coefficients of Soil Metals Concentrations for Detected Concentrations Only

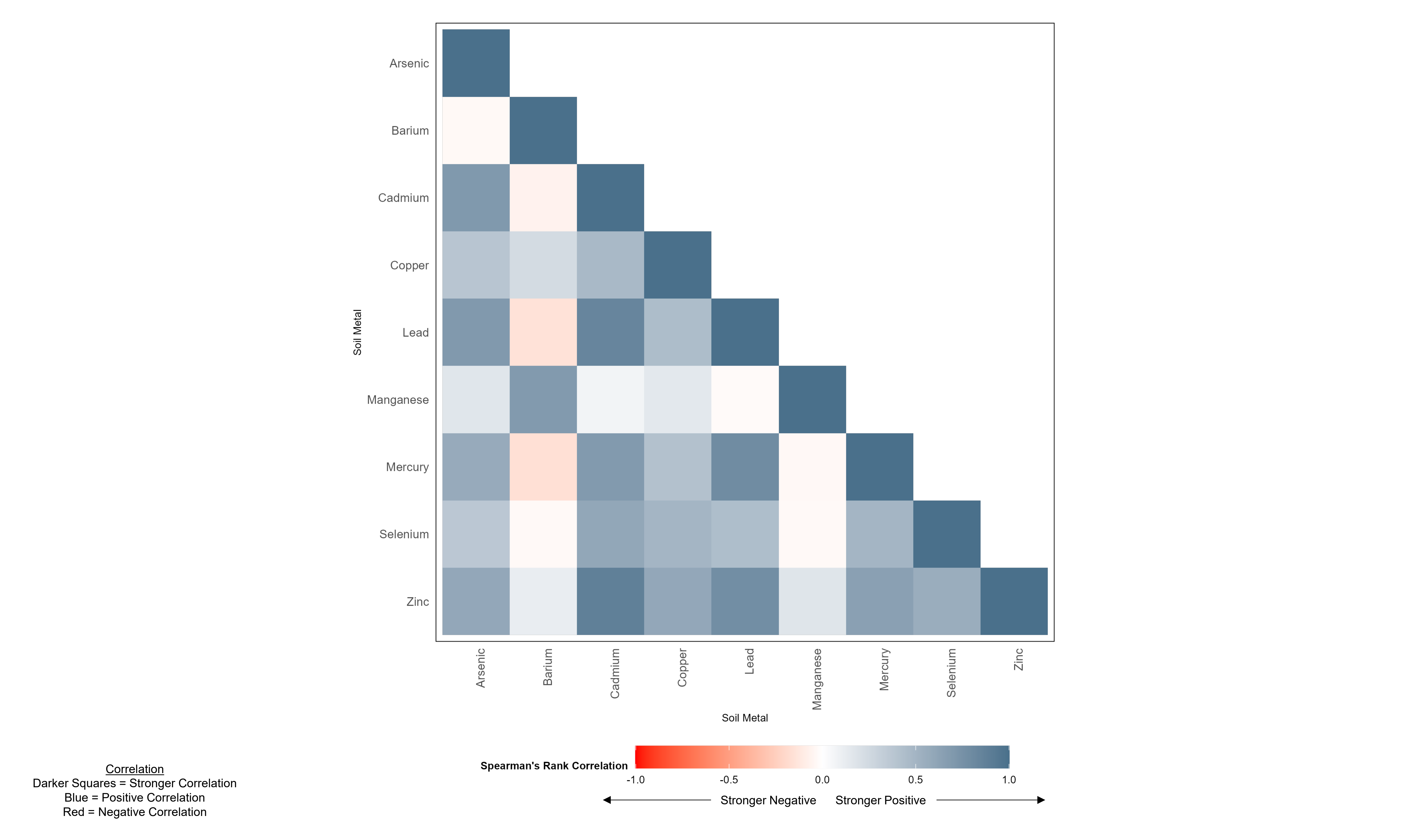
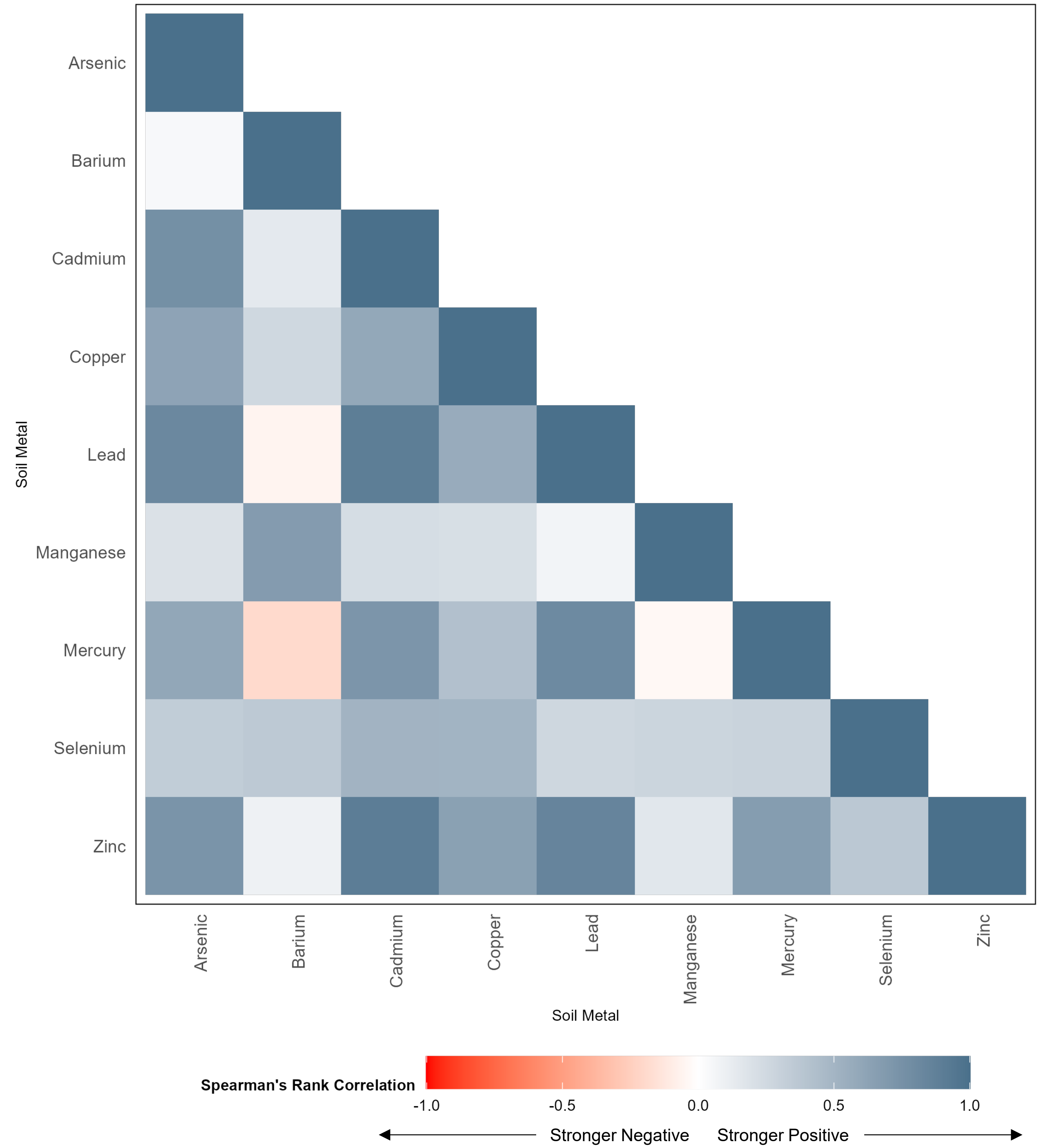


Figure F-1c. Spearman's Rank Correlation Coefficients of COC Soil Metals Concentrations for Detected and Nondetected Concentrations
Final Upland RI Report
Upper Columbia River, Washington



Correlation
Darker Squares = Stronger Correlation
Blue = Positive Correlation
Red = Negative Correlation

Figure F-1d. Spearman's Rank Correlation Coefficients of COC Soil Metals Concentrations for Detected Concentrations Only

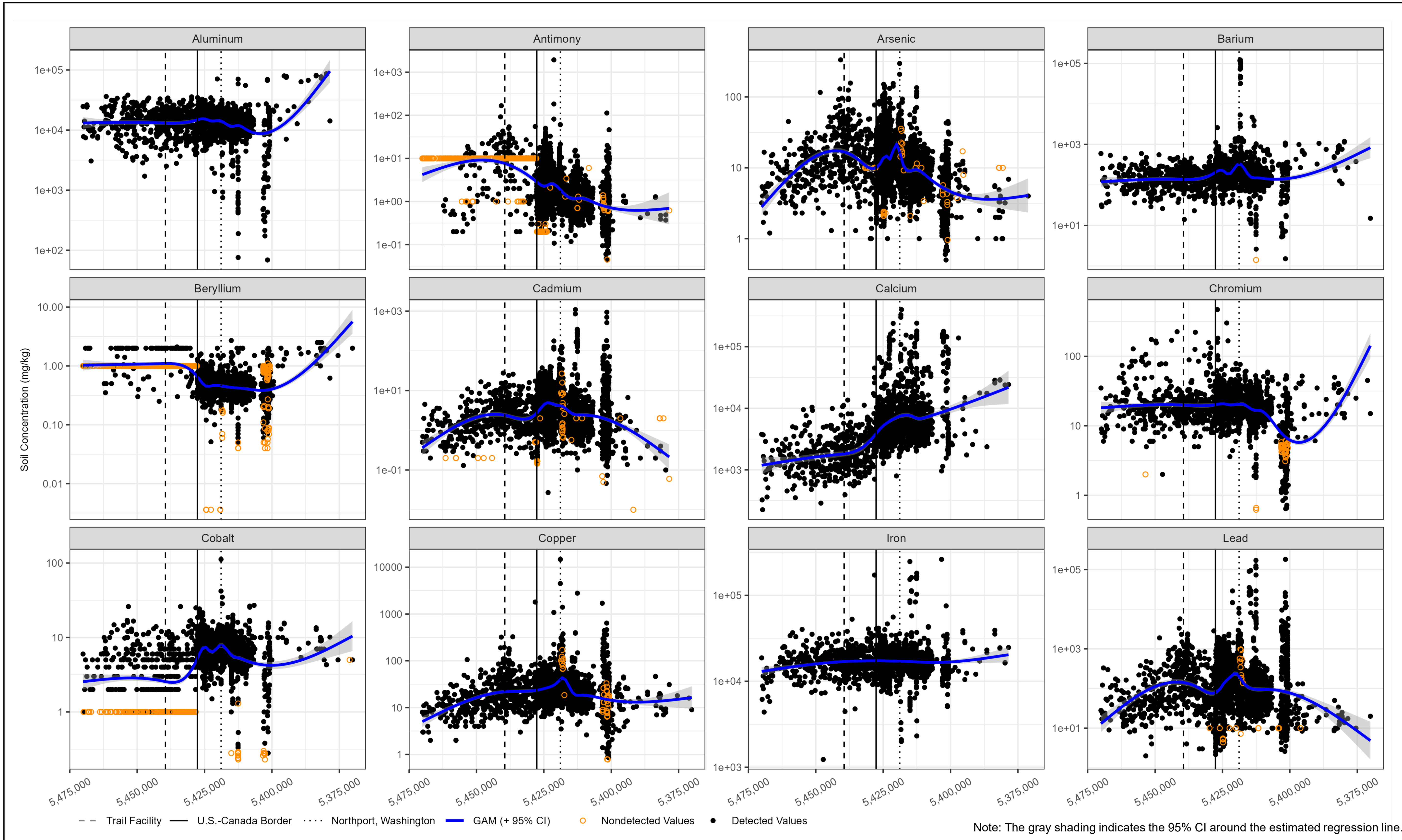


Figure F-2. Soil Metals Concentrations versus Distance from the Trail Facility
Final Upland RI Report
Upper Columbia River, Washington

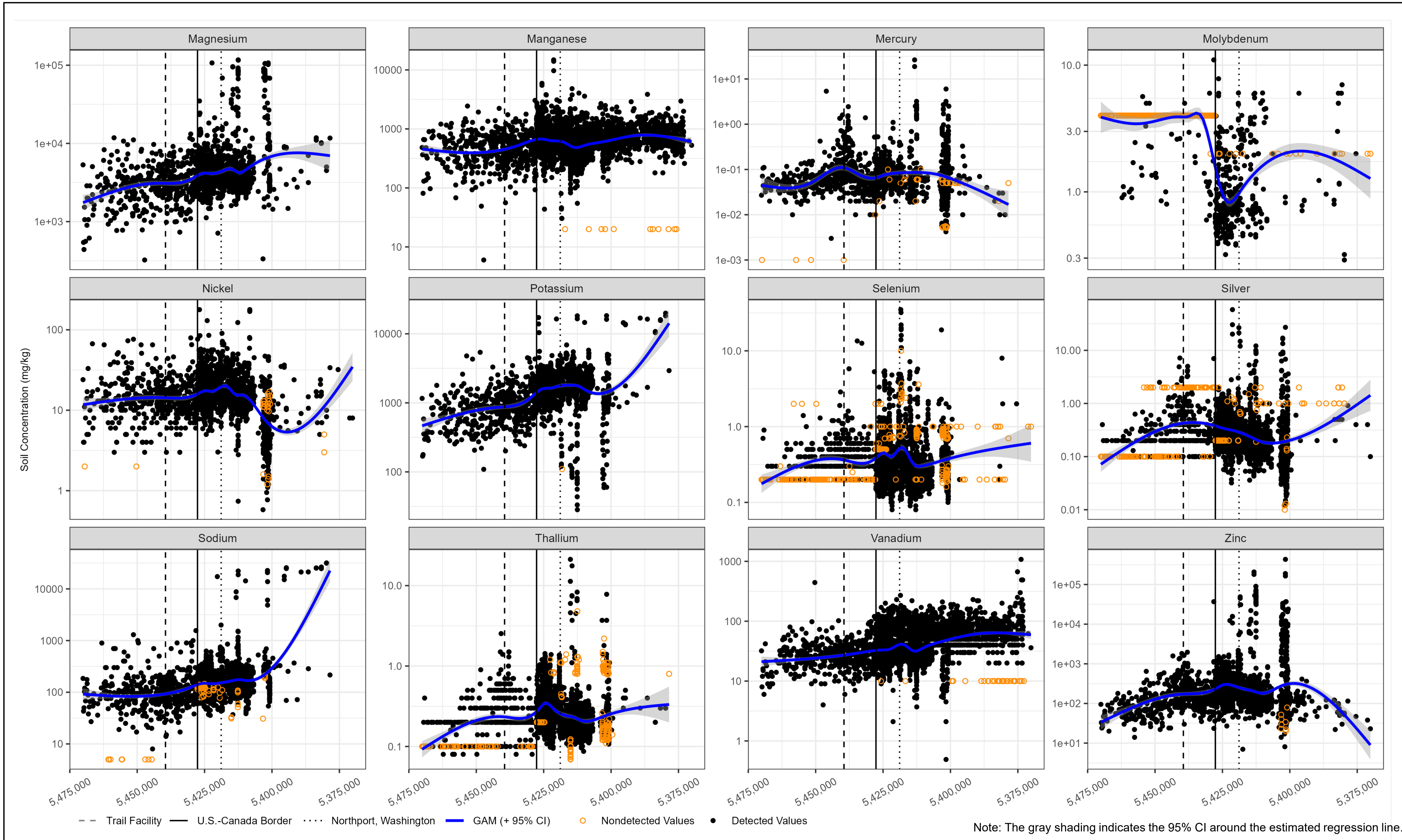


Figure F-2. (continued) Soil Metals Concentrations versus Distance from the Trail Facility
Final Upland RI Report
Upper Columbia River, Washington

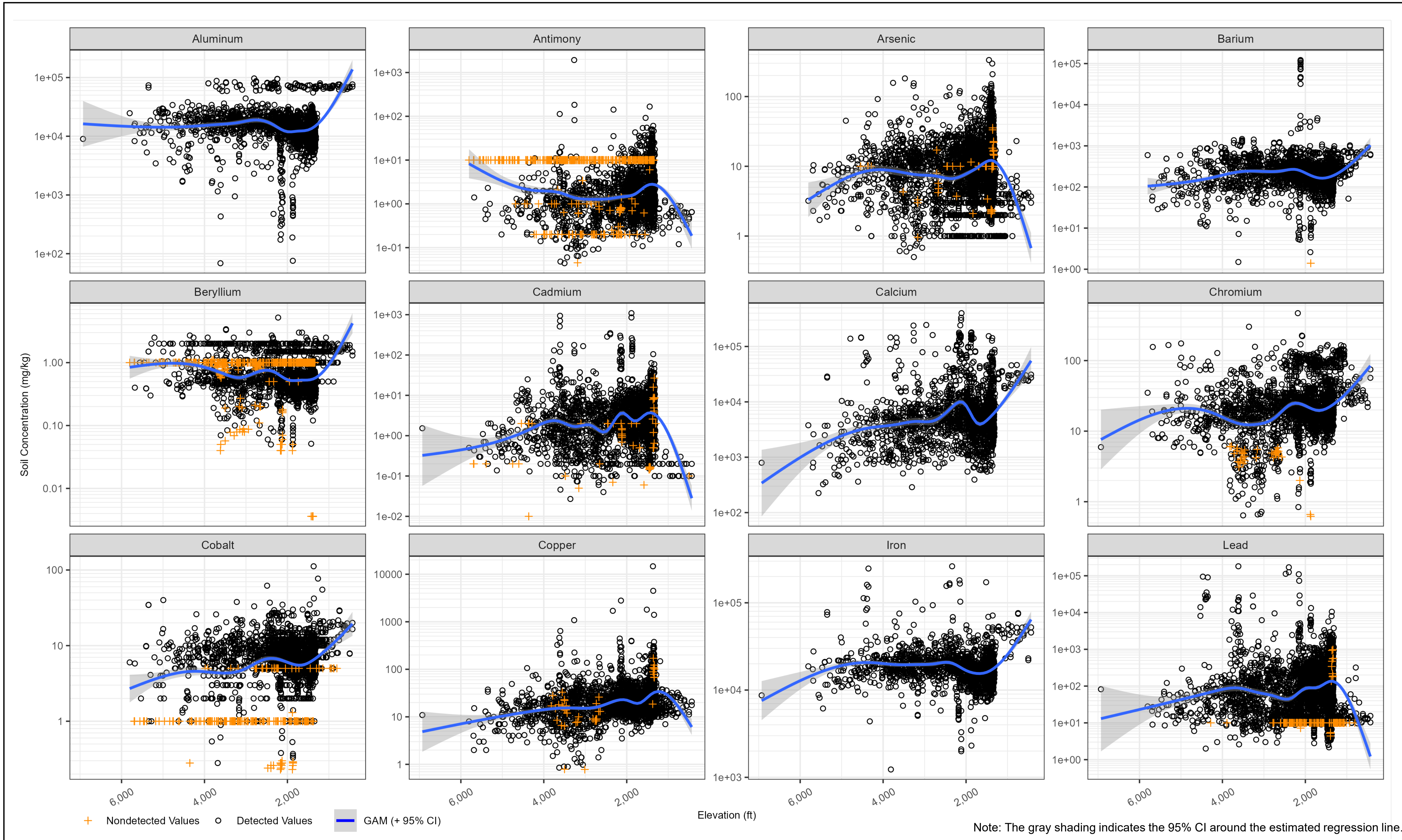


Figure F-3. Soil Metals Concentrations versus Elevation
Final Upland RI Report
Upper Columbia River, Washington

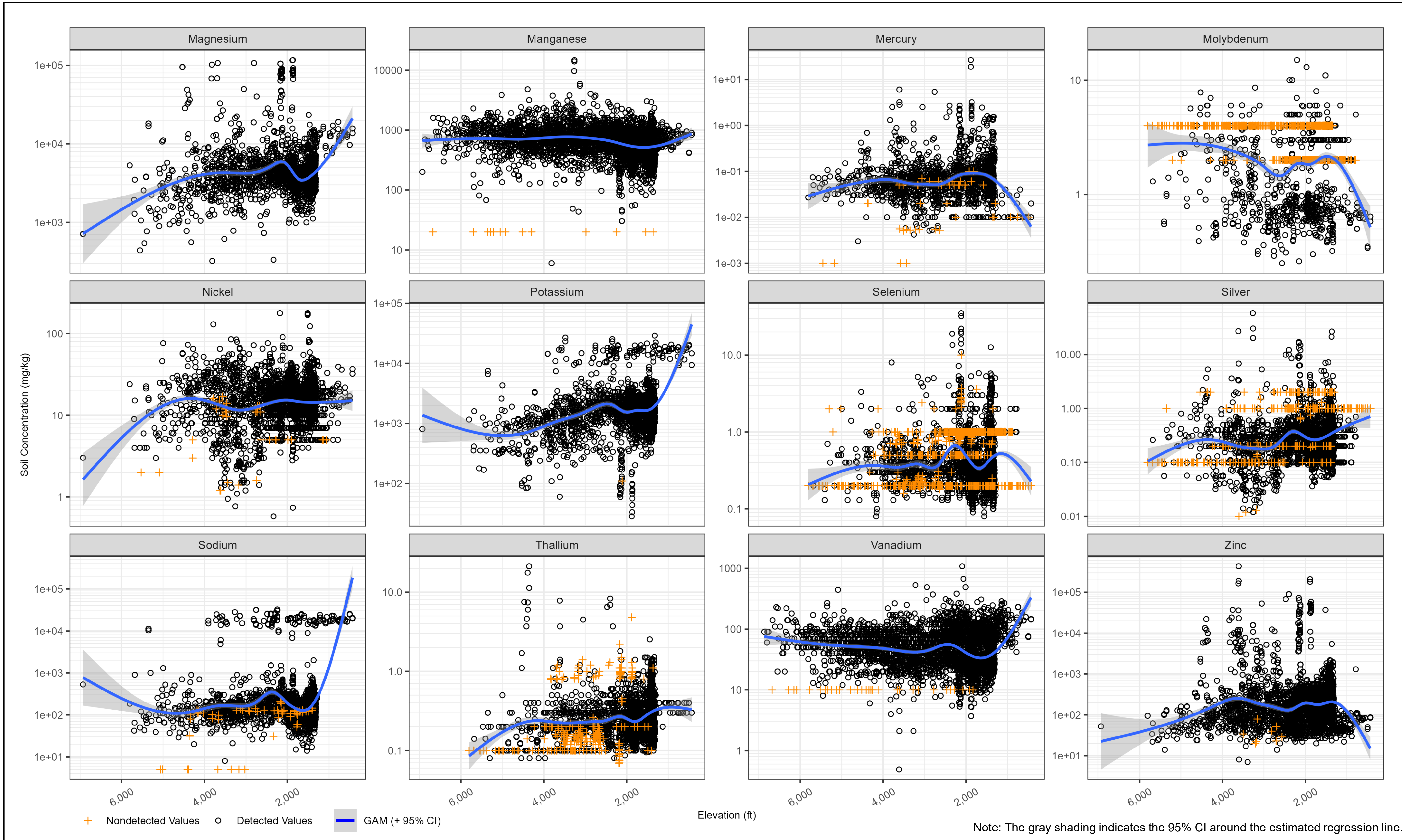


Figure F-3. (continued) Soil Metals Concentrations versus Elevation
Final Upland RI Report
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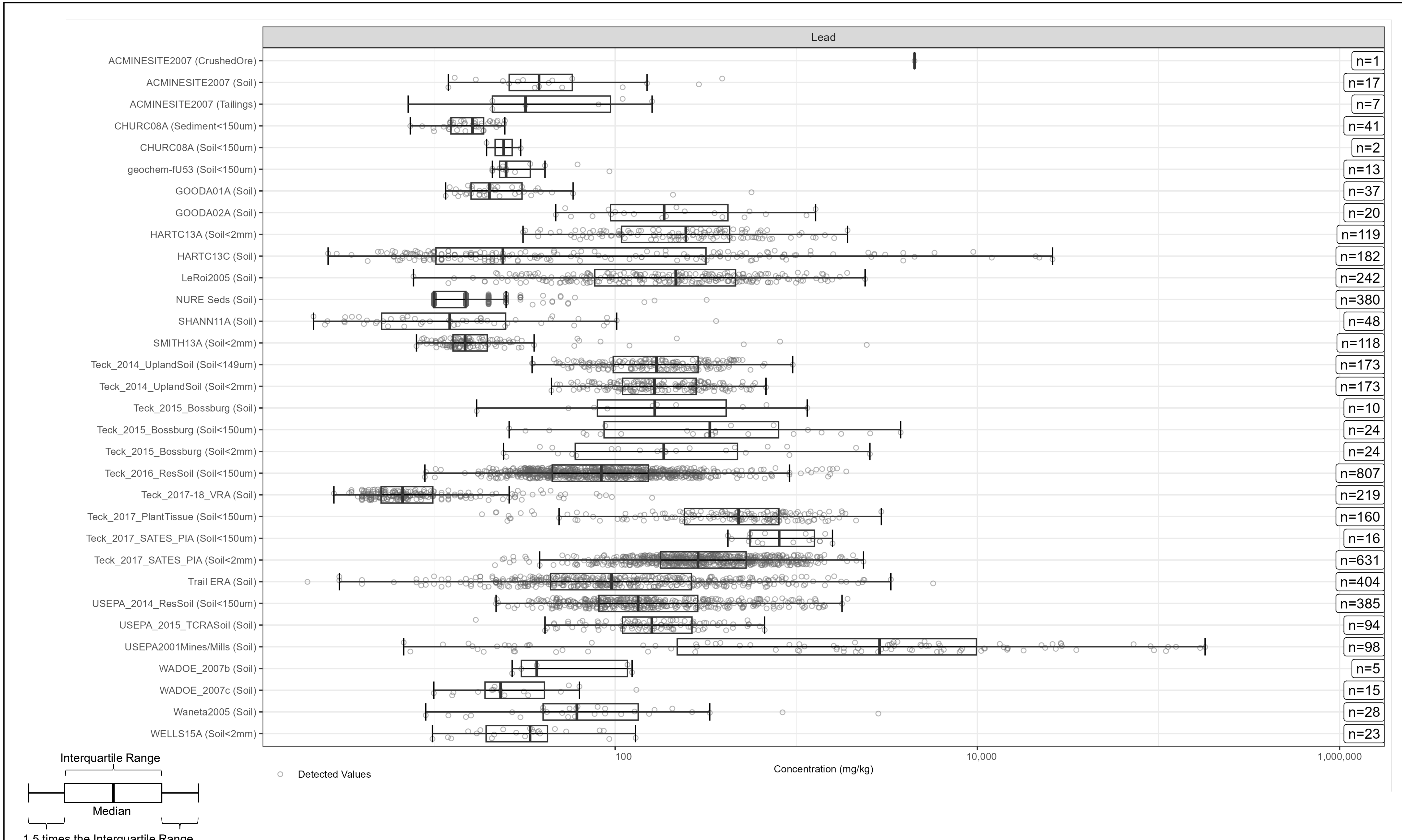

Figure F-4. Boxplots of Lead Concentrations by Study
Final Upland RI Report
Upper Columbia River, Washington

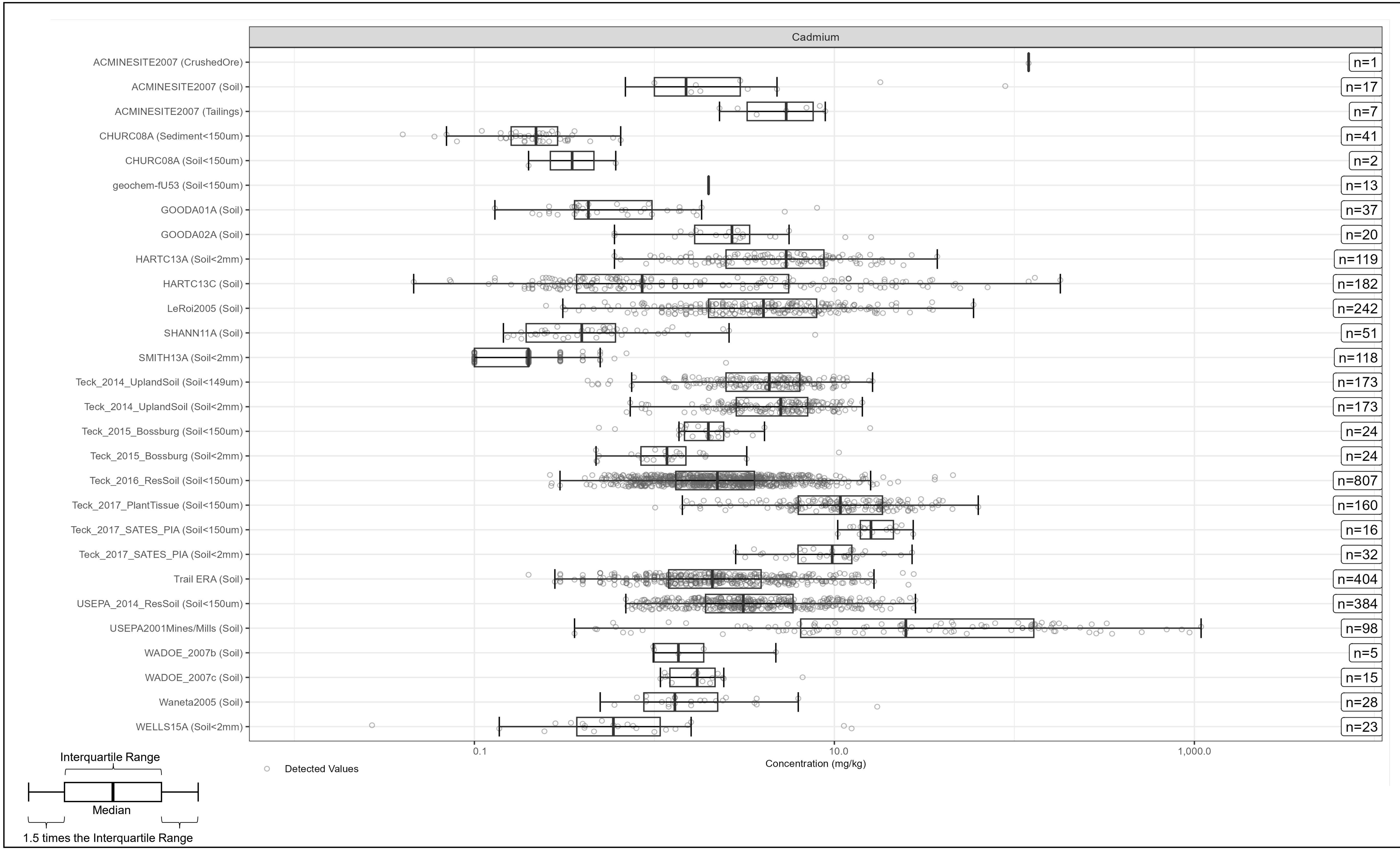

Figure F-5. Boxplots of Cadmium Concentrations by Study
Final Upland RI Report
Upper Columbia River, Washington

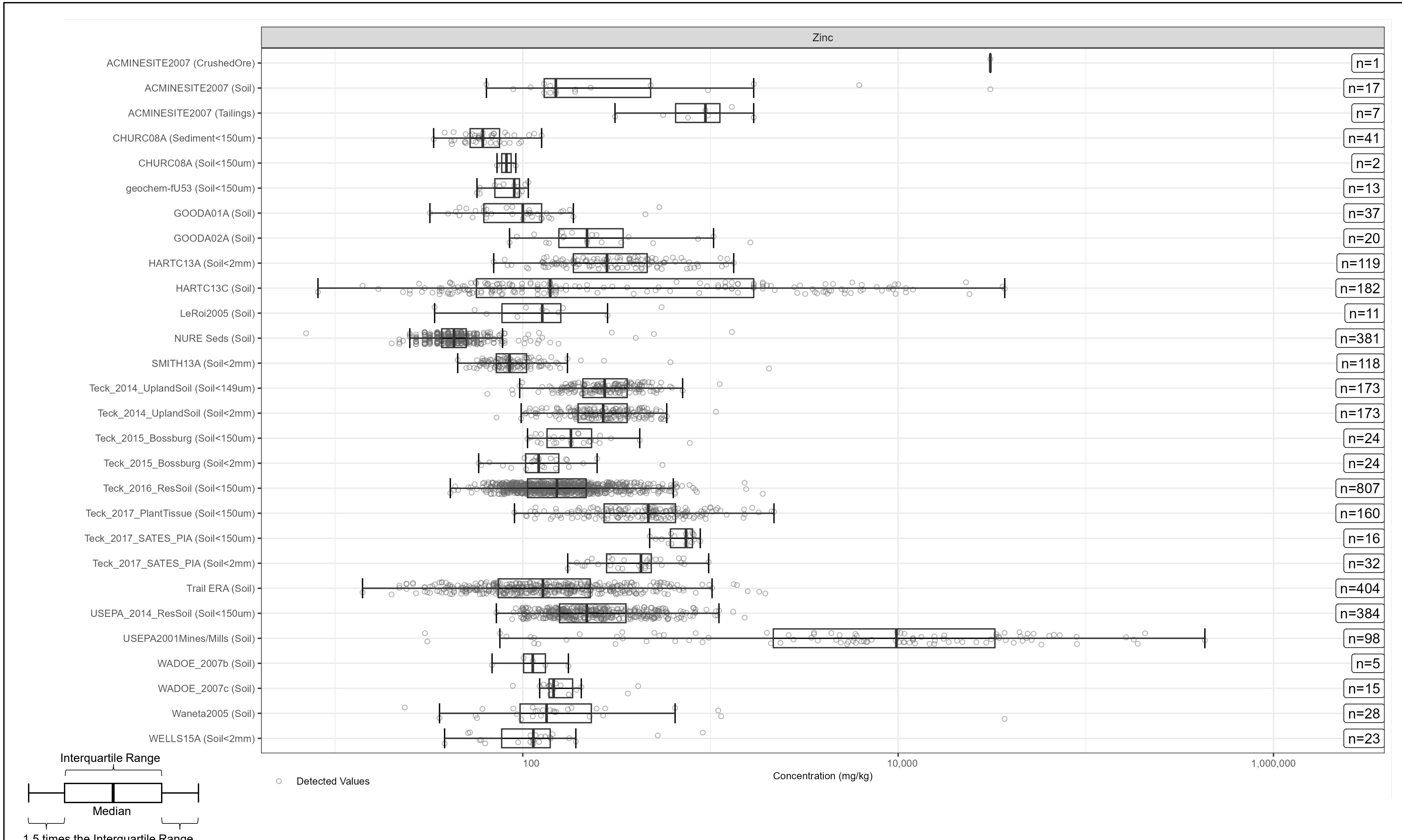

Figure F-6. Boxplots of Zinc Concentrations by Study
Final Upland RI Report
Upper Columbia River, Washington

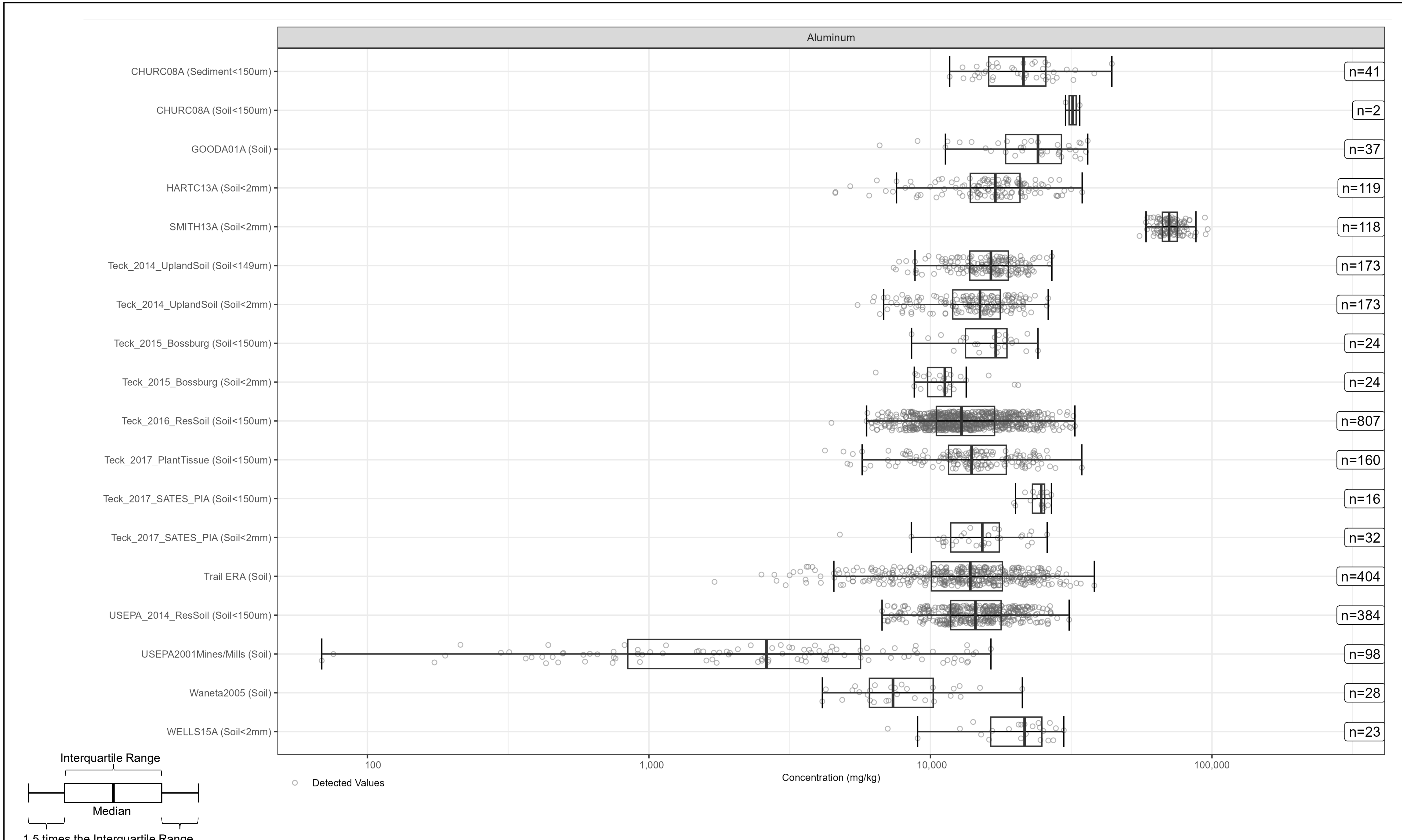

Figure F-7. Boxplots of Aluminum Concentrations by Study
Final Upland RI Report
Upper Columbia River, Washington

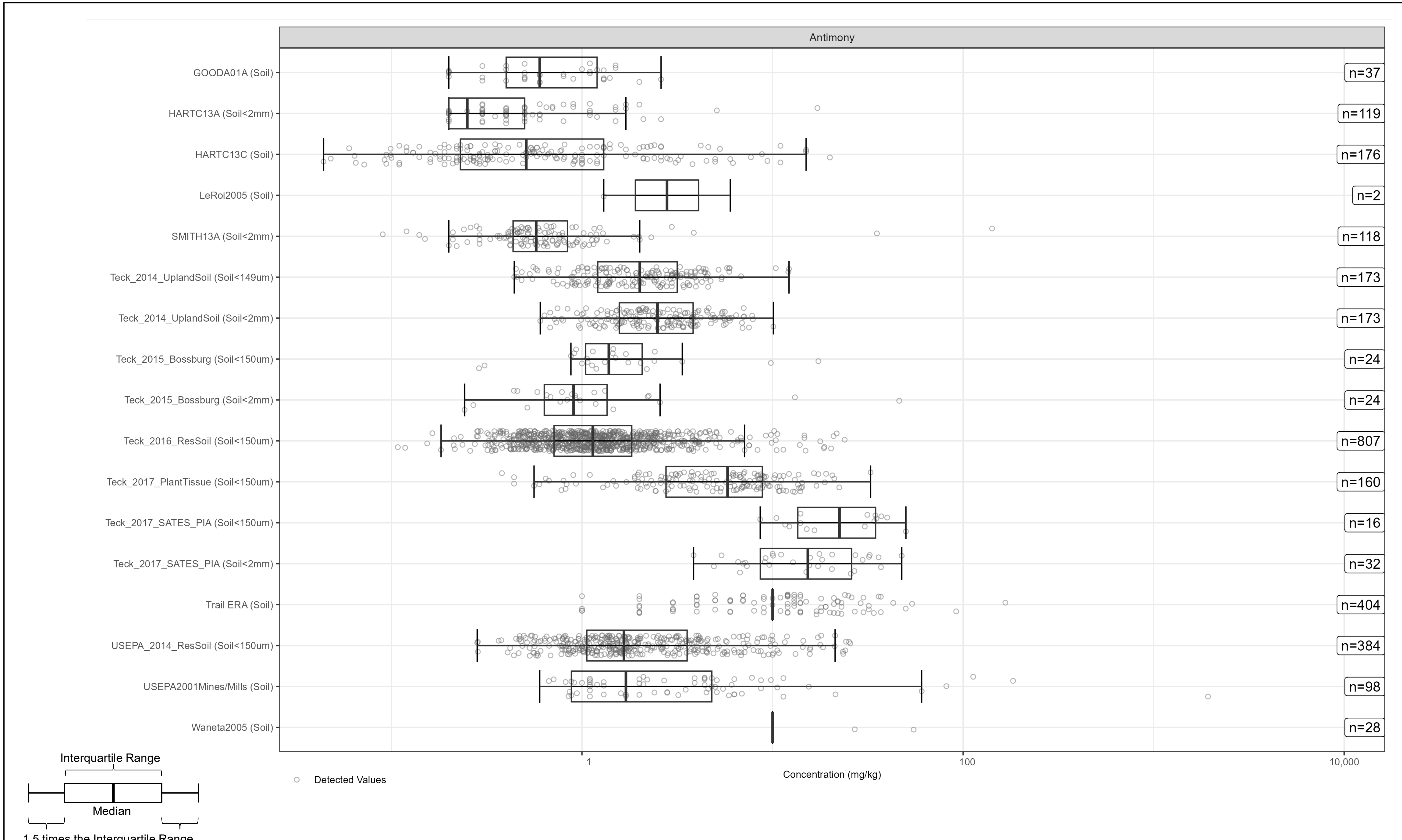

Figure F-8. Boxplots of Antimony Concentrations by Study

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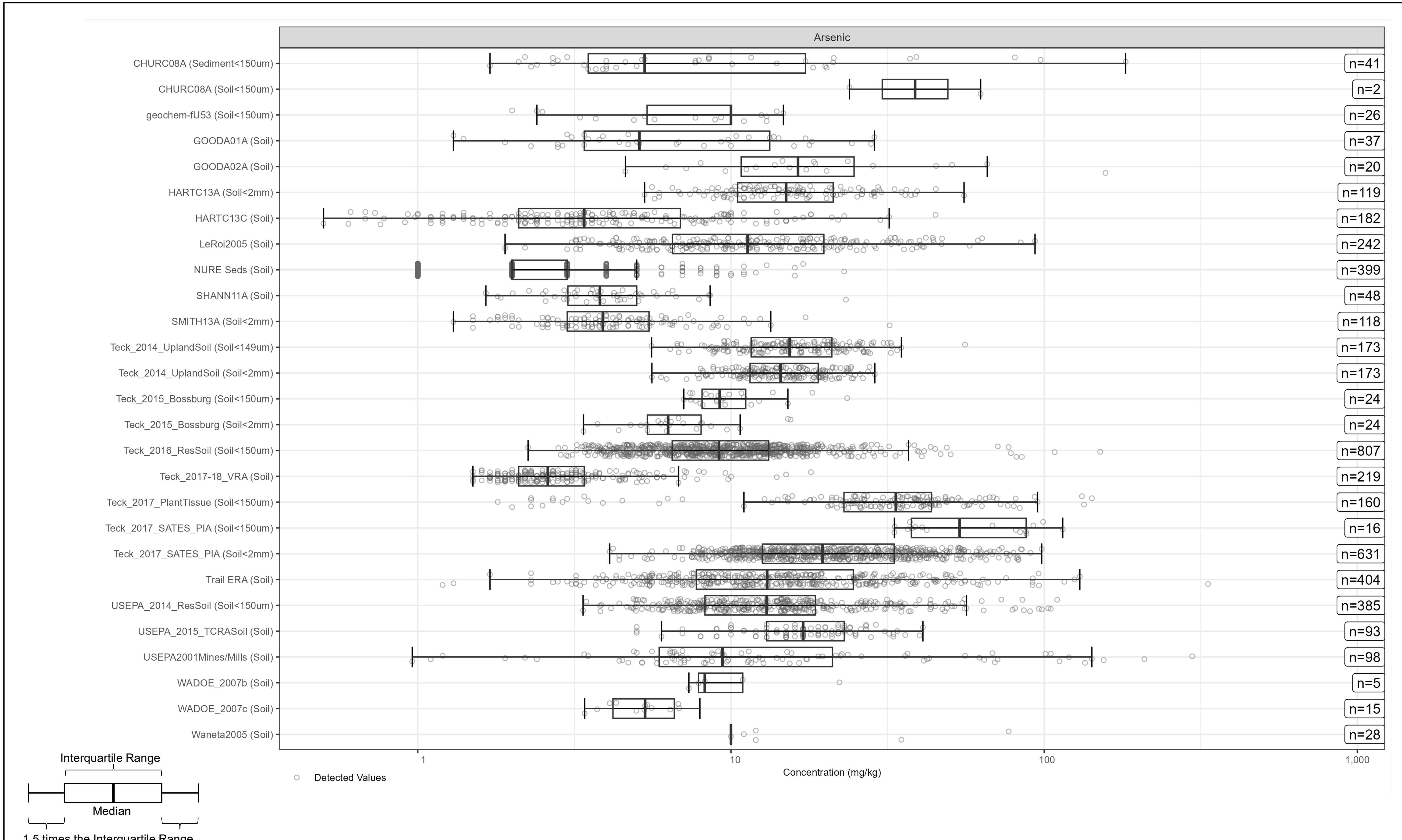

Figure F-9. Boxplots of Arsenic Concentrations by Study
Final Upland RI Report
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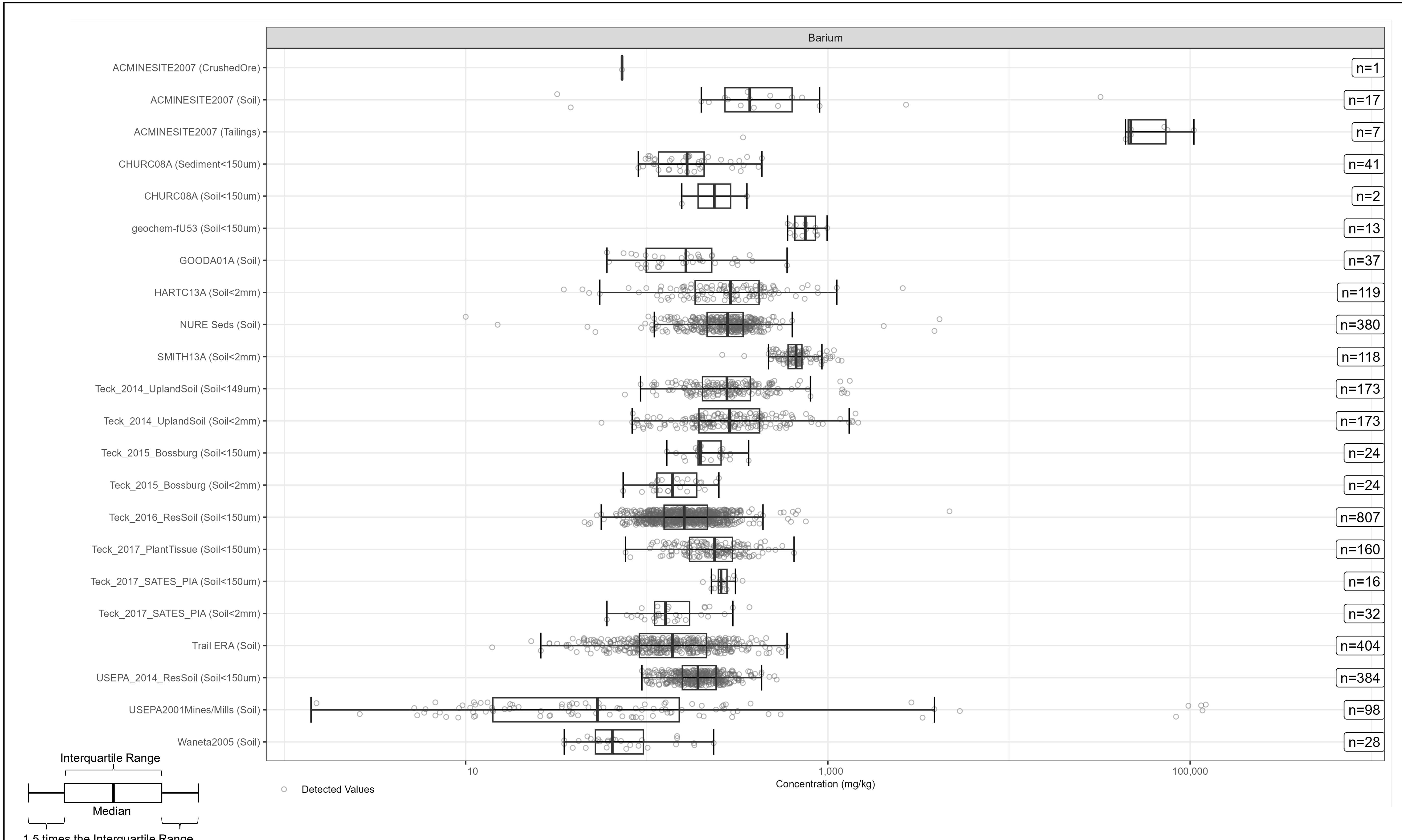

Figure F-10. Boxplots of Barium Concentrations by Study
Final Upland RI Report
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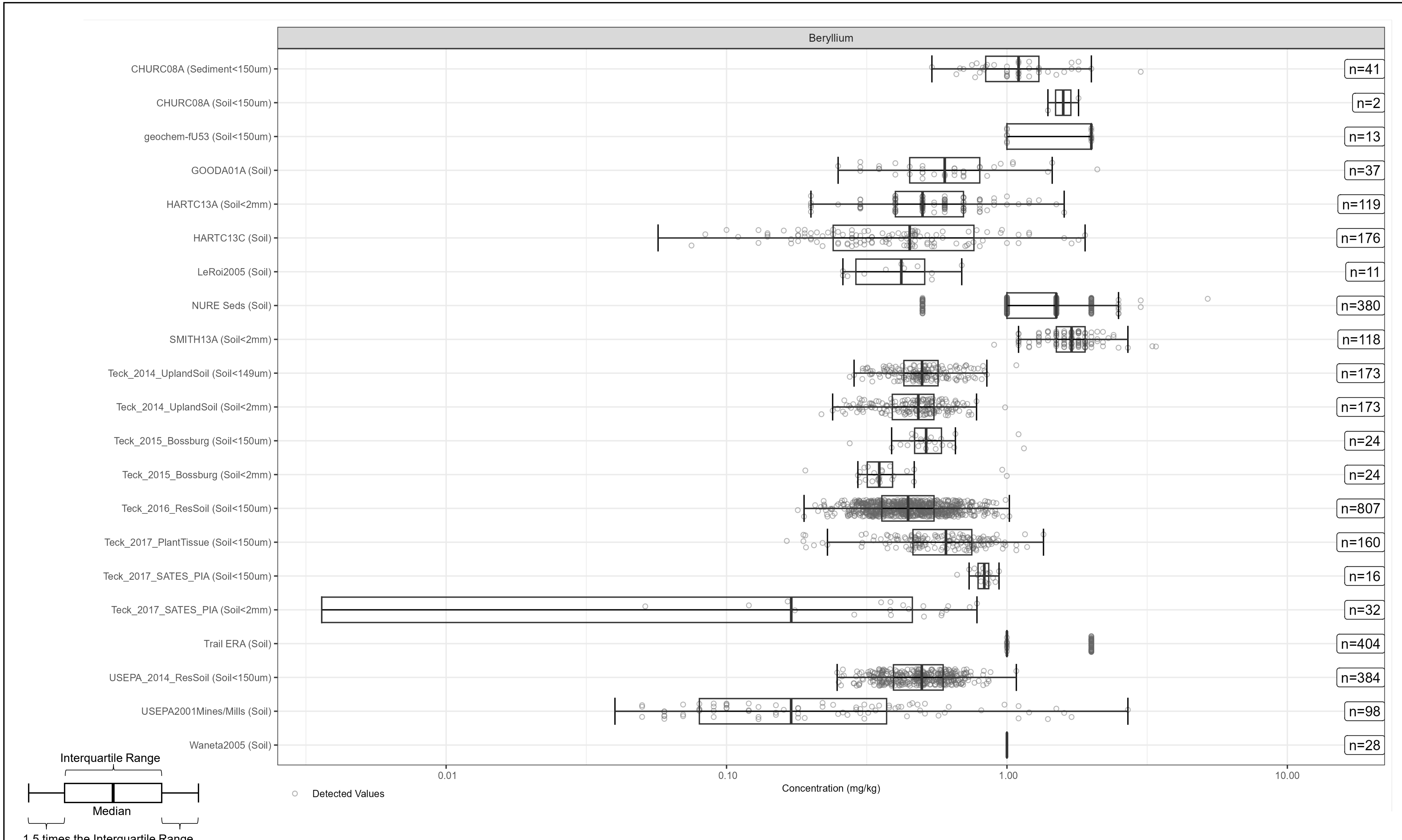

Figure F-11. Boxplots of Beryllium Concentrations by Study

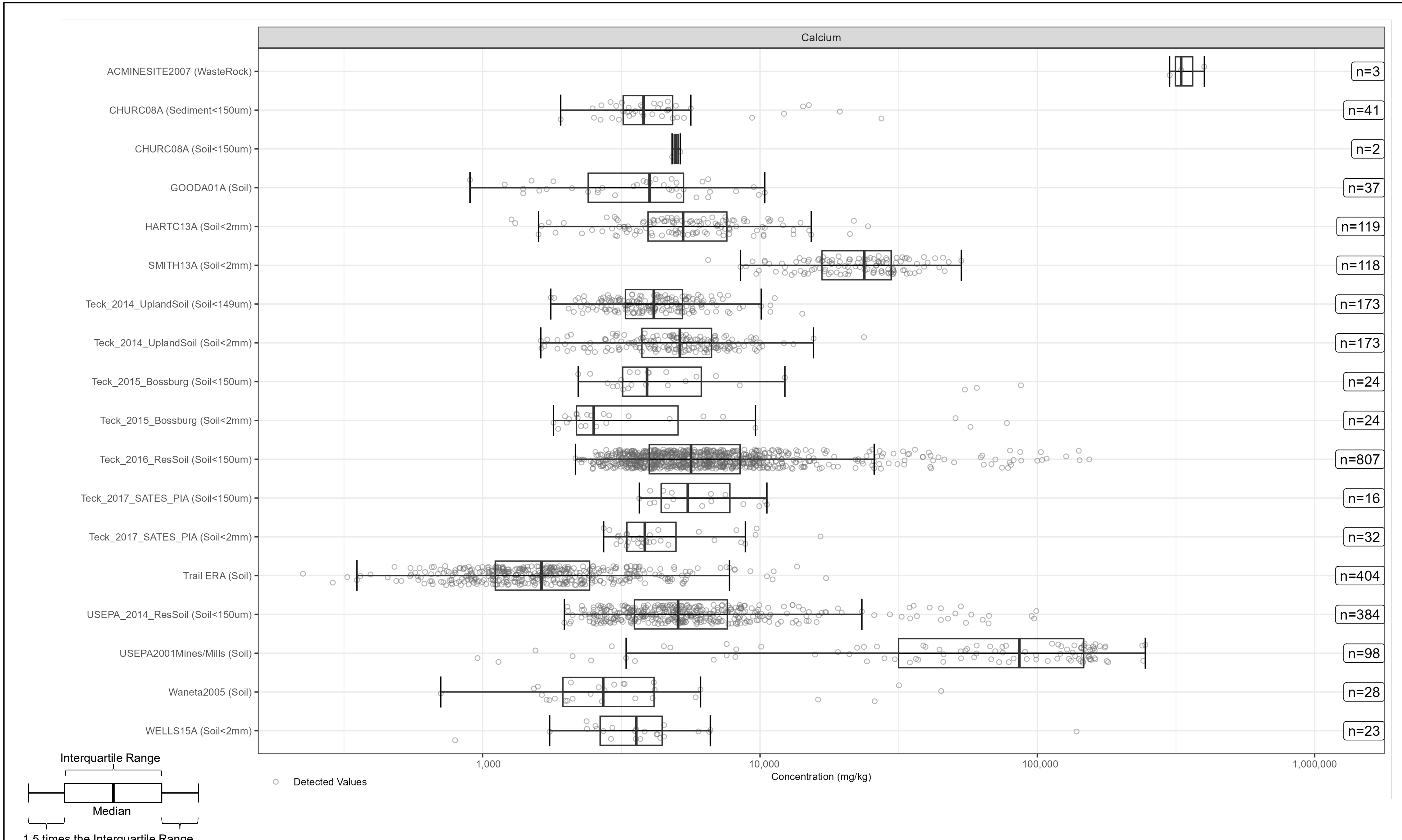

Figure F-12. Boxplots of Calcium Concentrations by Study
Final Upland RI Report
Upper Columbia River, Washington

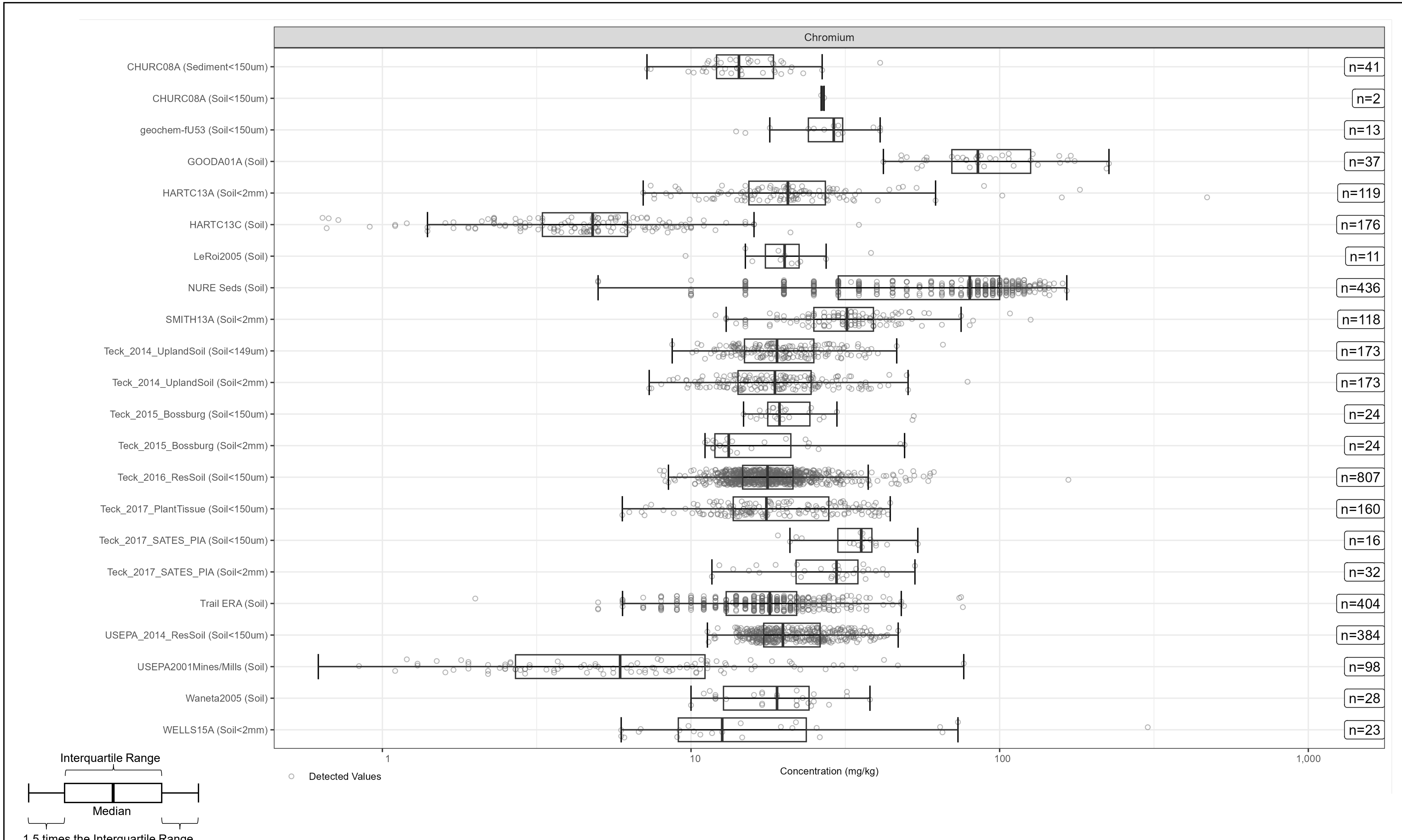

Figure F-13. Boxplots of Chromium Concentrations by Study
Final Upland RI Report
Upper Columbia River, Washington

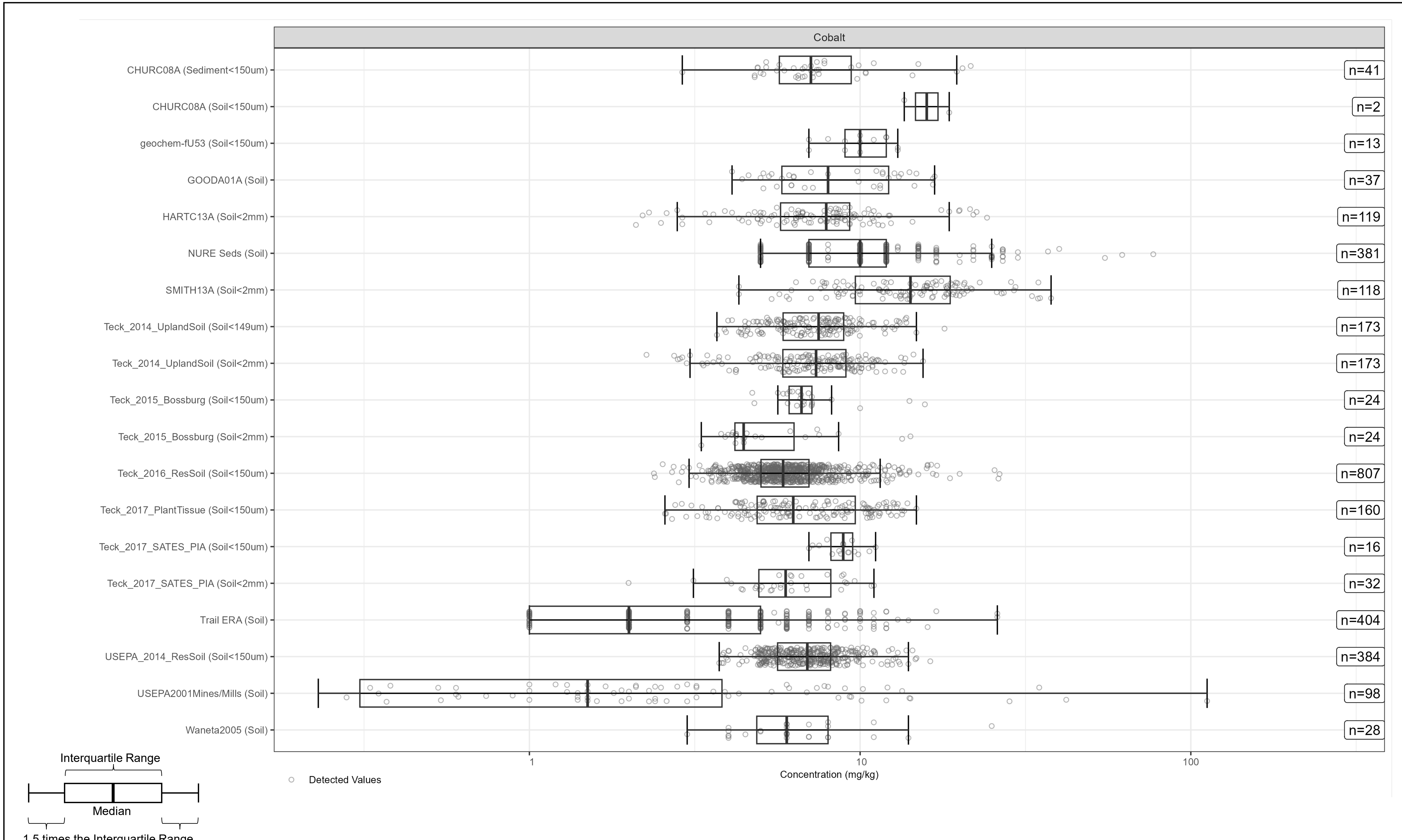

Figure F-14. Boxplots of Cobalt Concentrations by Study
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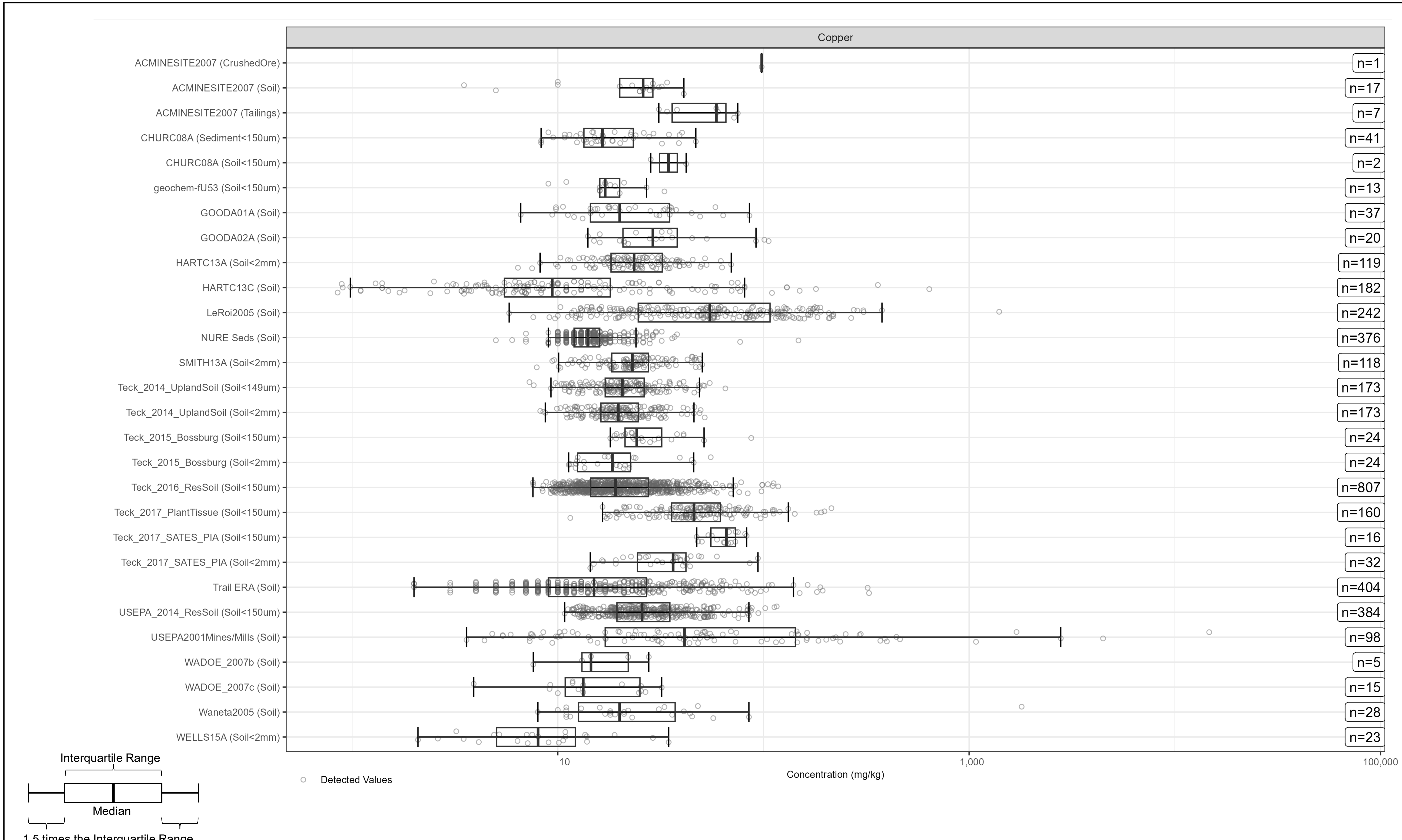

Figure F-15. Boxplots of Copper Concentrations by Study

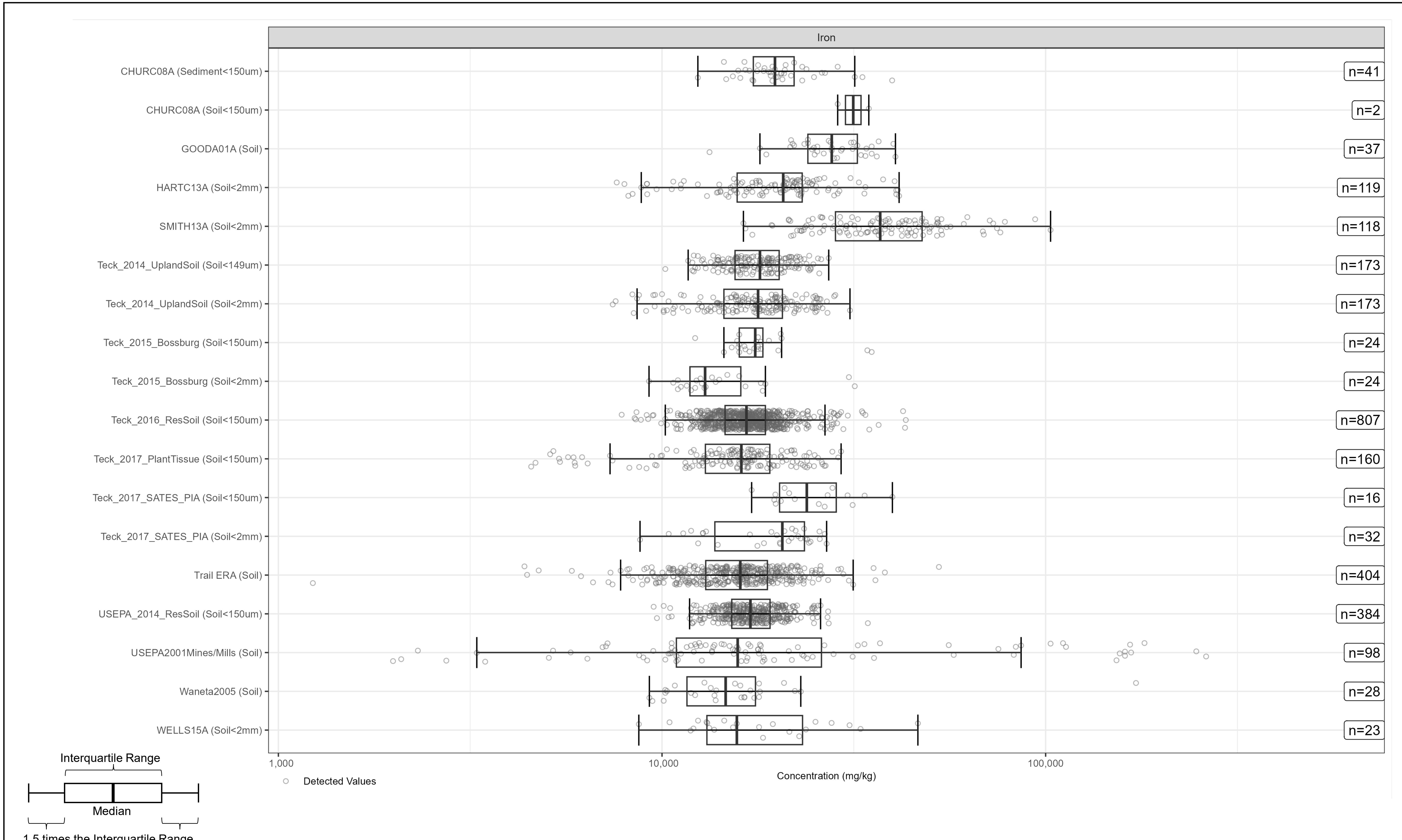

Figure F-16. Boxplots of Iron Concentrations by Study
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Upper Columbia River, Washington

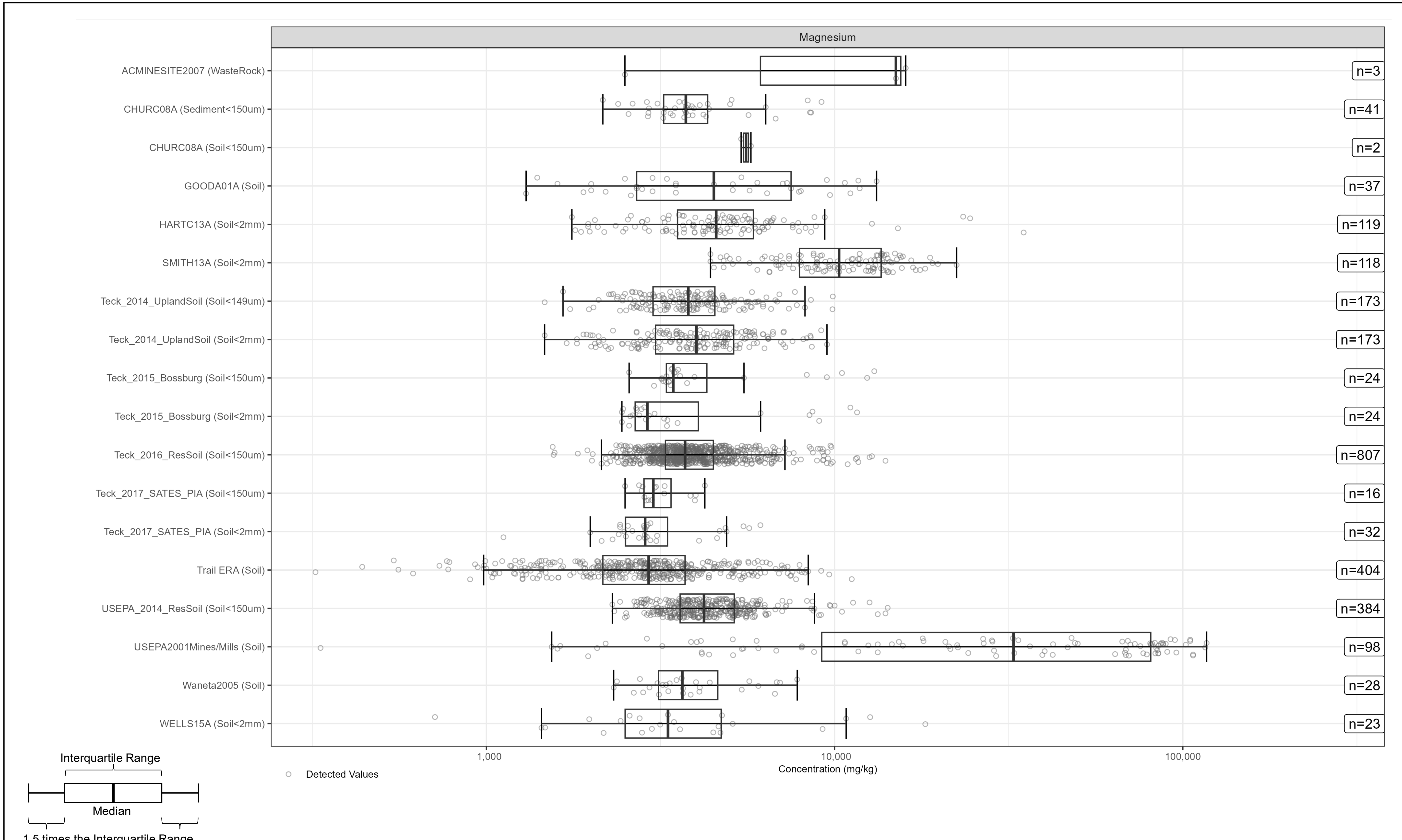

Figure F-17. Boxplots of Magnesium Concentrations by Study
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Upper Columbia River, Washington

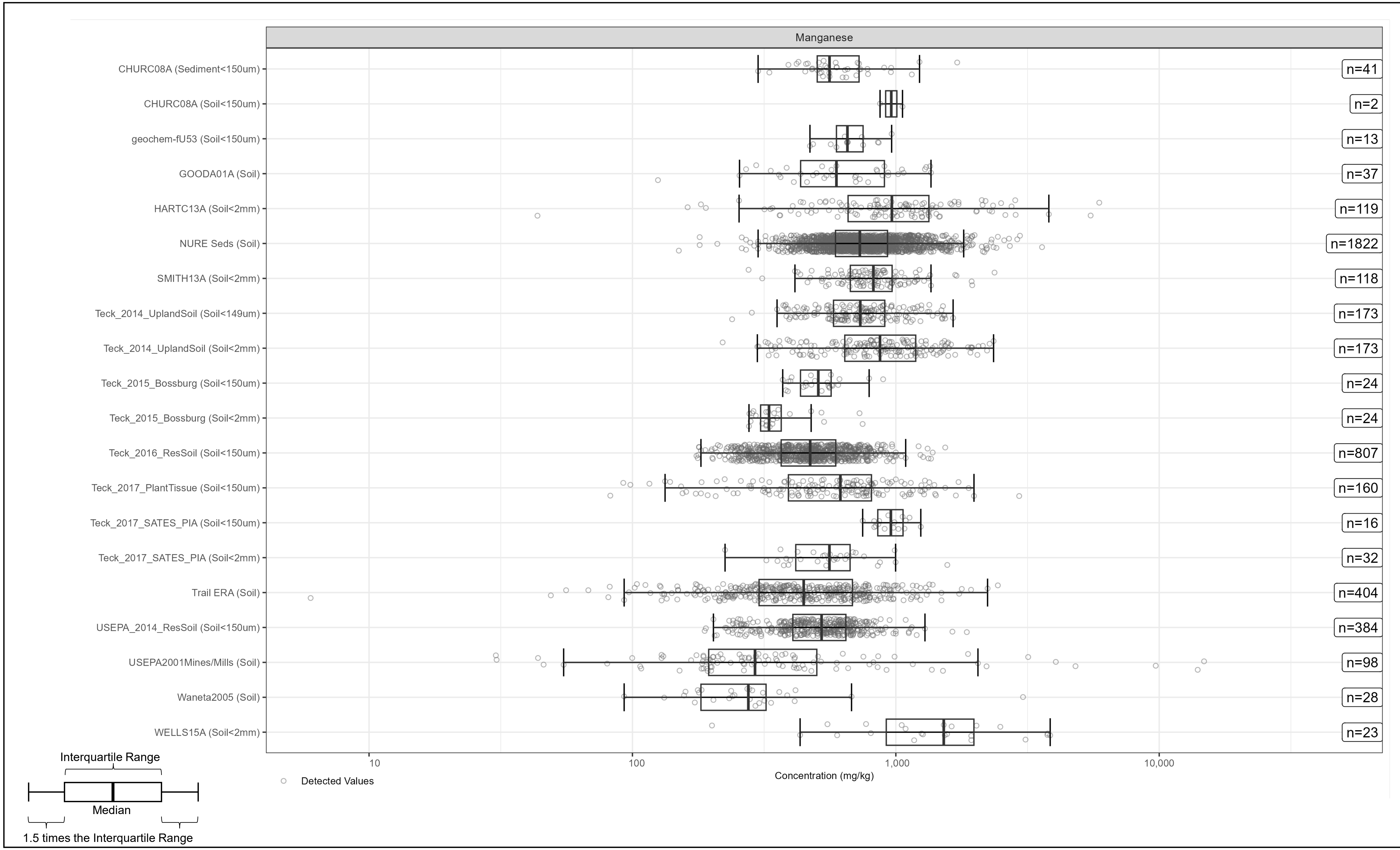

Figure F-18. Boxplots of Manganese Concentrations by Study
Final Upland RI Report
Upper Columbia River, Washington

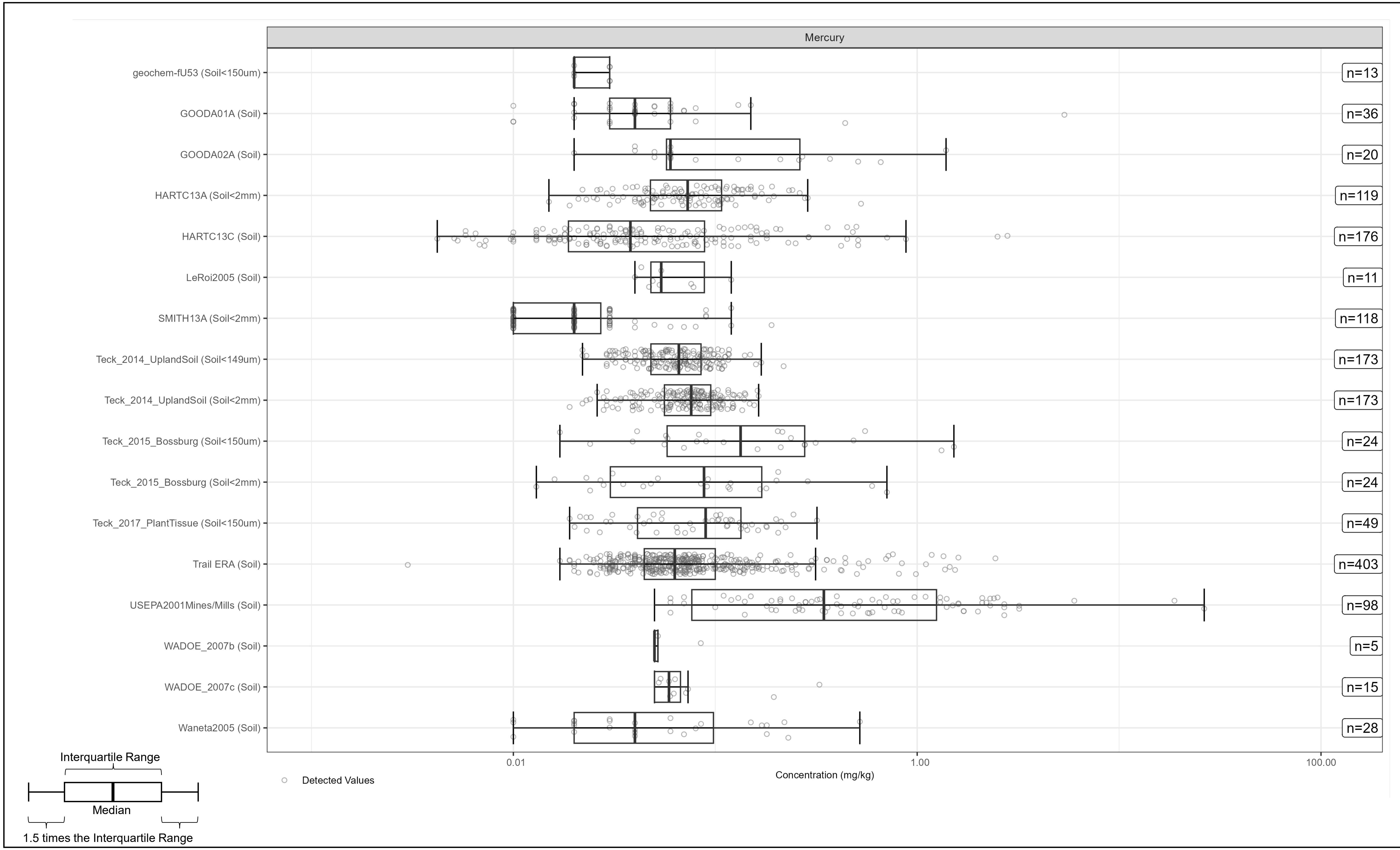

Figure F-19. Boxplots of Mercury Concentrations by Study
Final Upland RI Report
Upper Columbia River, Washington

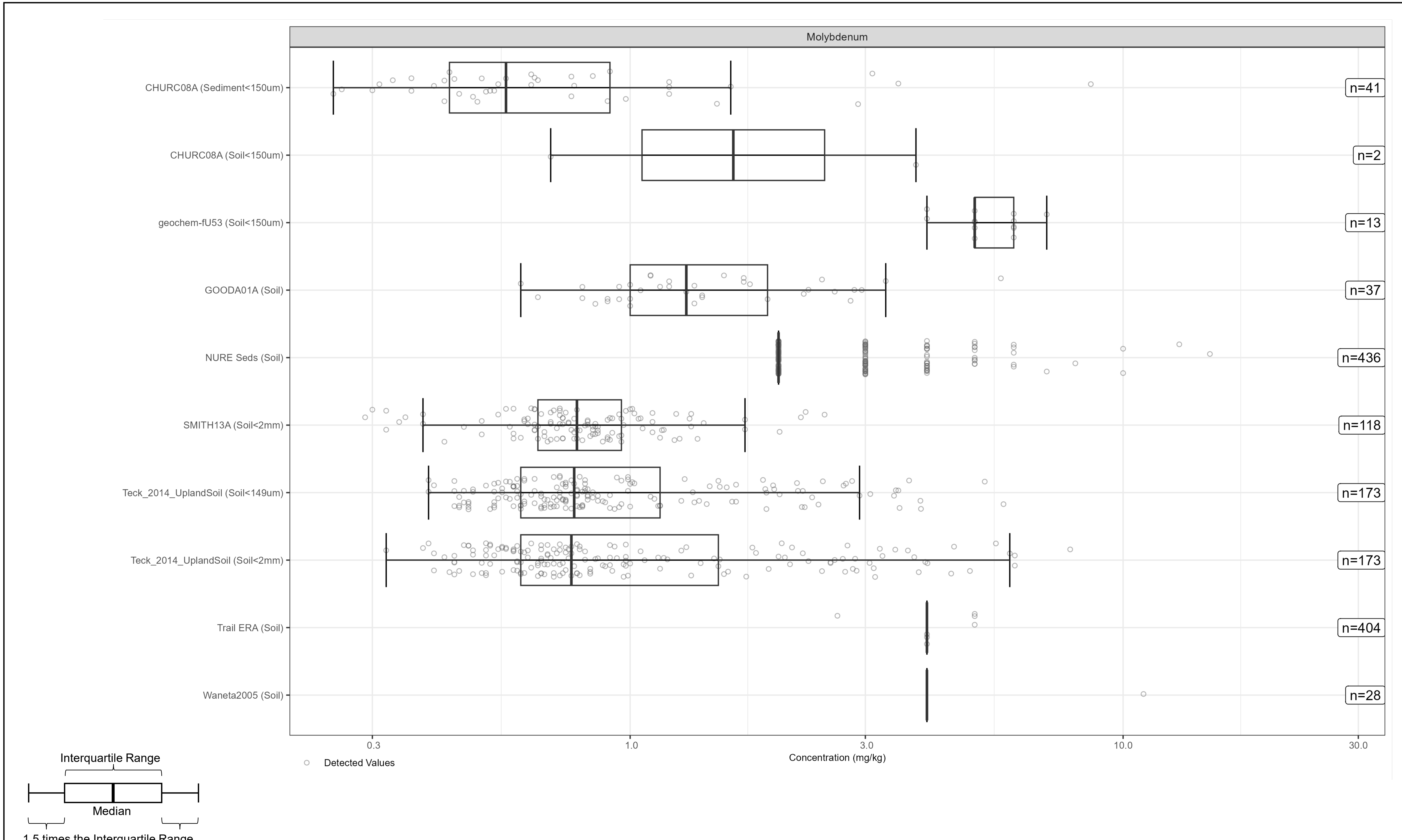

Figure F-20. Boxplots of Molybdenum Concentrations by Study

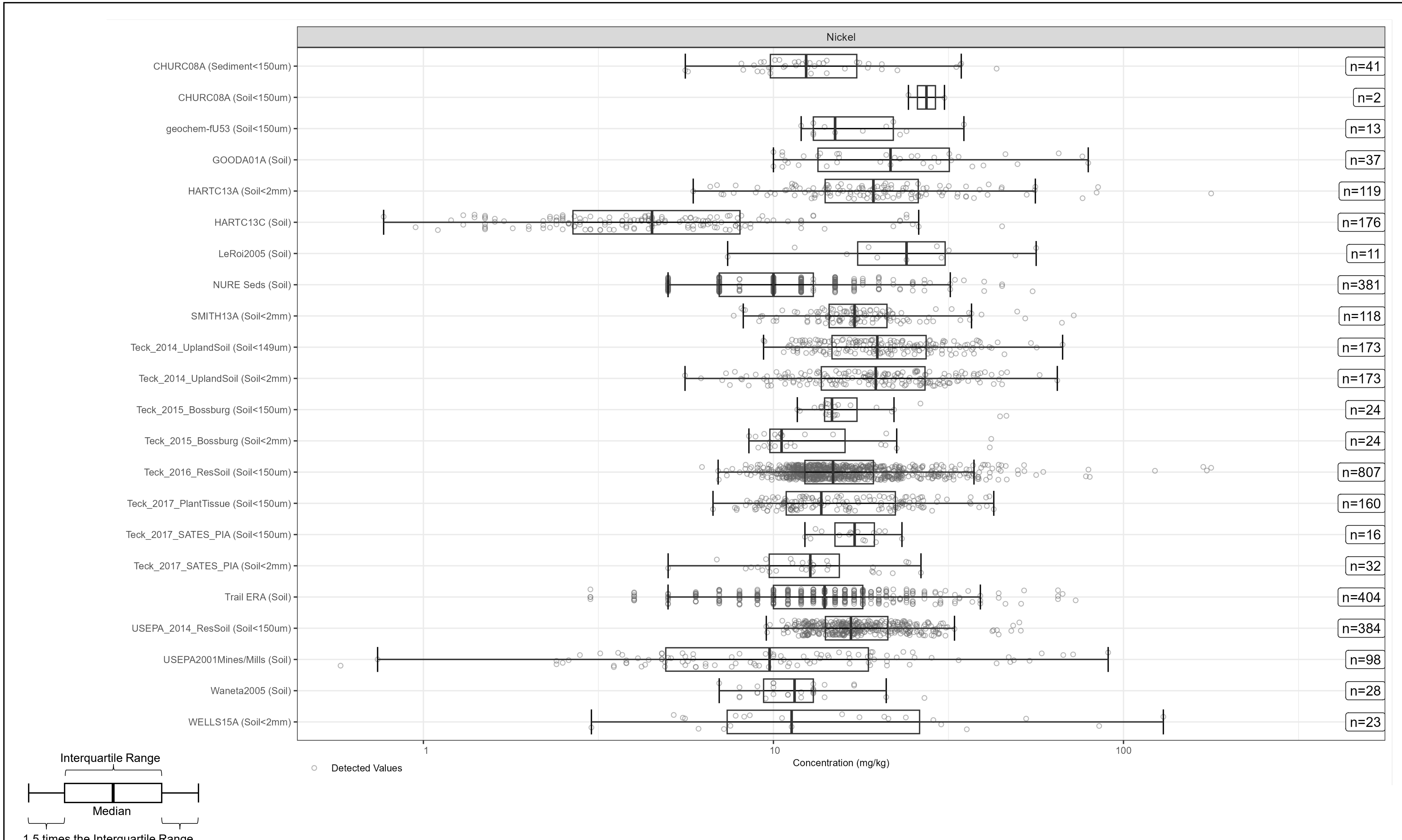

Figure F-21. Boxplots of Nickel Concentrations by Study

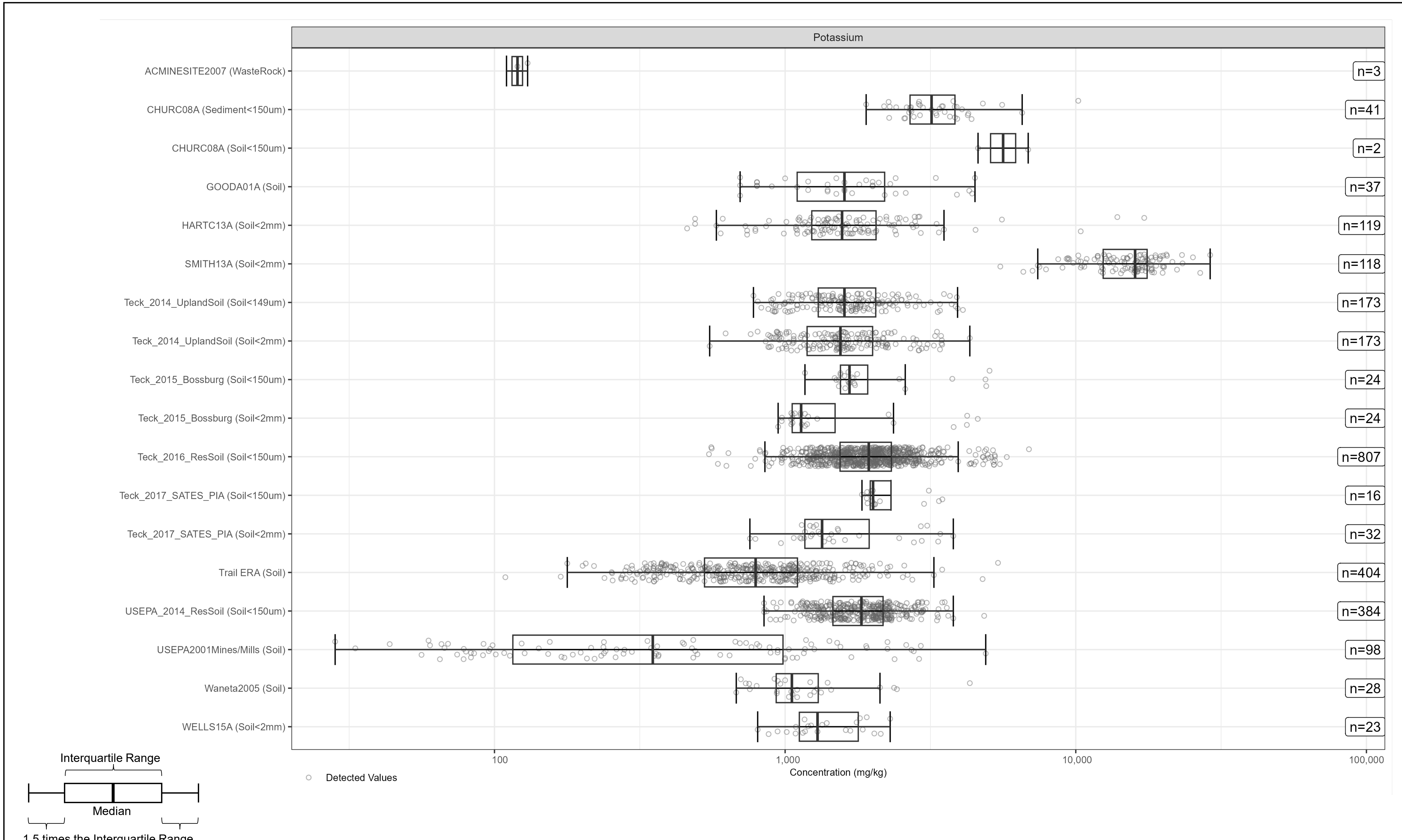

Figure F-22. Boxplots of Potassium Concentrations by Study

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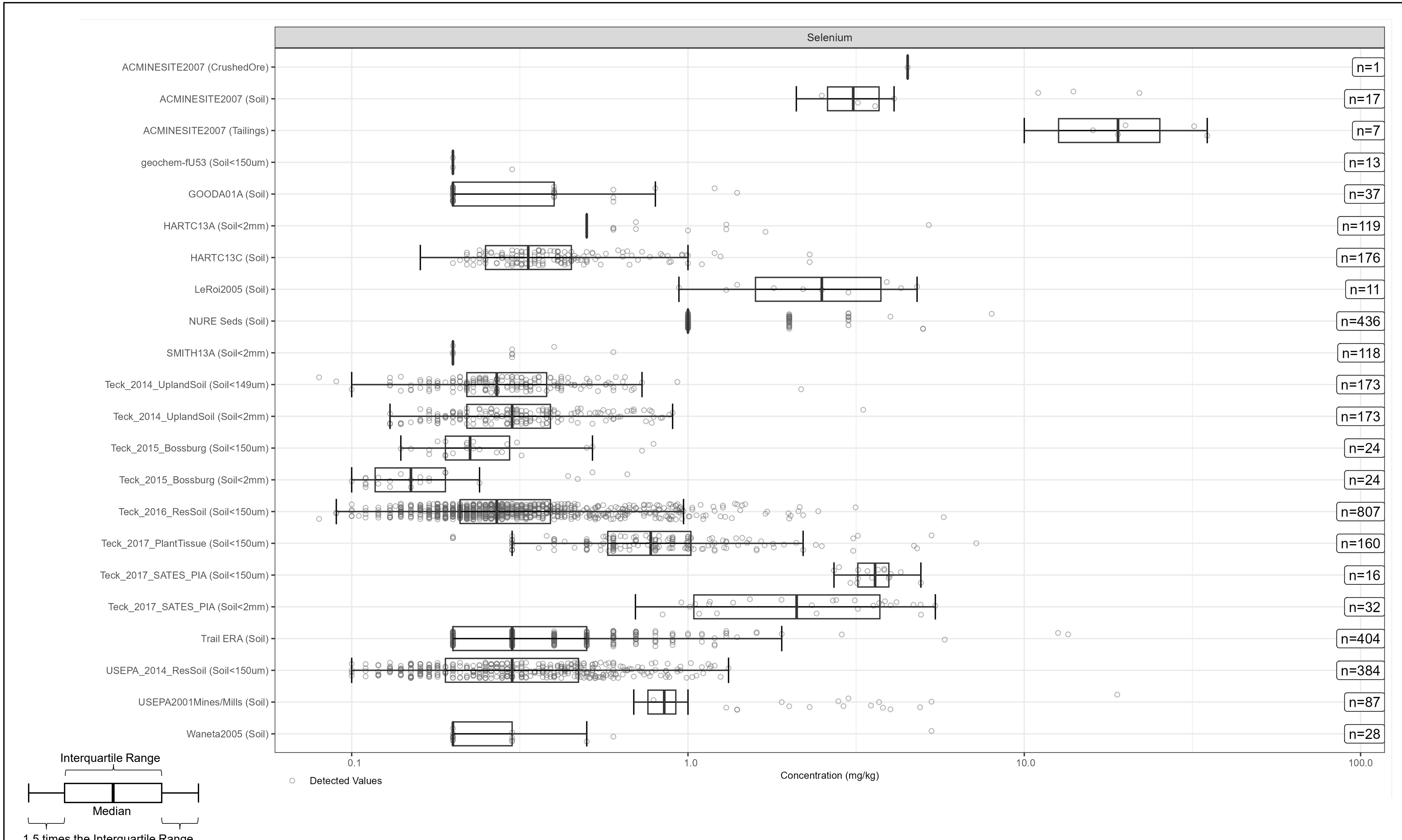

Figure F-23. Boxplots of Selenium Concentrations by Study
Final Upland RI Report
Upper Columbia River, Washington

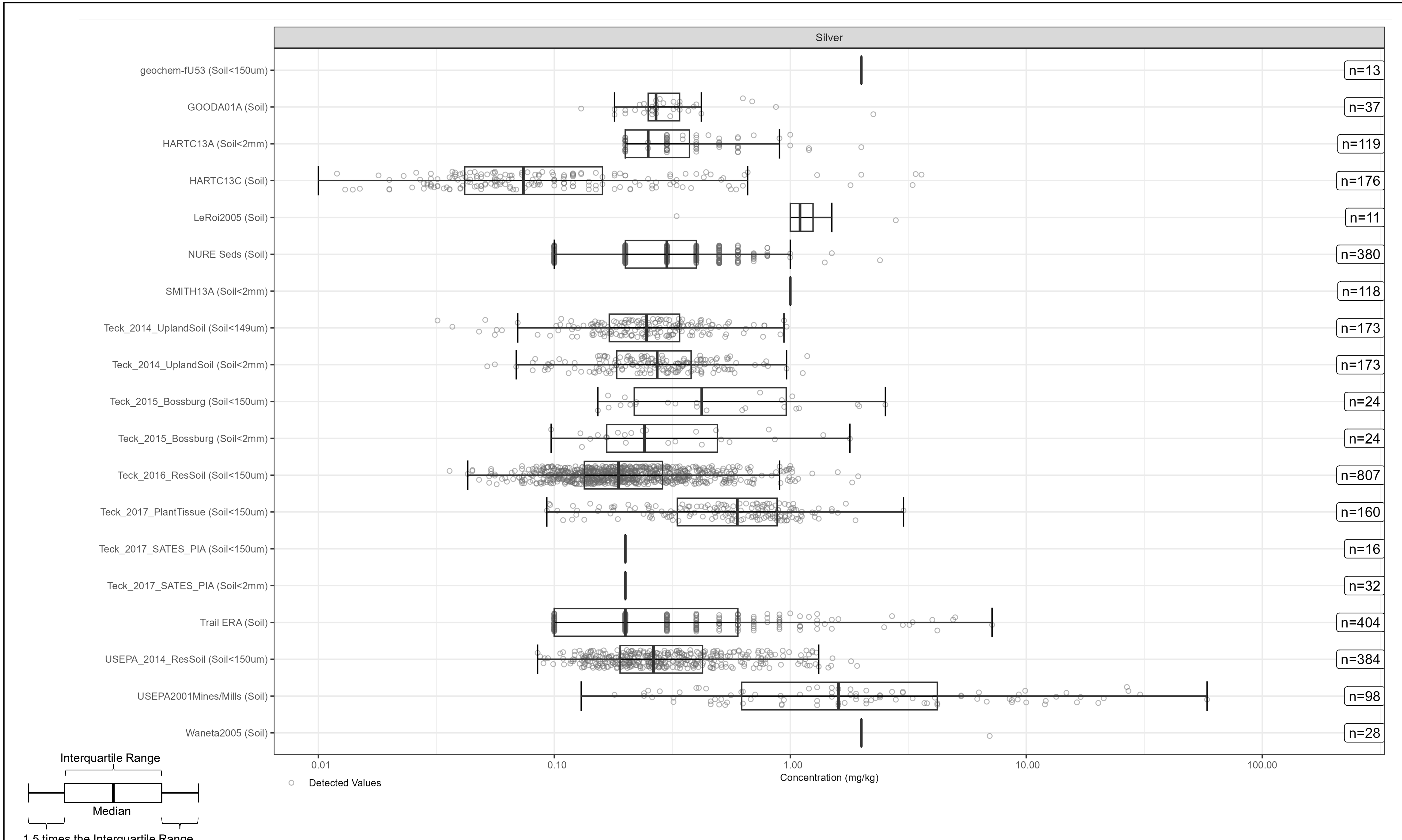

Figure F-24. Boxplots of Silver Concentrations by Study
Final Upland RI Report
Upper Columbia River, Washington

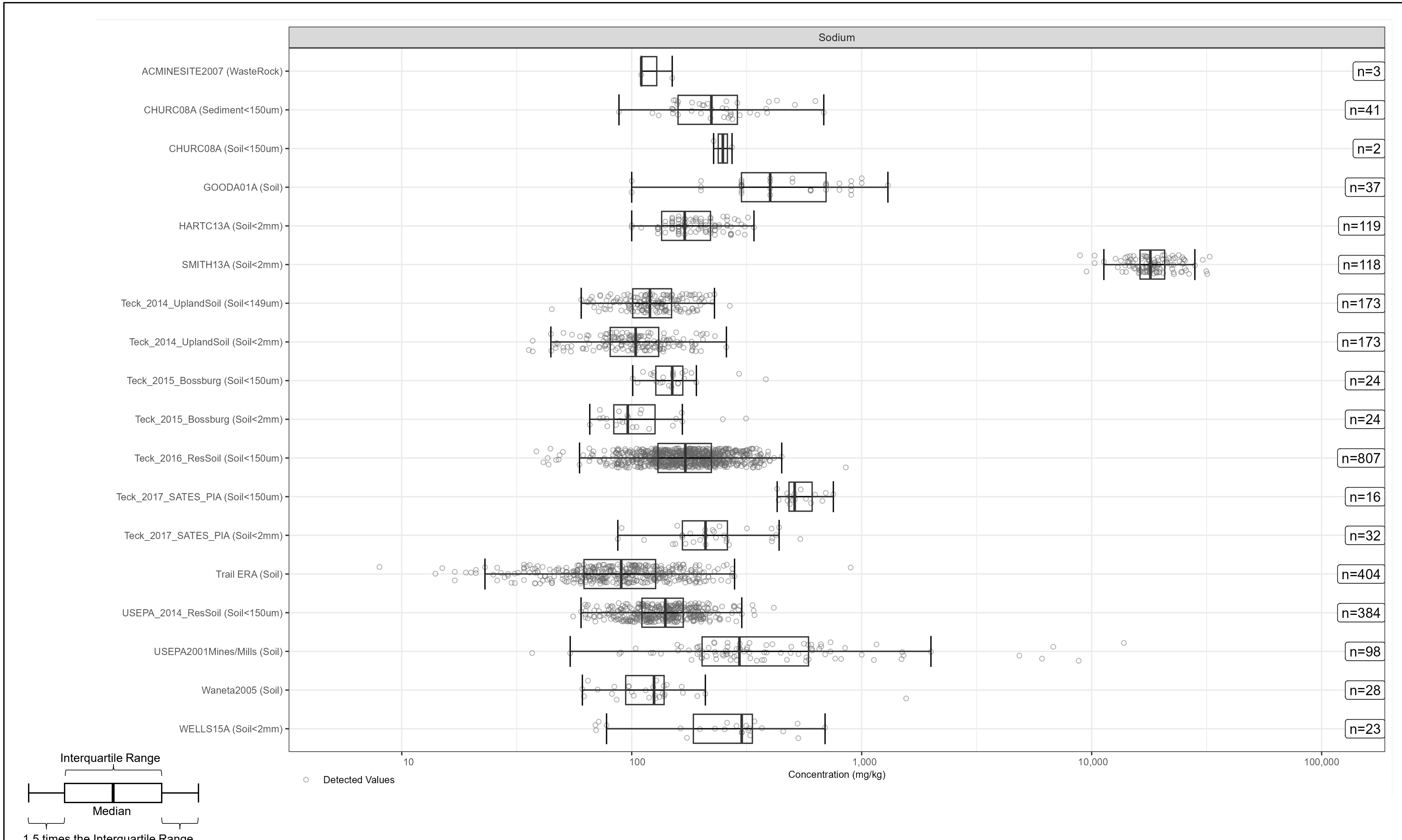

Figure F-25. Boxplots of Sodium Concentrations by Study

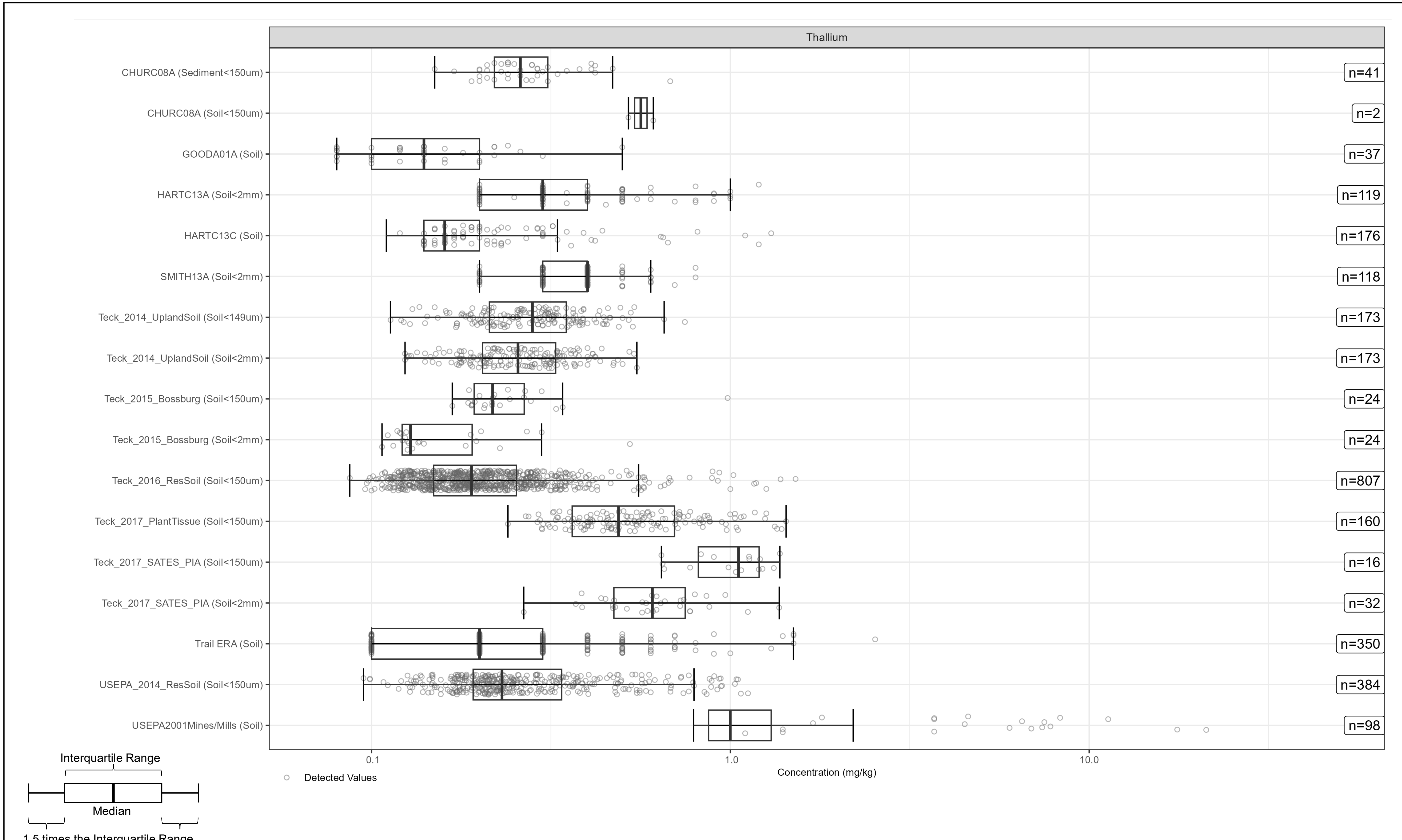

Figure F-26. Boxplots of Thallium Concentrations by Study

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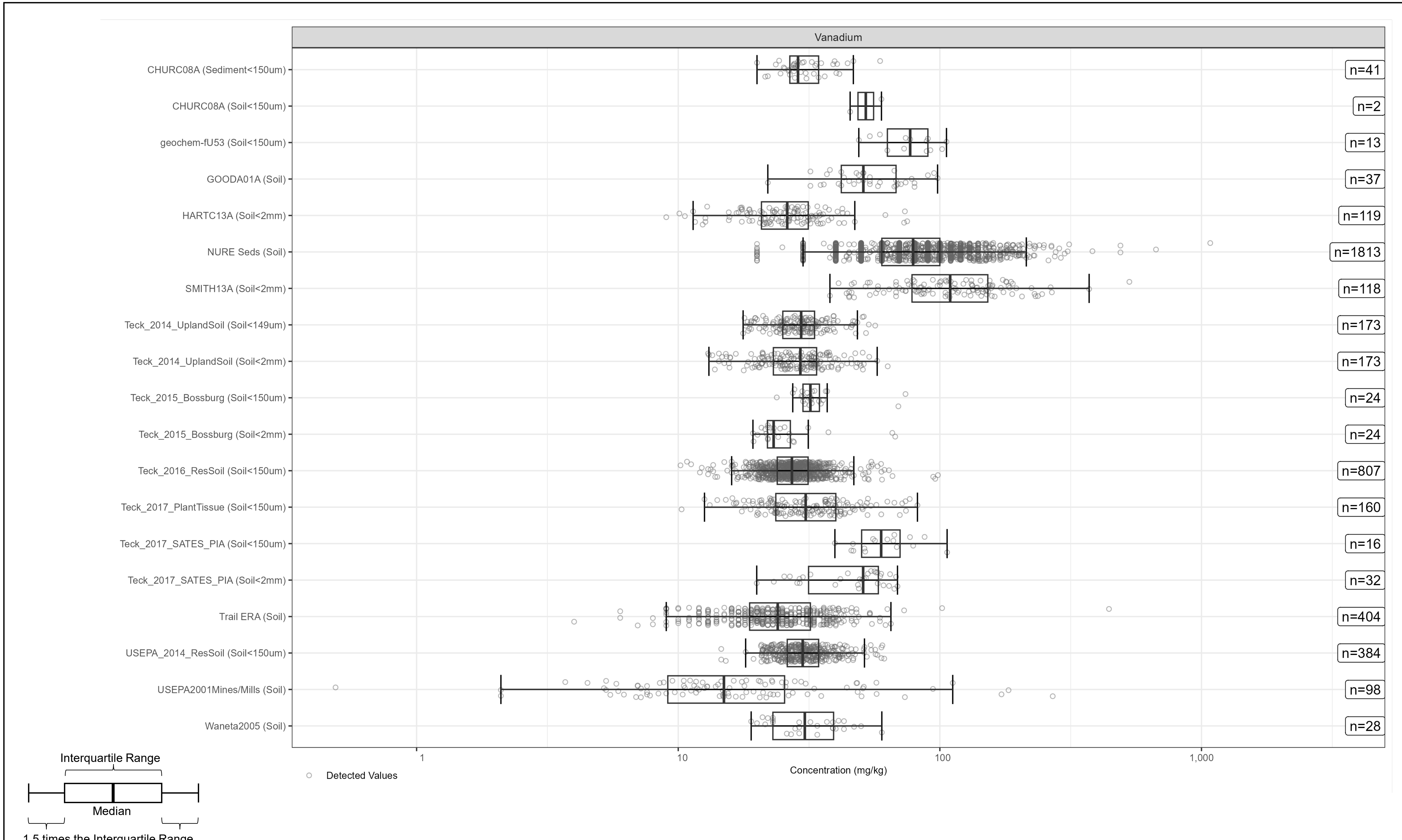
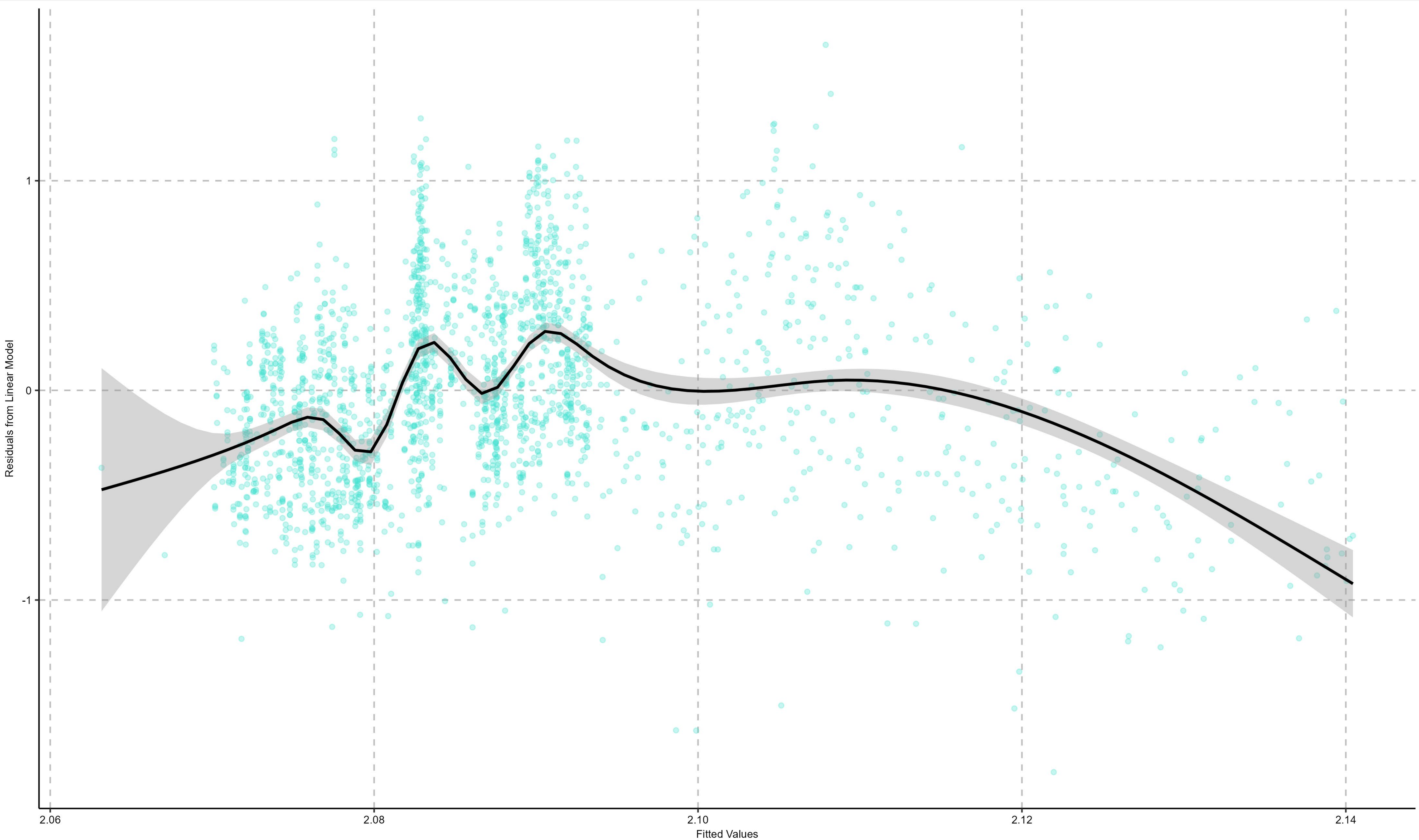
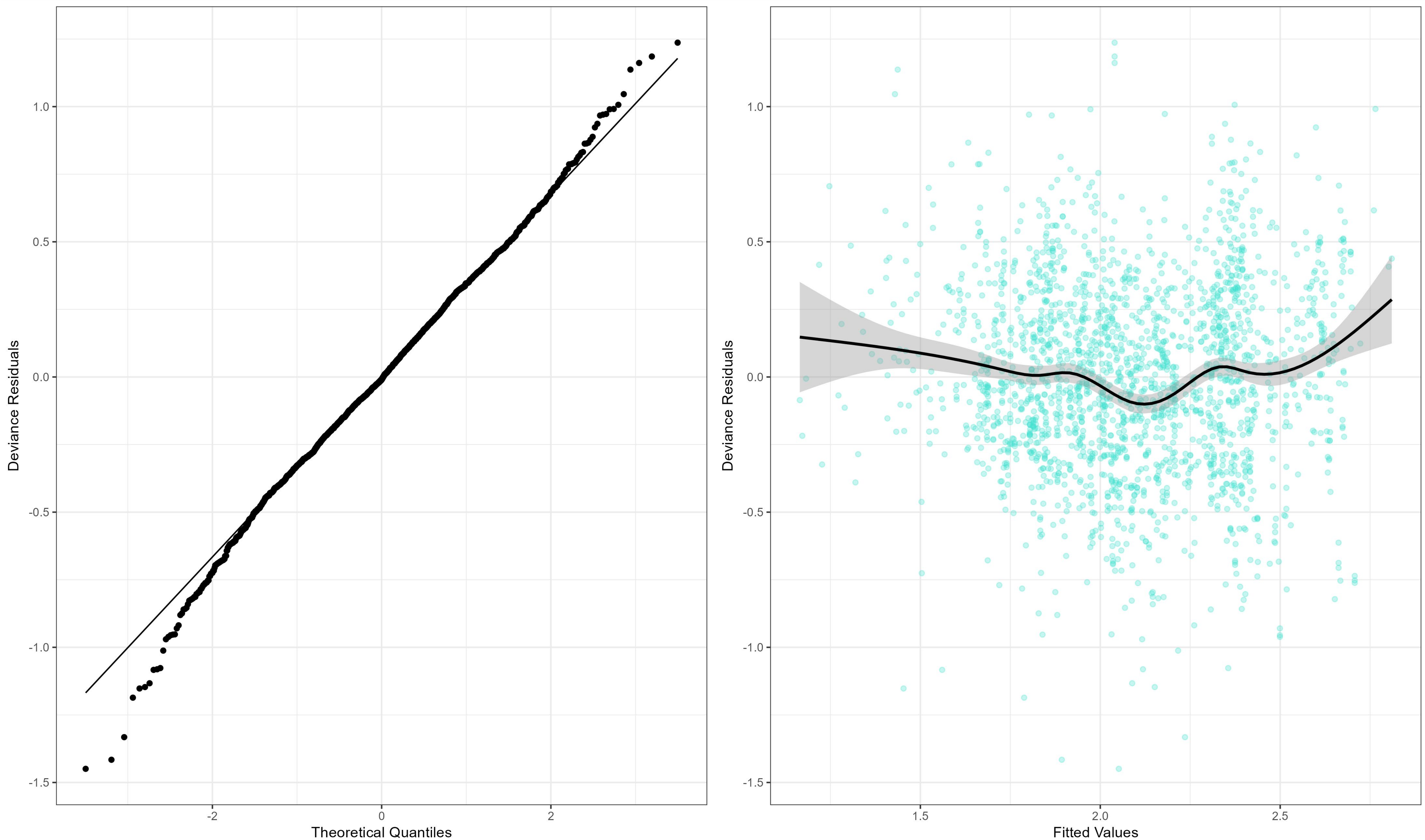


Figure F-27. Boxplots of Vanadium Concentrations by Study



Note: In this plot, the vertical axis represents the residuals, which are the differences between the observed values of the response variable and the predicted values of the response variable from the model. The horizontal axis represents the fitted values, which are the predicted values of the response variable based on the model. The black line shows a loess smooth line through the points and the gray shading indicates the 95% CI of that fit. If the data meet the assumptions of the model, this line should be a straight line centered at 0. Small deviations are not generally considered to be problematic, but obvious patterning suggests a mis-specified model.

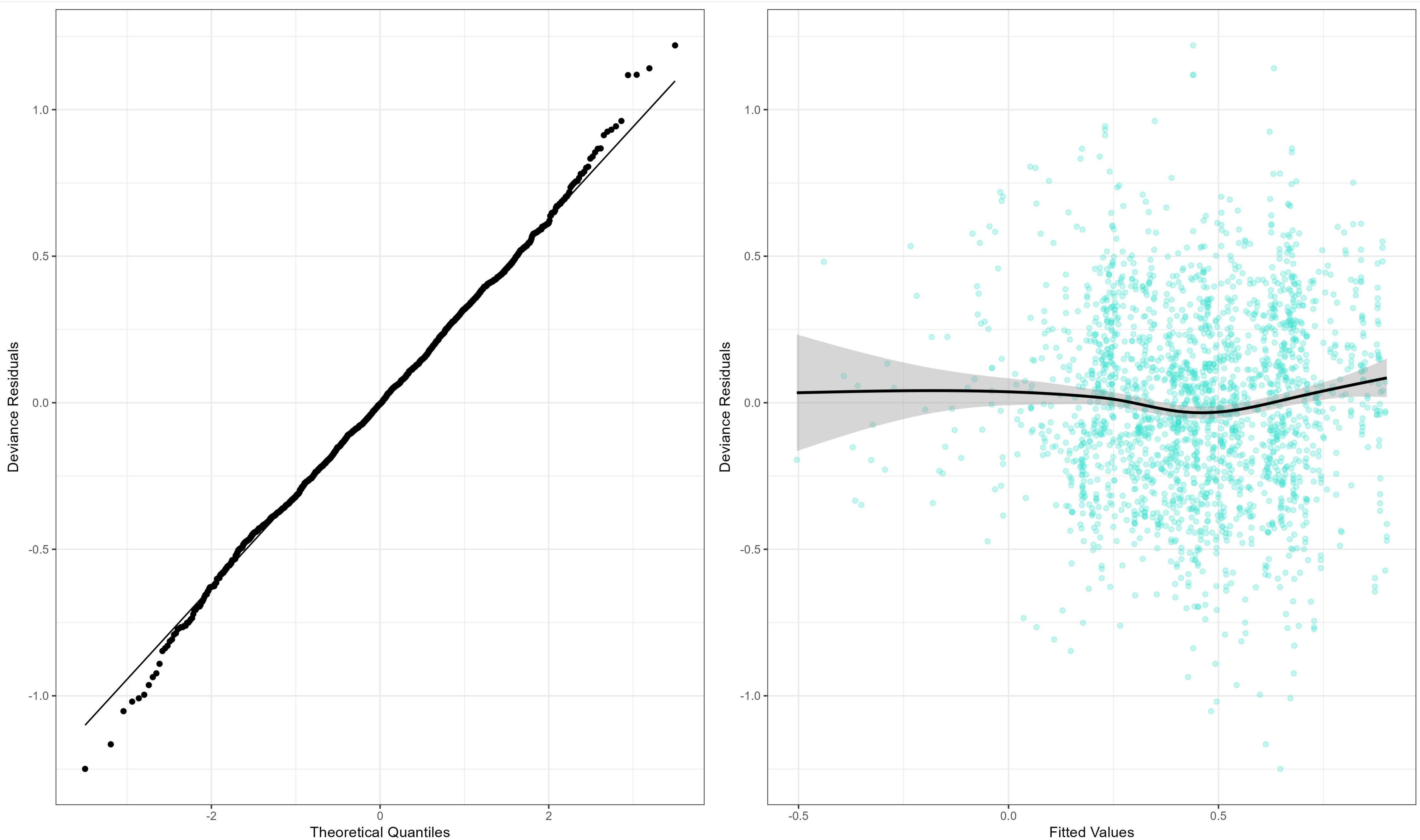
Figure F-28. Diagnostic Residuals Plot of a Linear Regression of Lead versus River Distance



Left plot: QQ-plot of residuals (which are the differences between the observed values of the response variable and the predicted values of the response variable from the model) on the y-axis vs. theoretical quantiles on the x-axis. Used to assess the goodness of fit of a statistical model by comparing the distribution of the residuals to the expected distribution under the assumed model. If the data meets the assumptions of the model, these points should lie mostly along a straight line. However, GAMs are robust to deviations from normality so some points above or below the line do not necessarily indicate a problem.

Right plot: The y-axis represents the residuals, and the x-axis represents the predicted values of the response variable based on the model. The black line shows a loess smooth line through the points and the gray shading indicates the 95% CI of that fit. If the data meet the assumptions of the model, this line should be a straight line centered at 0. Small deviations are not considered to be problematic, but obvious patterning suggests a mis-specified model.

Figure F-29. Regression Diagnostic Plots for Lead



Left plot: QQ-plot of residuals (which are the differences between the observed values of the response variable and the predicted values of the response variable from the model) on the y-axis vs. theoretical quantiles on the x-axis. Used to assess the goodness of fit of a statistical model by comparing the distribution of the residuals to the expected distribution under the assumed model. If the data meets the assumptions of the model, these points should lie mostly along a straight line. However, GAMs are robust to deviations from normality so some points above or below the line do not necessarily indicate a problem.

Right plot: The y-axis represents the residuals, and the x-axis represents the predicted values of the response variable based on the model. The black line shows a loess smooth line through the points and the gray shading indicates the 95% CI of that fit. If the data meet the assumptions of the model, this line should be a straight line centered at 0. Small deviations are not considered to be problematic, but obvious patterning suggests a mis-specified model.

Figure F-30. Regression Diagnostic Plots for Cadmium
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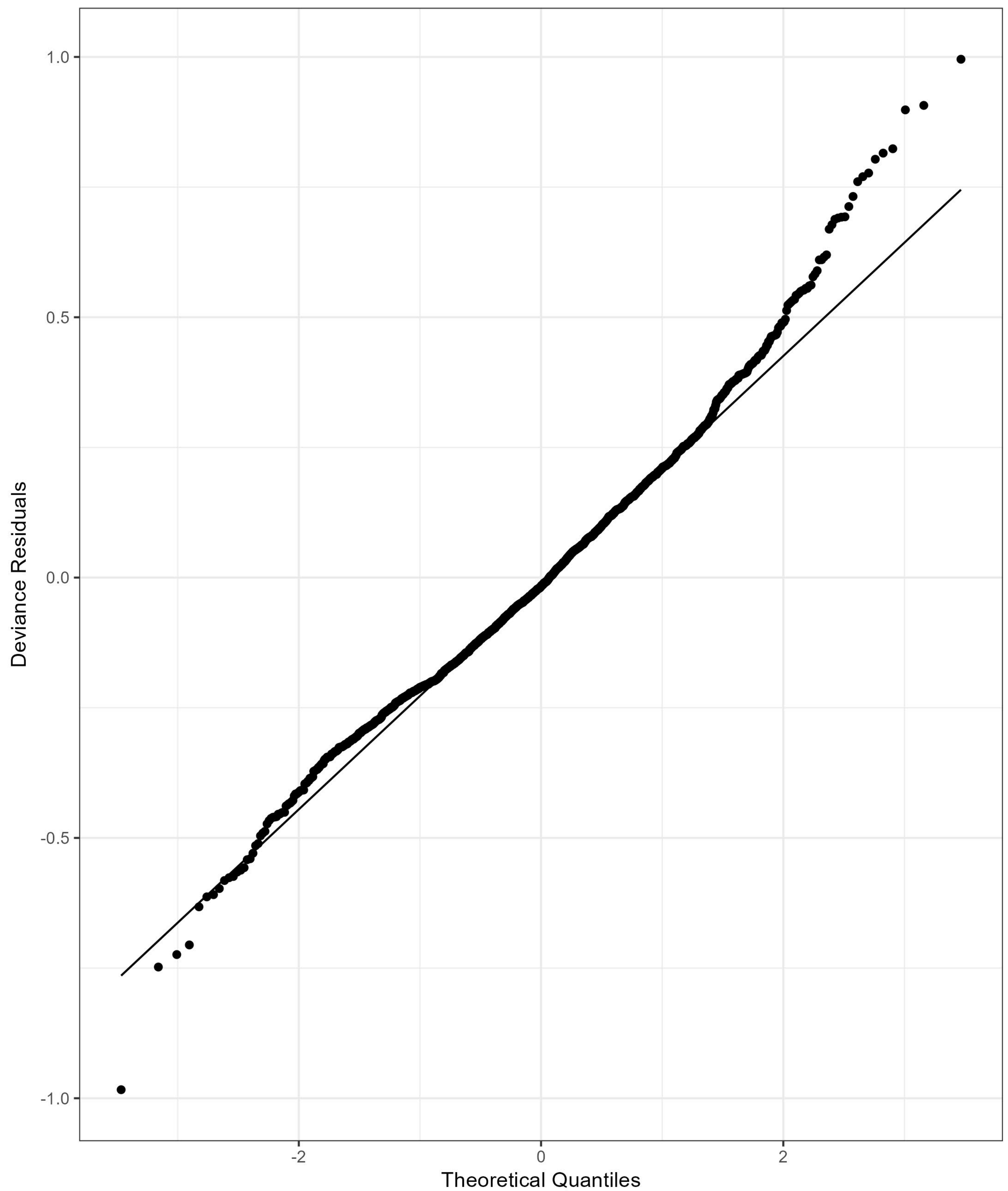
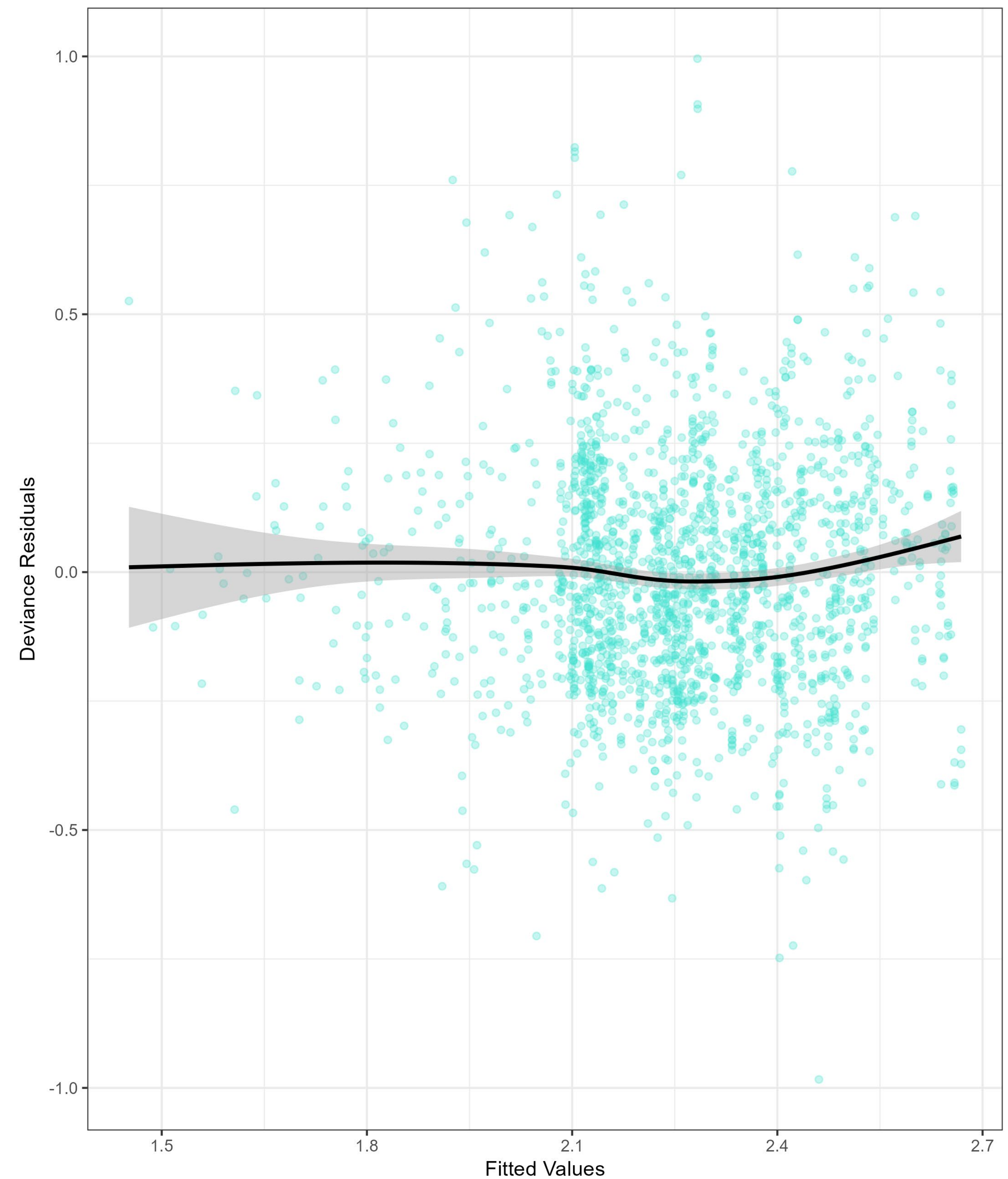
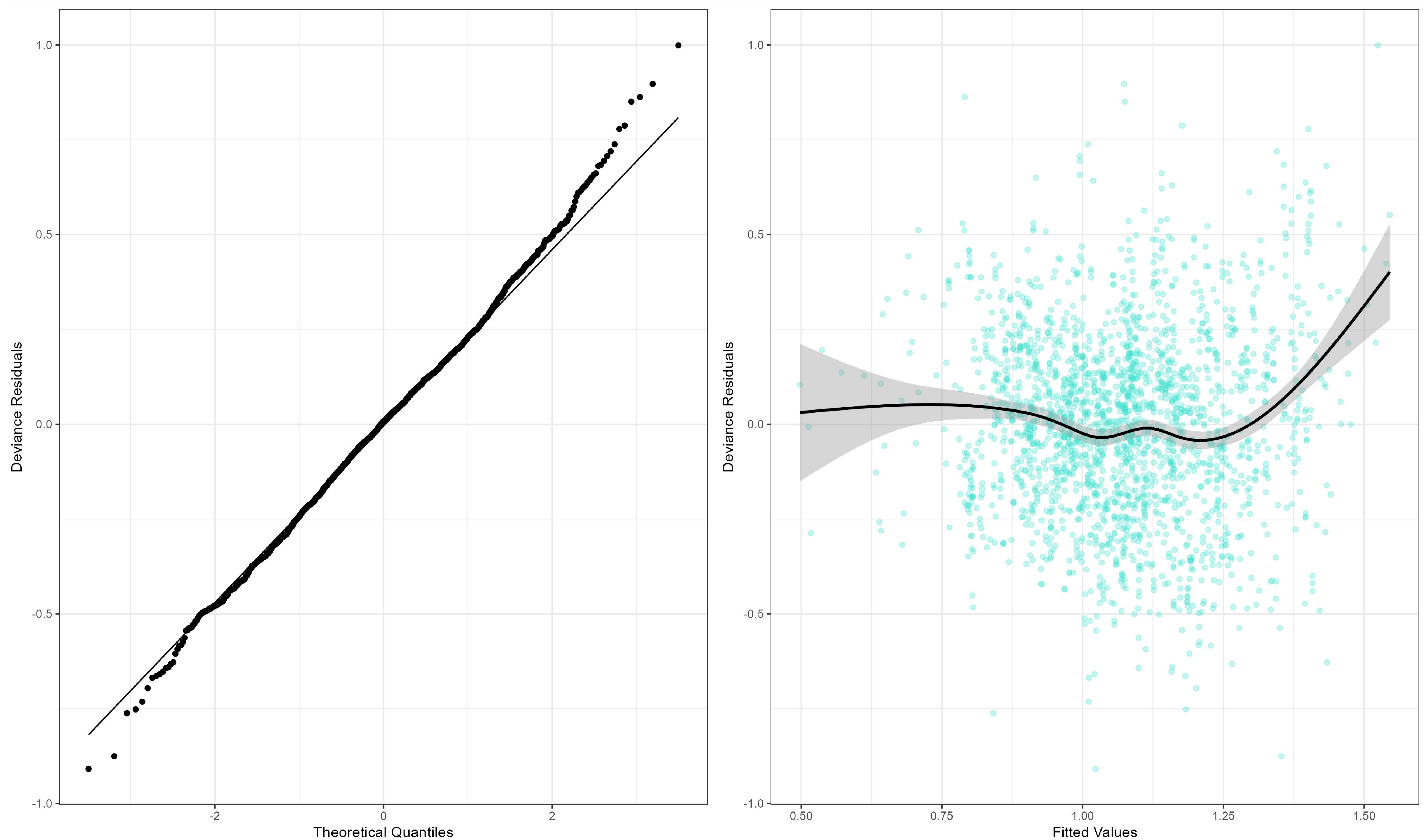




Left plot: QQ-plot of residuals (which are the differences between the observed values of the response variable and the predicted values of the response variable from the model) on the y-axis vs. theoretical quantiles on the x-axis. Used to assess the goodness of fit of a statistical model by comparing the distribution of the residuals to the expected distribution under the assumed model. If the data meets the assumptions of the model, these points should lie mostly along a straight line. However, GAMs are robust to deviations from normality so some points above or below the line do not necessarily indicate a problem.

Right plot: The y-axis represents the residuals, and the x-axis represents the predicted values of the response variable based on the model. The black line shows a loess smooth line through the points and the gray shading indicates the 95% CI of that fit. If the data meet the assumptions of the model, this line should be a straight line centered at 0. Small deviations are not considered to be problematic, but obvious patterning suggests a mis-specified model.

Figure F-31. Regression Diagnostic Plots for Zinc



Left plot: QQ-plot of residuals (which are the differences between the observed values of the response variable and the predicted values of the response variable from the model) on the y-axis vs. theoretical quantiles on the x-axis. Used to assess the goodness of fit of a statistical model by comparing the distribution of the residuals to the expected distribution under the assumed model. If the data meets the assumptions of the model, these points should lie mostly along a straight line. However, GAMs are robust to deviations from normality so some points above or below the line do not necessarily indicate a problem.

Right plot: The y-axis represents the residuals, and the x-axis represents the predicted values of the response variable based on the model. The black line shows a loess smooth line through the points and the gray shading indicates the 95% CI of that fit. If the data meet the assumptions of the model, this line should be a straight line centered at 0. Small deviations are not considered to be problematic, but obvious patterning suggests a mis-specified model.

Figure F-32. Regression Diagnostic Plots for Arsenic
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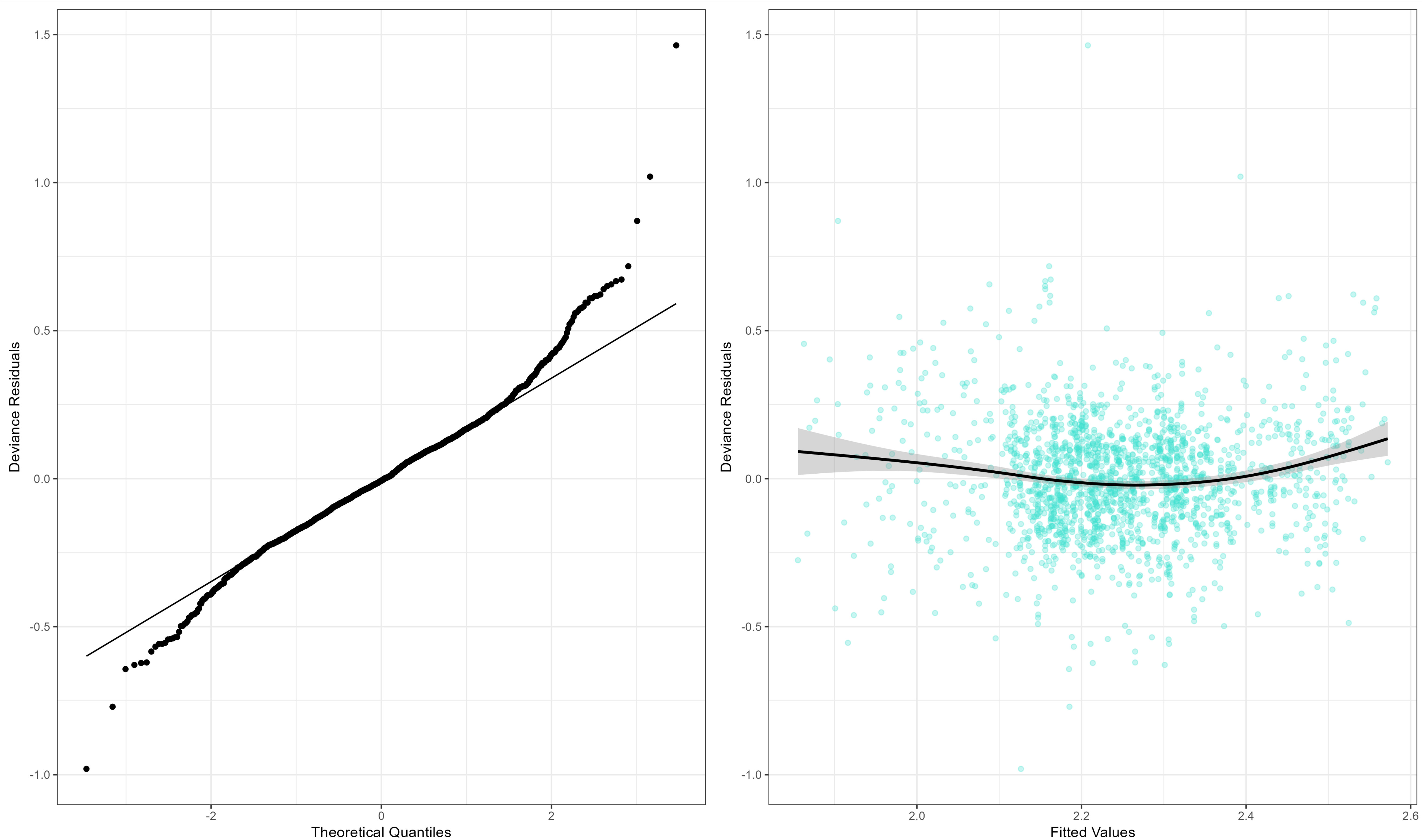
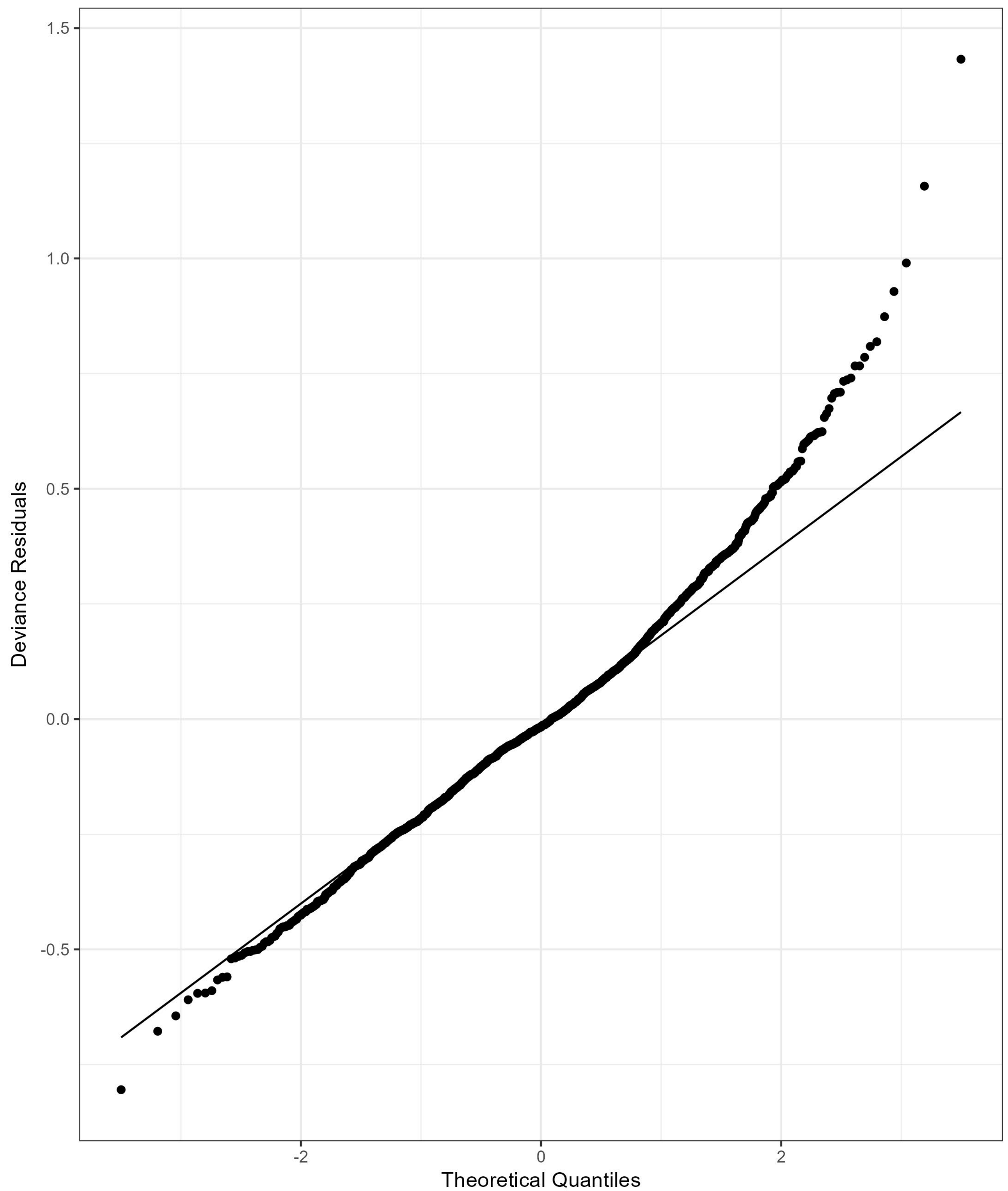
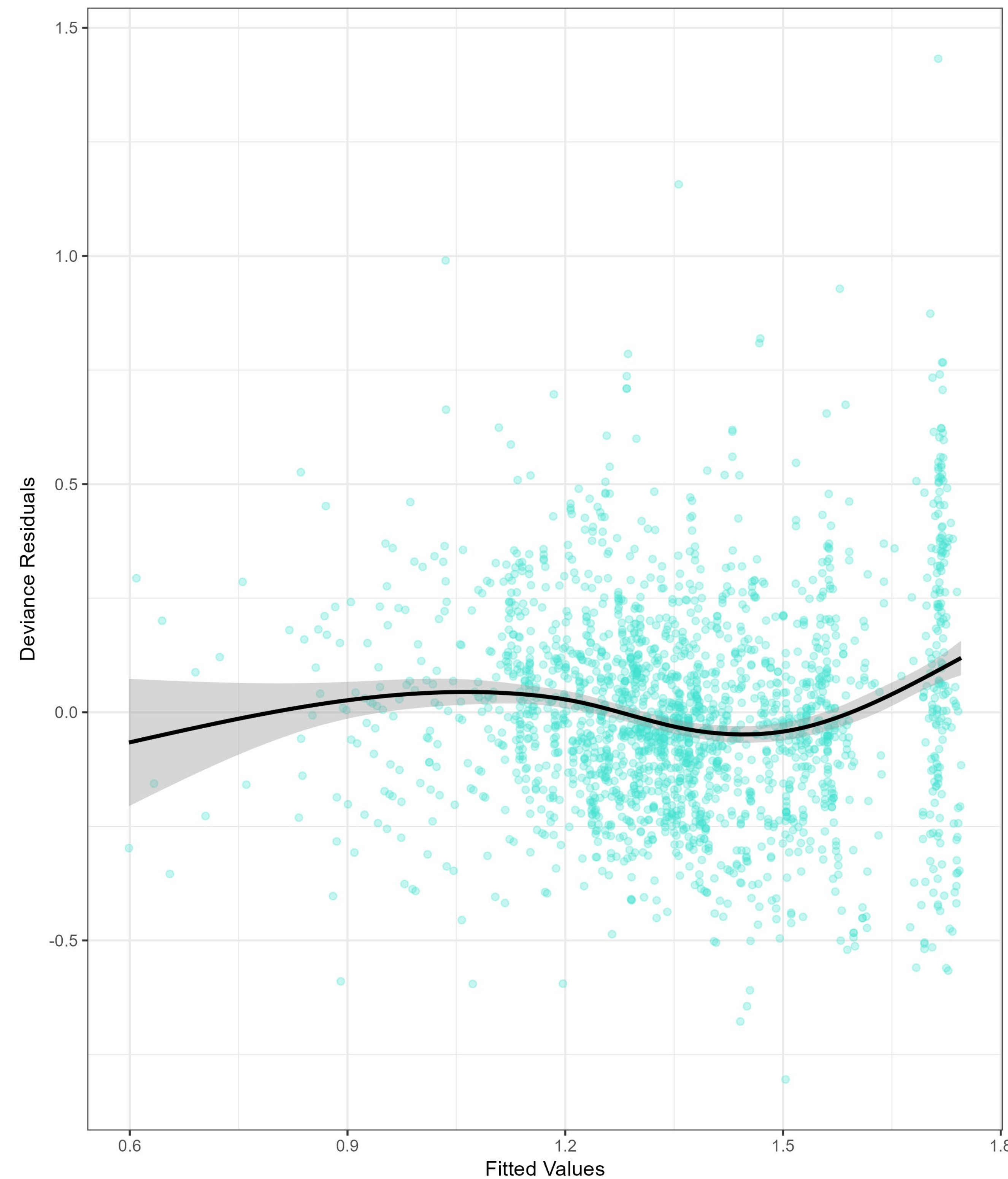


Left plot: QQ-plot of residuals (which are the differences between the observed values of the response variable and the predicted values of the response variable from the model) on the y-axis vs. theoretical quantiles on the x-axis. Used to assess the goodness of fit of a statistical model by comparing the distribution of the residuals to the expected distribution under the assumed model. If the data meets the assumptions of the model, these points should lie mostly along a straight line. However, GAMs are robust to deviations from normality so some points above or below the line do not necessarily indicate a problem.

Right plot: The y-axis represents the residuals, and the x-axis represents the predicted values of the response variable based on the model. The black line shows a loess smooth line through the points and the gray shading indicates the 95% CI of that fit. If the data meet the assumptions of the model, this line should be a straight line centered at 0. Small deviations are not considered to be problematic, but obvious patterning suggests a mis-specified model.

Figure F-33. Regression Diagnostic Plots for Barium

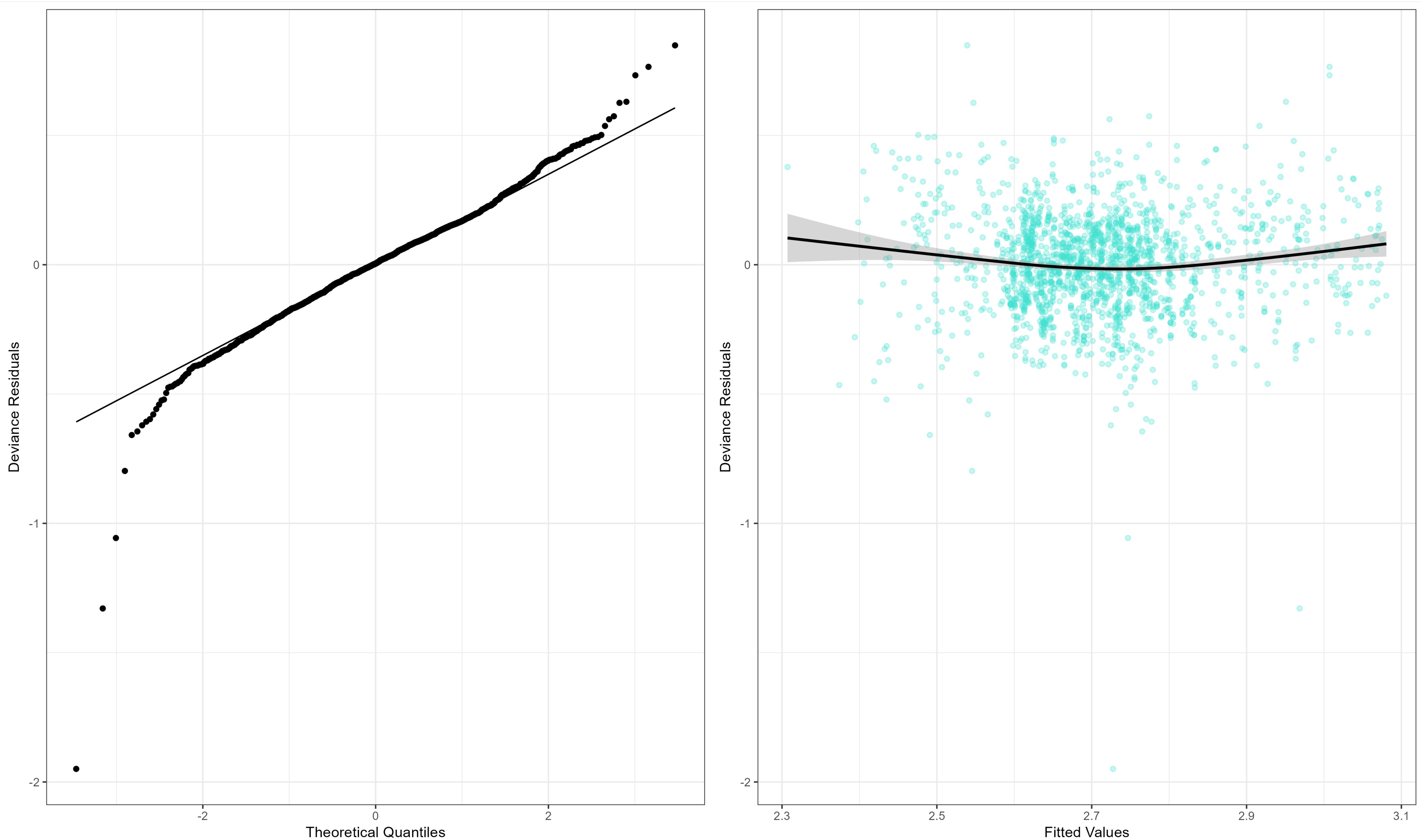




Left plot: QQ-plot of residuals (which are the differences between the observed values of the response variable and the predicted values of the response variable from the model) on the y-axis vs. theoretical quantiles on the x-axis. Used to assess the goodness of fit of a statistical model by comparing the distribution of the residuals to the expected distribution under the assumed model. If the data meets the assumptions of the model, these points should lie mostly along a straight line. However, GAMs are robust to deviations from normality so some points above or below the line do not necessarily indicate a problem.

Right plot: The y-axis represents the residuals, and the x-axis represents the predicted values of the response variable based on the model. The black line shows a loess smooth line through the points and the gray shading indicates the 95% CI of that fit. If the data meet the assumptions of the model, this line should be a straight line centered at 0. Small deviations are not considered to be problematic, but obvious patterning suggests a mis-specified model.

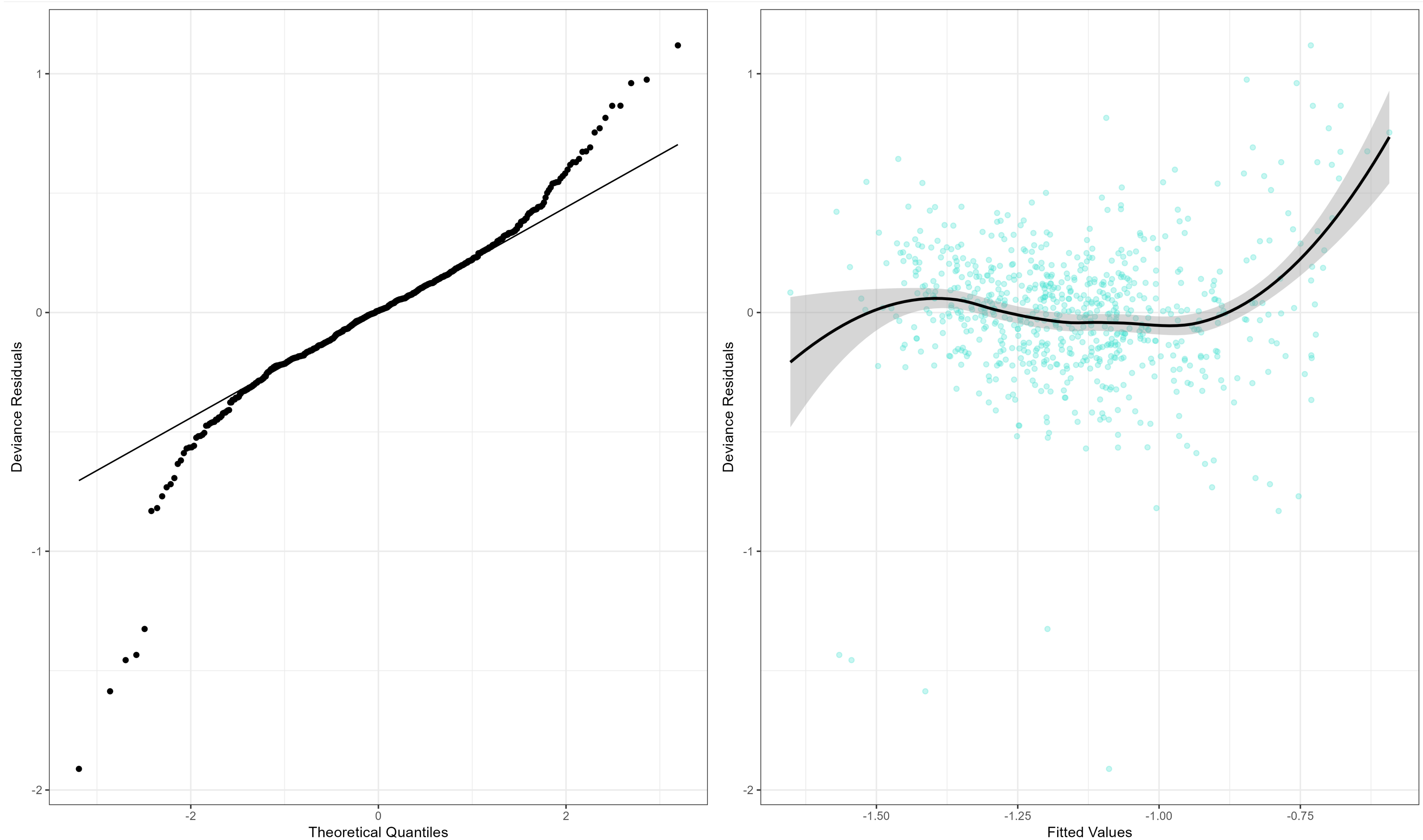
Figure F-34. Regression Diagnostic Plots for Copper



Left plot: QQ-plot of residuals (which are the differences between the observed values of the response variable and the predicted values of the response variable from the model) on the y-axis vs. theoretical quantiles on the x-axis. Used to assess the goodness of fit of a statistical model by comparing the distribution of the residuals to the expected distribution under the assumed model. If the data meets the assumptions of the model, these points should lie mostly along a straight line. However, GAMs are robust to deviations from normality so some points above or below the line do not necessarily indicate a problem.

Right plot: The y-axis represents the residuals, and the x-axis represents the predicted values of the response variable based on the model. The black line shows a loess smooth line through the points and the gray shading indicates the 95% CI of that fit. If the data meet the assumptions of the model, this line should be a straight line centered at 0. Small deviations are not considered to be problematic, but obvious patterning suggests a mis-specified model.

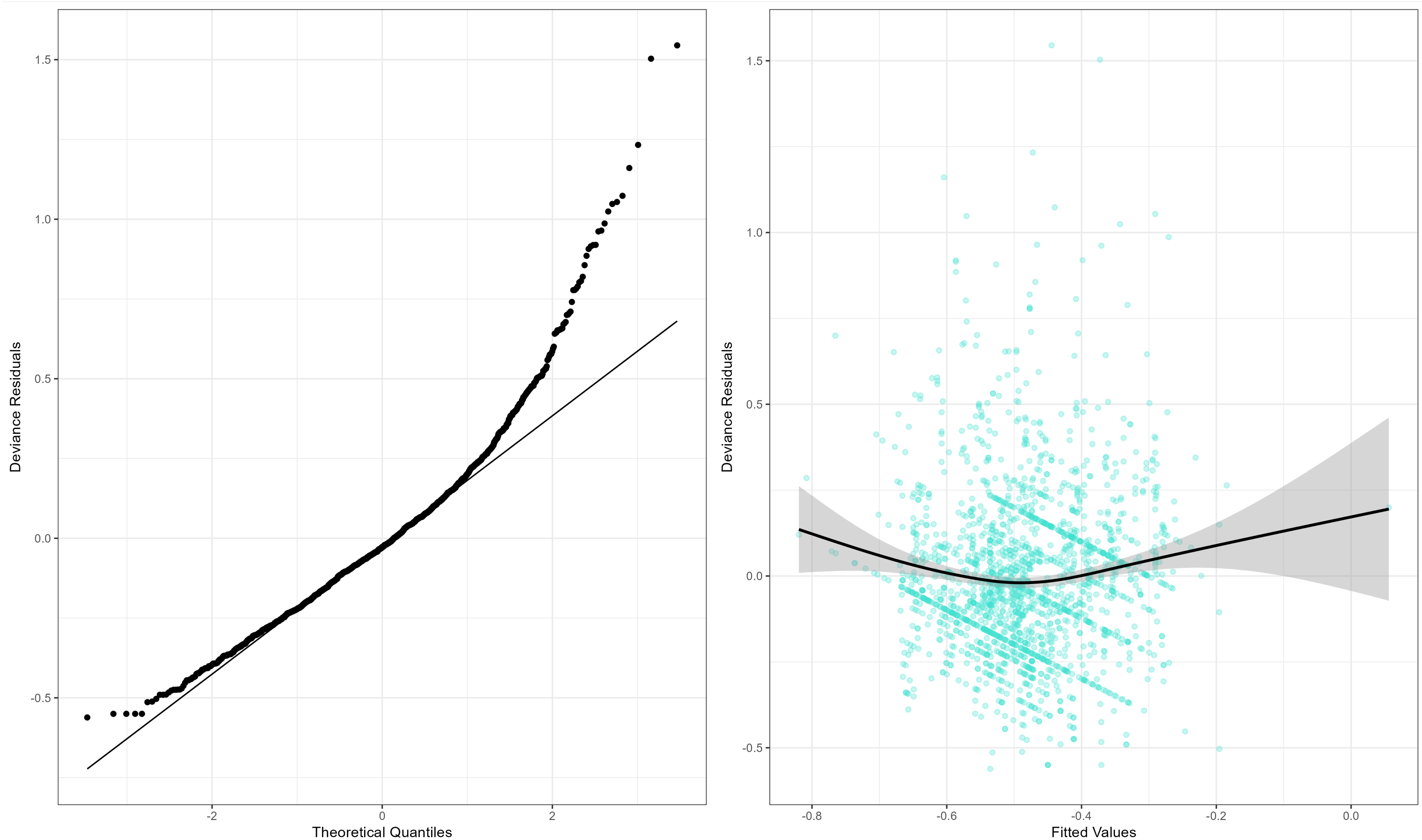
Figure F-35. Regression Diagnostic Plots for Manganese



Left plot: QQ-plot of residuals (which are the differences between the observed values of the response variable and the predicted values of the response variable from the model) on the y-axis vs. theoretical quantiles on the x-axis. Used to assess the goodness of fit of a statistical model by comparing the distribution of the residuals to the expected distribution under the assumed model. If the data meets the assumptions of the model, these points should lie mostly along a straight line. However, GAMs are robust to deviations from normality so some points above or below the line do not necessarily indicate a problem.

Right plot: The y-axis represents the residuals, and the x-axis represents the predicted values of the response variable based on the model. The black line shows a loess smooth line through the points and the gray shading indicates the 95% CI of that fit. If the data meet the assumptions of the model, this line should be a straight line centered at 0. Small deviations are not considered to be problematic, but obvious patterning suggests a mis-specified model.

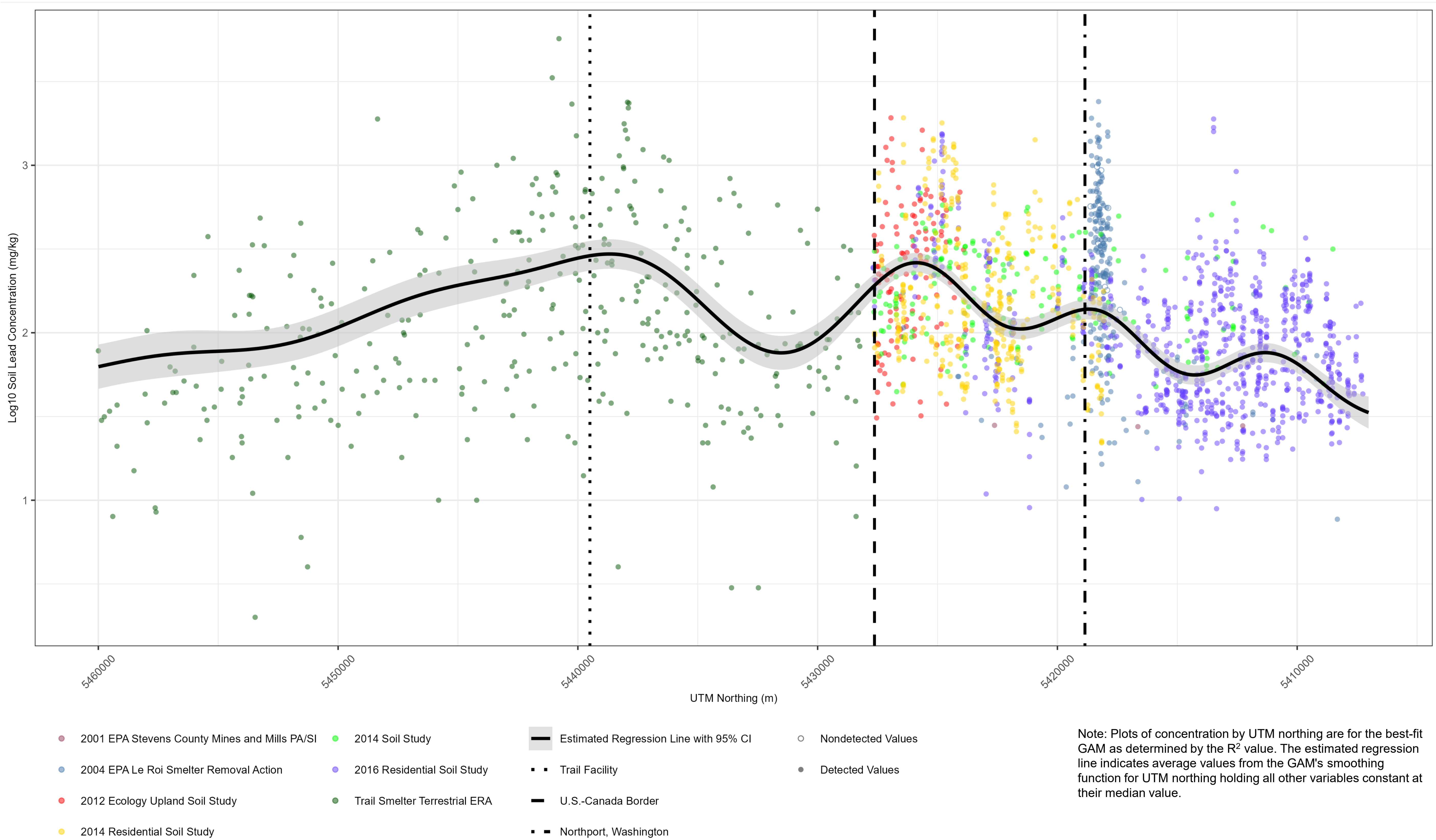
Figure F-36. Regression Diagnostic Plots for Mercury



Left plot: QQ-plot of residuals (which are the differences between the observed values of the response variable and the predicted values of the response variable from the model) on the y-axis vs. theoretical quantiles on the x-axis. Used to assess the goodness of fit of a statistical model by comparing the distribution of the residuals to the expected distribution under the assumed model. If the data meets the assumptions of the model, these points should lie mostly along a straight line. However, GAMs are robust to deviations from normality so some points above or below the line do not necessarily indicate a problem.

Right plot: The y-axis represents the residuals, and the x-axis represents the predicted values of the response variable based on the model. The black line shows a loess smooth line through the points and the gray shading indicates the 95% CI of that fit. If the data meet the assumptions of the model, this line should be a straight line centered at 0. Small deviations are not considered to be problematic, but obvious patterning suggests a mis-specified model.

Figure F-37. Regression Diagnostic Plots for Selenium



Note: Plots of concentration by UTM northing are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for UTM northing holding all other variables constant at their median value.

Figure F-38. Soil Lead Concentrations versus Distance from the Trail Facility

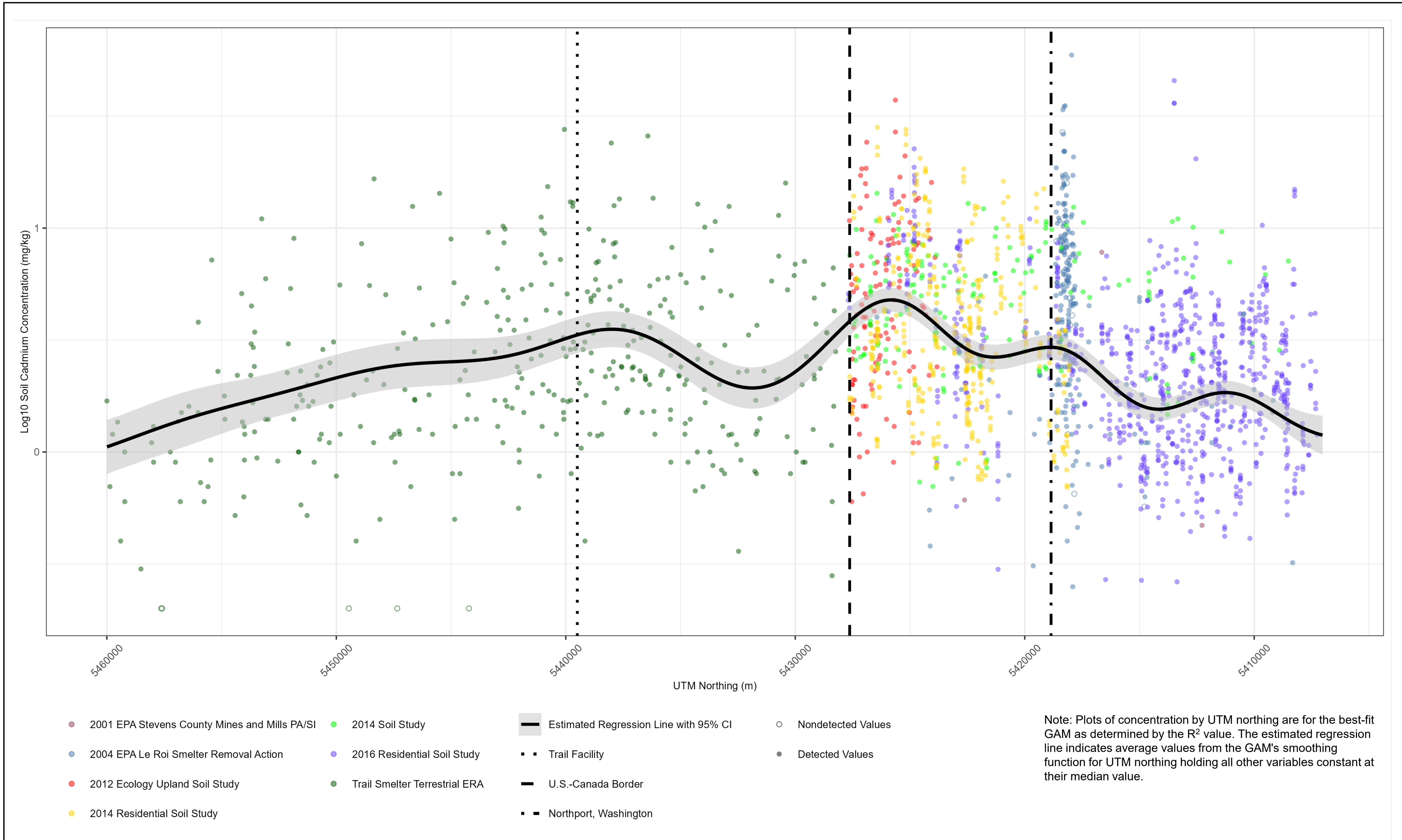
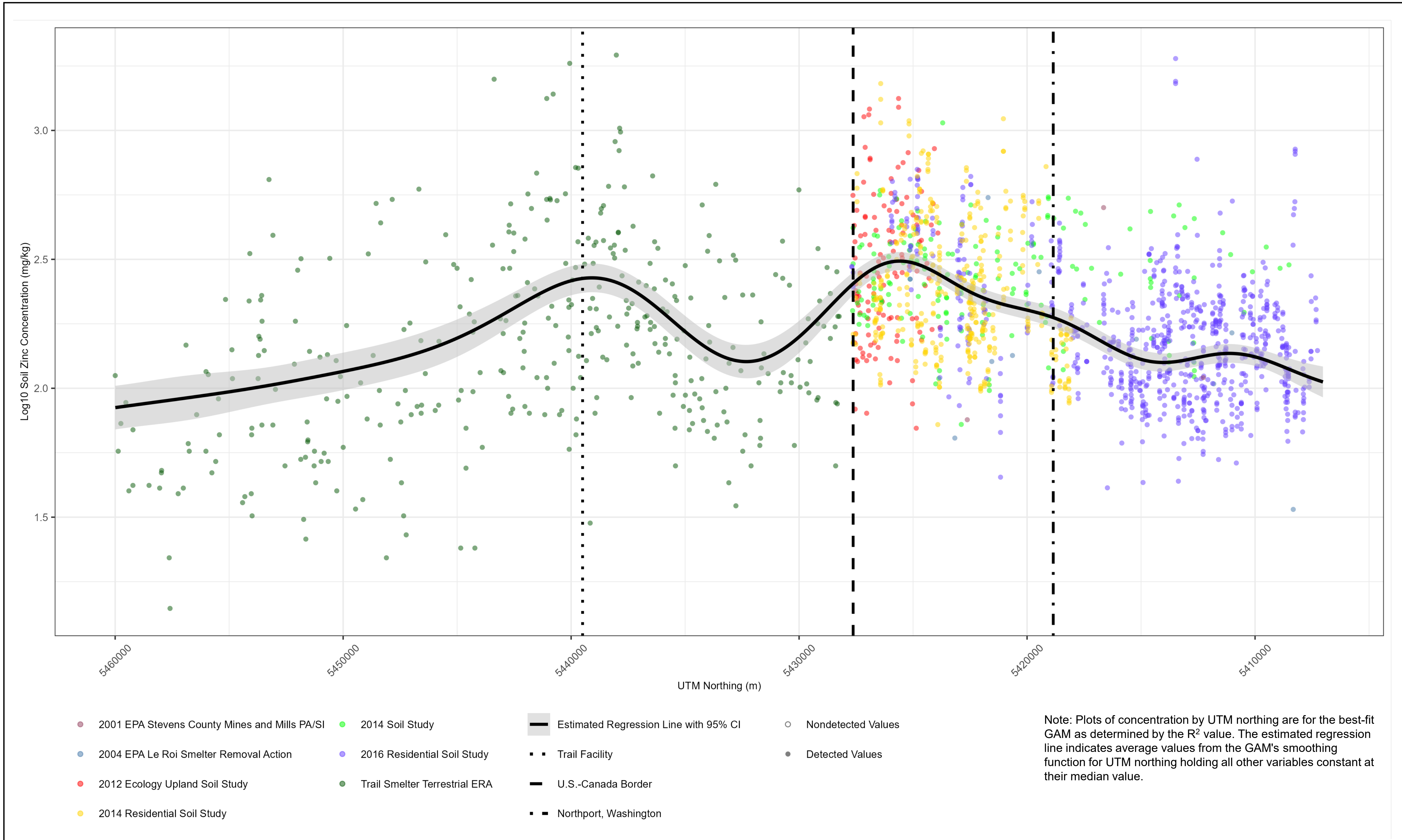


Figure F-39. Soil Cadmium Concentrations versus Distance from the Trail Facility



Note: Plots of concentration by UTM northing are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for UTM northing holding all other variables constant at their median value.

Figure F-40. Soil Zinc Concentrations versus Distance from the Trail Facility

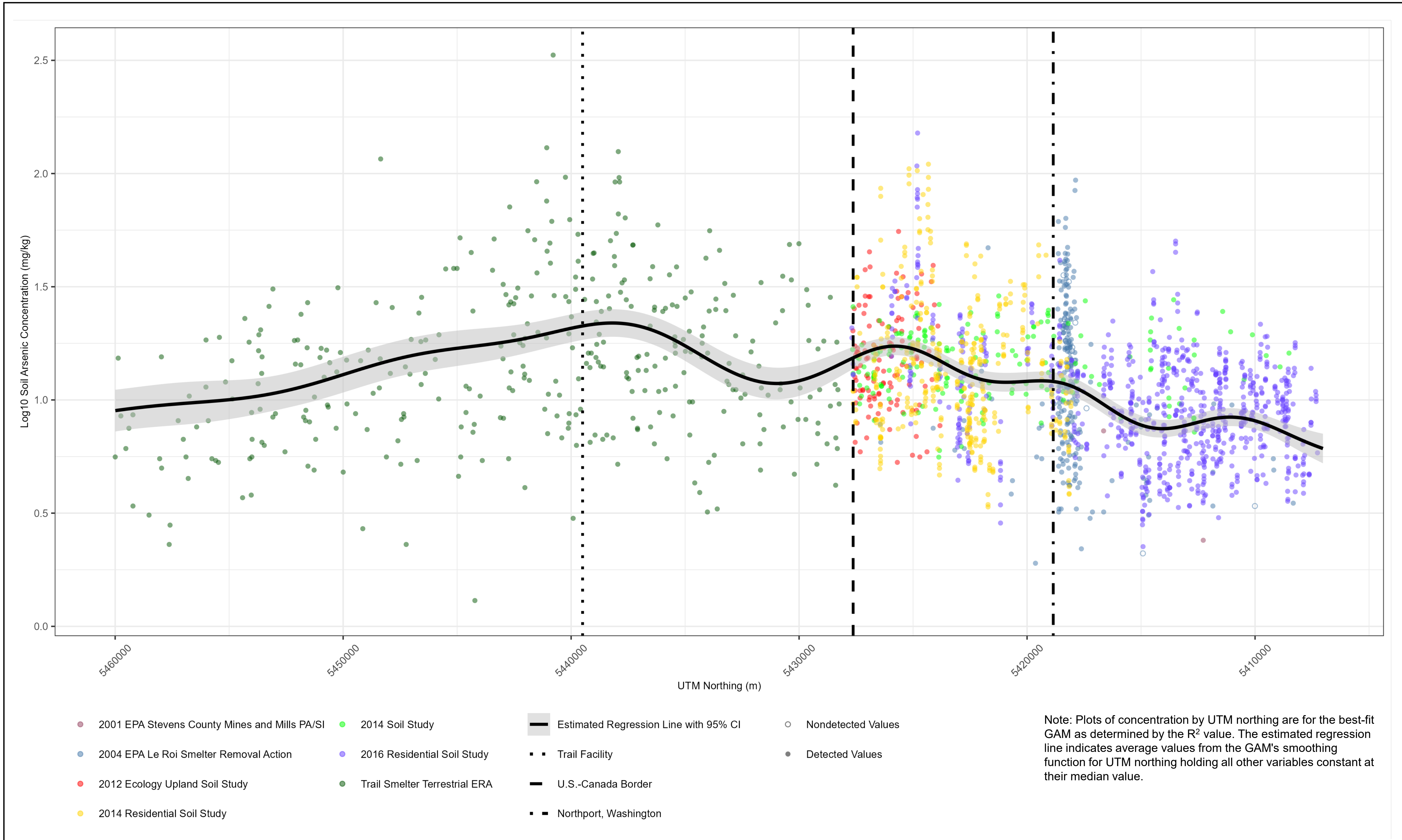


Figure F-41. Soil Arsenic Concentrations versus Distance from the Trail Facility

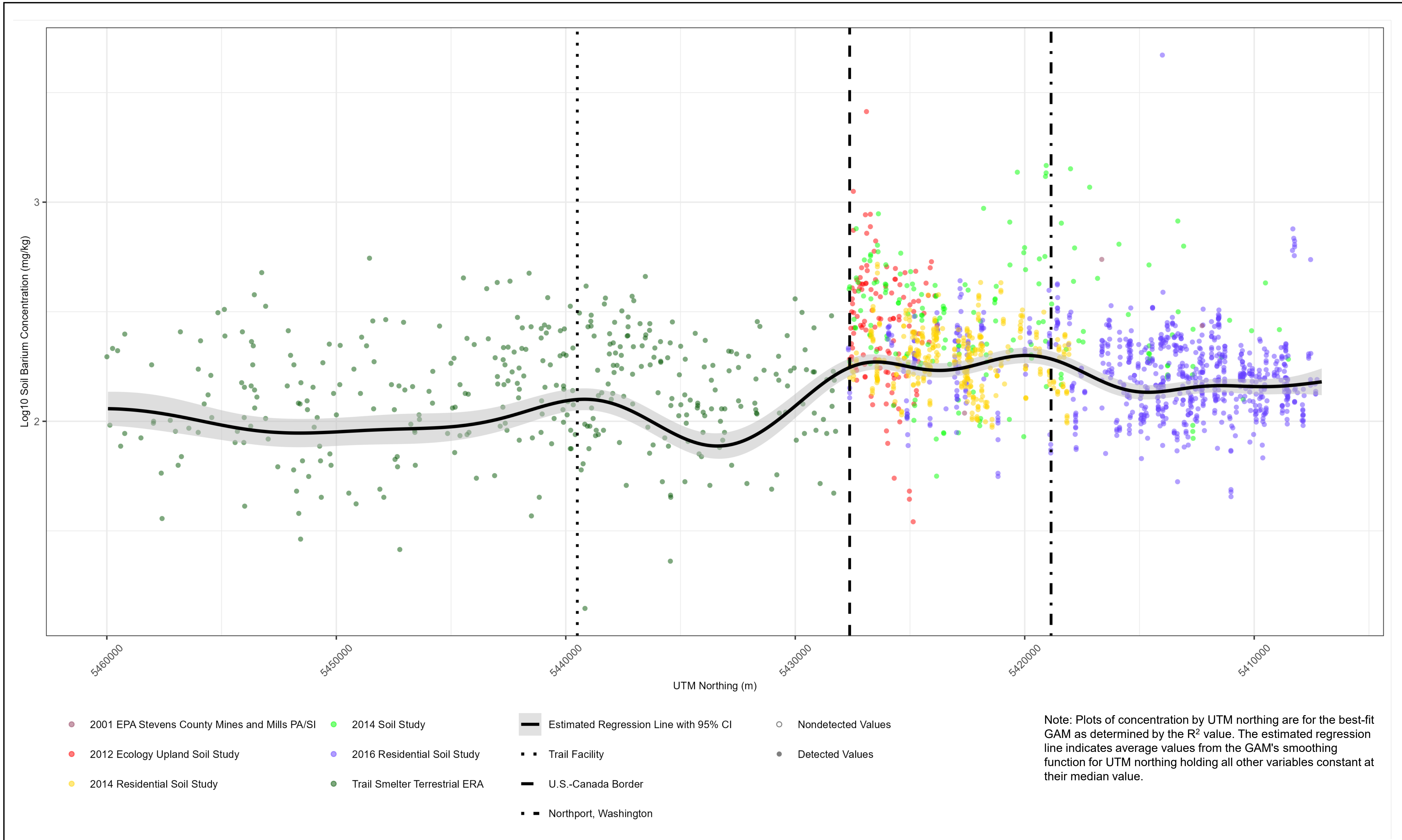


Figure F-42. Soil Barium Concentrations versus Distance from the Trail Facility

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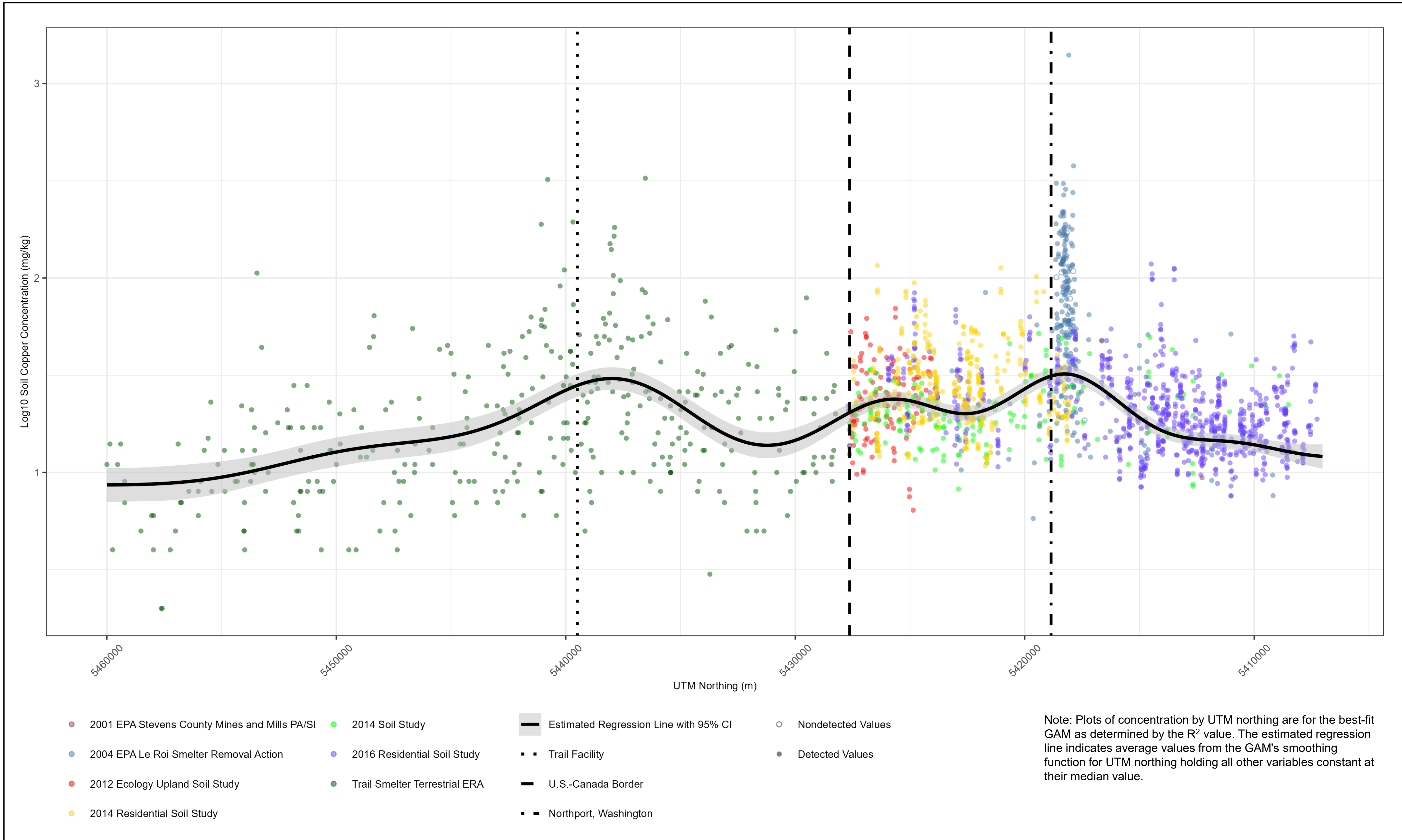

Figure F-43. Soil Copper Concentrations versus Distance from the Trail Facility

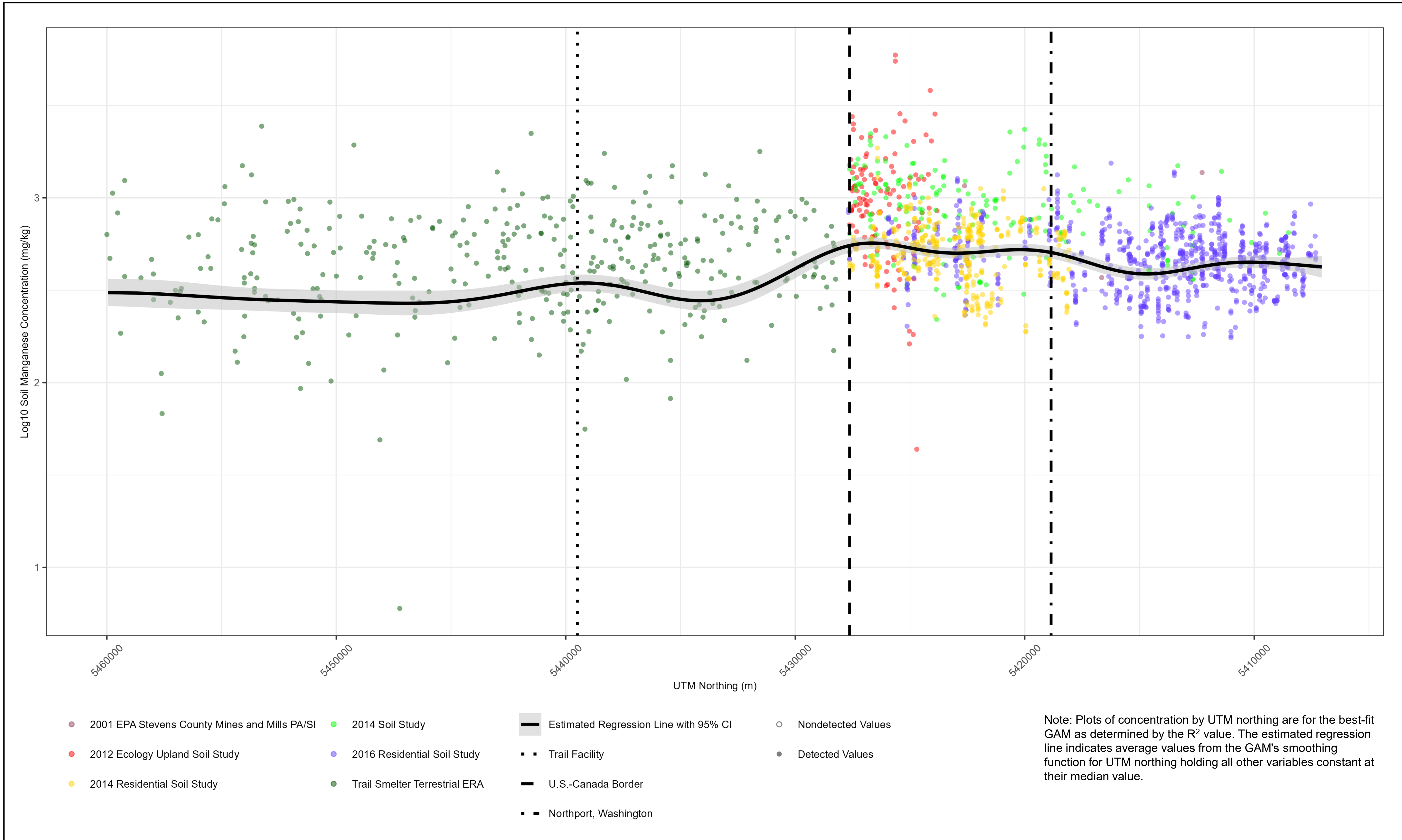

Figure F-44. Soil Manganese Concentrations versus Distance from the Trail Facility

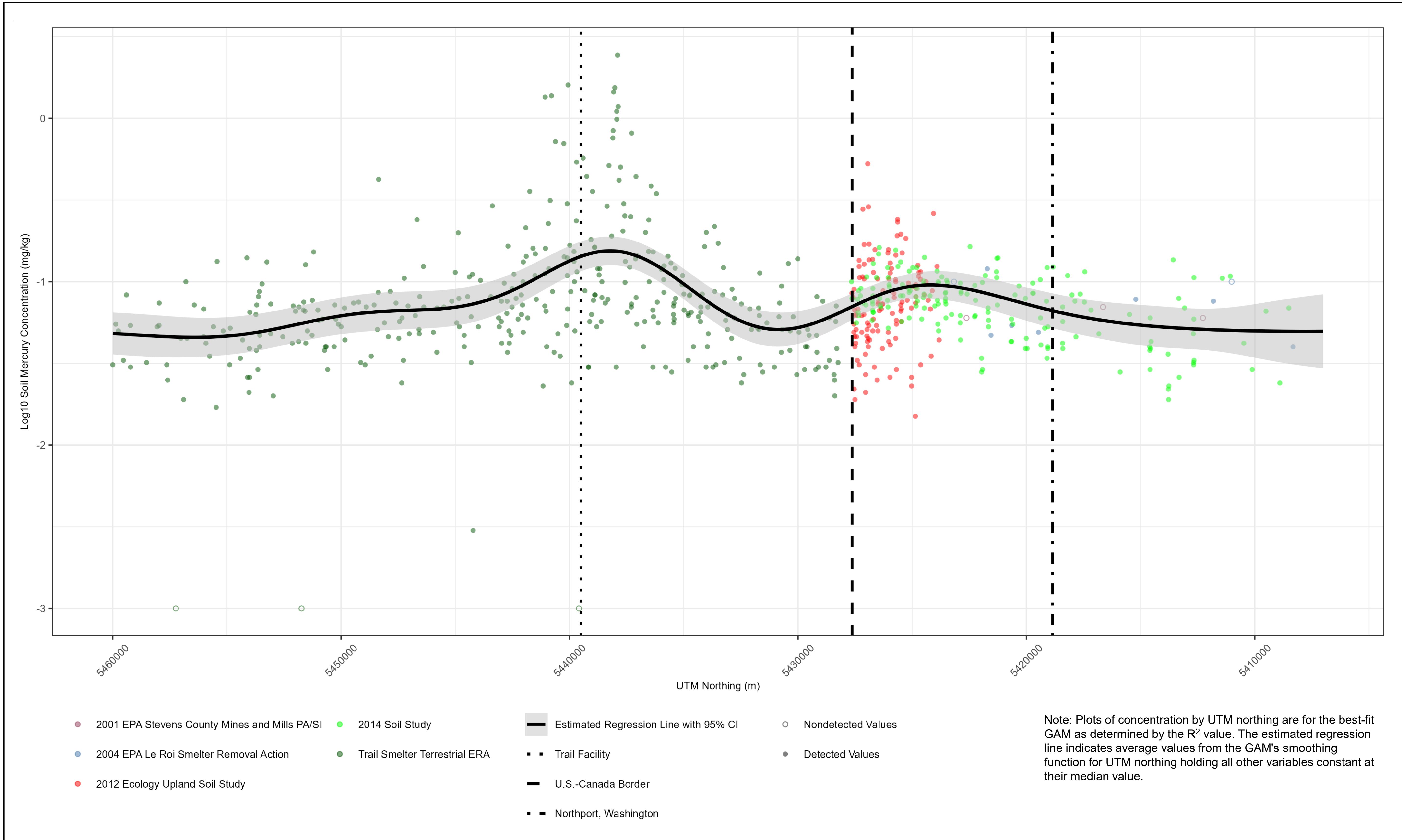

Figure F-45. Soil Mercury Concentrations versus Distance from the Trail Facility

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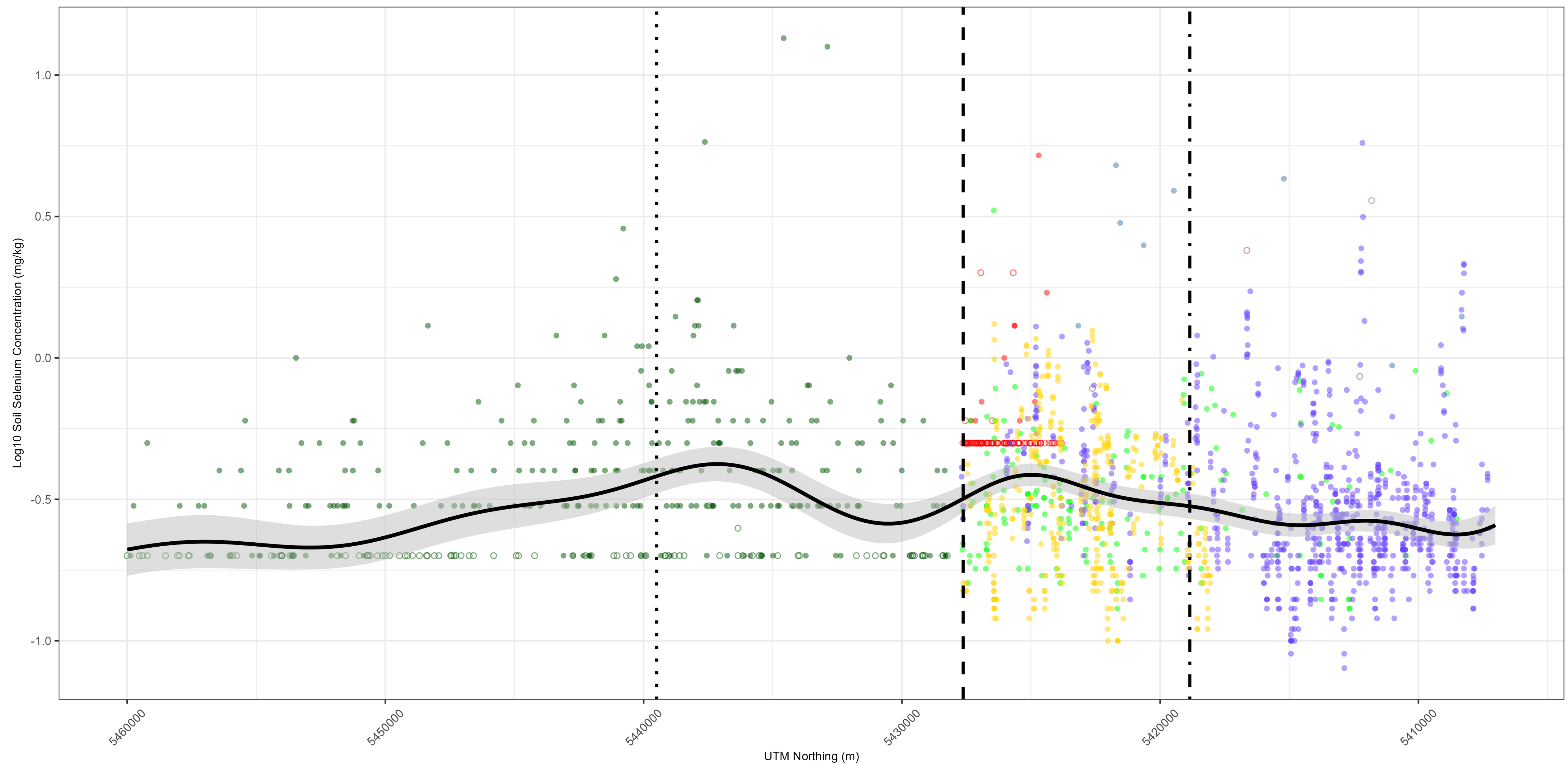


Note: Plots of concentration by UTM northing are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for UTM northing holding all other variables constant at their median value.

Figure F-46. Soil Selenium Concentrations versus Distance from the Trail Facility

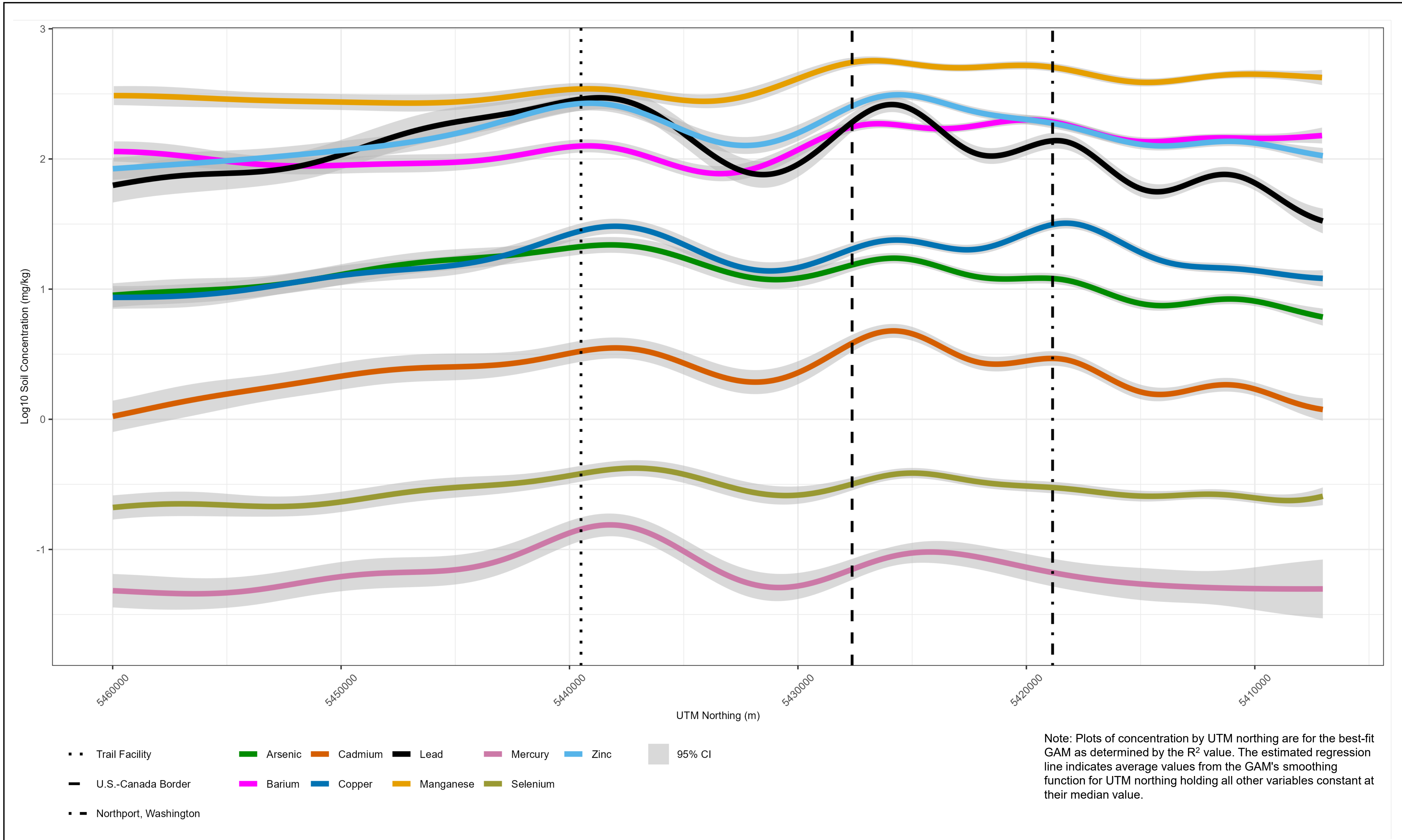
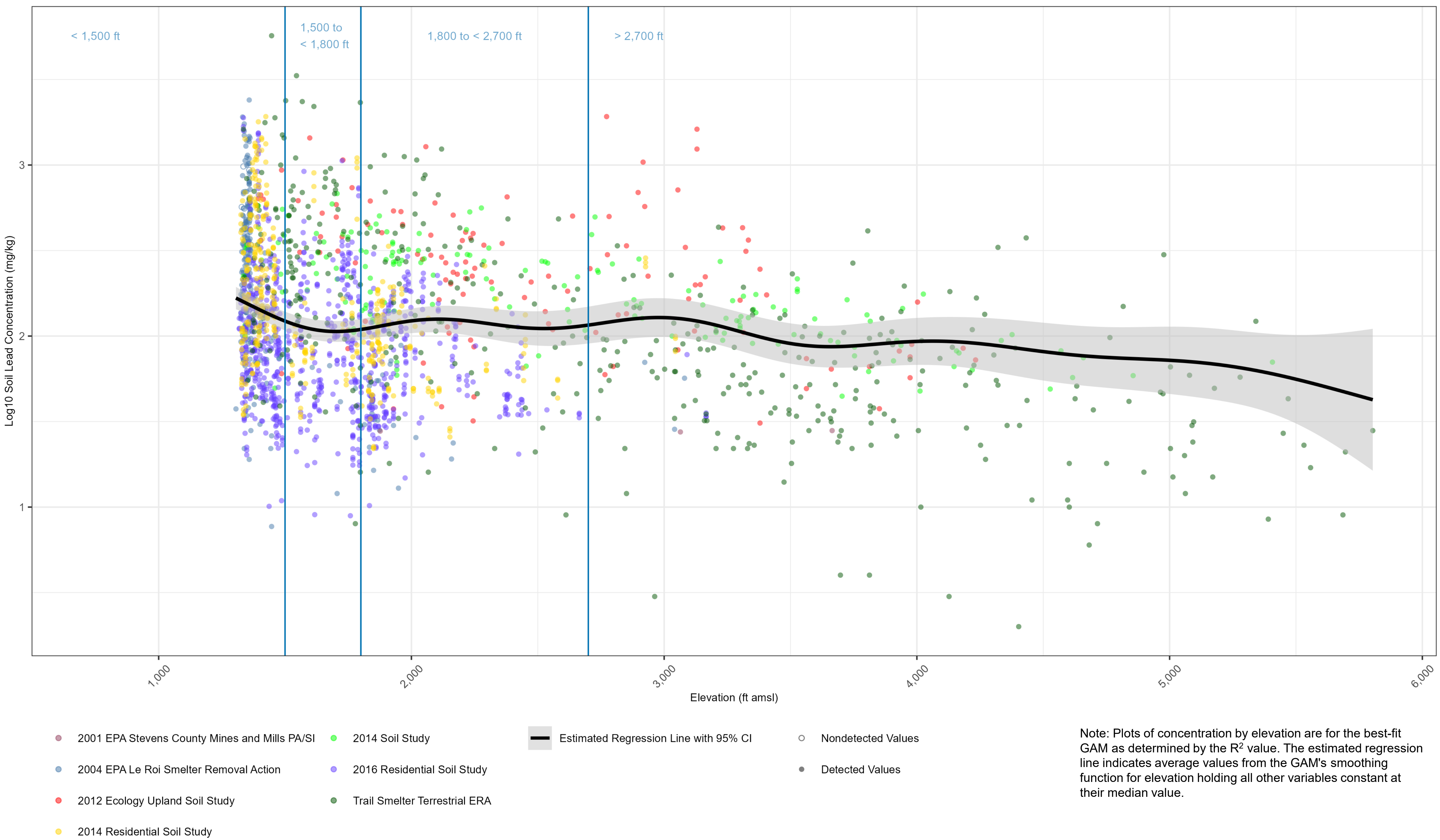
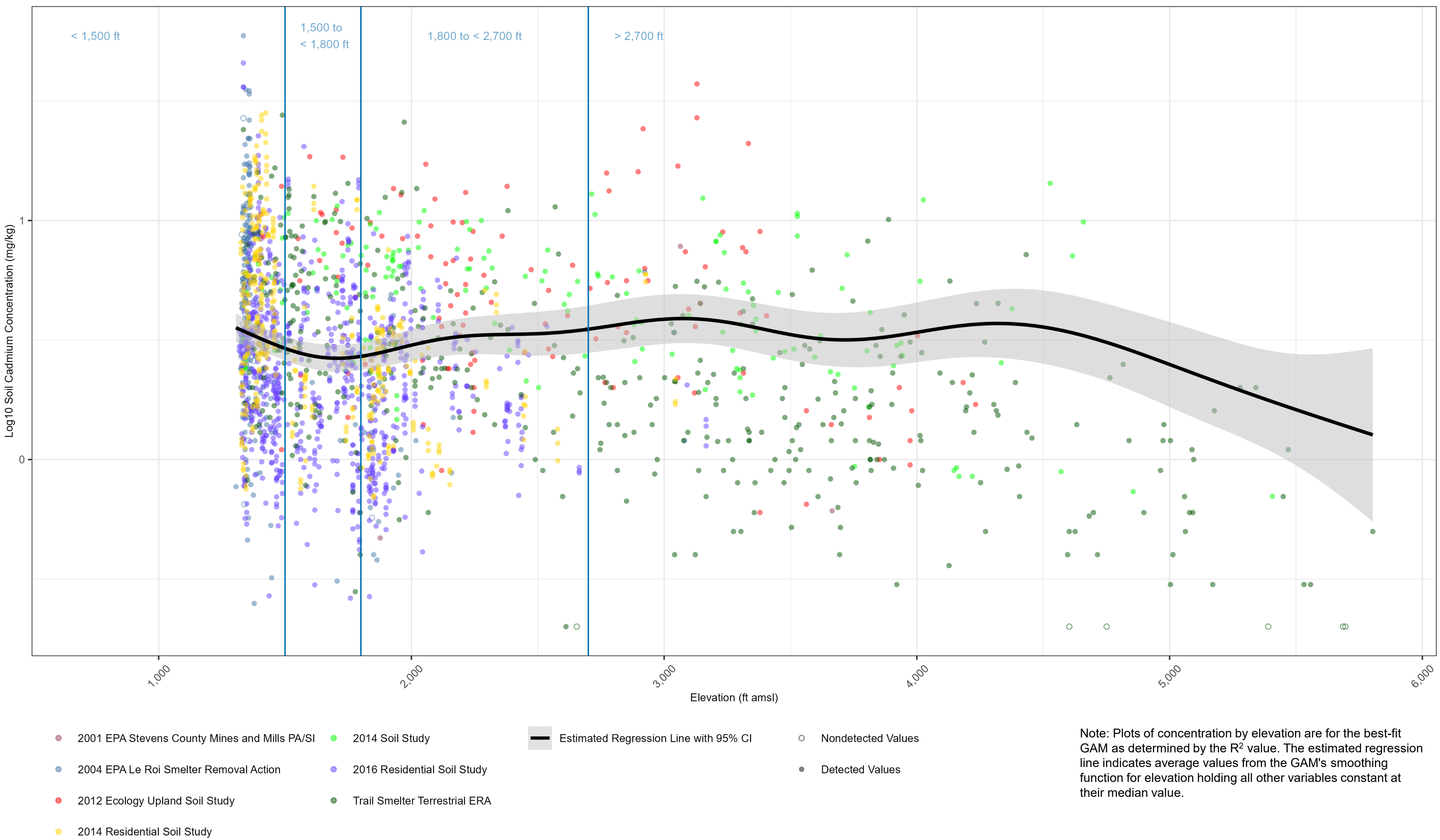


Figure F-47. Soil COC Concentrations versus Distance from the Trail Facility



Note: Plots of concentration by elevation are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for elevation holding all other variables constant at their median value.

Figure F-48. Soil Lead Concentrations versus Elevation



Note: Plots of concentration by elevation are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for elevation holding all other variables constant at their median value.

Figure F-49. Soil Cadmium Concentrations versus Elevation

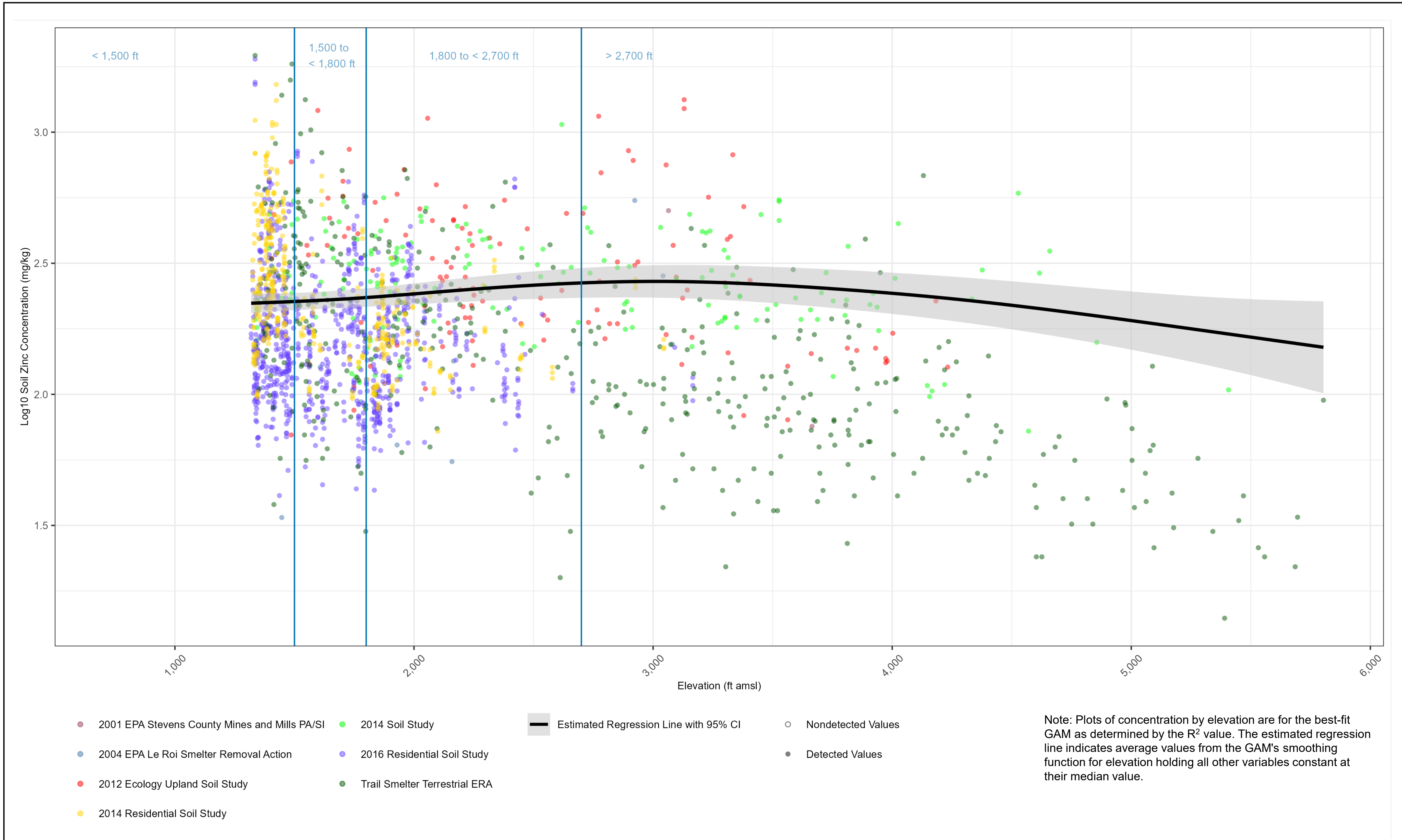


Figure F-50. Soil Zinc Concentrations versus Elevation

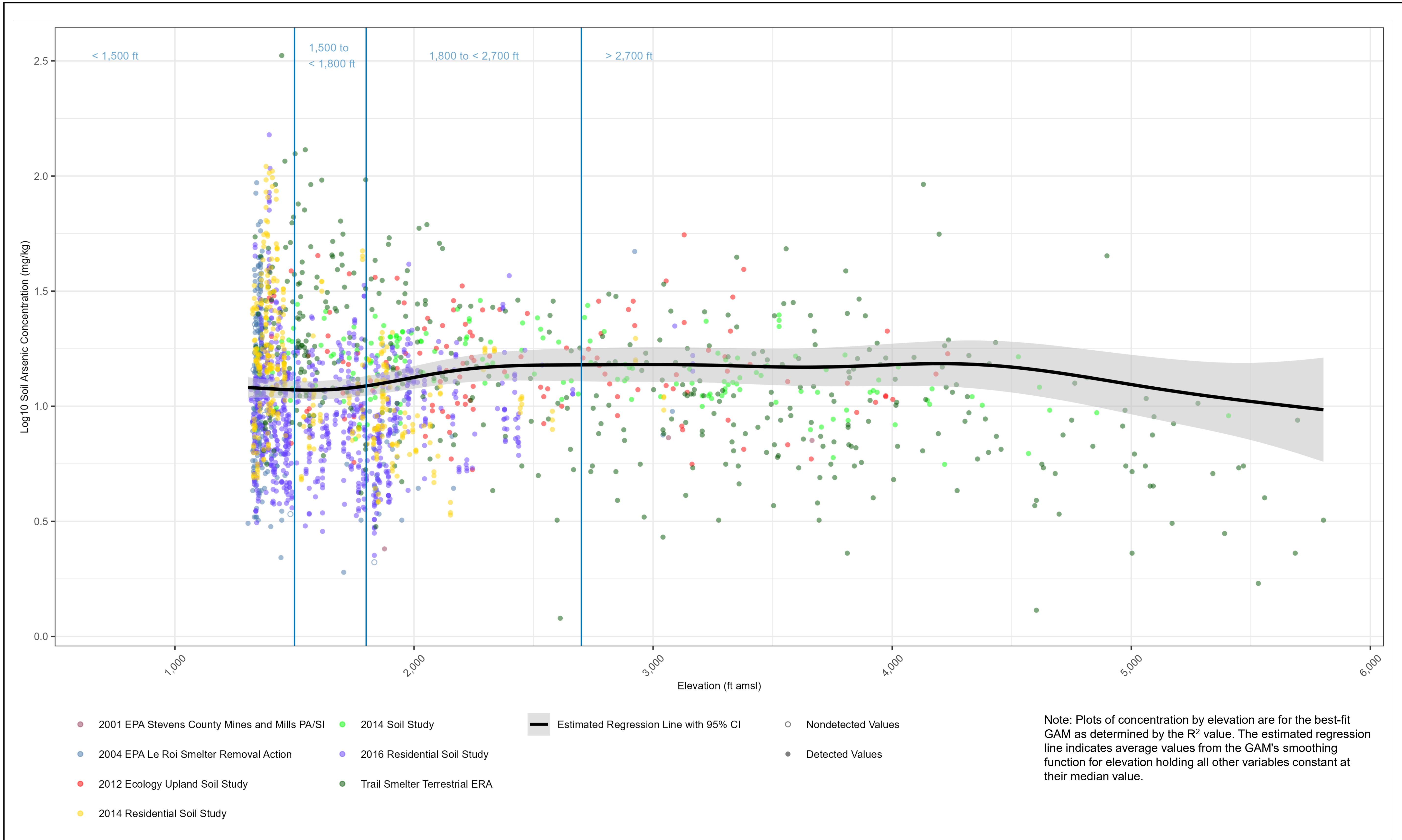
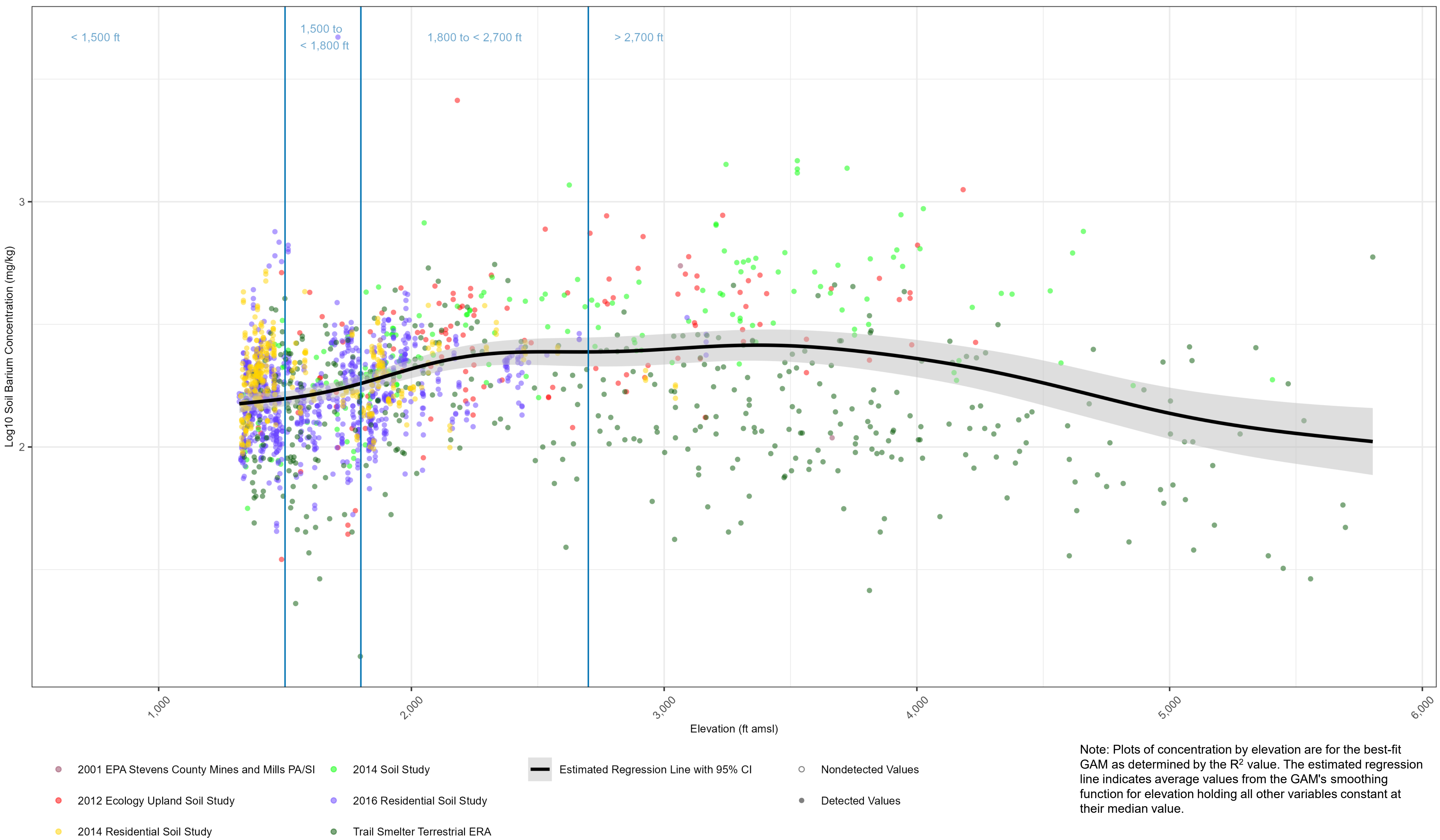


Figure F-51. Soil Arsenic Concentrations versus Elevation



Note: Plots of concentration by elevation are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for elevation holding all other variables constant at their median value.

Figure F-52. Soil Barium Concentrations versus Elevation

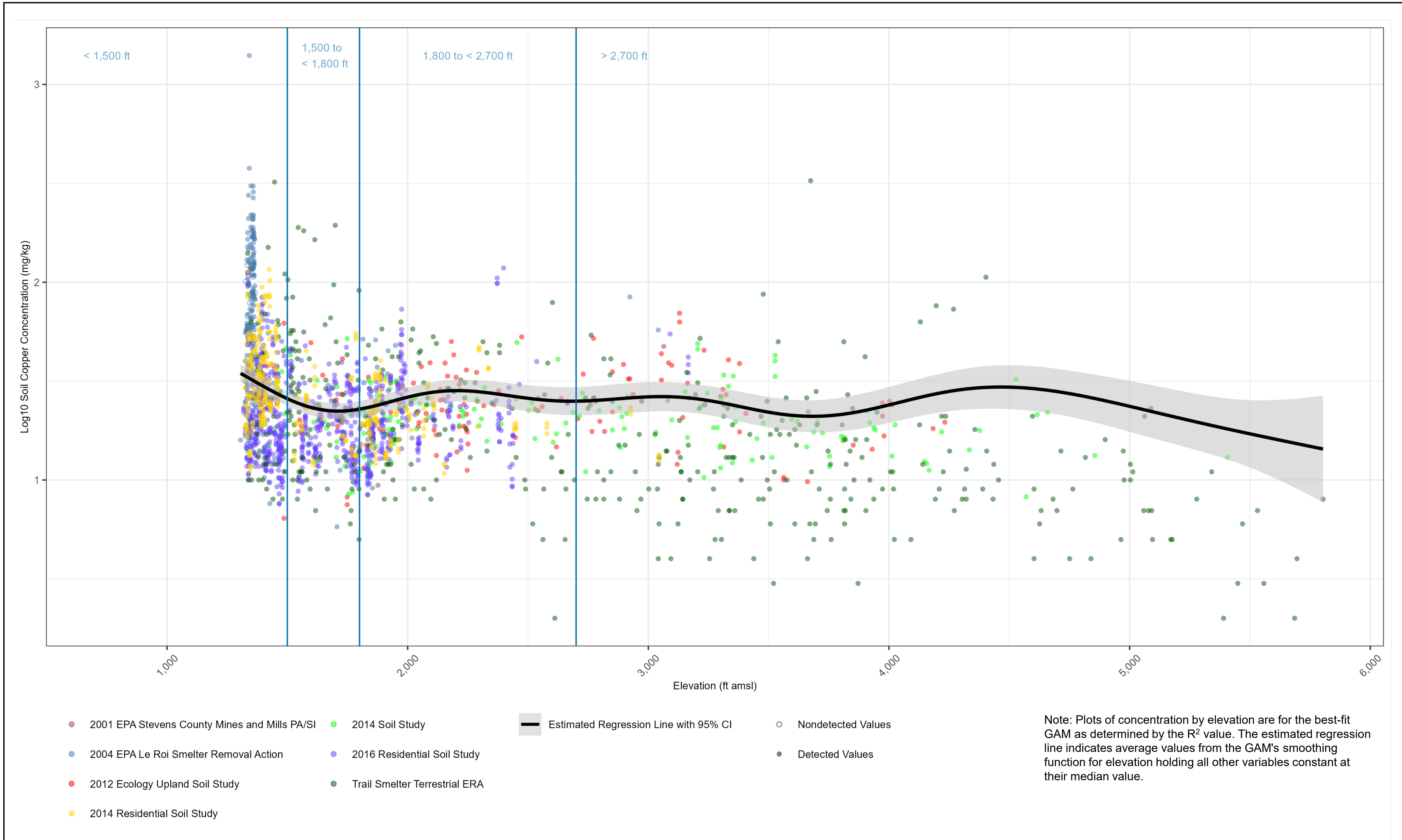
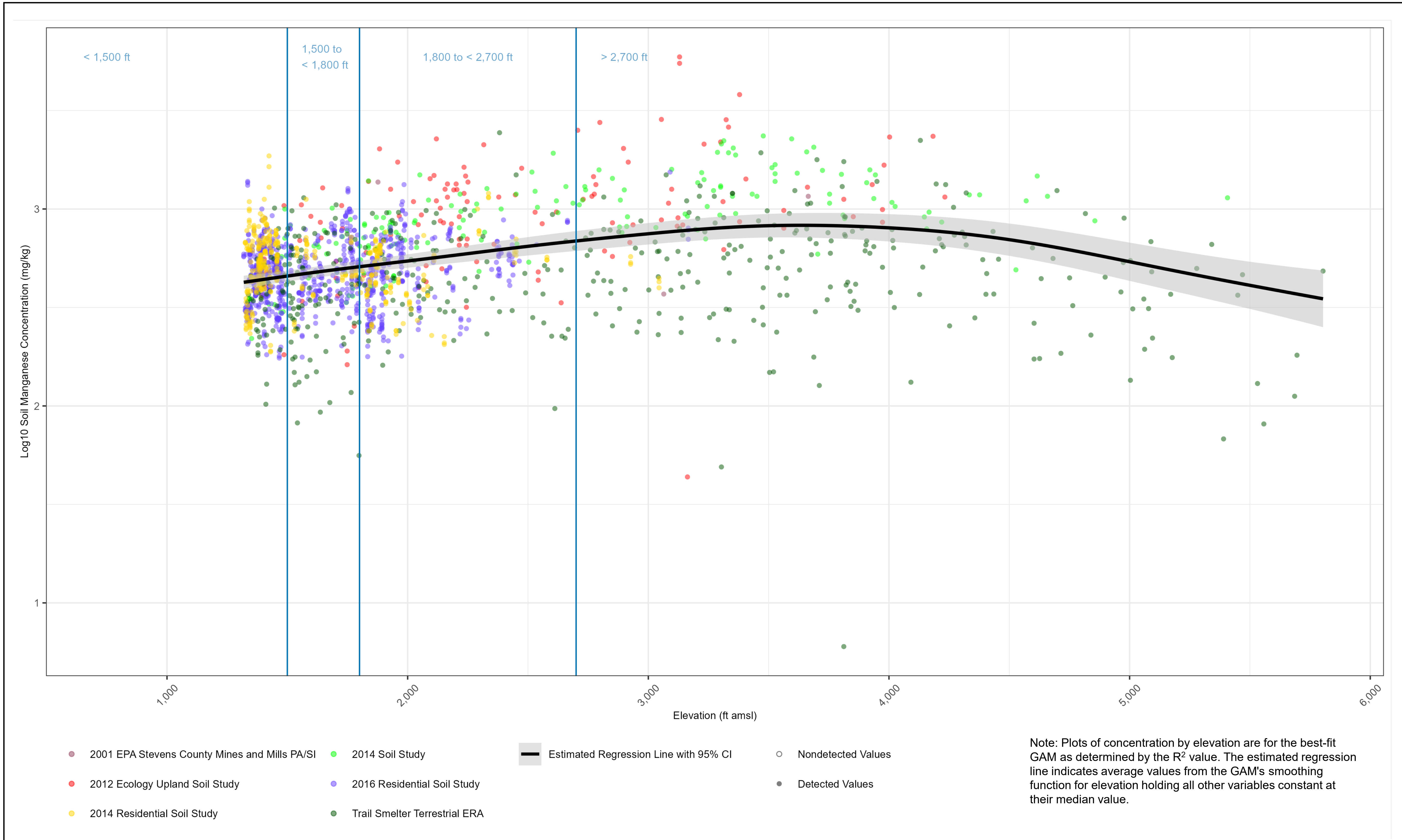
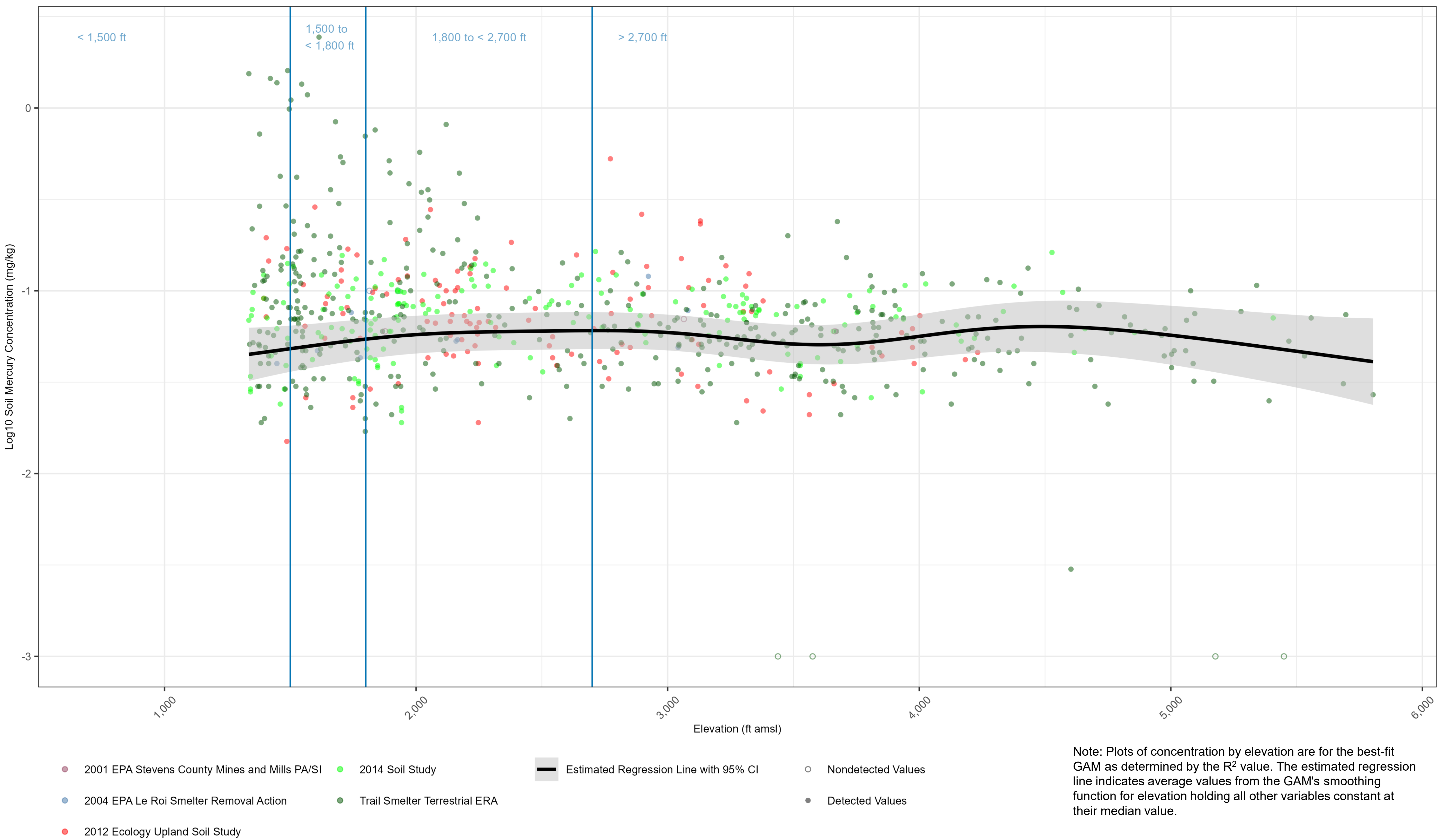


Figure F-53. Soil Copper Concentrations versus Elevation



Note: Plots of concentration by elevation are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for elevation holding all other variables constant at their median value.

Figure F-54. Soil Manganese Concentrations versus Elevation
Final Upland RI Report
Upper Columbia River, Washington



Note: Plots of concentration by elevation are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for elevation holding all other variables constant at their median value.

Figure F-55. Soil Mercury Concentrations versus Elevation

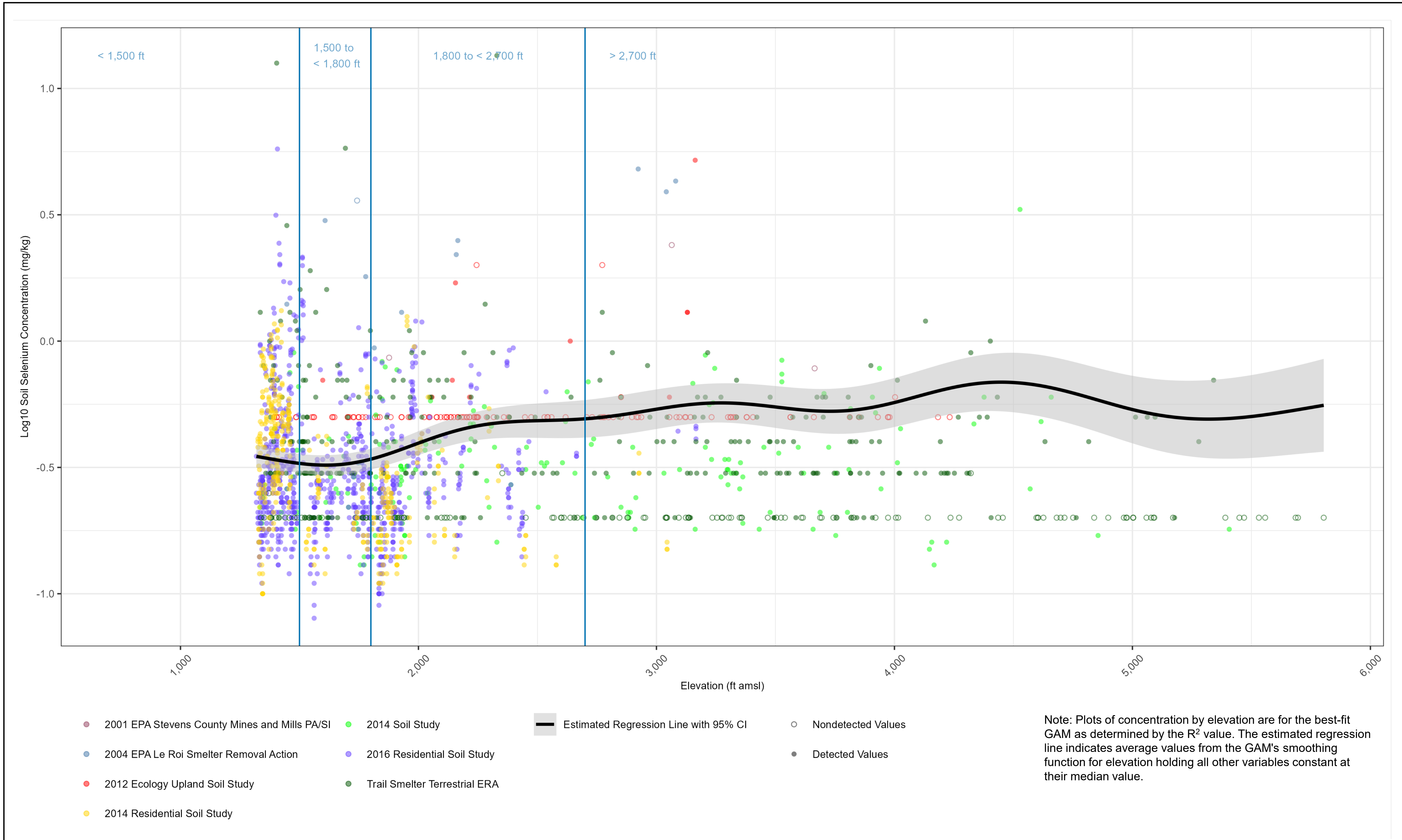
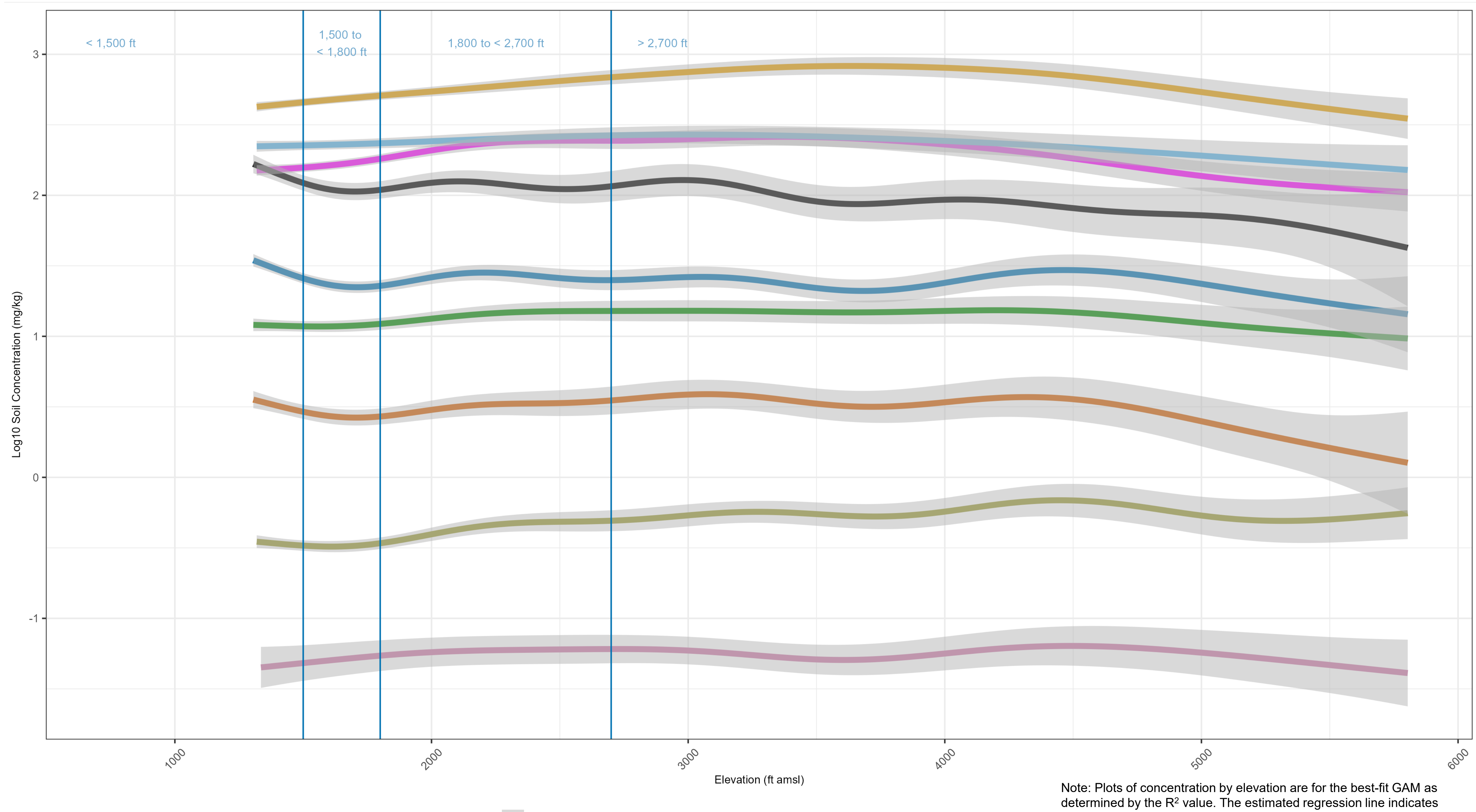


Figure F-56. Soil Selenium Concentrations versus Elevation



Note: Plots of concentration by elevation are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for elevation holding all other variables constant at their median value.

Figure F-57. Soil COC Concentrations versus Elevation
Final Upland RI Report
Upper Columbia River, Washington

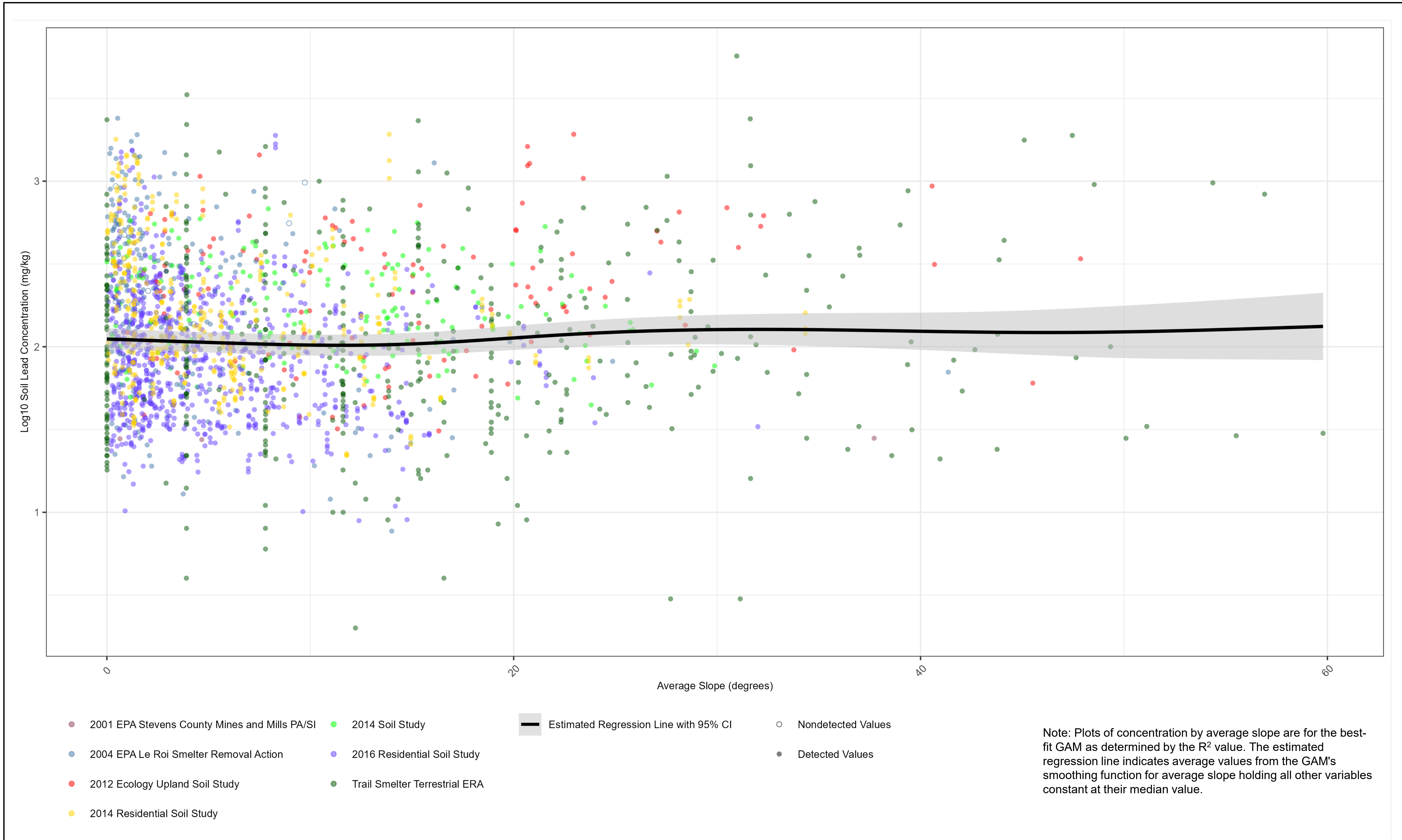


Figure F-58. Soil Lead Concentrations versus Slope
Final Upland RI Report
Upper Columbia River, Washington

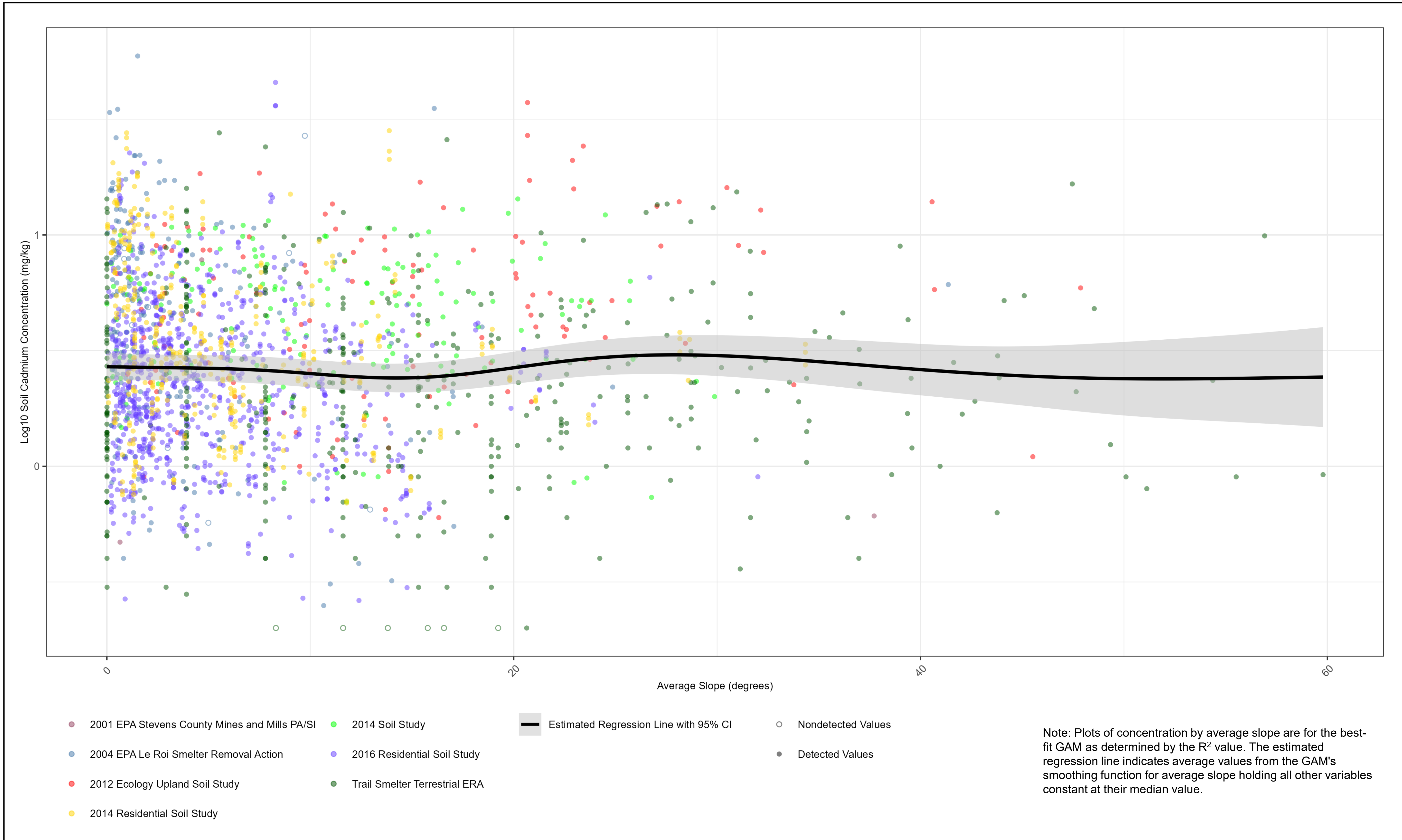


Figure F-59. Soil Cadmium Concentrations versus Slope

Final Upland RI Report

Upper Columbia River, Washington

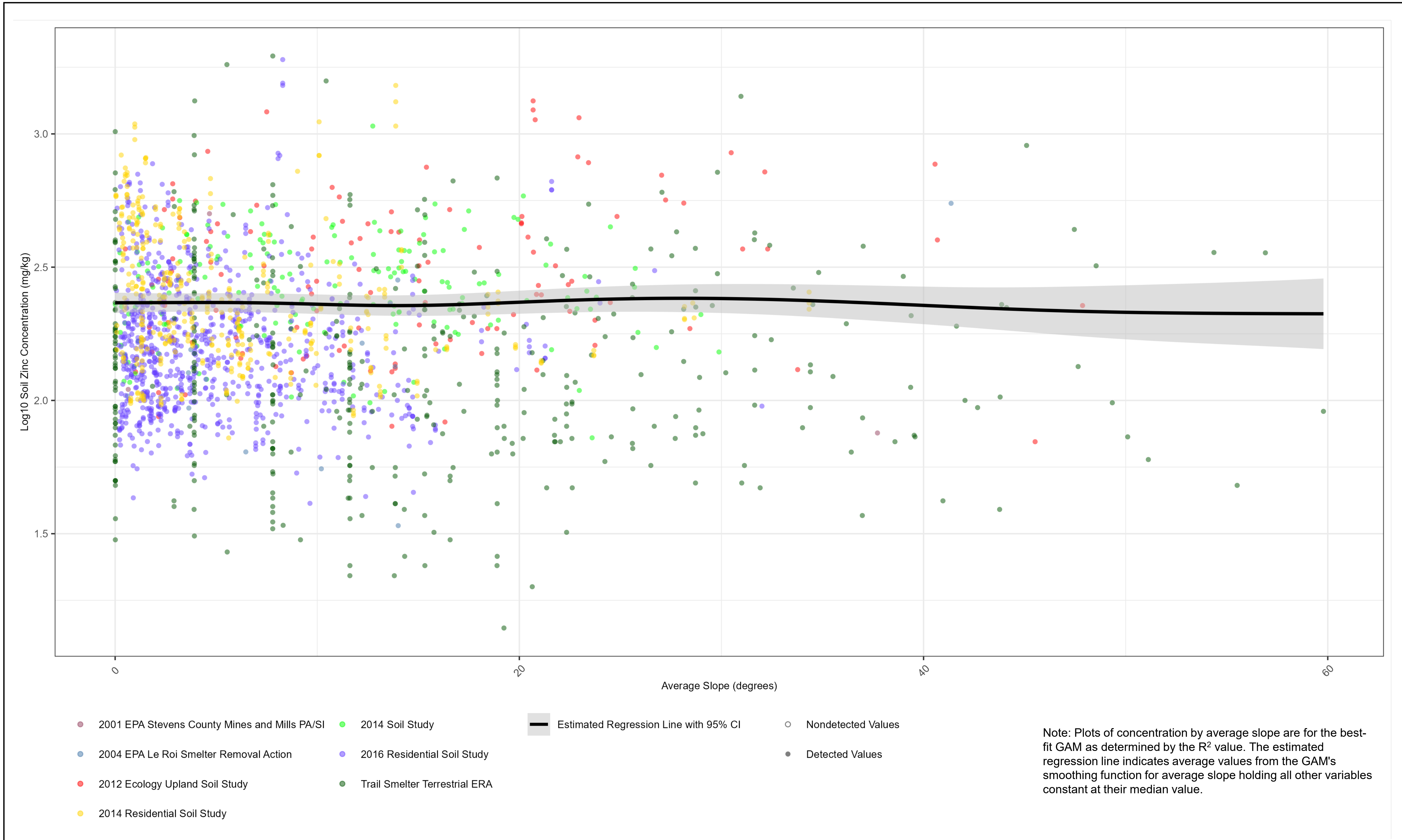


Figure F-60. Soil Zinc Concentrations versus Slope

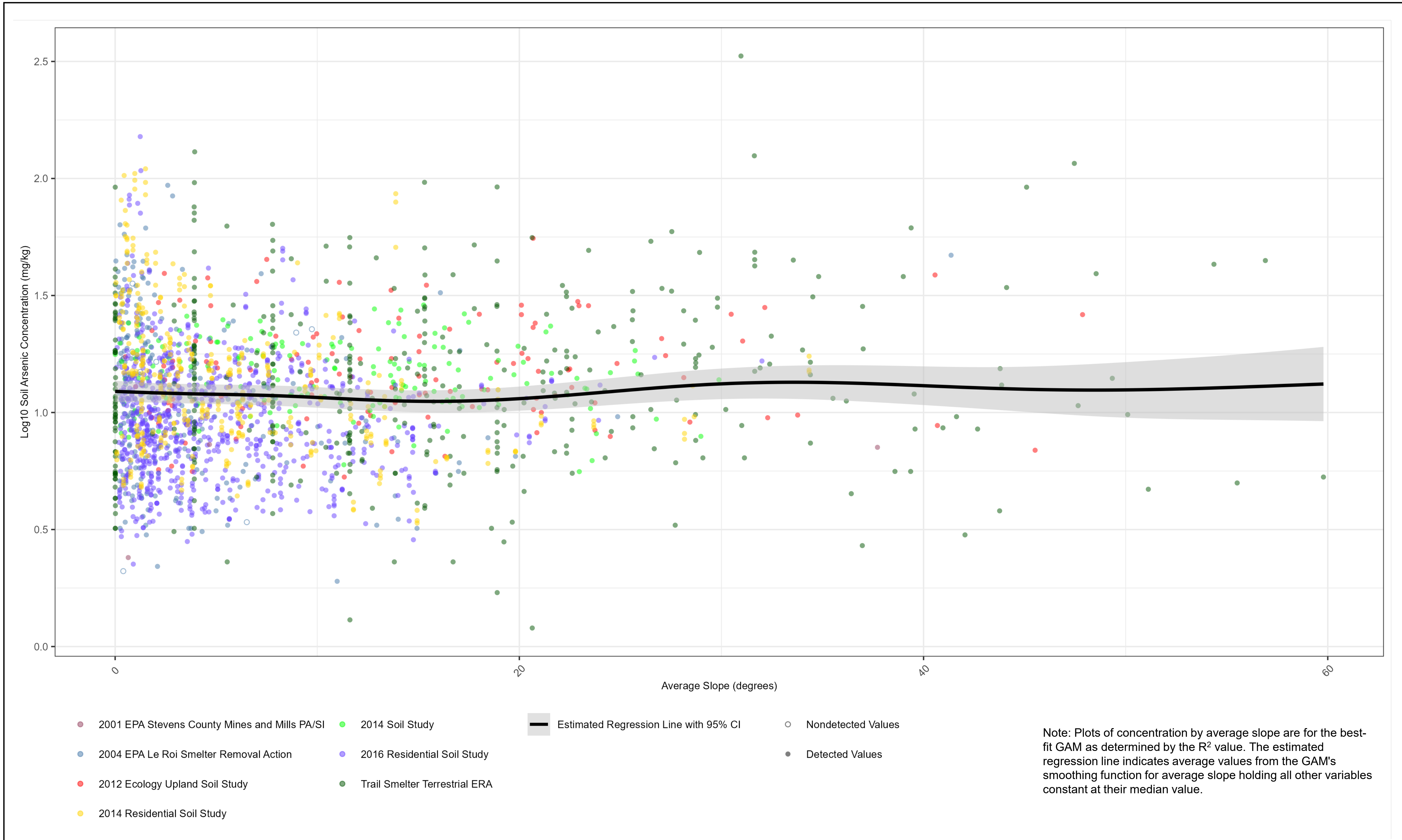


Figure F-61. Soil Arsenic Concentrations versus Slope

Final Upland RI Report

Upper Columbia River, Washington

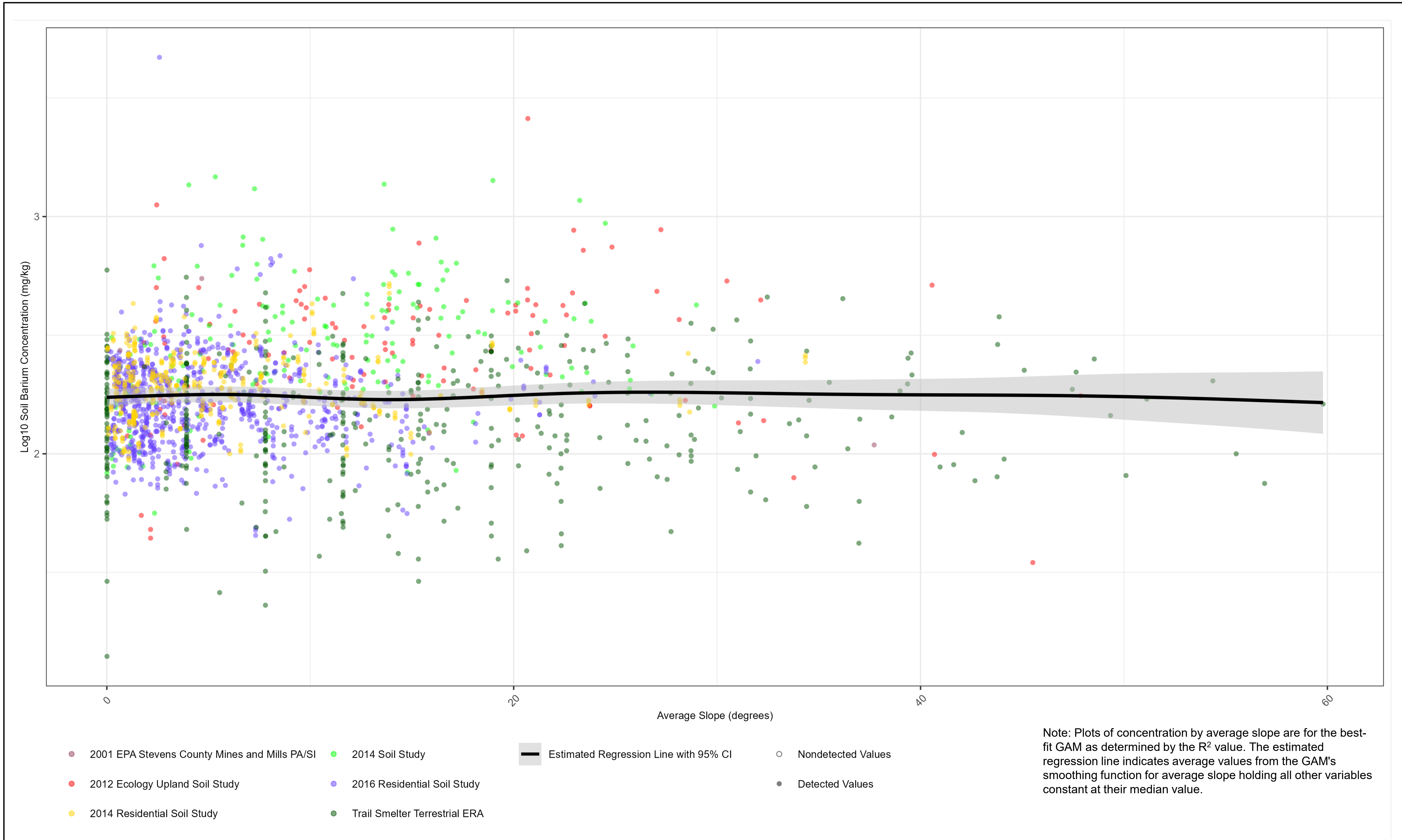


Figure F-62. Soil Barium Concentrations versus Slope

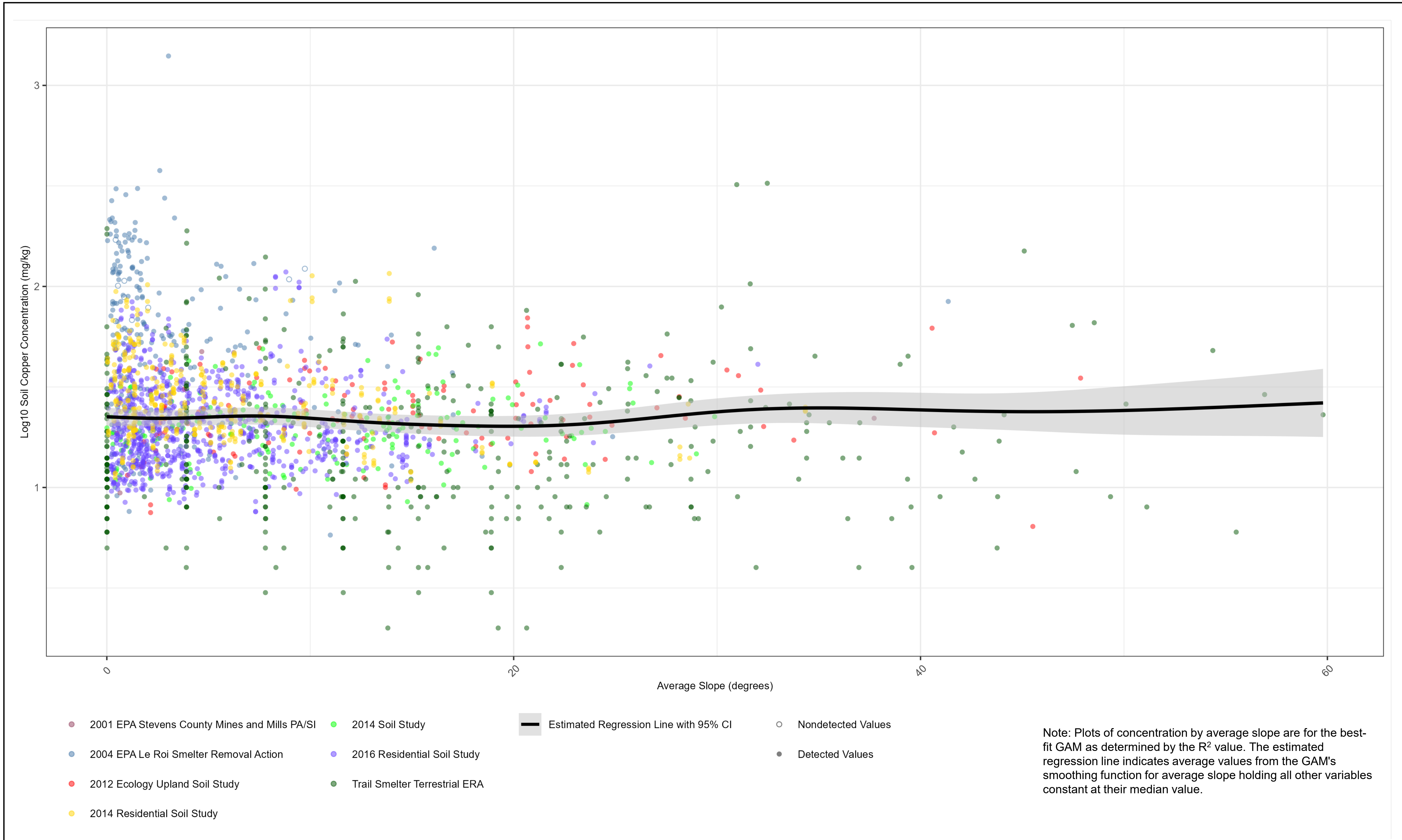
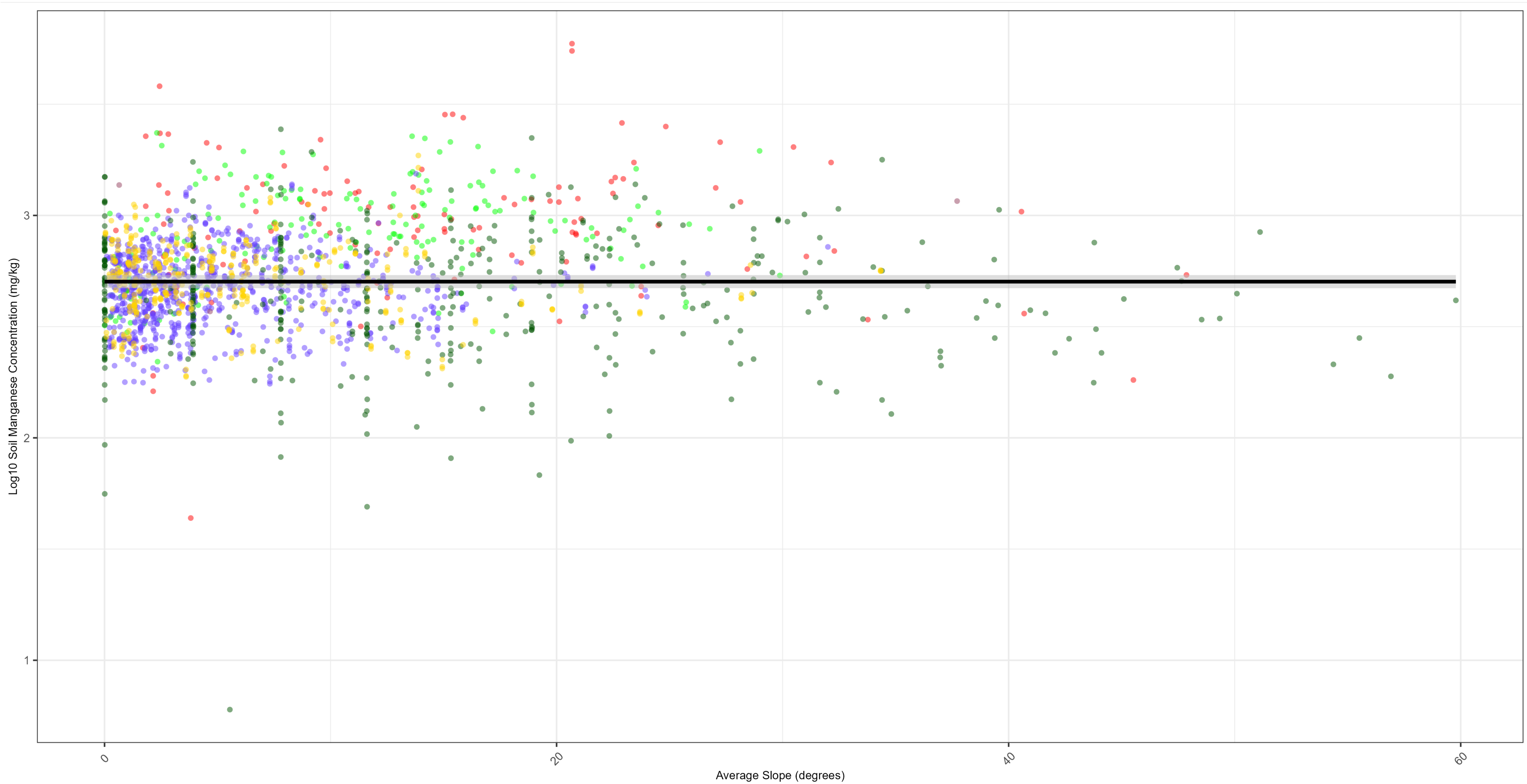


Figure F-63. Soil Copper Concentrations versus Slope



Note: Plots of concentration by average slope are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for average slope holding all other variables constant at their median value.

Figure F-64. Soil Manganese Concentrations versus Slope

Final Upland RI Report

Upper Columbia River, Washington

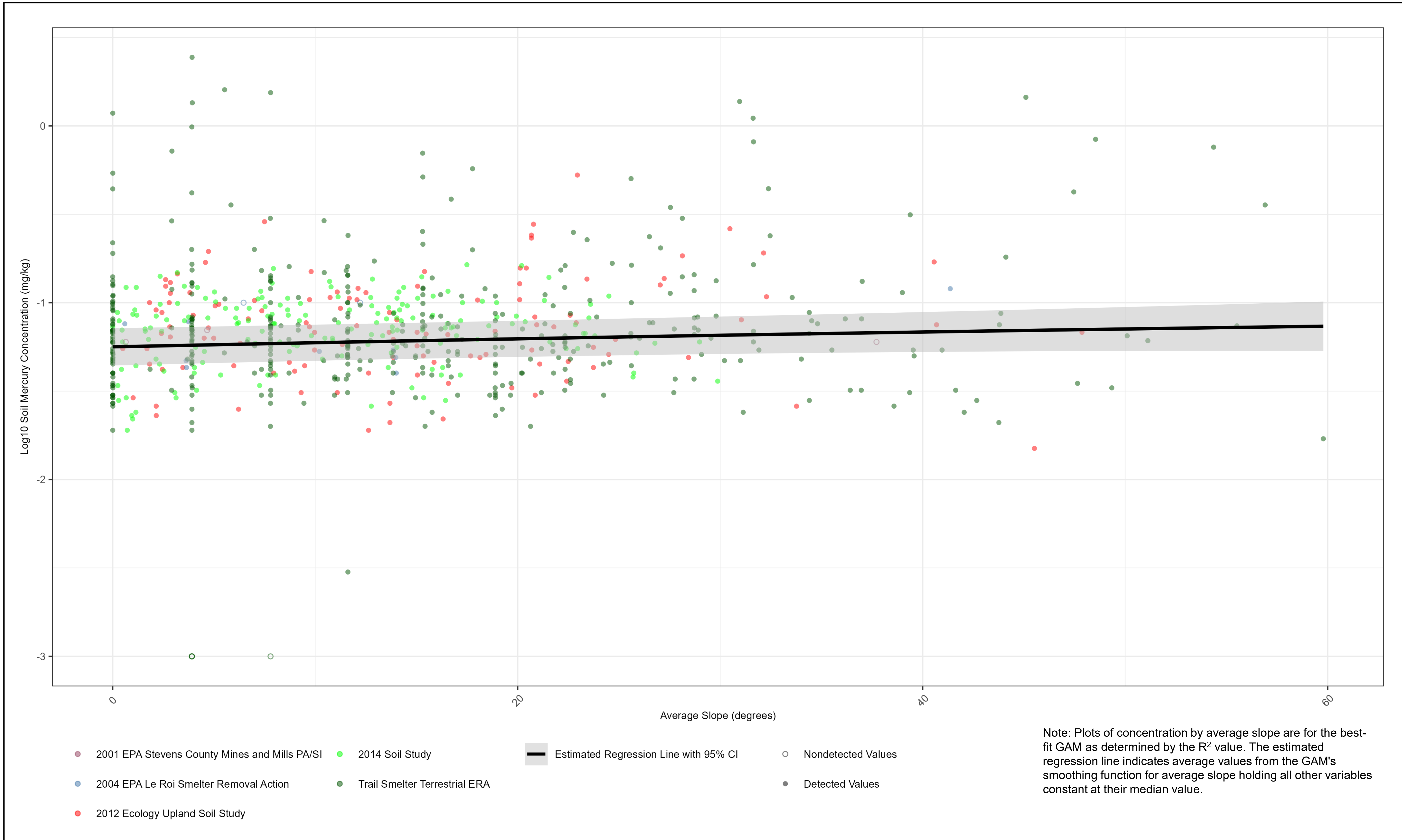
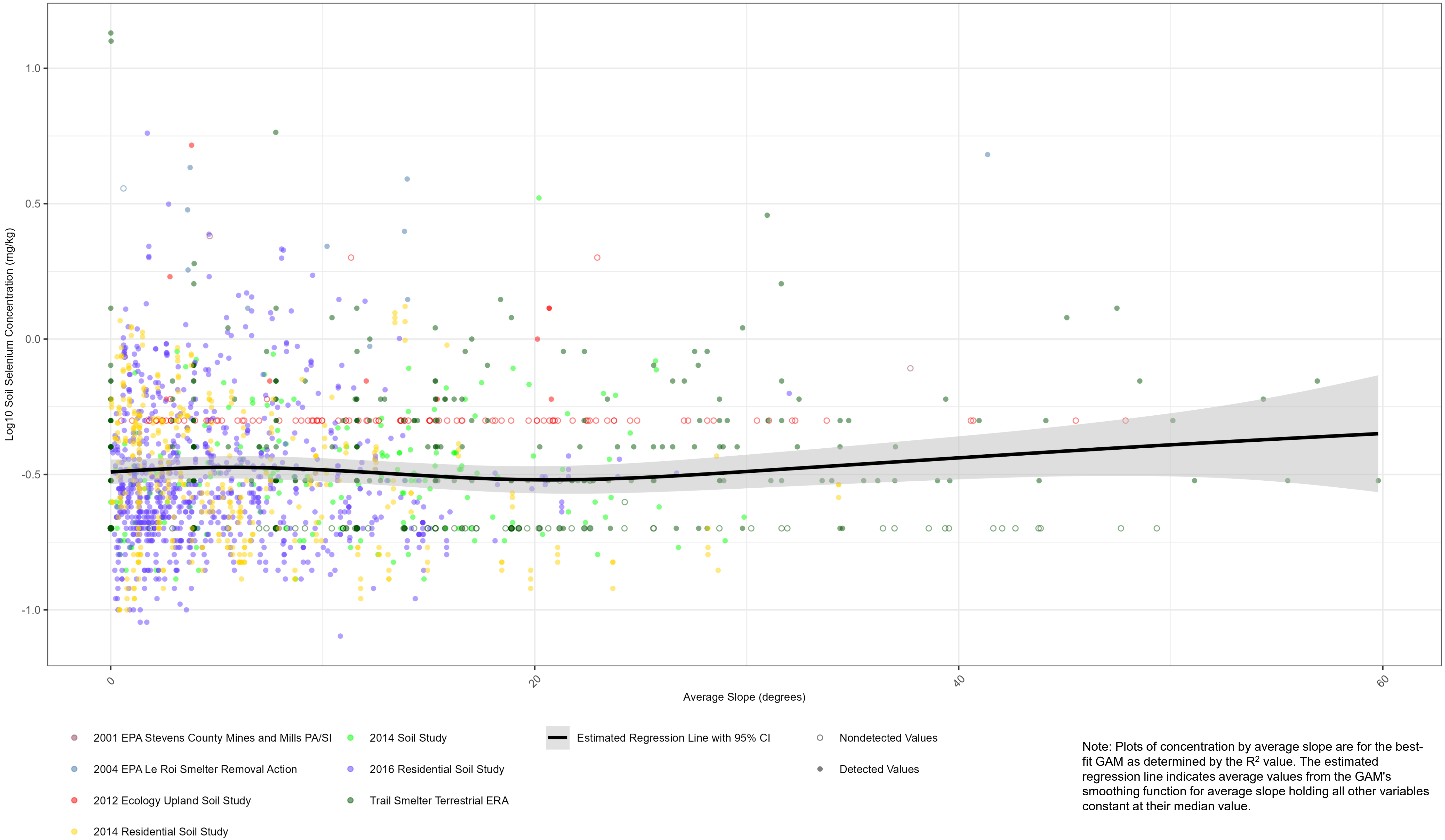
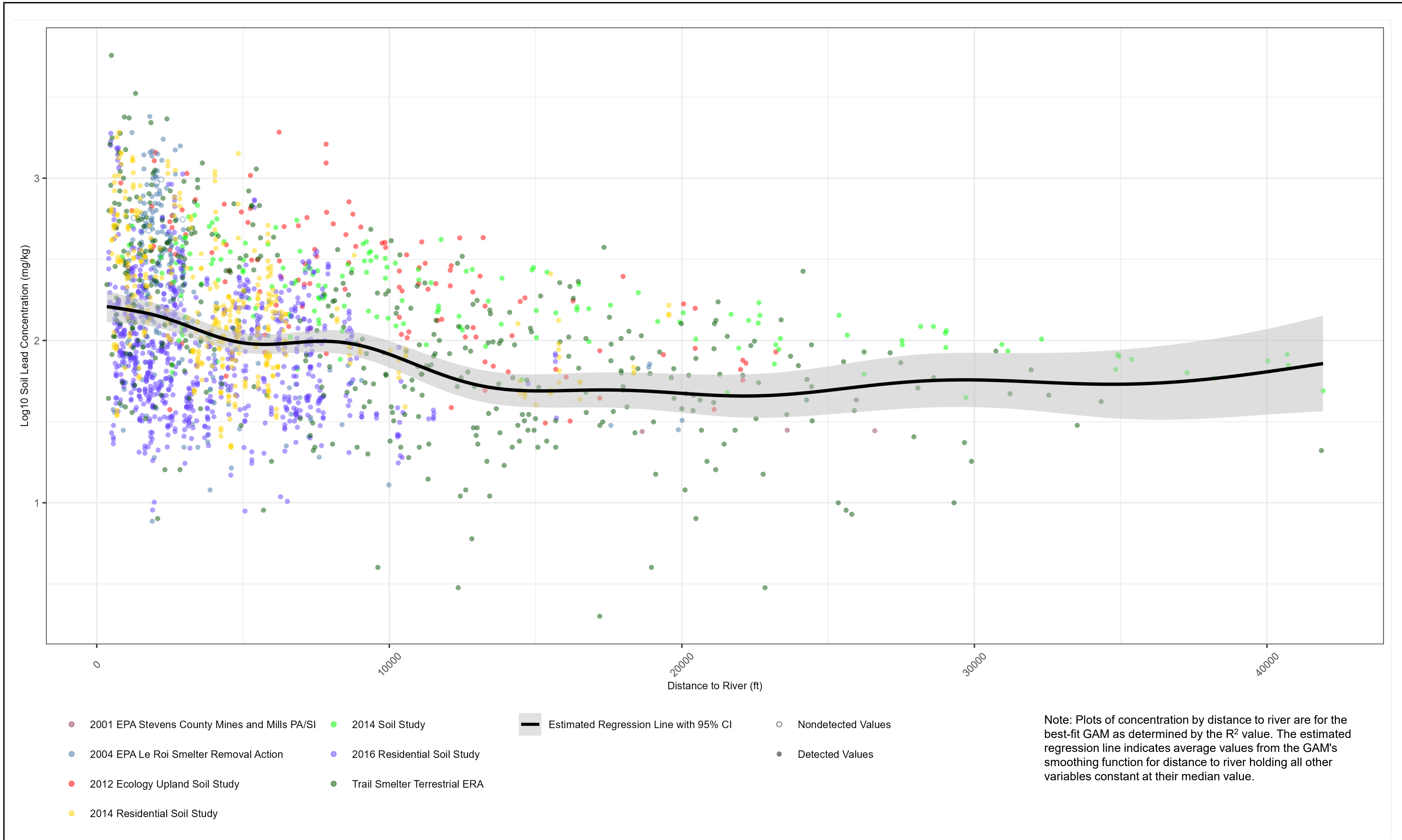


Figure F-65. Soil Mercury Concentrations versus Slope
Final Upland RI Report
Upper Columbia River, Washington



Note: Plots of concentration by average slope are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for average slope holding all other variables constant at their median value.

Figure F-66. Soil Selenium Concentrations versus Slope



Note: Plots of concentration by distance to river are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for distance to river holding all other variables constant at their median value.

Figure F-67. Soil Lead Concentrations versus Distance to River
Final Upland RI Report
Upper Columbia River, Washington

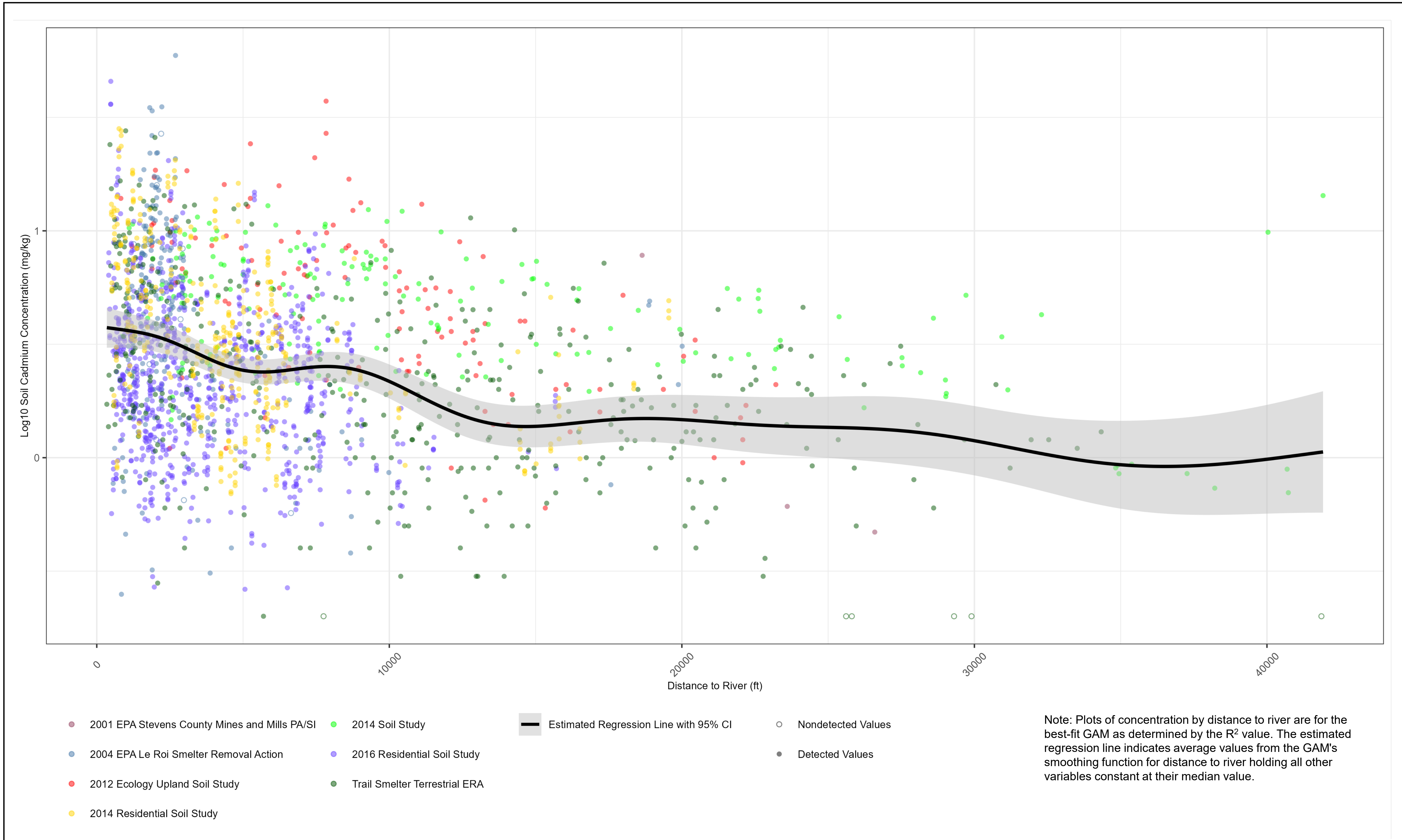


Figure F-68. Soil Cadmium Concentrations versus Distance to River

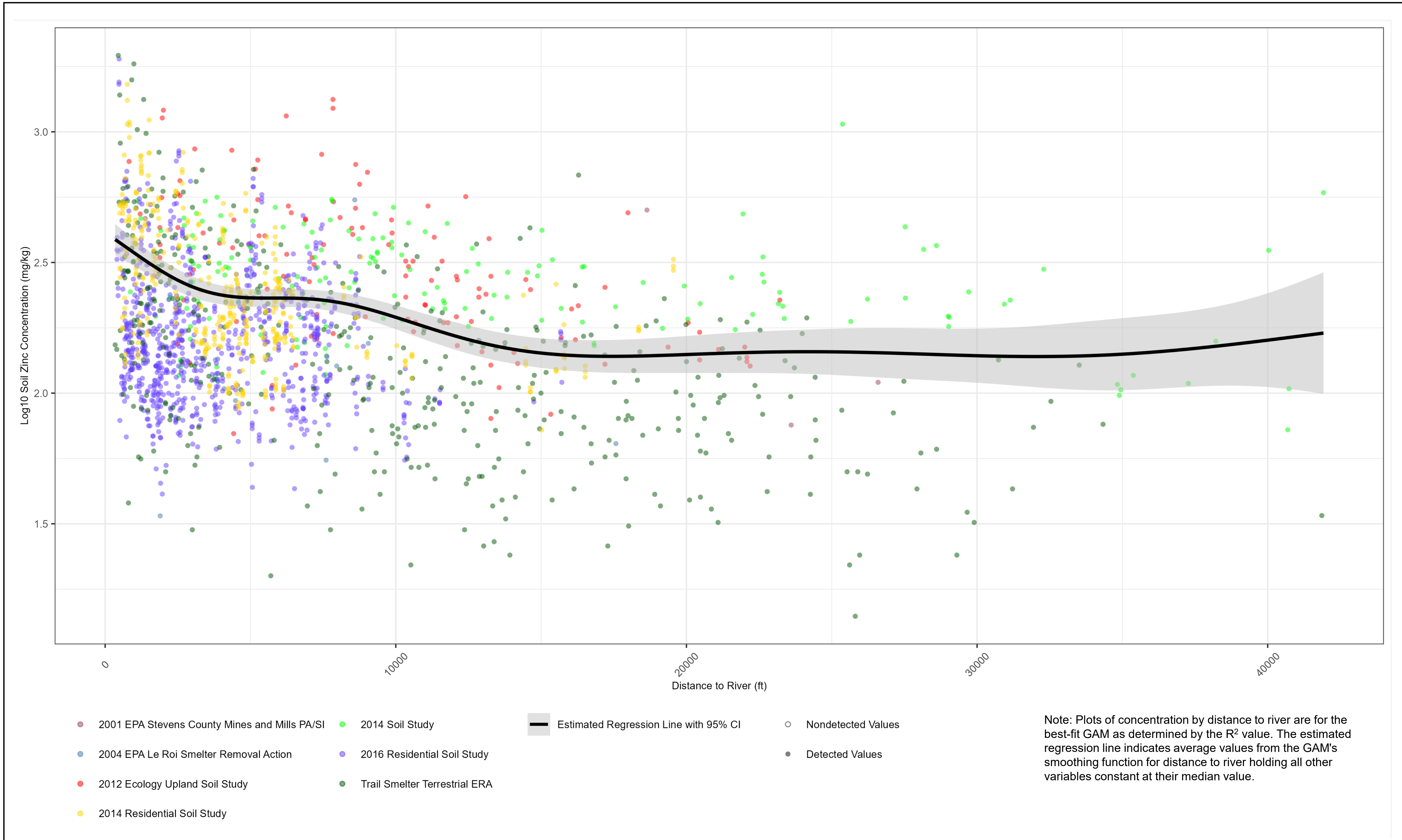


Figure F-69. Zinc Soil Concentrations versus Distance to River

Final Upland RI Report

Upper Columbia River, Washington

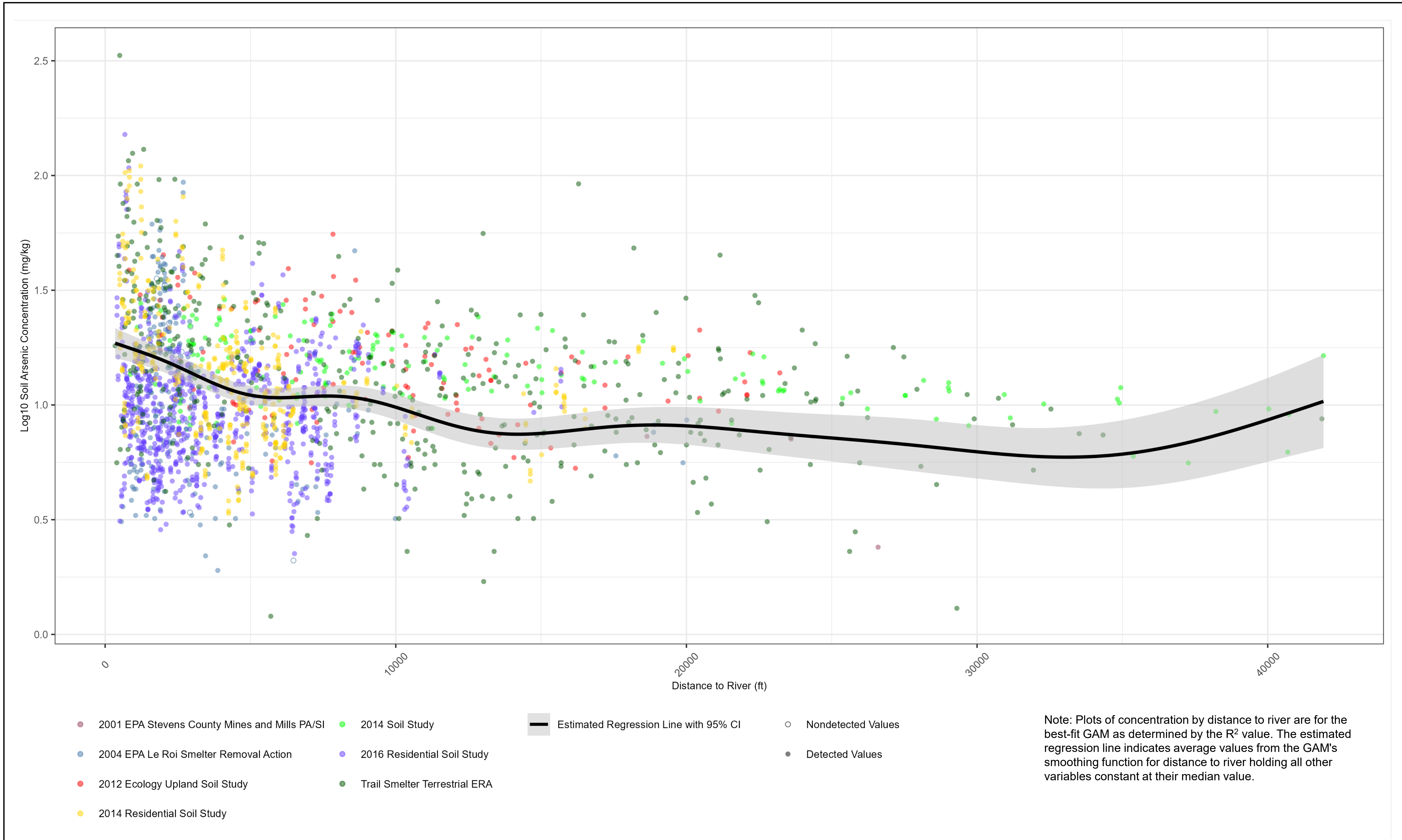
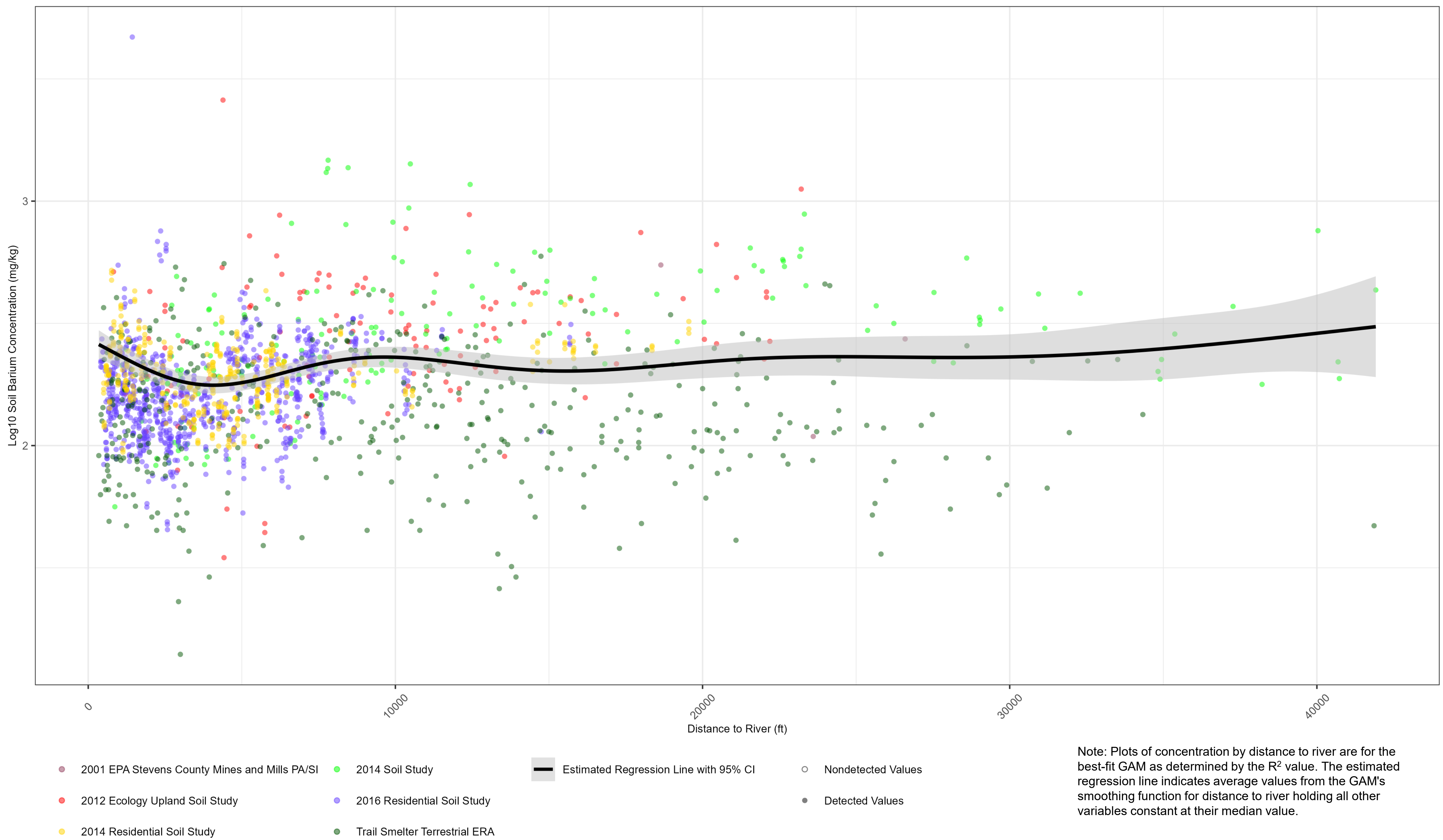


Figure F-70. Soil Arsenic Concentrations versus Distance to River



Note: Plots of concentration by distance to river are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for distance to river holding all other variables constant at their median value.

Figure F-71. Soil Barium Concentrations versus Distance to River

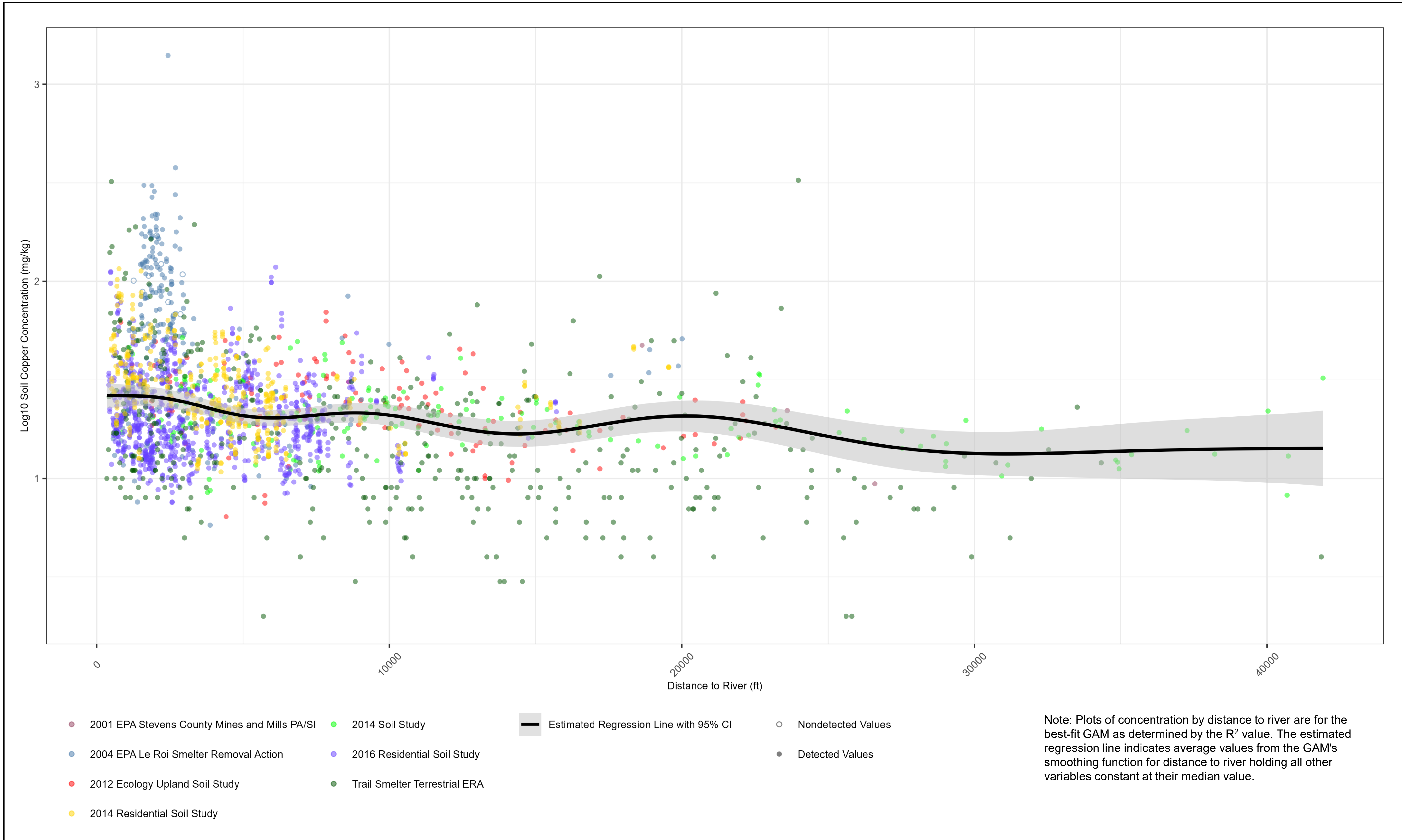


Figure F-72. Soil Copper Concentrations versus Distance to River
Final Upland RI Report
Upper Columbia River, Washington

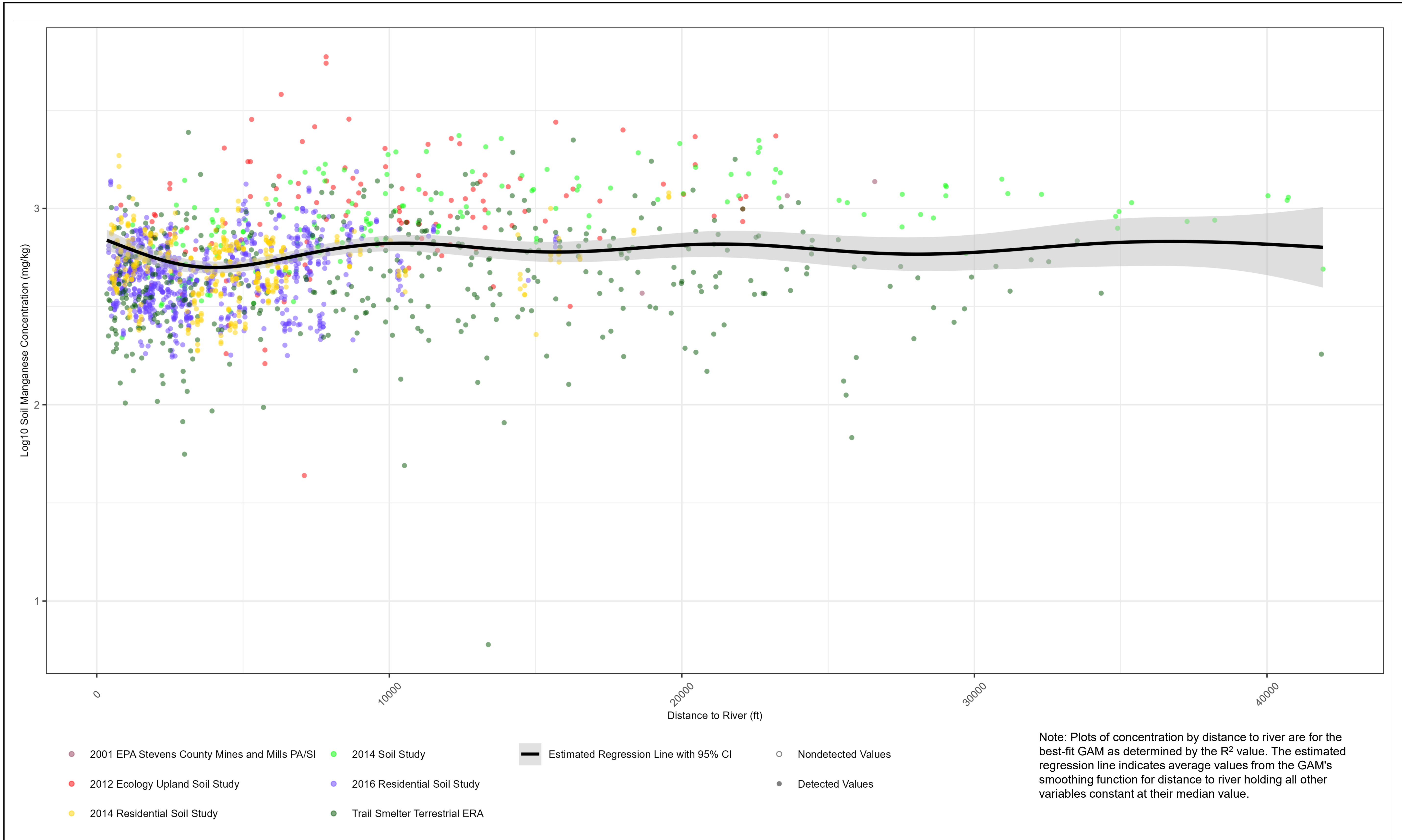
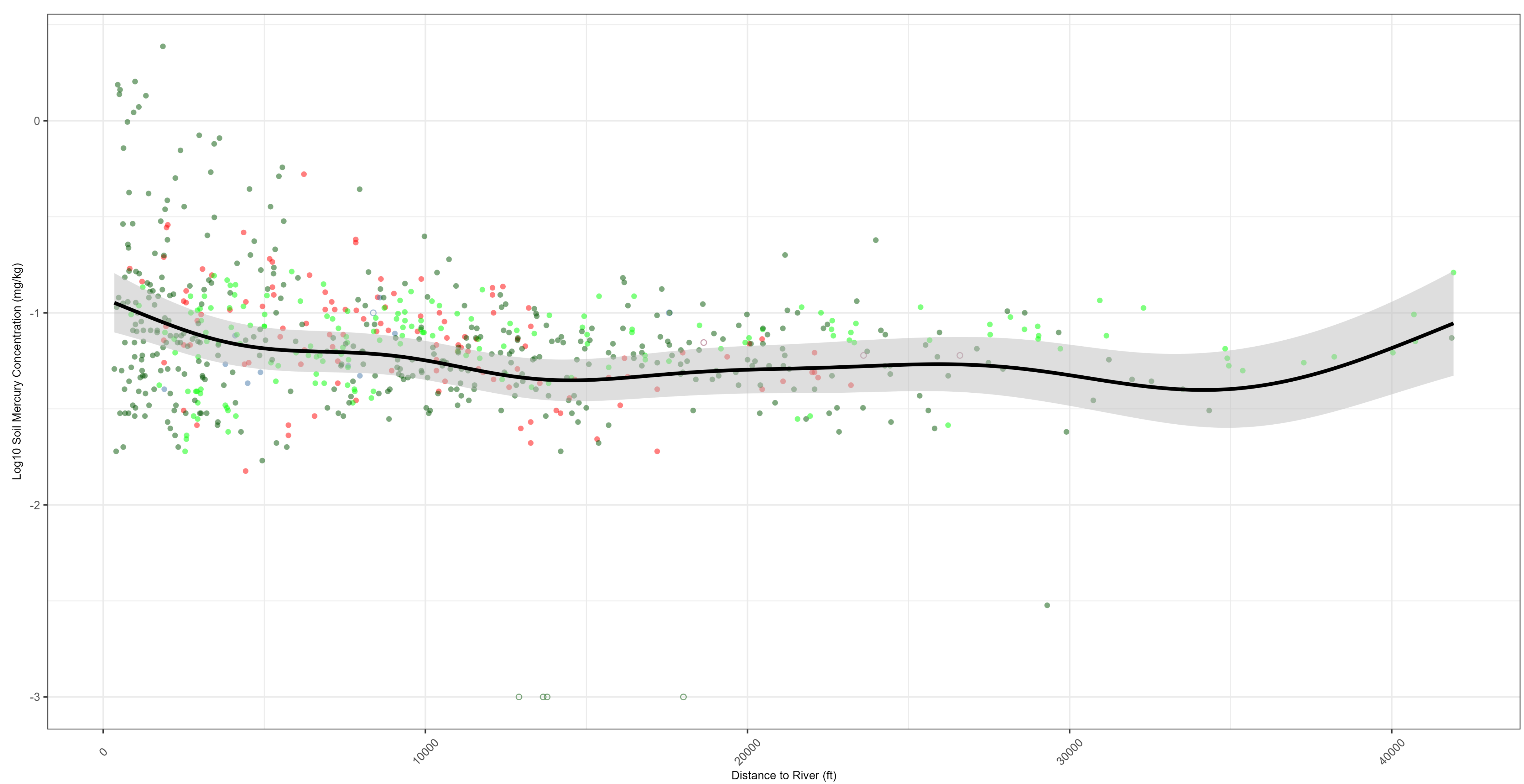
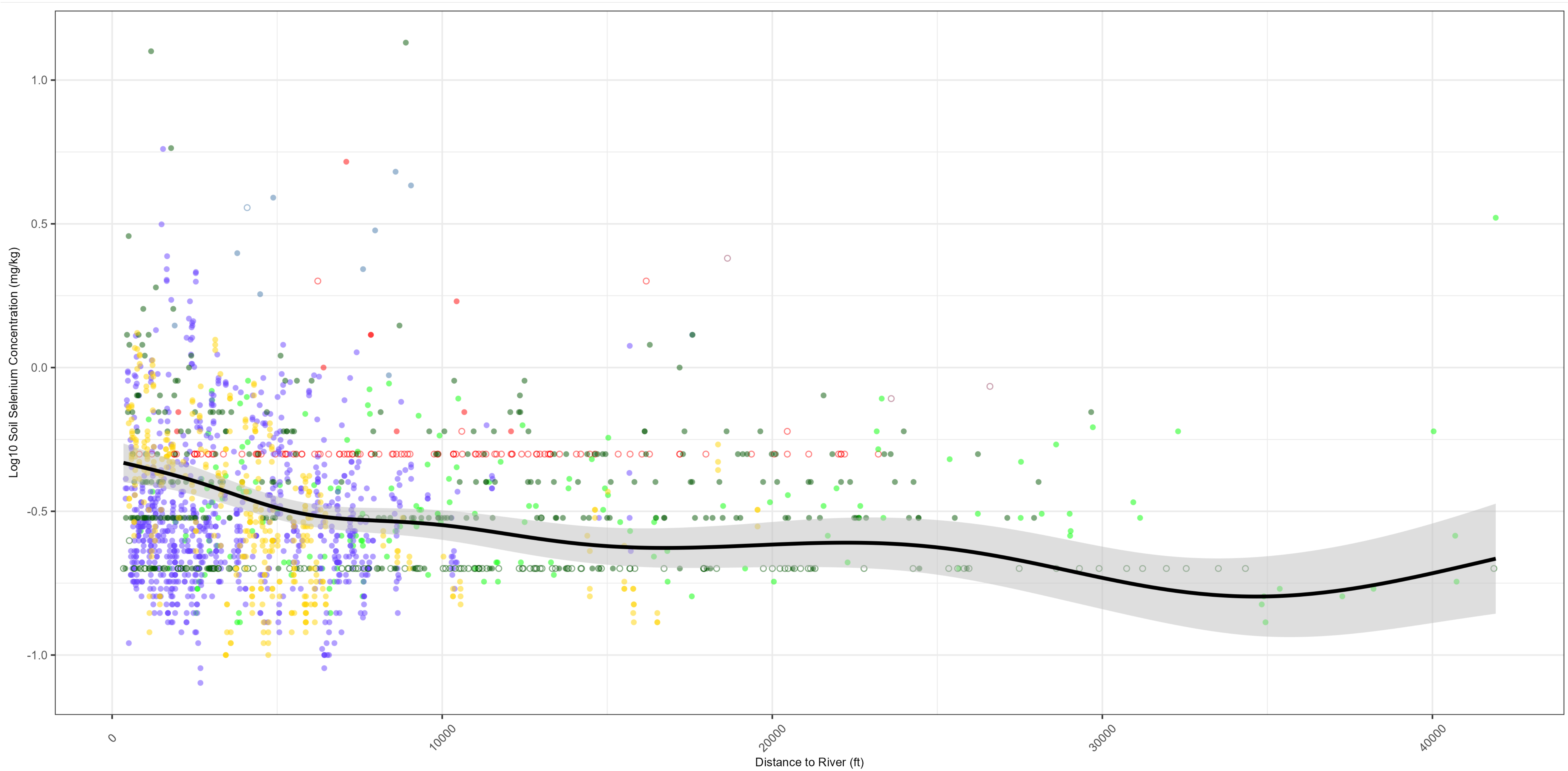


Figure F-73. Soil Manganese Concentrations versus Distance to River



Note: Plots of concentration by distance to river are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for distance to river holding all other variables constant at their median value.

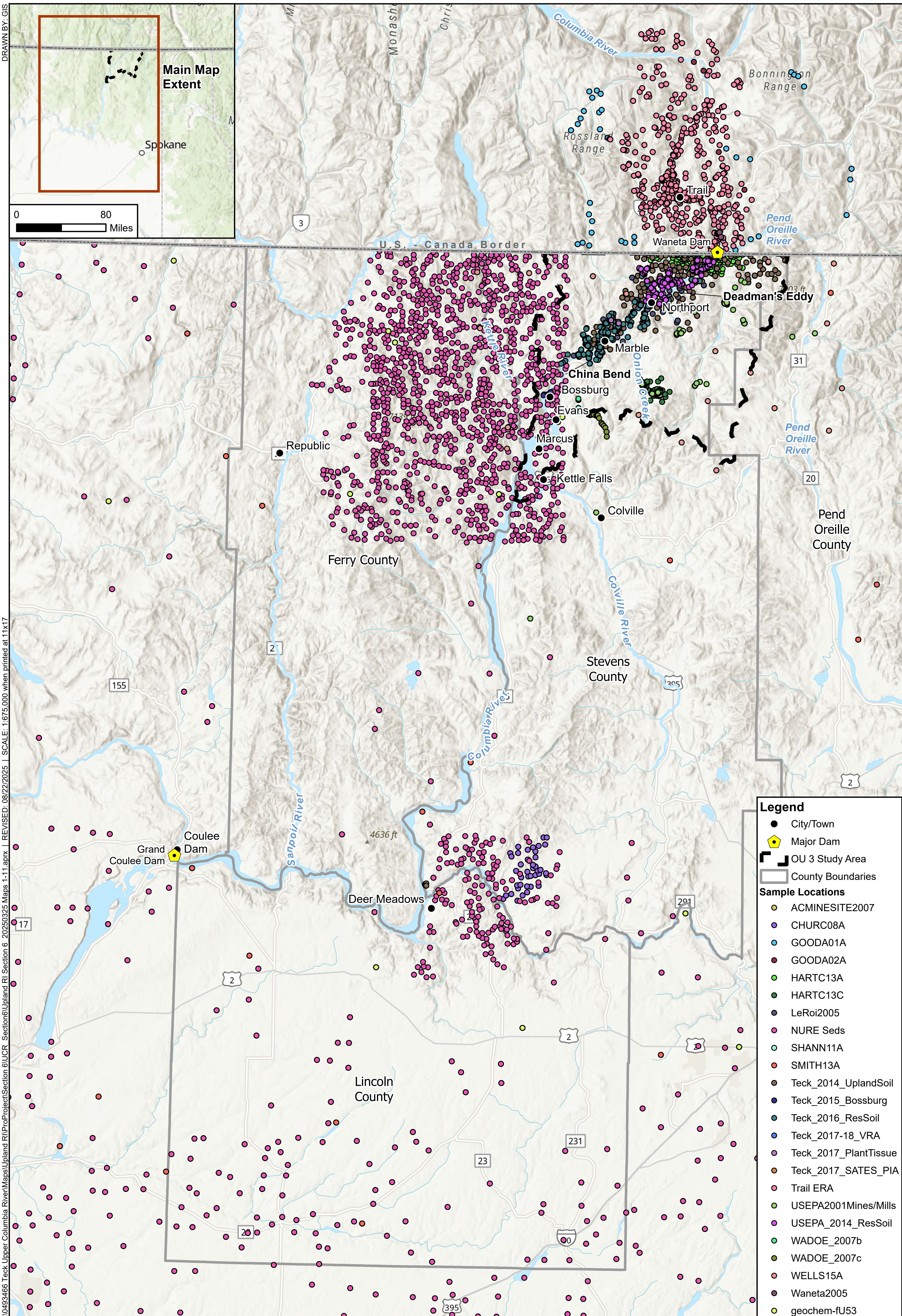
Figure F-74. Soil Mercury Concentrations versus Distance to River
Final Upland RI Report
Upper Columbia River, Washington



Note: Plots of concentration by distance to river are for the best-fit GAM as determined by the R^2 value. The estimated regression line indicates average values from the GAM's smoothing function for distance to river holding all other variables constant at their median value.

Figure F-75. Soil Selenium Concentrations versus Distance to River

MAPS



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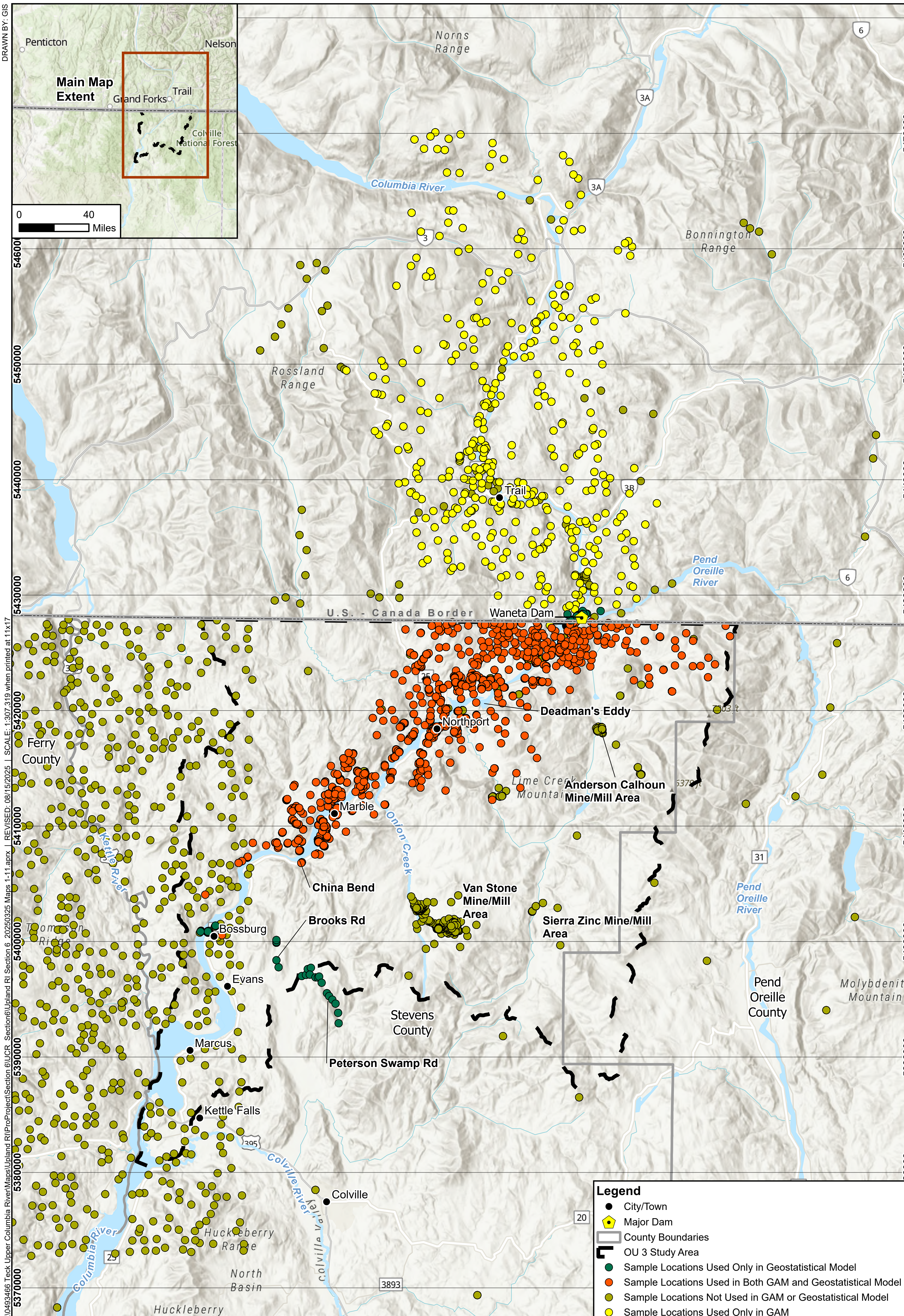
Map F-1. **Soil Sample Locations in the Upland RI Data Set**
Final Upland RI Report
Upper Columbia River, Washington

Source: Esri - World Topographic Map; NAD 1983 UTM Zone 11N

DRAWN BY: GIS

FILE: M:\US\Projects\S-U\Teck\0493466 Teck Upper Columbia River\Maps\Upland RI\ProProject\Section 6\UCR_Section6\Upland RI Section 6_20250325 Maps 1-11.aprx | REVISED: 08/22/2025 | SCALE: 1:675,000 when printed at 11x17



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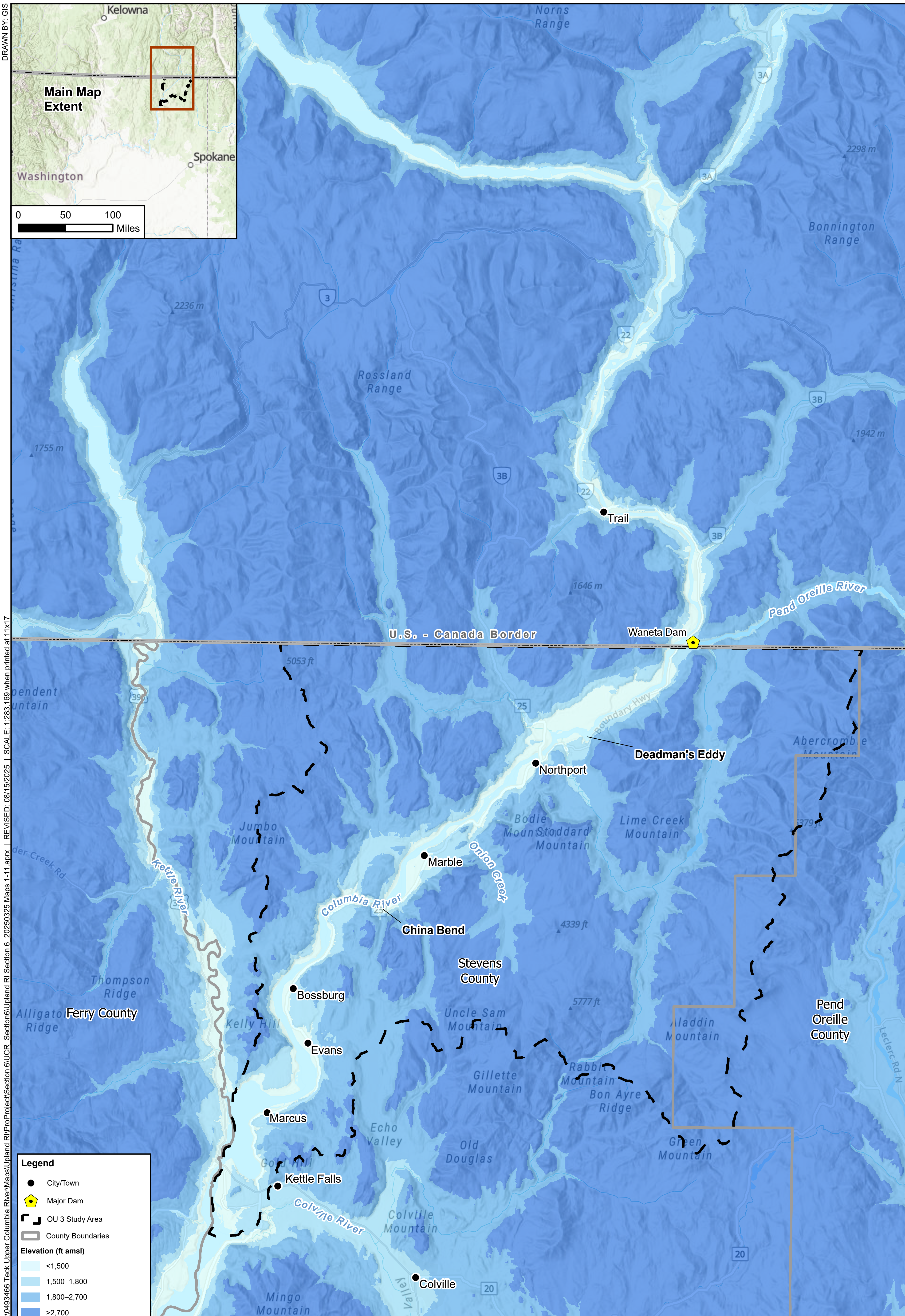
Map F-2. **Soil Sample Locations Used in the GAM and Geostatistical Model**
Final Upland RI Report
Upper Columbia River, Washington

Source: Esri - World Topographic Map; NAD 1983 UTM Zone 11N

DRAWN BY: GIS

FILE: M:\US\Projects\S-U\Teck\0493466 Teck Upper Columbia River\Maps\Upland RI\ProProject\Section 6\UCR_Section6\Upland RI Section 6_20250325 Maps 1-11.aprx | REVISED: 08/15/2025 | SCALE: 1:307,319 when printed at 11x17



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0 5 10 Miles

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Map F-3. **Elevation Bands for the GAM**
Final Upland RI Report
Upper Columbia River, Washington

Source: Esri - World Topographic Map; NAD 1983 UTM Zone 11N

FILE: M:\US\Projects\S-U\Teck\0493466 Teck Upper Columbia River\Maps\Upland RI\ProProject\Section 6\UCR_Section6\Upland RI Section 6_20250325 Maps 1-11.aprx | REVISED: 08/15/2025 | SCALE: 1:283,169 when printed at 11x17

DRAWN BY: GIS

ATTACHMENT A GAM OUTPUTS

Attachment A
GAM Outputs
Final Upland RI Report
Upper Columbia River, Washington

Analyte	Term	Estimate [a]	Std. Error [b]	t-value [c]	p-value	R-Squared
Arsenic	(Intercept)	1.037	0.008253	125.6	p<0.001	0.293
Arsenic	sideof_riverWest	0.06154	0.01165	5.282	p<0.001	0.293
Arsenic	s(y_coord)	12.59	14	42.92	p<0.001	0.293
Arsenic	s(elevation_ft)	6.098	9	2.595	p<0.001	0.293
Arsenic	s(average_slope)	4.196	9	1.066	0.03868	0.293
Arsenic	s(distanceto_river_ft)	7.385	9	14.52	p<0.001	0.293
Barium	(Intercept)	2.257	0.00736	306.6	p<0.001	0.272
Barium	sideof_riverWest	-0.01603	0.009716	-1.649	0.09922	0.272
Barium	s(y_coord)	12.68	14	26.91	p<0.001	0.272
Barium	s(elevation_ft)	6.197	9	13.91	p<0.001	0.272
Barium	s(average_slope)	4.367	9	0.489	0.4066	0.272
Barium	s(distanceto_river_ft)	7.852	9	8.991	p<0.001	0.272
Cadmium	(Intercept)	0.4453	0.01071	41.59	p<0.001	0.3104
Cadmium	sideof_riverWest	0.008866	0.01513	0.5861	0.5578	0.3104
Cadmium	s(y_coord)	12.72	14	38.75	p<0.001	0.3104
Cadmium	s(elevation_ft)	7.942	9	4.555	p<0.001	0.3104
Cadmium	s(average_slope)	4.59	9	1.143	0.03819	0.3104
Cadmium	s(distanceto_river_ft)	7.554	9	11.1	p<0.001	0.3104
Copper	(Intercept)	1.359	0.007683	176.8	p<0.001	0.4191
Copper	sideof_riverWest	0.008833	0.01086	0.8132	0.4162	0.4191
Copper	s(y_coord)	13.18	14	49.52	p<0.001	0.4191
Copper	s(elevation_ft)	8.128	9	9.701	p<0.001	0.4191
Copper	s(average_slope)	5.52	9	1.33	0.03589	0.4191
Copper	s(distanceto_river_ft)	7.462	9	5.798	p<0.001	0.4191
Lead	(Intercept)	2.051	0.01176	174.3	p<0.001	0.4056
Lead	sideof_riverWest	0.06886	0.01662	4.144	p<0.001	0.4056
Lead	s(y_coord)	12.84	14	62.48	p<0.001	0.4056
Lead	s(elevation_ft)	8.153	9	4.768	p<0.001	0.4056
Lead	s(average_slope)	3.373	9	0.9805	0.02842	0.4056
Lead	s(distanceto_river_ft)	7.57	9	12.87	p<0.001	0.4056
Manganese	(Intercept)	2.707	0.007371	367.3	p<0.001	0.2771
Manganese	sideof_riverWest	0.00685	0.009714	0.7052	0.4808	0.2771
Manganese	s(y_coord)	12.2	14	24.7	p<0.001	0.2771
Manganese	s(elevation_ft)	4.287	9	12.93	p<0.001	0.2771
Manganese	s(average_slope)	0.001057	9	0.00002505	0.7882	0.2771
Manganese	s(distanceto_river_ft)	7.507	9	7.882	p<0.001	0.2771
Mercury	(Intercept)	-1.171	0.01697	-69.02	p<0.001	0.2875
Mercury	sideof_riverWest	0.0367	0.02335	1.572	0.1164	0.2875
Mercury	s(y_coord)	11.36	14	11.88	p<0.001	0.2875
Mercury	s(elevation_ft)	5.175	9	1.086	0.06757	0.2875
Mercury	s(average_slope)	0.9513	9	0.5811	0.01347	0.2875
Mercury	s(distanceto_river_ft)	6.713	9	3.61	p<0.001	0.2875
Selenium	(Intercept)	-0.4985	0.009111	-54.71	p<0.001	0.1346
Selenium	sideof_riverWest	0.0259	0.01204	2.151	0.0316	0.1346

Attachment A
GAM Outputs
Final Upland RI Report
Upper Columbia River, Washington

Analyte	Term	Estimate [a]	Std. Error [b]	t-value [c]	p-value	R-Squared
Selenium	s(y_coord)	13.23	14	13.12	p<0.001	0.1346
Selenium	s(elevation_ft)	7.319	9	7.7	p<0.001	0.1346
Selenium	s(average_slope)	4.025	9	1.075	0.03234	0.1346
Selenium	s(distanceto_river_ft)	6.018	9	8.74	p<0.001	0.1346
Zinc	(Intercept)	2.254	0.008425	267.5	p<0.001	0.4194
Zinc	sideof_riverWest	0.007742	0.01111	0.6967	0.4861	0.4194
Zinc	s(y_coord)	12.58	14	61.26	p<0.001	0.4194
Zinc	s(elevation_ft)	3.173	9	2.102	p<0.001	0.4194
Zinc	s(average_slope)	3.424	9	0.3175	0.507	0.4194
Zinc	s(distanceto_river_ft)	7.441	9	16.73	p<0.001	0.4194

Notes:
[a] Coefficient estimate for intercept and side of river; edf for smooth terms
[b] Standard error for intercept and side of river terms; reference df for smooth terms
[c] t-value for intercept and side of river terms; Chi-sq for smooth terms

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