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Elemental Atmospheric Pollution Assessment Via Moss-Based Measurements in Portland, Oregon

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Cover: Moss (*Orthotrichum lyellii*), by Sarah Jovan.

Abstract

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Mosses accumulate pollutants from the atmosphere and can serve as an inexpensive screening tool for mapping air quality and guiding the placement of monitoring instruments. We measured 22 elements using 346 moss samples collected across Portland, Oregon, in December 2013. Our objectives were to develop citywide maps showing concentrations of each element in moss and identify potential air pollution "hotspots." We used simple dot maps, histograms, and summary statistics to describe the distribution of each element. Fifteen metals had highly right-skewed distributions, indicating high metal concentrations (relative to concentrations measured in our dataset) in moss at one or more locations. These metals included high-priority toxics such as cadmium, nickel, lead, and arsenic. Past research shows that element concentrations in moss reflect atmospheric concentrations, although the strength of these relationships varies by element and is unknown for the elements we sampled. Therefore, atmospheric concentrations would need to be measured by an air quality monitor in order to determine whether hotspots suggested by the moss indicator are problematic or pose a health risk. We provide the raw data for all elements we measured to enable scientists, regulators, and citizens to further investigate the importance and possible sources of moss-identified hotspots.

Keywords: Bioindicators, moss, heavy metals, air quality, mapping, sampling.

Contents

1 **Introduction**
2 **Methods**
4 Laboratory Analysis
6 Correlations Between Metal Distributions
7 **Mapping**
9 **Results and Discussion**
9 Element Associations
11 High Concentrations and "Hotspots"
36 Limitations and Guidelines
38 **Conclusions**
38 **English Equivalents**
39 **Literature Cited**
42 **Appendix**

Introduction

Many studies have used mosses and lichens to study atmospheric heavy-metal pollution (e.g., Berg and Steinnes 1997a, Gerdol et al. 2014, Nickel et al. 2014, Owczarek et al. 2001, Rühling and Tyler 1968). Mosses and lichens are commonly used as bioindicators of air quality because they readily accumulate pollutants over time. Unlike plants, they lack roots and absorb nutrients from the atmosphere. Mosses and lichens also lack the impermeable waxy coating of plant leaves so they absorb water over their entire surface like a sponge. Their high cation exchange capacity, a term that quantifies their ability to hold exchangeable, positively charged ions, helps cells capture dissolved nutrients during rain events (Bates 1994) and passively trap pollutants including heavy metals. Particulate pollutants also become trapped on the outer surfaces of the mosses and lichens (Aboal et al. 2011).

Mosses and lichens are commonly used as bioindicators of air quality because they readily accumulate pollutants over time.

Traditional air quality monitoring relies on specialized instruments. However owing to high purchasing costs and the expense of operation and data analysis, only a small number of instruments is usually available. For instance, Portland, Oregon, has one permanent air toxics monitor, and it costs $40,000 annually to measure metals.[1] One instrument is not sufficient to resolve the varying nature of pollutant concentrations on spatial scales smaller than the size of a metropolitan area, such as at the neighborhood level or smaller. Measuring pollutant levels in bioindicators is less costly than using instruments (each moss sample costs about $150 for labor and lab analysis), thereby making it possible to collect the large number of samples needed to detect and quantify pollutants that disperse short distances from their source.

One air toxics monitoring instrument is not sufficient to resolve the varying nature of pollutant concentrations on spatial scales smaller than the size of a metropolitan area, such as at the neighborhood level or smaller. Measuring pollutant levels in bioindicators is less costly than using instruments (each moss sample costs about $150 for labor and lab analysis).

In this study, we analyzed 346 moss samples collected within a short timeframe (Dec. 2-23, 2013) across Portland, Oregon, enabling a spatially detailed, yet economical, **preliminary** assessment of atmospheric pollution. One study has been published using these data, linking cadmium (Cd) concentrations in moss to stained glass manufacturers (Donovan et al. 2016). The purpose of this report is to present the raw data for all 22 elements we measured in moss, making it possible for others to model pollutant distributions and investigate possible emissions sources. Data are published here as dot maps showing the spatial distribution of the sample. All data are provided in tabular format (see app., table 6) and may be downloaded from the Web (http://www.fs.fed.us/pnw/research/moss/).

Please note that the moss sample data for each element serve only as an index, meaning that high concentrations in moss are suggestive (but not conclusive) of high concentrations in the atmosphere. Although past research suggests moss

[1] Anthony Barnack. Personal communication. Ambient Air Monitoring Coordinator, Oregon Department of Environmental Quality, 811 SW 6th Avenue, Portland, OR 97204-1390.

Research has found that metal concentrations in moss are correlated with atmospheric metal concentrations, but the strength of these relationships is uncertain and varies by element.

concentrations reflect atmospheric concentrations for many elements, the strength of these relationships is unknown and varies by element (Aboal et al. 2010). The time period represented by metals in moss is also unknown. Thus, for a particular element, a moss sample with a relatively high value or a "hotspot" shown on a map should not be interpreted by itself as a health hazard. Conversely, samples with low values do not necessarily indicate "healthy" neighborhoods. To infer about risks to human or environmental health, more research is needed to determine the exact relationship between moss concentrations and air concentrations as measured by the air quality instruments. The association between high levels of Cd and two stained-glass manufacturers described in Donovan et al. (2016) was supported by further research, including an exhaustive investigation of other possible sources of Cd in the area, additional moss sampling and, most importantly, air quality monitoring instruments placed on site. Limitations and guidelines for interpreting the moss data presented in this report are discussed further on p. 36.

Methods

A moss sample with a relatively high value for a particular element or a "hotspot" shown on a map should not be interpreted by itself as a health hazard. Conversely, samples with low values do not necessarily indicate "healthy" neighborhoods.

We placed a 1-km^2 grid across Portland, Oregon, including a 1-km buffer beyond the city limits. Major industrial and forested areas were excluded. We selected a residential address randomly within each grid cell and collected moss from the nearest hardwood tree or shrub (n = 278 "base points"). To capture variability in metal concentrations across short distances, we randomly selected 72 base points where we collected an additional sample nearby. At 12 of those 72 sites, the second sample was from the same tree. For the remaining 60, moss was sampled within 10 to 100 m of the randomly selected base points (6 at each 10-m increment). We could not find the moss at four sites, making for a total of 346 moss samples. As the potential for weather conditions to affect metal concentrations in the moss was unknown, we collected all samples within a short period (Dec. 2-23, 2013) in six traverses across the city. Most samples were taken from street trees, but occasionally we collected from trees in parks, wayside areas, or on private property with the permission of the landowner.

All samples were georeferenced using a recreational grade global positioning system (GPS) device and registered in geographic (latitude/longitude) projection. The detailed definition of the projection is shown in the appendix (app., fig. 6). Spatial overlays of the sample locations with precisely registered high-resolution airborne imagery indicated that the precision of the GPS recordings was about 6.5 m. Sample points were subsequently projected to a Cartesian system (Lambert Conformal Conic), which maintains a constant linear unit omnidirectionally. The detailed definition of the projection is shown in the appendix (app., fig. 7).

The species sampled was *Orthotrichum lyellii* Hook. & Taylor (fig. 1), a widespread moss that grows on hardwood trees in British Columbia, Washington, Oregon, Idaho, and California (Lawton 1971). This species is the most common epiphytic moss on street trees in Portland, often forming large patches on trunks and branches. Wearing powder-free nitrile gloves, we collected about 5 g (dry weight) of moss from multiple patches on each sampled tree. All moss was collected from at least 1 m off the ground to avoid road spray and pet-related contaminants. Samples were stored at 4 °C in metallized polyester Kapak[2] bags sealed with duct tape.

Samples were prepared for elemental analysis in a lab using petri dishes, forceps, and scissors sterilized with 70 percent ethanol. Wearing clean powder-free nitrile gloves, we separated the upper two-thirds of moss stems, discarding the base of the moss (fig. 2). Bark, necrotic tissue, insects, and debris were carefully removed from the sample using forceps. Moss samples weighing at least 1.5 g (dry weight) were sent to the Forestry Sciences Laboratory in Logan, Utah, for elemental analysis.

Figure 1—*Orthotrichum lyellii* Hook. & Taylor.

[2] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

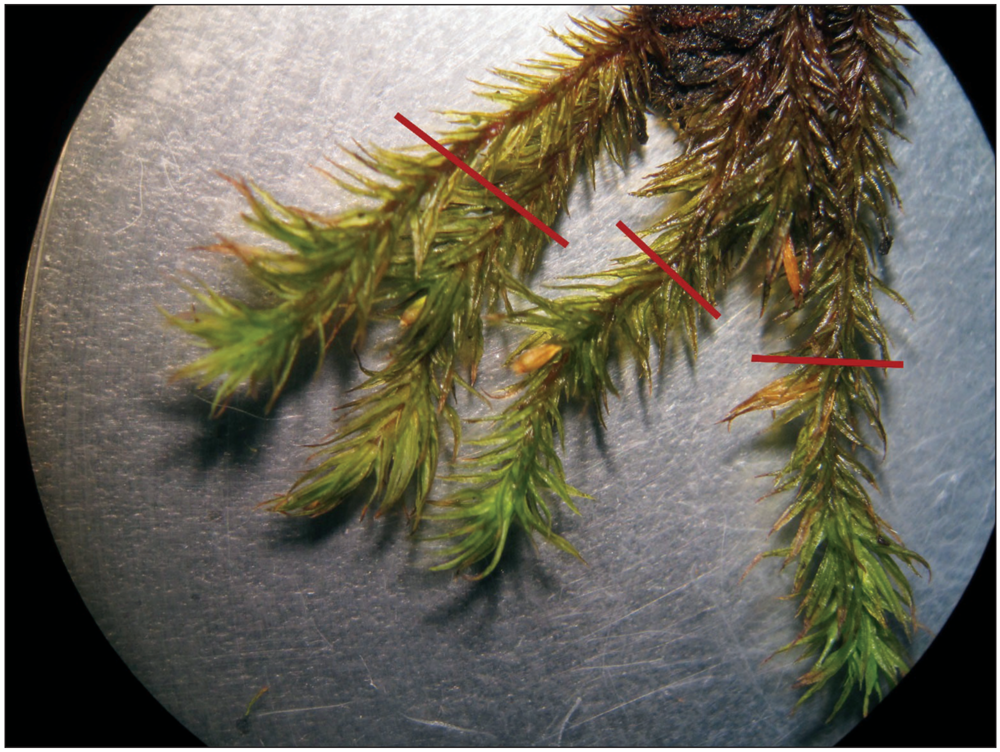

Figure 2—Example illustrating location of moss stem cutoff. About the top two-thirds of the stem is analyzed for metal concentrations. Tissue that is dark brown or covered in debris is avoided.

Laboratory Analysis

Samples were dried for 24 hours at 40 °C and ground to a fine powder. The HNO_3 + H_2O_2 digestion method was used to prepare the dried and ground samples for analysis. Briefly, 4 mL of concentrated reagent-grade HNO_3 were added to 0.5-g subsamples in 50-mL graduated plastic digestion tubes. After being covered with plastic watch glasses, the tubes were allowed to sit overnight in a fume hood to ensure initial HNO_3-imposed oxidation of the samples at ambient temperature. The samples were digested at 95 °C for 90 minutes in a graphite block digestor. The samples were allowed to cool, and 4 mL of reagent-grade 30 percent H_2O_2 was added to each tube, followed by a 30-minute digestion at 95 °C. After cooling, a second 4-mL aliquot of H_2O_2 was added to each sample, followed by a 45-minute digestion at 95 °C. If the sample was not clear or pale yellow, a third H_2O_2 digestion was done for 45 minutes. After cooling, deionized water was added to each tube to the 25-mL mark. The samples were filtered through 0.45-um membrane filters to remove undigested particulates, primarily silicate minerals not dissolved in HNO_3 + H_2O_2, and stored in 22-mL plastic scintillation vials until analysis.

Digests were analyzed for 22 elements (phosphorus–P, potassium–K, magnesium–Mg, calcium–Ca, sulfur–S, molybdenum-Mo, manganese–Mn, iron–Fe, nickel–Ni, copper–Cu, zinc–Zn, boron–B, sodium–Na, strontium–Sr, barium–Ba, aluminum–Al, silicon–Si, chromium–Cr, cobalt–Co, cadmium–Cd, lead–Pb, and arsenic–As) using inductively coupled plasma (ICP) optical emission spectrometry. Table 1 shows element full names and abbreviations. Quality control/quality assurance measures consisted of independent check standards to monitor ICP calibration performance, reagent and method blanks, repeat analysis of a bulk sample of *Orthotrichum* collected in the Portland area in 2013 (table 2), and assessment of overall method accuracy by analyzing the International Atomic Energy Agency value (IAEA-336) epiphytic lichen species, *Evernia prunastri* L. Ach. reference standard collected in Portugal (International Atomic Energy Agency 1999) (table 3).

Reported concentrations are in mg/kg except for Ca, Mg, K, P, and S, which are in percentage (%) of sample dry weight.

Table 1—Names, symbols, units, and class membership of elements analyzed in the study

Element	Symbol (unit)	Class
Phosphorus	P (%)	Plant-essential macronutrients
Potassium	K (%)	
Magnesium	Mg (%)	Plant-essential secondary nutrients
Calcium	Ca (%)	
Sulfur	S (%)	
Molybdenum	Mo (mg/kg)	Plant-essential micronutrients
Manganese	Mn (mg/kg)	
Iron	Fe (mg/kg)	
Nickel	Ni (mg/kg)	
Copper	Cu (mg/kg)	
Zinc	Zn (mg/kg)	
Boron	B (mg/kg)	
Sodium	Na mg/kg)	Soil mineral elements[a]
Strontium	Sr (mg/kg)	
Barium	Ba (mg/kg)	
Aluminum	Al (mg/kg)	
Silicon	Si (mg/kg)	
Chromium	Cr (mg/kg)	Environmentally important trace elements[b]
Cobalt	Co (mg/kg)	
Cadmium	Cd (mg/kg)	
Lead	Pb (mg/kg)	
Arsenic	As (mg/kg)	

[a] Na and Si are plant beneficial for some taxa, but not essential.
[b] Generally toxic to plant life, animal life (except Cr(III) at low levels) or both.

Table 2—Quality control data for inductively coupled plasma optical emission spectrometry for element analysis of *Orthotrichum lyellii* repeat analysis sample (n = 12)[a]

Element (unit)	Measured range	Measured mean ± std err	Detection limit (mg/kg)[b]	Class
P (%)	0.198 - 0.215	0.206 ± 0.002	0.283	Plant-essential macronutrients
K (%)	0.401 - 0.466	0.442 ± 0.007	0.255	
Mg (%)	0.189 - 0.206	0.199 ± 0.002	0.002	Plant-essential secondary nutrients
Ca (%)	0.487 - 0.523	0.500 ± 0.003	0.001	
S (%)	0.111 - 0.126	0.119 ± 0.001	0.111	
Mo (mg/kg)	0.380 - 0.520	0.470 ± 0.010	0.056	Plant-essential micronutrients
Mn (mg/kg)	108 - 116	111 ± 1	0.011	
Fe (mg/kg)	698 - 817	767 ± 11	0.040	
Ni (mg/kg)	1.0 - 1.2	1.1 ± 0.0	0.115	
Cu (mg/kg)	7.9 - 9.0	8.4 ± 0.1	0.118	
Zn (mg/kg)	35.9 - 41.8	37.3 ± 0.5	0.030	
B (mg/kg)	15.2 - 16.4	15.7 ± 0.1	Not available	
Na (mg/kg)	200 - 229	215 ± 3	0.090	Soil mineral elements
Sr (mg/kg)	27.6 - 29.7	28.6 ± 0.2	0.002	
Ba (mg/kg)	33.3 - 37.3	34.7 ± 0.3	0.009	
Al (mg/kg)	320 - 371	345 ± 5	0.076	
Si (mg/kg)	322 - 498	400 ± 17	Not available	
Cr (mg/kg)	1.38 - 1.76	1.58 ± 0.03	0.043	Environmentally important trace elements
Co (mg/kg)	0.37 - 0.43	0.40 ± 0.01	0.058	
Cd (mg/kg)	0.09 - 0.12	0.104 ± 0.002	0.0095	
Pb (mg/kg)	1.90 - 2.90	2.3 ± 0.1	0.225	
As (mg/kg)	0.07 - 0.32	0.161 ± 0.029	0.237	

Note: gray shading used to demarcate element classes shown in table 1.
[a] The *Orthotricum* sample was used to track analysis repeatability and is not a certified reference standard.
[b] As dictated by established standards, detection limits for plant-essential macro and secondary nutrients are reported in mg/kg and their concentrations in percentage of dry weight.

Correlations Between Metal Distributions

Note that even in environments virtually free from anthropogenic effects, the distribution of a given element can vary substantially because elements may be released at different levels by natural sources.

We computed sample descriptive statistics, including the mean, median, minimum, and maximum concentrations of all the elements. We assessed associations between elements by computing their correlations. Many of the elements measured belong to the same functional group or class (table 1). For example, P and K are essential macronutrients for plants. We would thus expect them to exhibit some level of correlation. Note that even in environments virtually free from anthropogenic effects, the distribution of a given element can vary substantially because elements may be released at different levels by natural sources. We also calculated the Fisher-Pearson skewness coefficient for each element (Shepard 1968) to identify elements with exceptionally high (i.e., high relative to the rest of the concentration data for that element) (table 4) concentrations. Elements with exceptionally high values have higher skewness coefficients than elements without.

Table 3—Quality control data for inductively coupled plasma optical emission spectrometry for element analysis of the IAEA-336 *Evernia prunastri* reference sample (n = 9)

Element (unit)	IAEA value (95% CI)	Measured range	Measured mean ± std err	Detection limit (mg/kg[a])	Class
P (%)	0.061 (0.049-0.073)	0.047-0.053	0.051 ± 0.001	0.283	Plant-essential macronutrients
K (%)	0.184 (0.164-0.204)	0.121-0.165	0.145 ± 0.004	0.255	
Mg (%)	0.058	0.047-0.053	0.051 ± 0.001	0.002	Plant-essential secondary nutrients
Ca (%)	0.282	0.210-0.238	0.222 ± 0.003	0.001	
S (%)	None listed	0.058-0.085	0.063 ± 0.003	0.111	
Mo (mg/kg)	None listed	0.00-0.12	0.03 ± 0.02	0.056	Plant-essential micronutrients
Mn (mg/kg)	63 (46-70)	51-57	54 ± 1	0.011	
Fe (mg/kg)	430 (380-480)	229-314	277 ± 8	0.040	
Ni (mg/kg)	1.65	0.6-0.8	0.7 ± 0.0	0.115	
Cu (mg/kg)	3.6 (3.1-4.1)	2.0-2.5	2.3 ± 0.1	0.118	
Zn (mg/kg)	30.4 (27.0-33.8)	26.9-29.7	28.1 ± 0.4	0.030	
B (mg/kg)	None listed	1.2-2.0	1.5 ± 0.1	Not available	
Na (mg/kg)	320 (280-360)	236-276	261 ± 4	0.090	Soil mineral elements
Sr (mg/kg)	9.3 (8.2-10.4)	6.1-7.0	6.5 ± 0.1	0.002	
Ba (mg/kg)	6.4 (5.3-7.5)	1.8-4.8	3.2 ± 0.4	0.009	
Al (mg/kg)	680 (570-790)	206-240	217 ± 4	0.076	
Si (mg/kg)	None listed	197-370	280 ± 23	Not available	
Cr (mg/kg)	1.06 (0.89-1.23)	0.39-0.52	0.46 ± 0.02	0.043	Environmentally important trace elements
Co (mg/kg)	0.29 (0.24-0.34)	0.19-0.26	0.22 ± 0.01	0.058	
Cd (mg/kg)	0.117 (0.100-0.134)	0.07-0.10	0.084 ± 0.004	0.0095	
Pb (mg/kg)	4.9 (4.3-5.5)	4.0-4.8	4.4 ± 0.1	0.225	
As (mg/kg)	0.63 (0.55-0.71)	0.18-0.60	0.42 ± 0.05	0.237	

Note: The P, Mg, Ca, Ni, Al, Cr, Cd, and Pb concentration values supplied with the IAEA-336 sample are not recommended reference values and are for informational purposes only (Mg, Ca, and Ni are listed as uncertain). IAEA = International Atomic Energy Agency. CI = confidence interval. Gray shading used to demarcate element classes shown in table 1.

[a] As dictated by established standards, detection limits for plant-essential macro and secondary nutrients are reported in mg/kg and their concentrations in percentage of dry weight.

Mapping

Dot maps, one per element, were generated, and sampling locations were color coded by concentrations measured in the moss. A green-yellow-brown color ramp was used to indicate low–to–high relative concentrations. Histograms of element concentrations were color coded using the same scheme. Where sampling locations were in close proximity, the one reporting the highest concentration was shown in the foreground. The maps include freeways and major road arterials for reference purposes. A color-blind-friendly version of the maps is available at http://www.fs.fed.us/pnw/pubs/pnw_gtr938_maps.pdf

Dot maps, one per element, were generated, and sampling locations were color coded by concentrations measured in the moss.

For elements with highly skewed distributions exhibiting a few extremely high concentrations, the color scheme was restricted to an upper, element-specific, threshold. These thresholds were imposed arbitrarily by examining the form of the

Table 4—Element descriptive statistics

Element	Minimum	Maximum	Mean	Median	Fisher-Pearson Skewness coefficient	Samples with value below detection limits
P	0.0958	0.4333	0.2133	0.2074	0.5739	0
K	0.2537	1.2120	0.5219	0.5146	1.1343	0
Mg	0.0775	0.3130	0.1646	0.1592	0.5536	0
Ca	0.2598	0.8659	0.5189	0.5042	0.4161	0
S	0.0712	0.2406	0.1261	0.1234	0.8035	0
Mo	BD[a]	3.7700	0.8008	0.6675	2.6471	2
Mn	18.1650	449.8050	87.6504	63.5525	2.0260	0
Fe	447.1600	4802.8300	1115.2190	996.4600	2.5414	0
Ni	0.6750	43.4500	2.8338	2.2000	8.8199	0
Cu	5.3550	357.2500	19.0601	12.8925	8.2733	0
Zn	24.0750	250.0600	71.9426	60.3025	1.6644	0
B	2.7600	101.2050	19.3121	15.7025	1.6918	0
Na	BD	382.5900	138.7499	138.9000	0.5663	1
Sr	12.8300	113.7550	35.7719	33.7275	1.7317	0
Ba	16.1450	175.0100	51.1529	46.4400	1.6553	0
Al	220.3050	1713.4400	527.4580	487.1700	1.8221	0
Si	23.8950	1324.8900	459.6801	445.1550	0.8157	0
Cr	1.0150	10.0400	2.3852	2.0500	2.5543	0
Co	0.2700	2.5200	0.6577	0.5975	2.4552	0
Cd	BD	4.3800	0.3083	0.2300	6.7973	1
Pb	1.0300	128.9500	7.0914	4.9950	9.2178	0
As	BD	0.9450	0.3757	0.3500	1.7642	177

Note: Measurement units per element are given in table 1. Gray shading used to demarcate element classes shown in table 1.
[a] BD indicates concentration below detection limits.

histograms for Pb, Ni, Cu, Cd, Mo, Cr, Fe, Co, Al, and As. High outlying values are shown in black on the histogram and as black squares on the map instead of filled circles. The element concentration is reported next to each square on the map. This alternative color scheme was devised to ensure that the variability in sample values remains evident even in the presence of a few high values. Subsequently, we created a ranked list of locations based on the number of elements measured at that site with concentrations in the top eight highest values. Sample locations with high concentrations for several elements is one way to prioritize hotspots for further air quality investigations.

To protect the privacy of individual landowners, the coordinates of samples located on private property were shifted manually to the closest trees in public areas using as reference orthorectified, high-resolution aerial imagery taken at the same time the moss data were collected. Of the 346 sample points, 121 were shifted. The mean planar shifting distance was 5.00 m, more than two orders of magnitude smaller than mean minimum distance between sample locations. It is unlikely that such a small shift will affect any spatial analysis conducted by users of the moss data. Appendix table 6 and dot maps show the shifted coordinates.

Results and Discussion

For each element, sample descriptive statistics and number of samples with concentration values below the detection limit are shown in table 4. Correlations between element concentrations measured in moss are shown in table 5. Correlations higher than 0.50 are shaded in gray; shading becomes progressively darker as the strength of the correlation increases.

Element Associations

Identification of pollution emissions sources can be aided by examining associations between elements. Strong positive correlations between elements suggest they are often co-emitted or share a common origin. Here we provide the table of correlations (table 5) and a basic summary mainly for reference. Further analysis using multivariate techniques, such as Principal Components Analysis, is recommended to help resolve the relative contribution of different types of emissions sources (e.g., natural vs. vehicular vs. industrial) to element concentrations measured in moss (e.g., Berg and Steinnes 1997b, Schaug et al. 1990). The correlation between P and K is substantial (0.62), suggesting P and K are often high in the same locations. This is unsurprising considering that both elements are naturally abundant plant macronutrients that are also widely used in plant and grass fertilizers. Otherwise, highly correlated elements spanned multiple classes. Sulfur, a plant-essential secondary nutrient, and a product of combustion of sulfur-containing fuels, exhibits correlations higher than 0.50 with seven elements (Mo, Fe, Zn, B, Al, Cr, and Co), none of which belong to its class (table 1). This closely correlated group of elements and S are commonly, but not exclusively, emitted by various industrial processes. For instance, Al and Fe levels in moss are often associated with wind-blown soil particulates (Steinnes 1995), and Mo and Zn may occur from vehicular sources (e.g., exhaust, tire and brake wear) (Zechmeister et al. 2005). Sulfur may also be released by natural sources, the most likely in Portland being biomass burning and decomposition of organic matter (Bates and Lamb 1992). Seven other elements commonly emitted from industrial sources were not associated strongly with any (As, Cu, Mn, and Pb) or at most two other elements (Cd, Ni, Sr) (table 5).

Identification of pollution emissions sources can be aided by examining associations between elements. Strong positive correlations between elements suggest they are often co-emitted or share a common origin.

Table 5—Correlations between metal concentrations observed in the sample

	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
P	•	0.62	0.45	0.20	0.46	0.18	0.06	0.17	0.08	-0.05	0.17	0.38	0.16	0.12	0.28	0.13	0.14	0.23	0.17	0.19	0.05	-0.02
K		•	0.41	0.06	0.29	0.08	0.12	0.05	0.05	-0.06	0.04	0.38	0.48	-0.06	0.09	0.02	0.05	0.12	0.06	0.13	0.04	-0.03
Mg			•	0.15	0.31	0.20	0.06	0.17	0.09	-0.03	0.10	0.46	0.22	0.14	0.23	0.12	0.20	0.23	0.19	0.16	-0.05	0.06
Ca				•	0.50	0.23	-0.28	0.26	0.10	0.20	0.17	0.70	-0.15	0.63	0.52	0.29	0.26	0.32	0.21	0.36	0.26	0.33
S					•	0.59	0.09	0.66	0.22	0.17	0.53	0.51	0.25	0.29	0.45	0.56	0.39	0.69	0.54	0.40	0.37	0.29
Mo						•	0.12	0.72	0.56	0.14	0.51	0.24	0.19	0.15	0.35	0.59	0.25	0.83	0.71	0.23	0.27	0.31
Mn							•	0.11	-0.01	-0.07	0.14	-0.16	0.22	-0.20	0.09	0.06	0.10	0.09	0.09	-0.09	-0.02	-0.01
Fe								•	0.28	0.19	0.61	0.21	0.23	0.25	0.38	0.92	0.44	0.87	0.89	0.24	0.34	0.31
Ni									•	0.02	0.16	0.10	0.08	0.03	0.13	0.32	0.14	0.45	0.59	0.08	0.12	0.28
Cu										•	0.19	0.10	-0.01	0.14	0.13	0.14	0.06	0.21	0.12	0.11	0.17	0.19
Zn											•	0.22	0.11	0.13	0.23	0.52	0.22	0.59	0.54	0.37	0.33	0.21
B												•	0.10	0.38	0.39	0.20	0.27	0.28	0.20	0.58	0.20	0.28
Na													•	-0.14	0.02	0.21	0.24	0.24	0.21	0.06	0.05	0.12
Sr														•	0.57	0.31	0.16	0.19	0.23	0.14	0.15	0.18
Ba															•	0.41	0.35	0.37	0.36	0.22	0.19	0.23
Al																•	0.53	0.72	0.88	0.20	0.28	0.37
Si																	•	0.35	0.42	0.19	0.18	0.17
Cr																		•	0.79	0.29	0.41	0.33
Co																			•	0.23	0.27	0.35
Cd																				•	0.18	0.30
Pb																					•	0.08
As																						•

Note: Darker cell background indicates higher correlations values. Dotted lines demarcate element classes shown in table 1.

High Concentrations and "Hotspots"

Dot maps of element concentrations in moss and corresponding histograms are shown in figure 3. As might be expected, the dot maps show unique spatial distributions for the seven elements that lacked strong associations with other elements. Most exhibit one or a few hotspots (figs. 3i, 3j, 3t, and 3u) whereas possible As and Sr hotspots were numerous and widespread (figs. 3n and 3v).

Skewness coefficients (table 4) varied by element. All highly skewed histograms (fig. 3) showed a tail towards the right, indicating the presence of one or more exceptionally high concentrations in our dataset. In studies of small-scale industrial emissions, elements with highly right-skewed distributions typically indicate the presence of pollution point sources (Fernandez et al. 2007, Varela et al. 2014). The most skewed elements included all elements in the plant-essential micronutrients and environmentally important trace elements classes (Zn, B, As, Mn, Co, Fe, Cr, Mo, Cd, Cu, Ni, and Pb). All of these elements may be emitted from certain industrial activities and can be hazardous if present in high concentrations in the atmosphere. Also substantially skewed were the distributions of Sr, Al, and Ba, soil mineral elements that may also be emitted by industry. The elements Cd, Cu, Ni, and Pb had the highest coefficients owing to a few very high concentrations measured in the moss samples. Three of the four (Cd, Ni, and Pb) are heavy metals on the Environmental Protection Agency's list of urban toxics posing the greatest health risk in urban areas.[3]

The elements Cd, Cu, Ni, and Pb had the highest skewness coefficients owing to a few very high concentrations measured in the moss samples. Three of the four (Cd, Ni, and Pb) are heavy metals on the Environmental Protection Agency's list of urban toxics posing the greatest health risk in urban areas.

On the other hand, elements belonging to the plant-essential macro- and secondary nutrients, plus the soil minerals Na and Si, were relatively free of exceptionally high concentrations. These elements are all abundant in nature and, with the exception of S and Si, are less commonly released from industrial sources. Because elements with right-skewed distributions often indicate pollution point sources, it would thus be expected that elements primarily derived from natural sources would have more normally distributed data.

Ranking locations with high concentrations of multiple elements of concern is one approach to prioritizing hotspots for further investigation. Figure 4 shows where moss concentrations were in the top eight highest for the six most toxic metals in our dataset (Ni, Cr, Co, Cd, Pb, and As). Figure 5 shows locations in the top 8 for the 10 most skewed elements, which includes all 6 of the most toxic metals (Mo, Fe, Ni, Cu, Zn, Cr, Co, Cd, Pb, and As). Despite its highly skewed distribution, manganese (Mn) was excluded as prior research suggests levels measured in moss are controlled by factors other than atmospheric concentrations (Boquete et al. 2011). Increasing the number of elements used in calculating the top 8 concentration from 6 to 10 does not alter the overall hotspot pattern although a few other sample locations with more than one value in the top-8 values emerge.

Ranking locations with high concentrations of multiple elements of concern is one approach to prioritizing hotspots for further investigation.

[3] Environmental Protection Agency. 2015. Urban air toxic pollutants. https://www.epa.gov/urban-air-toxics/urban-air-toxic-pollutants. (April 2016).

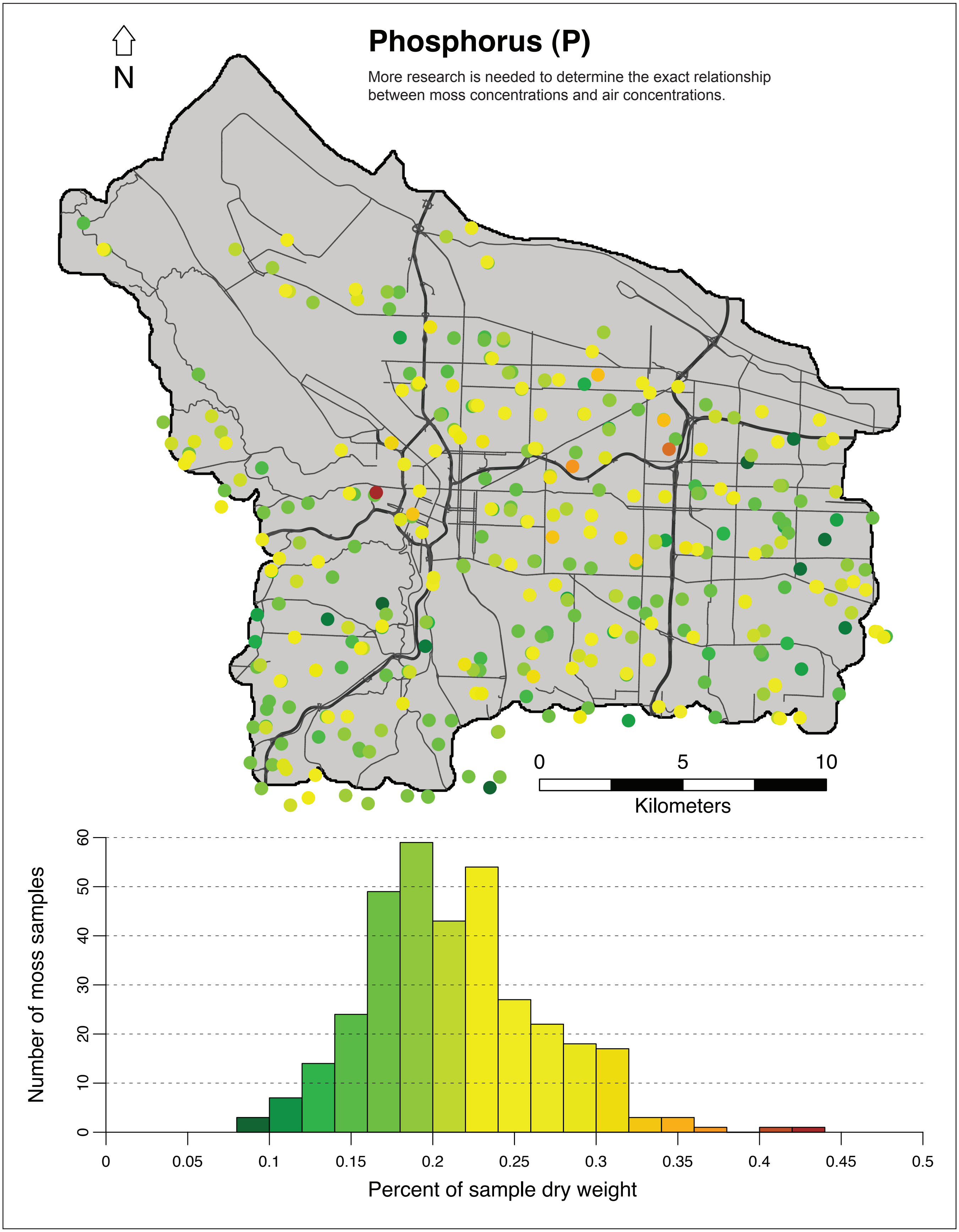

Figure 3a—Dot map of phosphorus concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

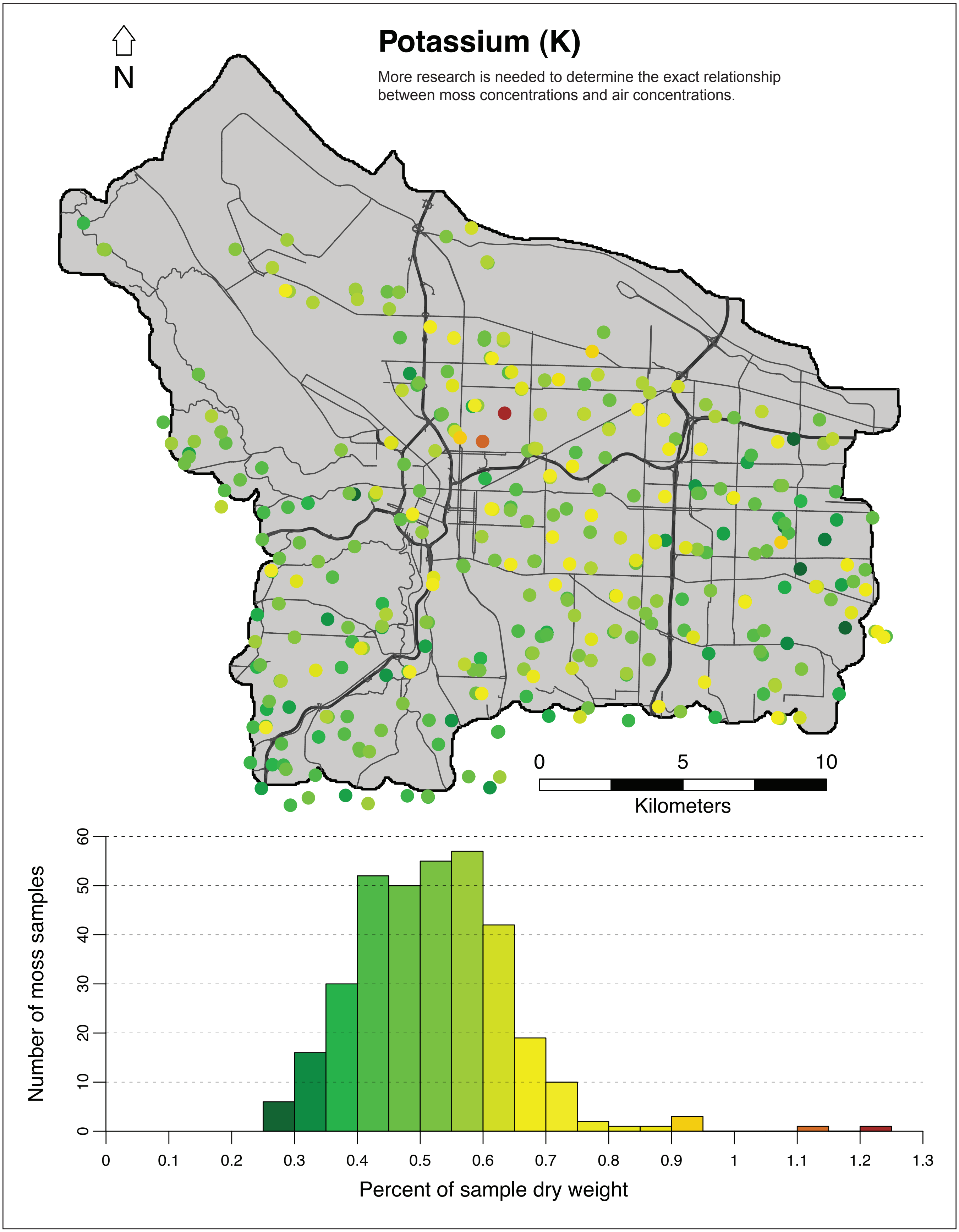

Figure 3b—Dot map of potassium concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

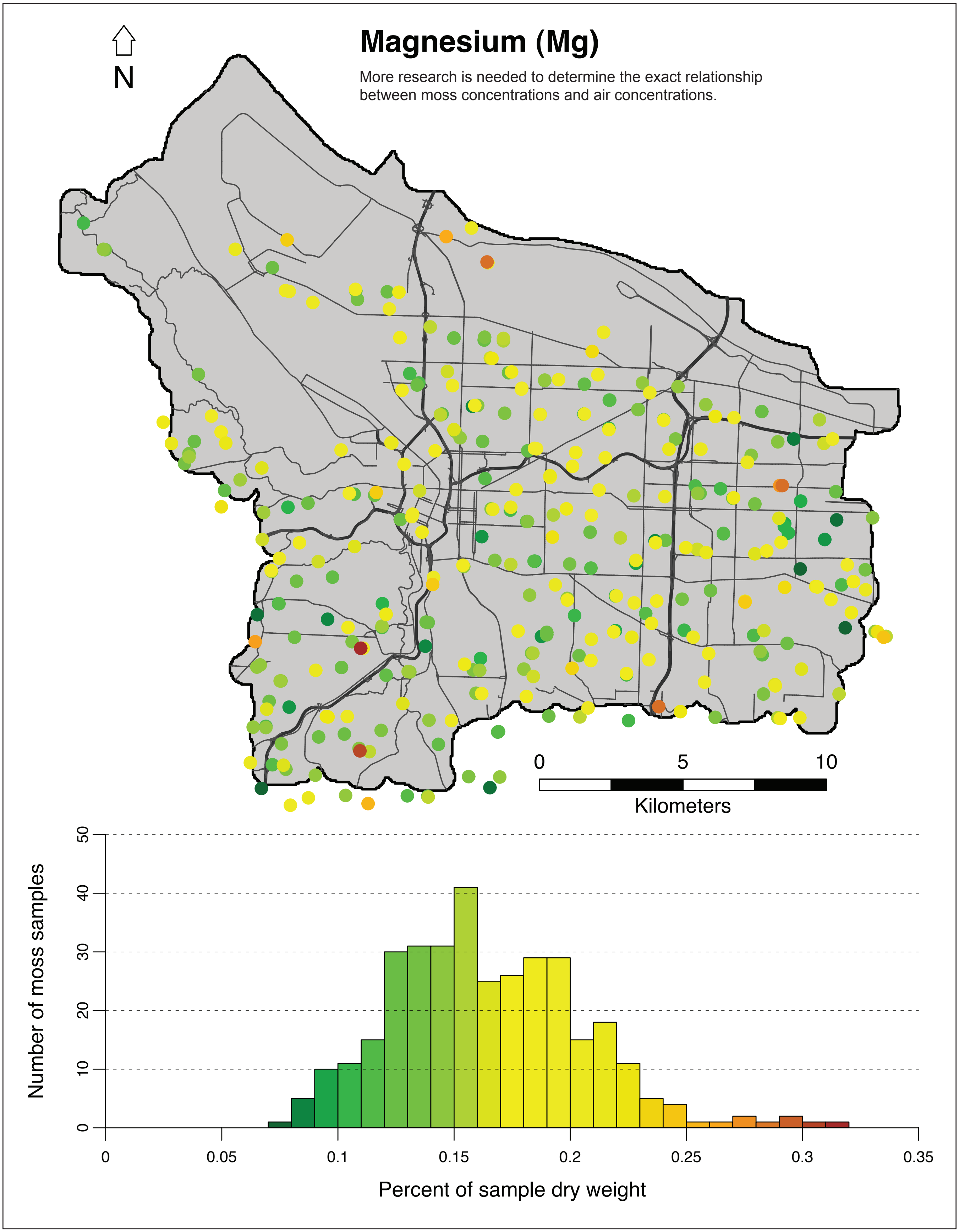

Figure 3c—Dot map of magnesium concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

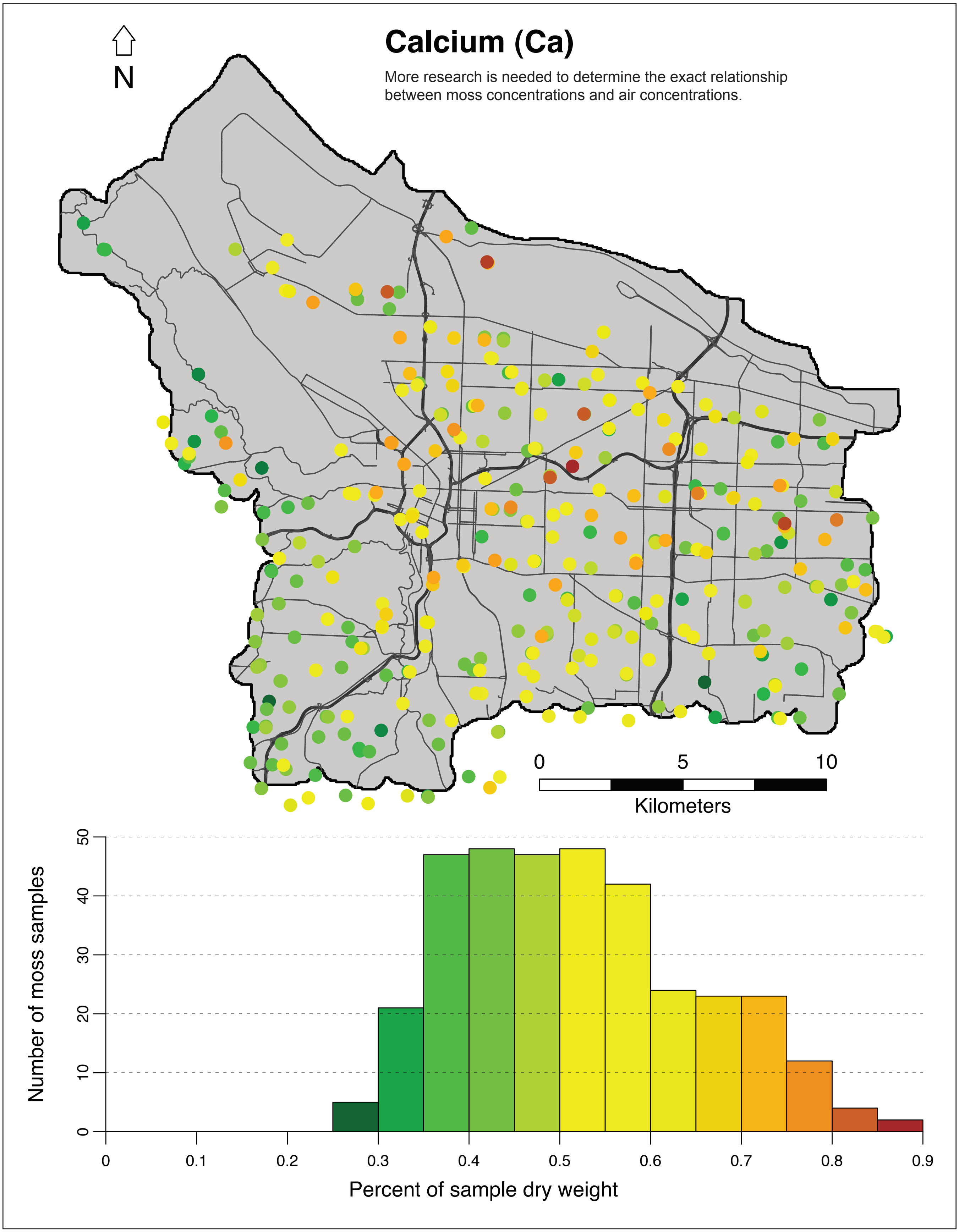

Figure 3d—Dot map of calcium concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

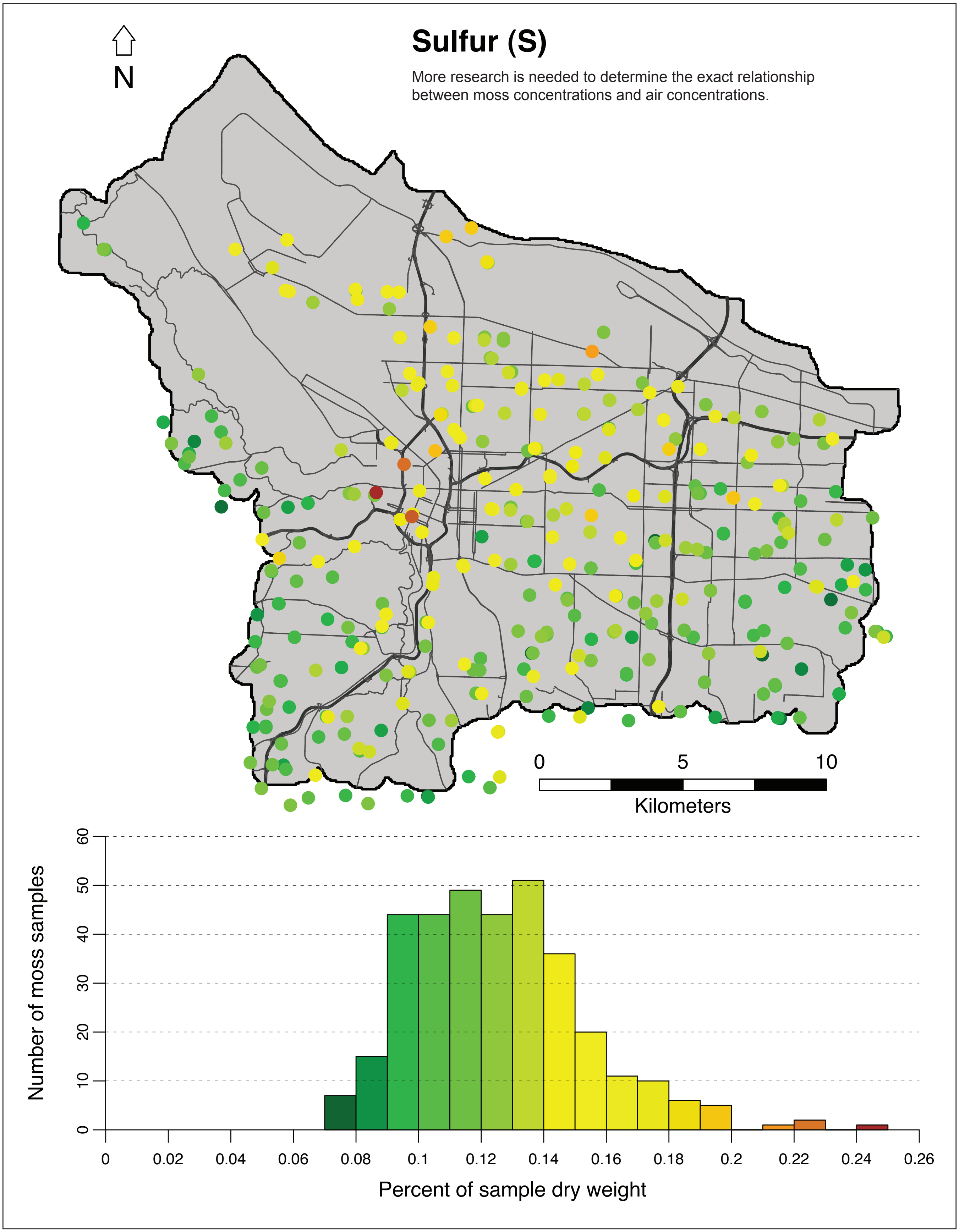

Figure 3e—Dot map of sulfur concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

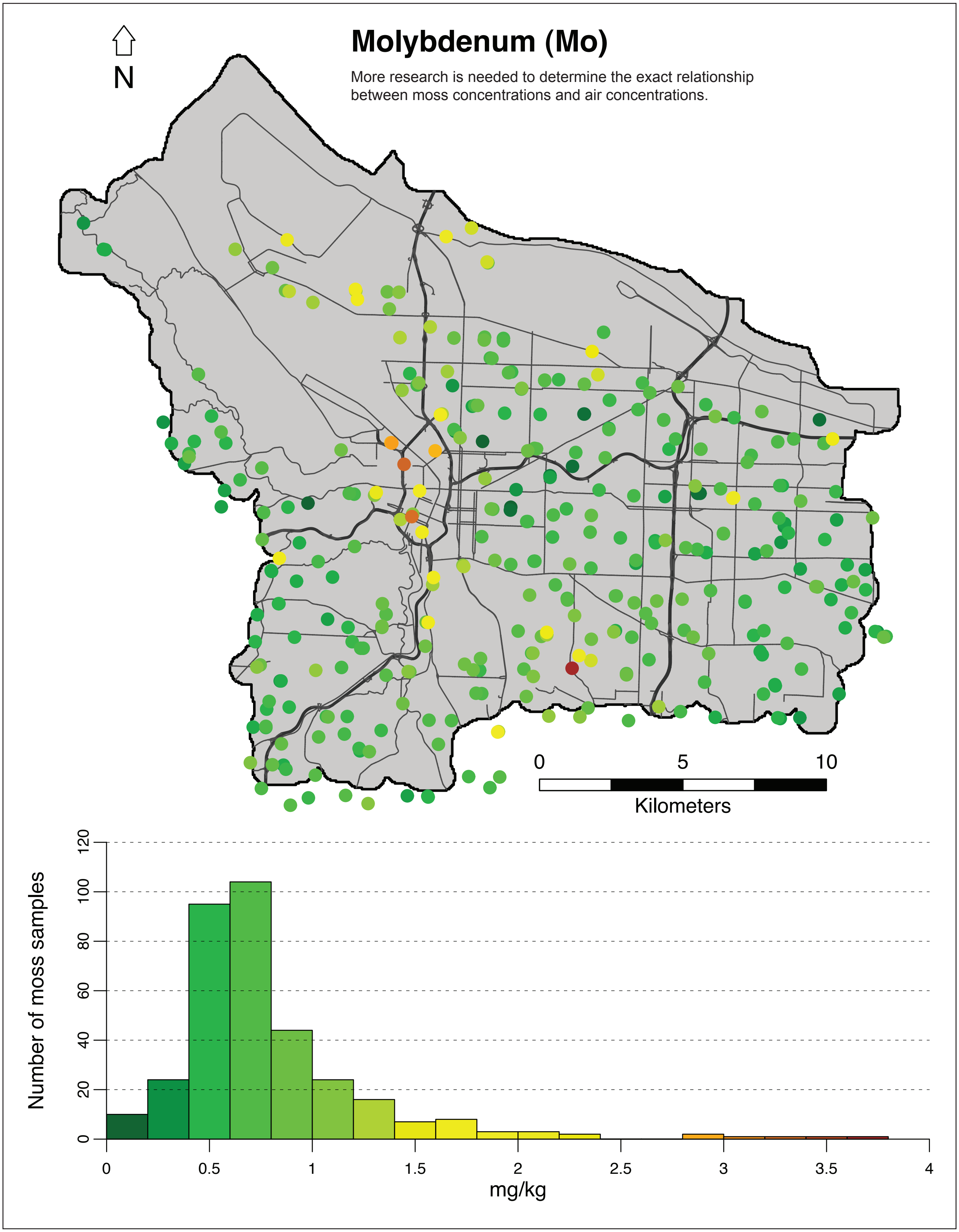

Figure 3f—Dot map of molybdenum concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

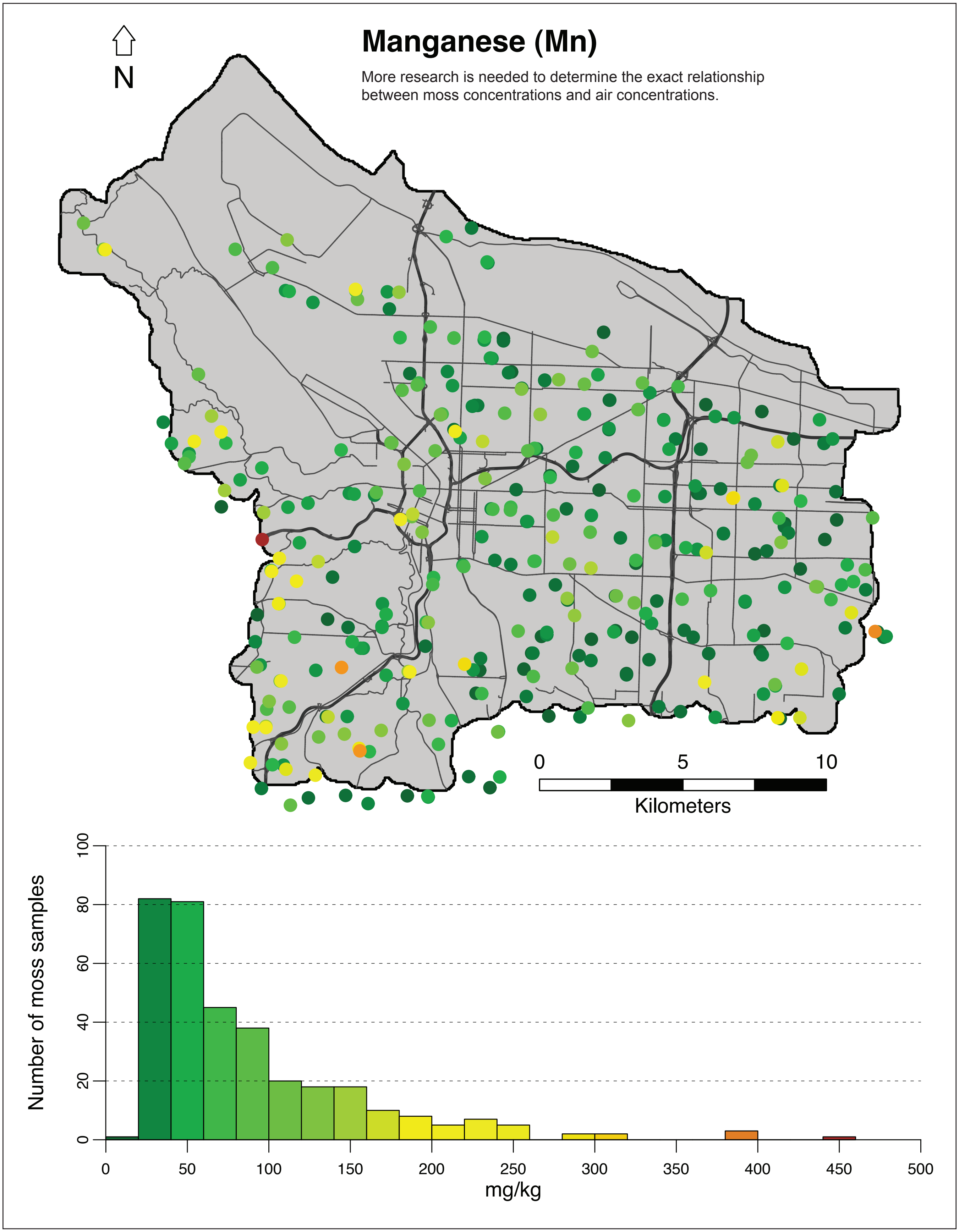

Figure 3g—Dot map of manganese concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

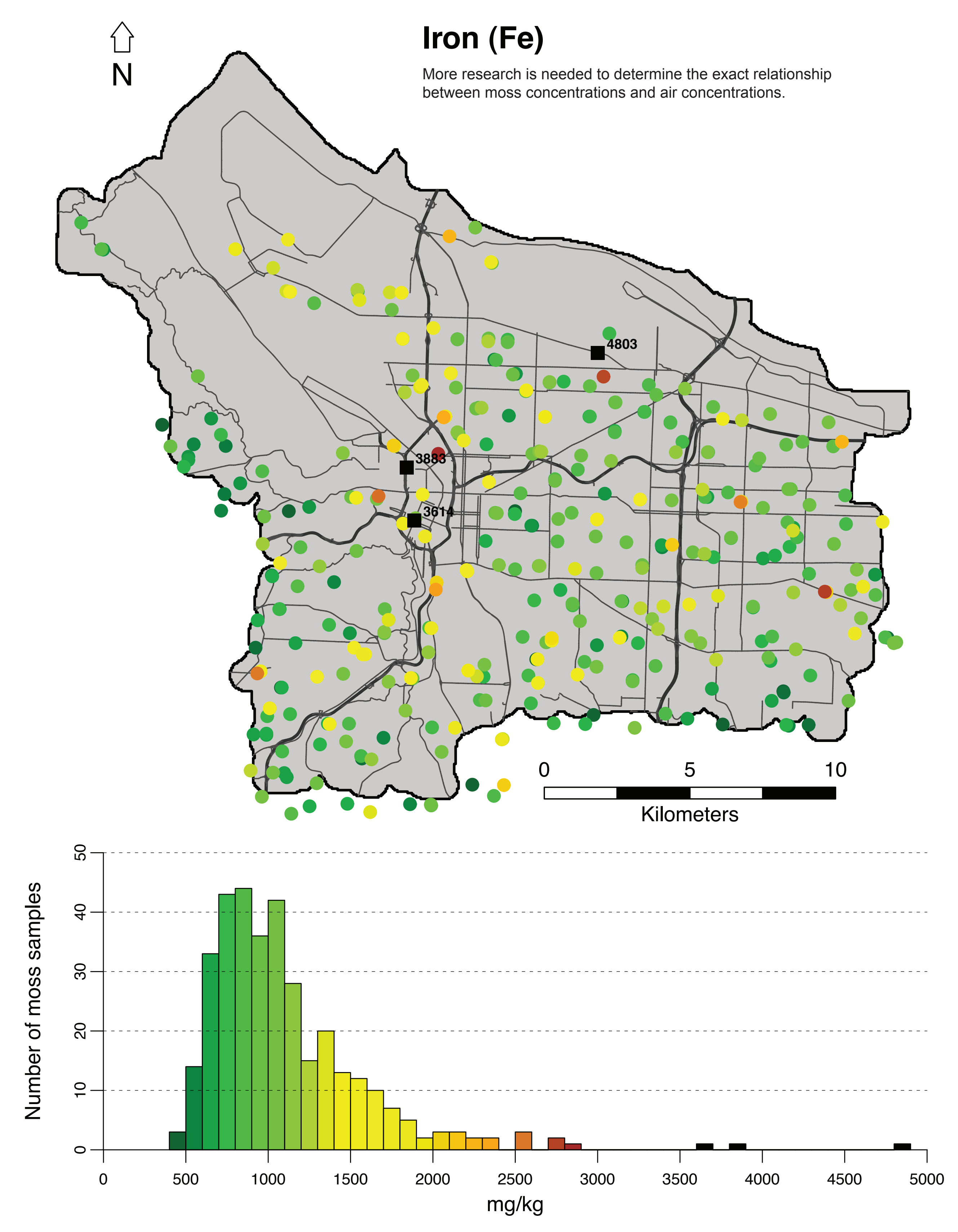

Figure 3h—Dot map of iron concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

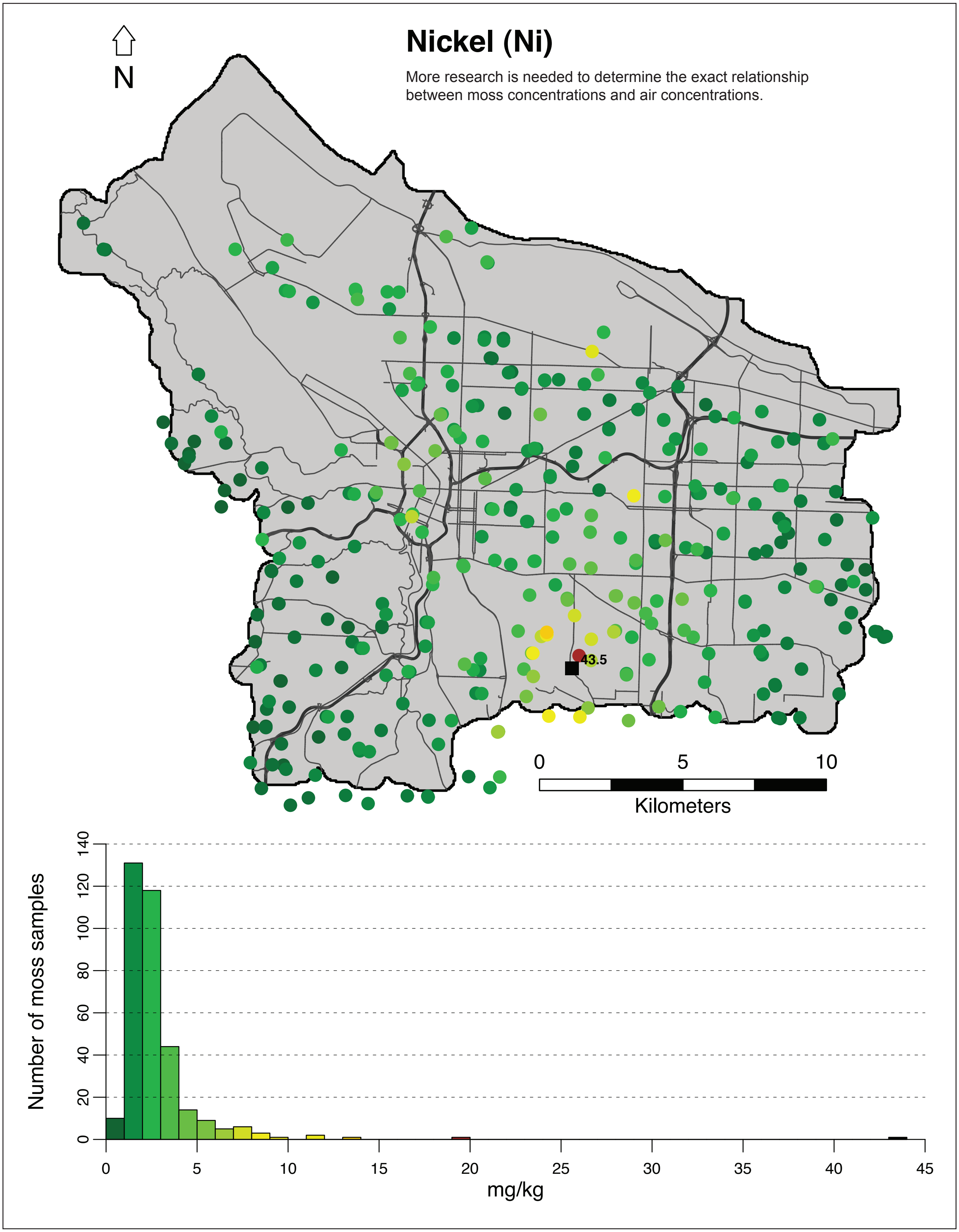

Figure 3i—Dot map of nickel concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

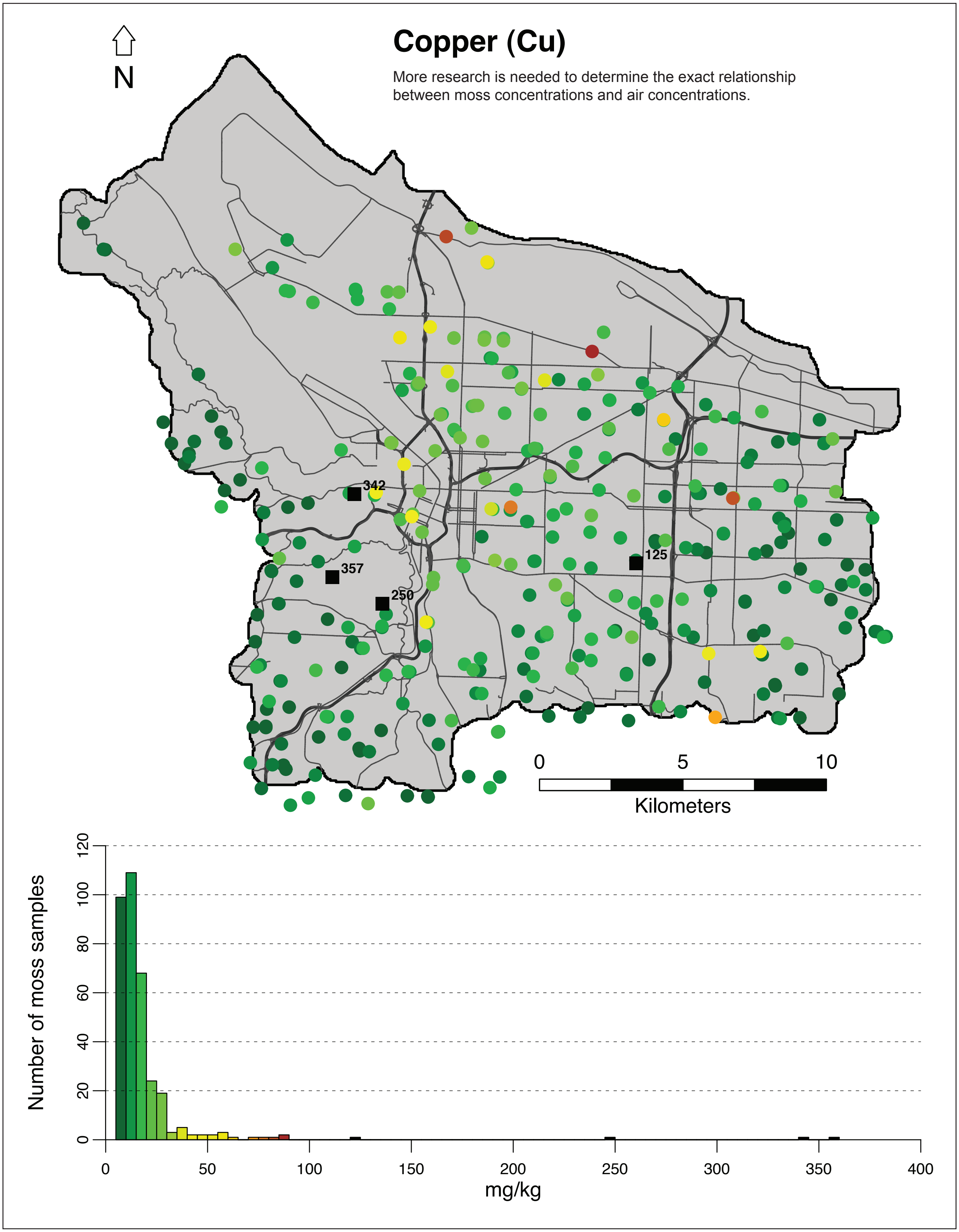

Figure 3j—Dot map of copper concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

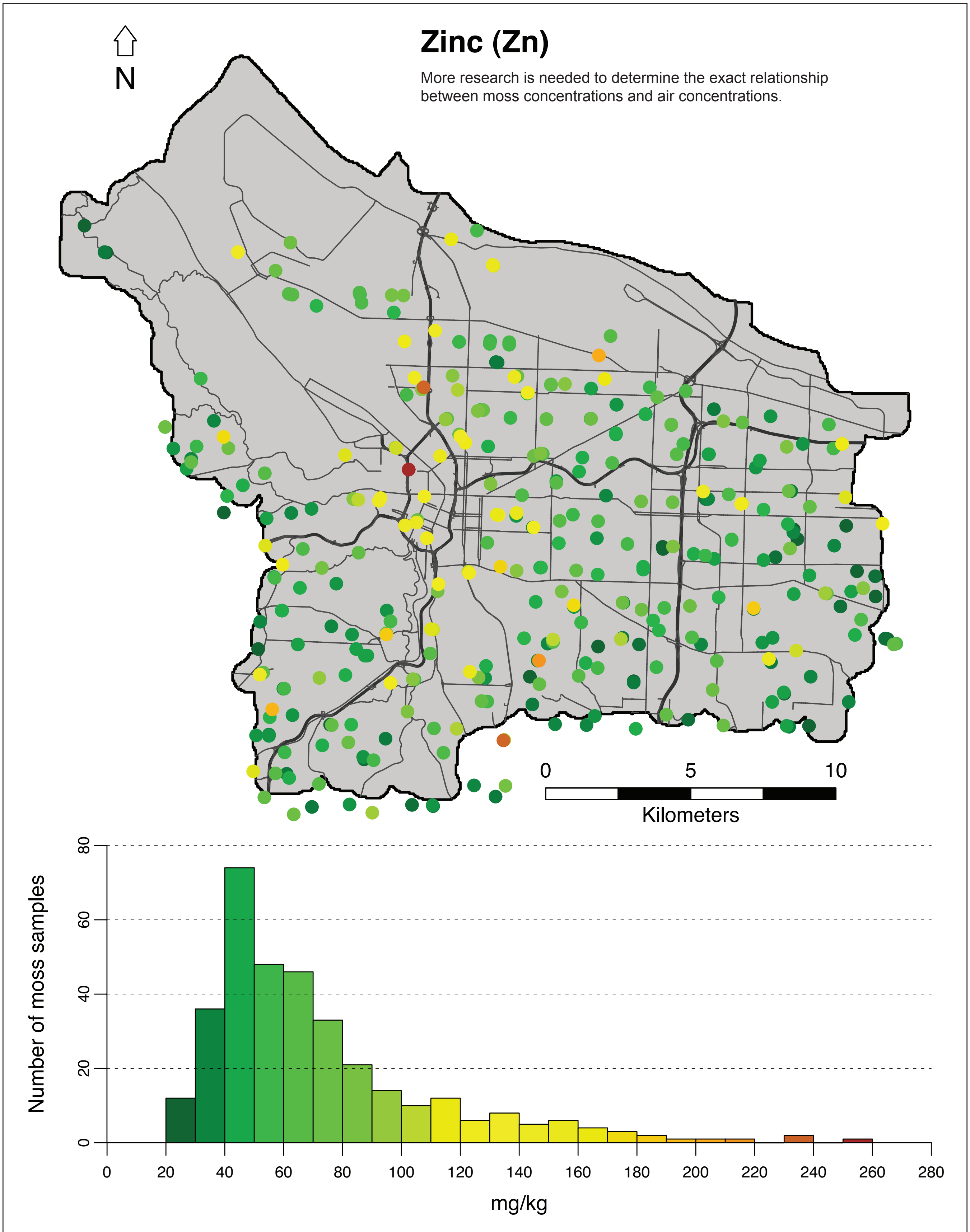

Figure 3k—Dot map of zinc concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

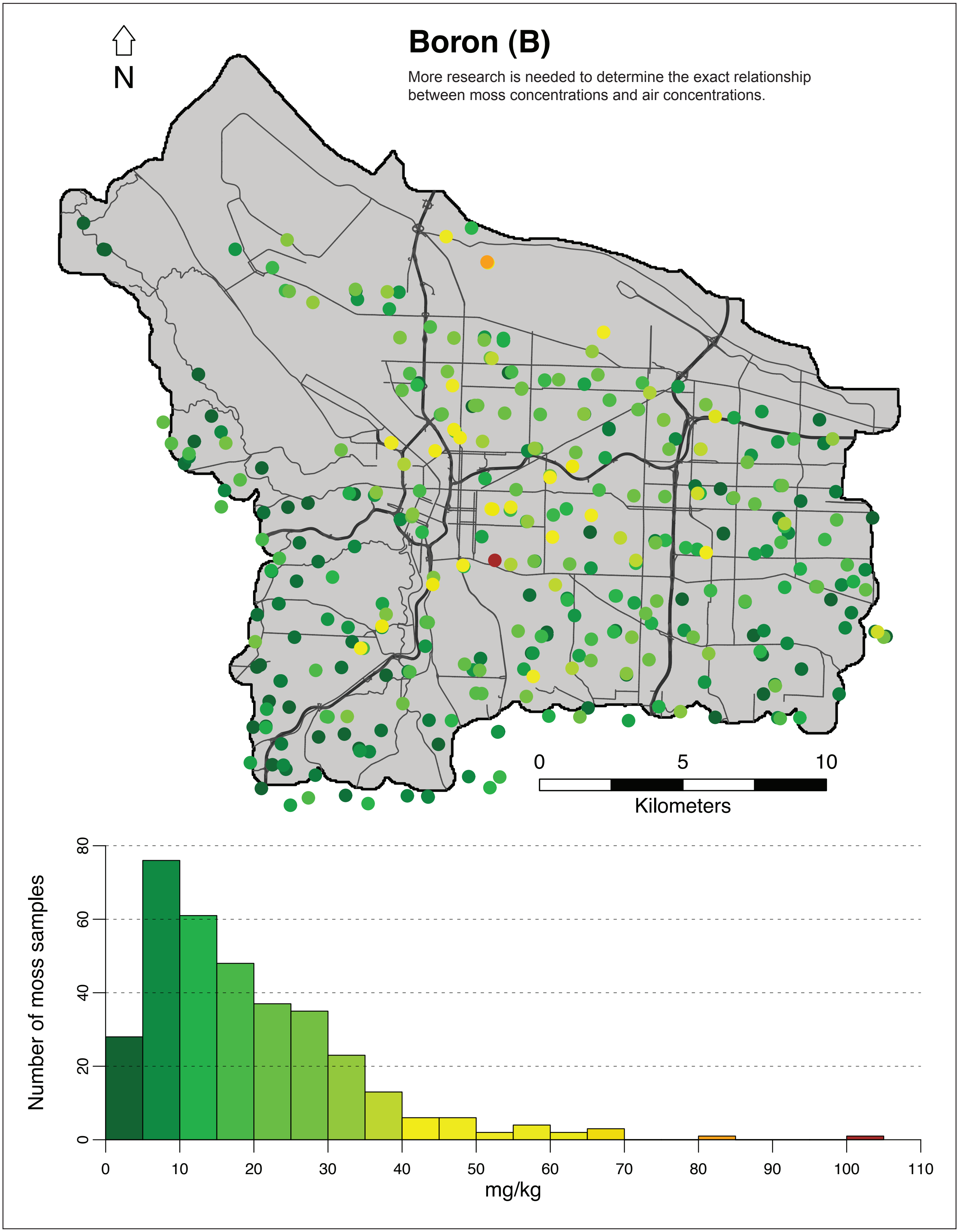

Figure 3l—Dot map of boron concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

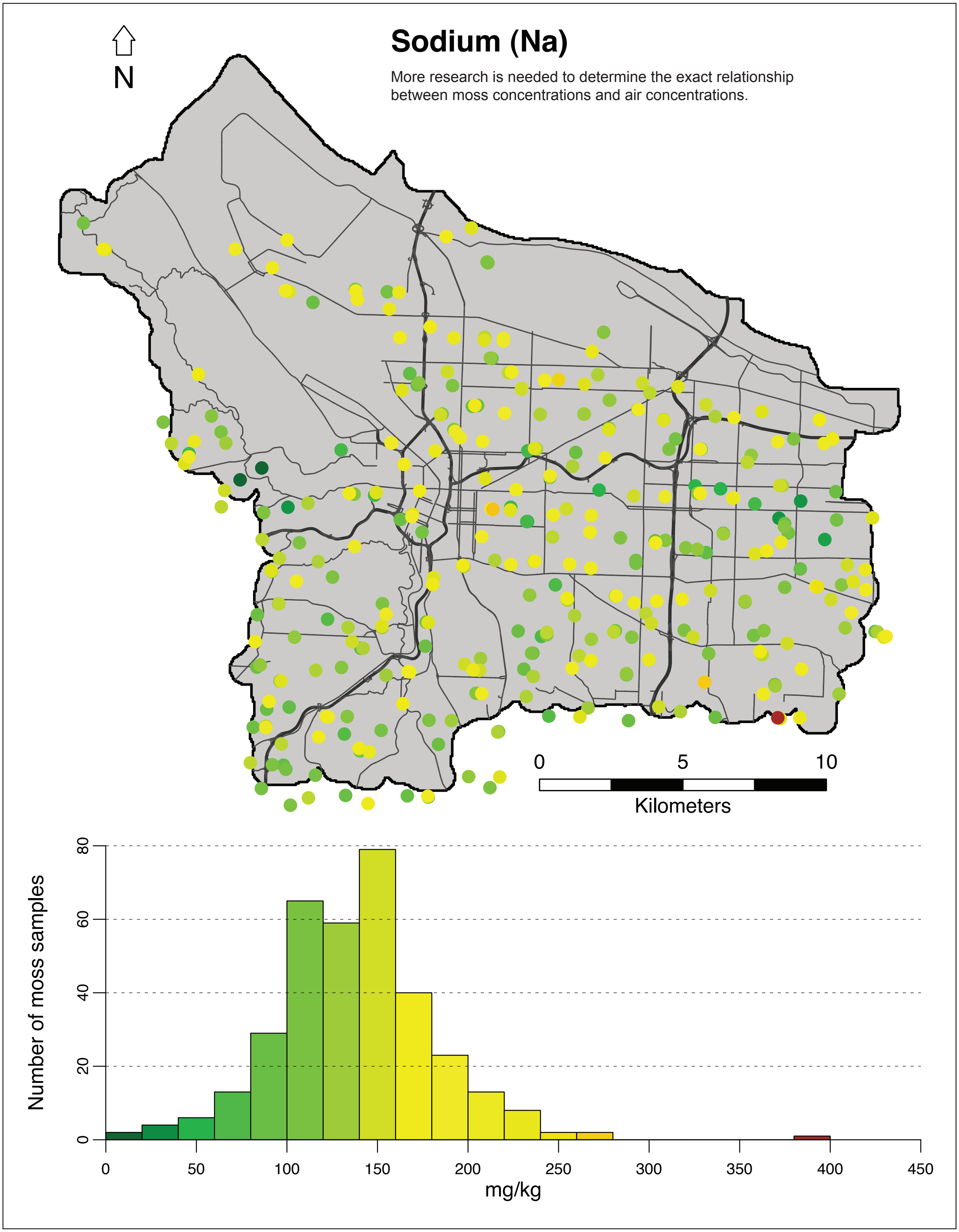

Figure 3m—Dot map of sodium concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

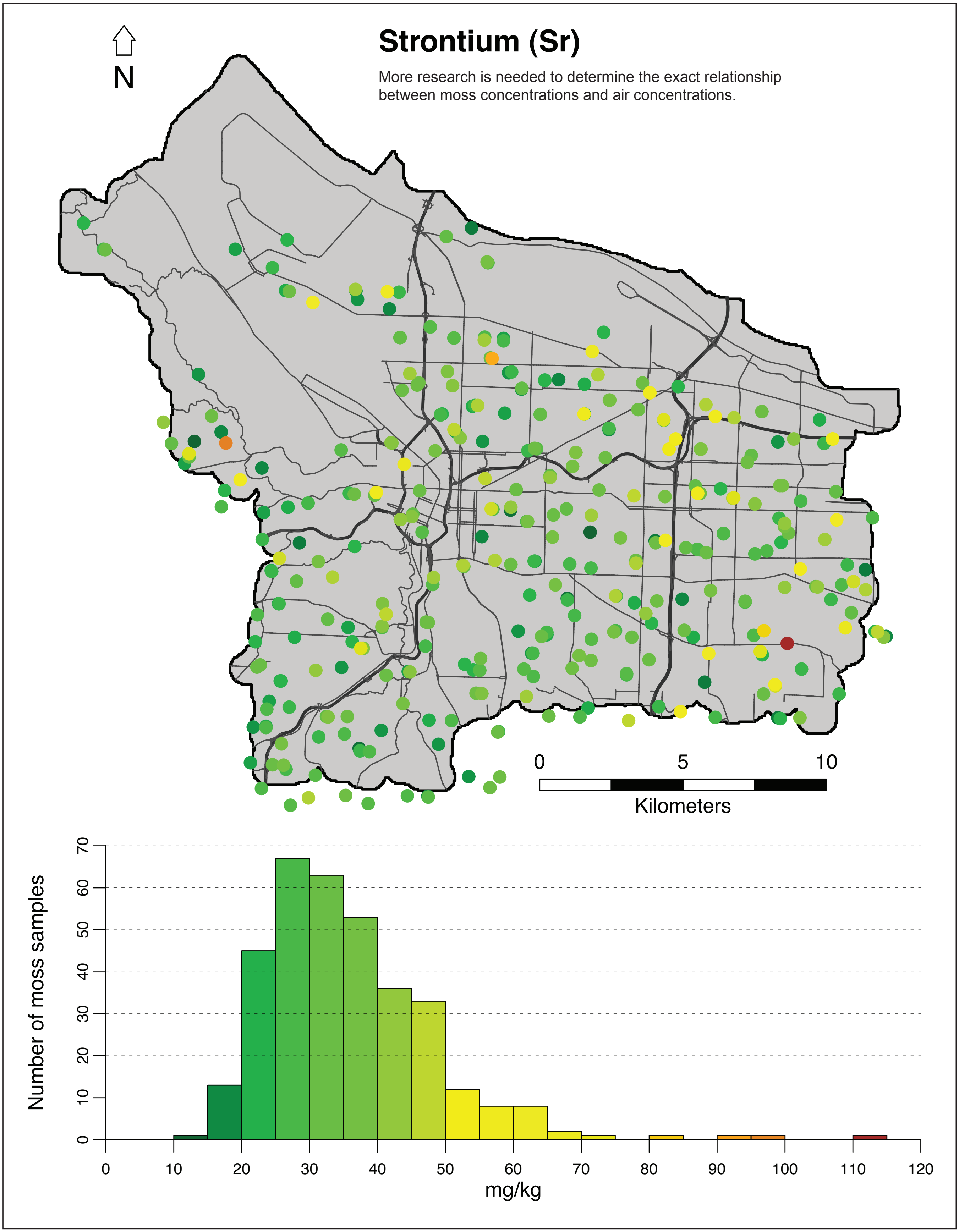

Figure 3n—Dot map of strontium concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

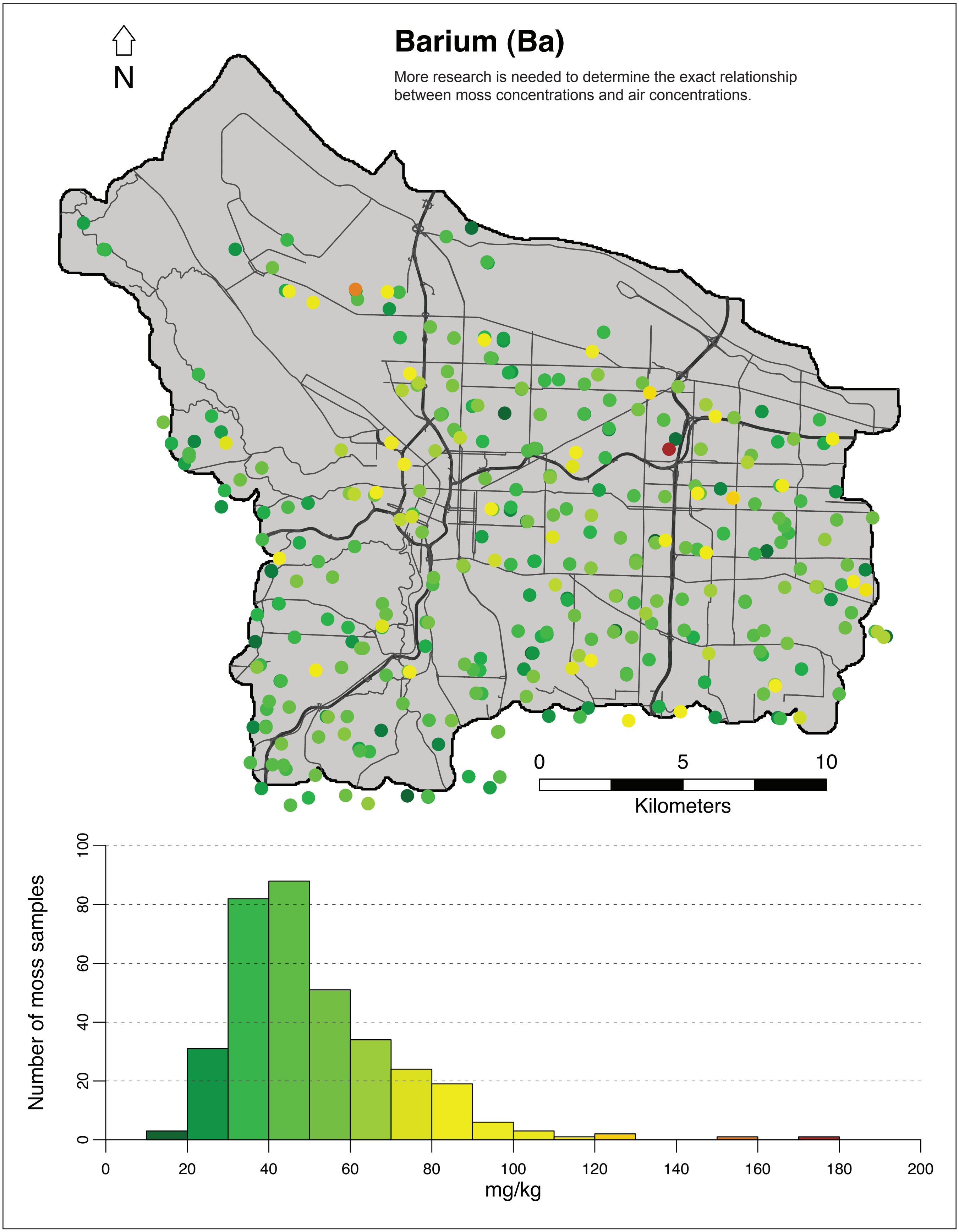

Figure 3o—Dot map of barium concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

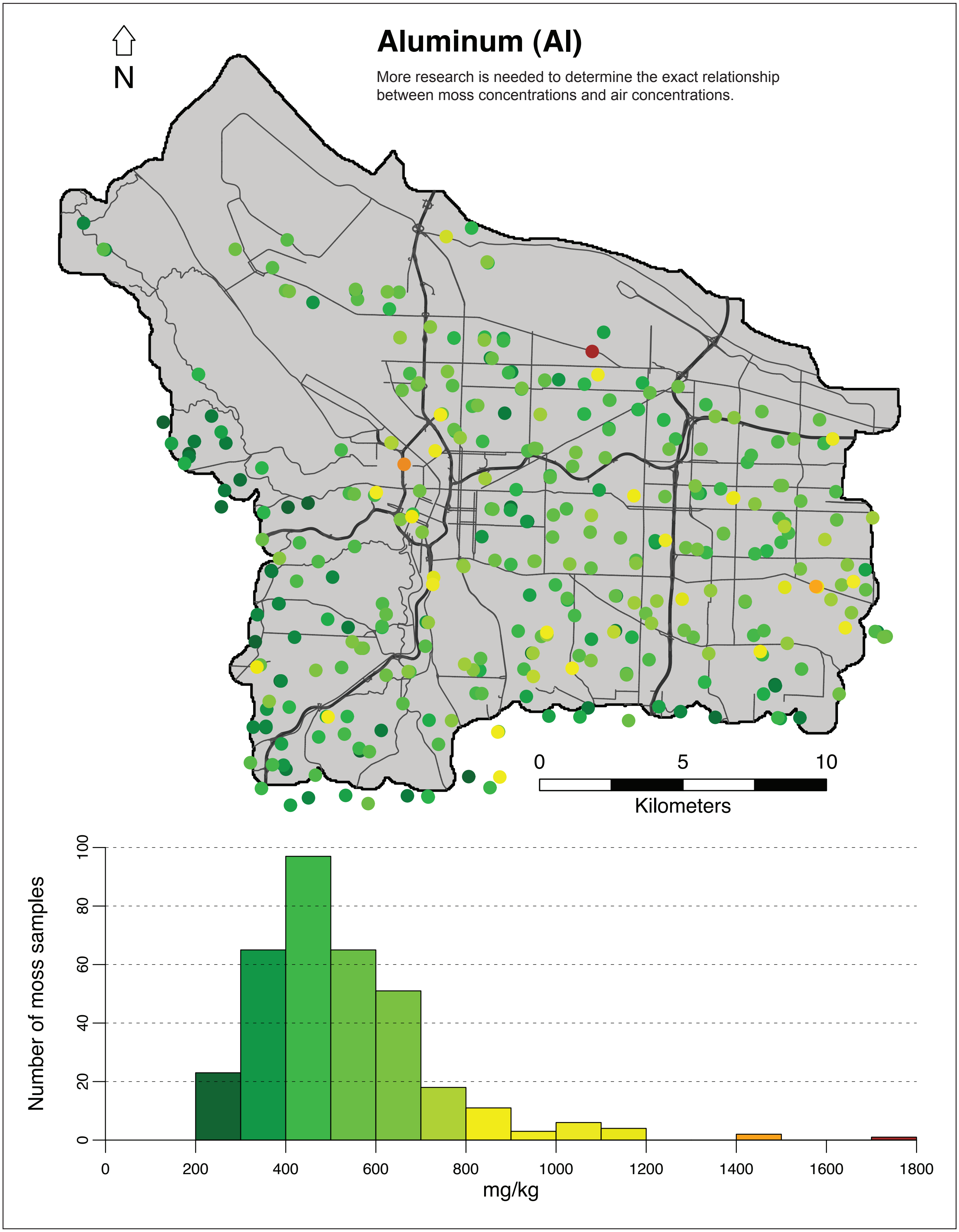

Figure 3p—Dot map of aluminum concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

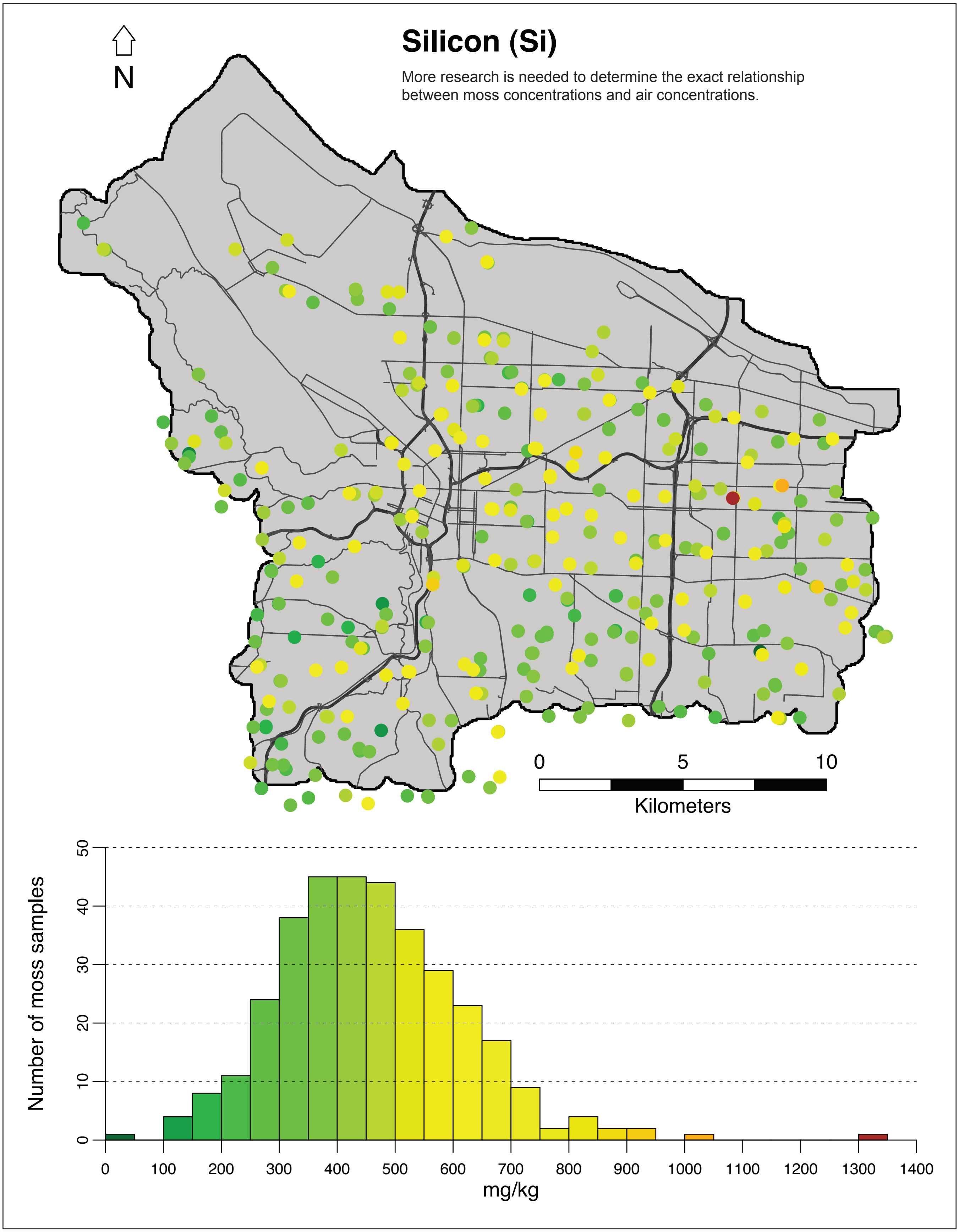

Figure 3q—Dot map of silicon concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

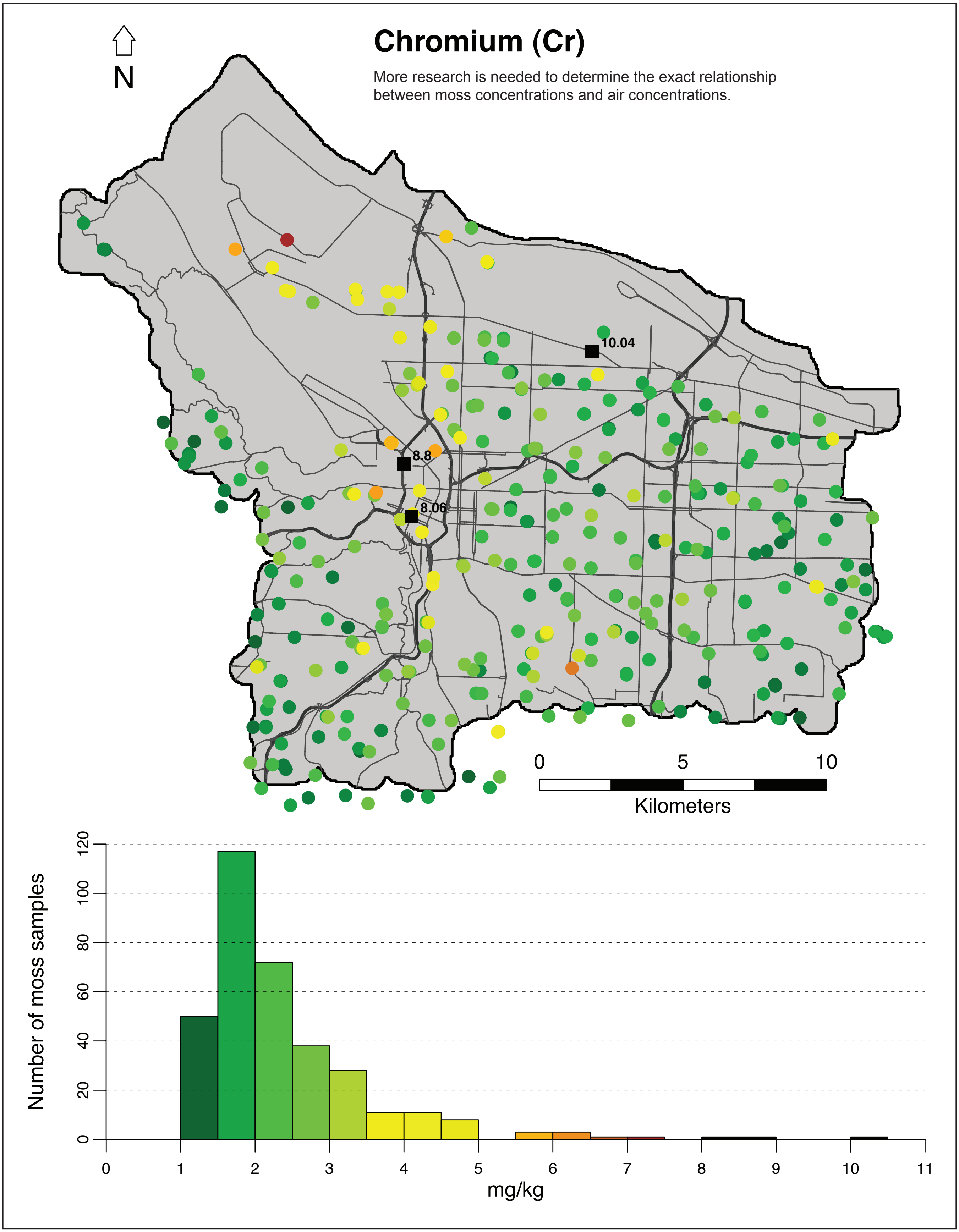

Figure 3r—Dot map of chromium concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

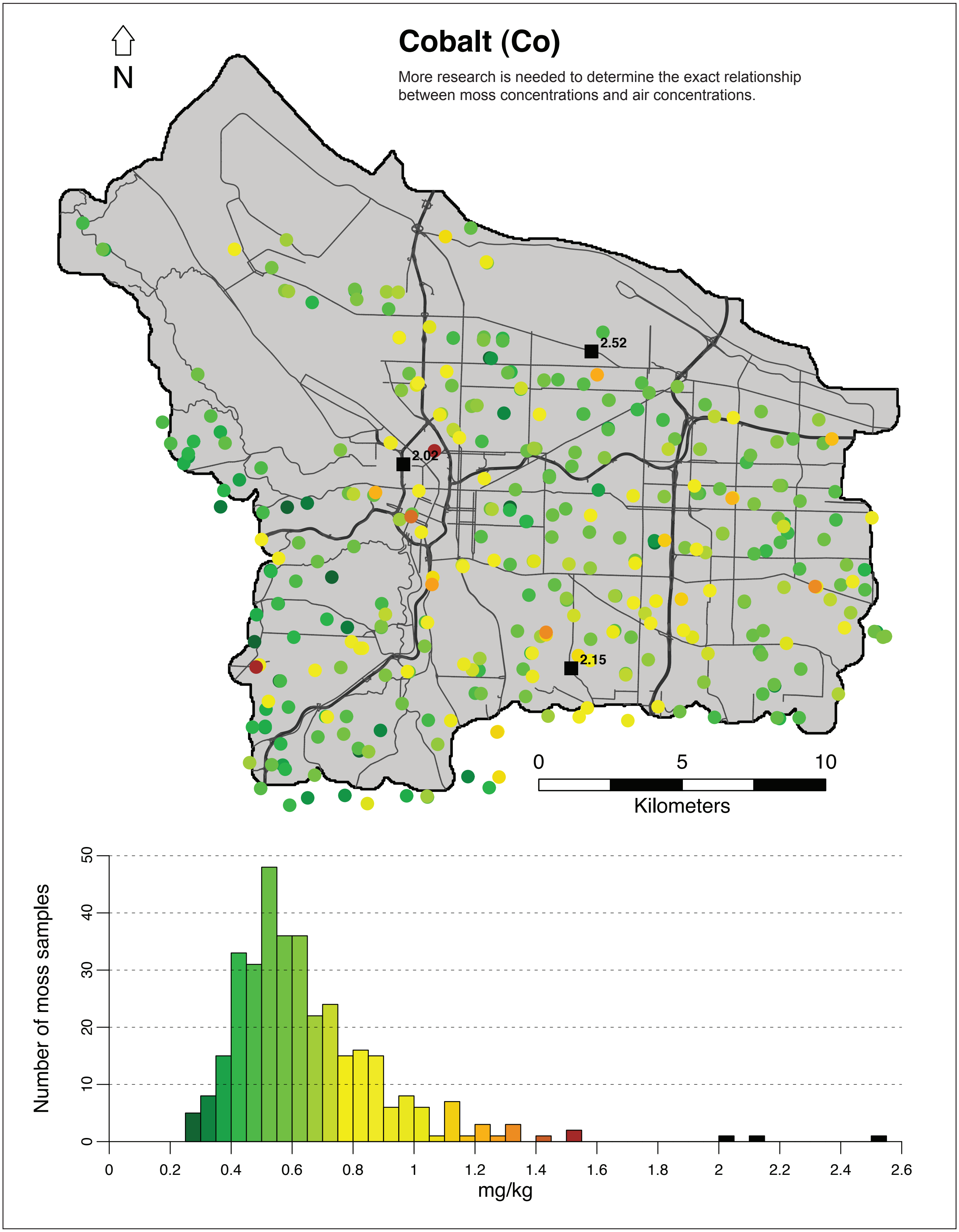

Figure 3s—Dot map of cobalt concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

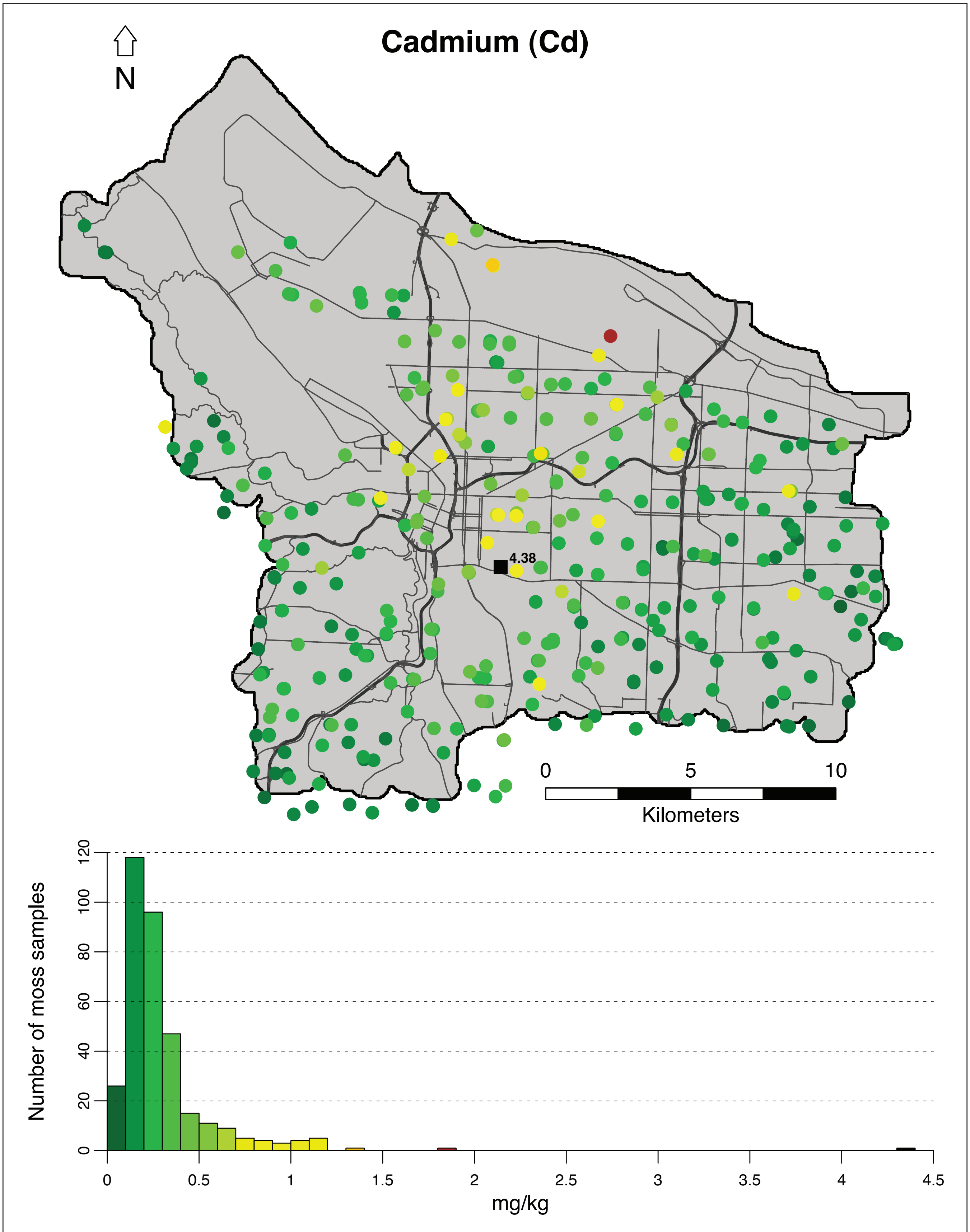

Figure 3t—Dot map of cadmium concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

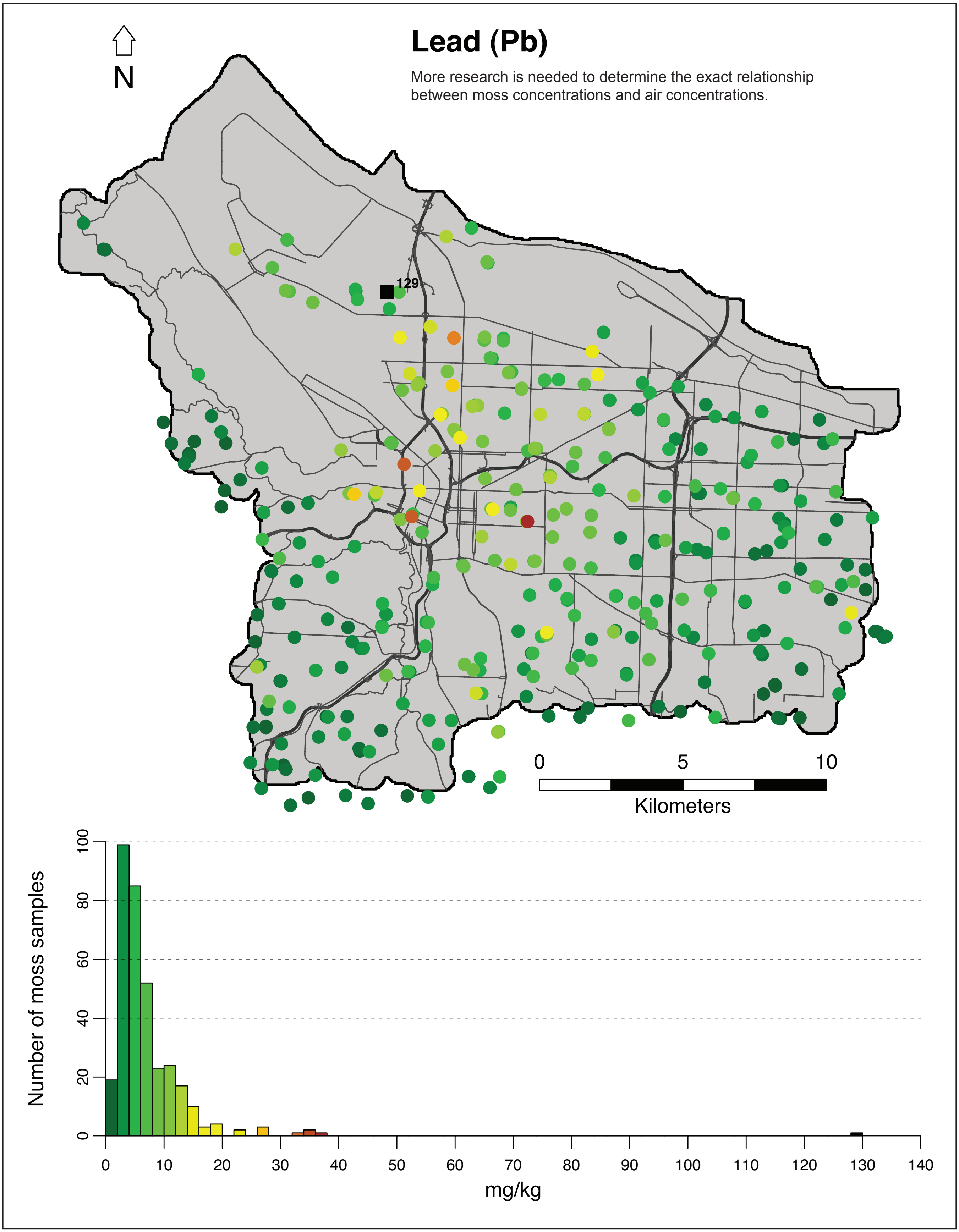

Figure 3u—Dot map of lead concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme.

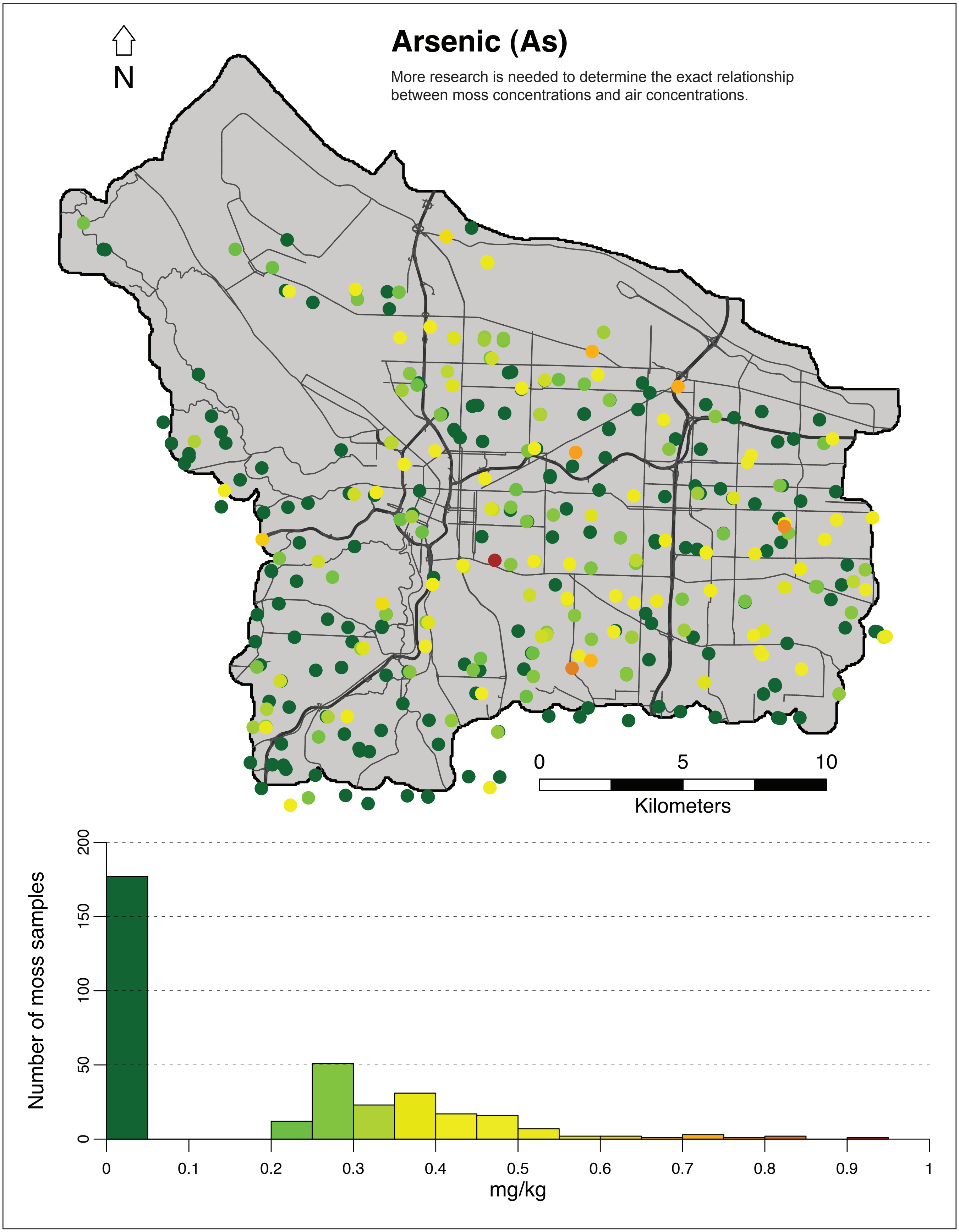

Figure 3v—Dot map of arsenic concentrations found in moss samples and corresponding distribution histogram. See text pp. 7 and 8 for details on the coloring scheme. Mode of histogram is below the detection limit (0.237 mg/kg) for arsenic.

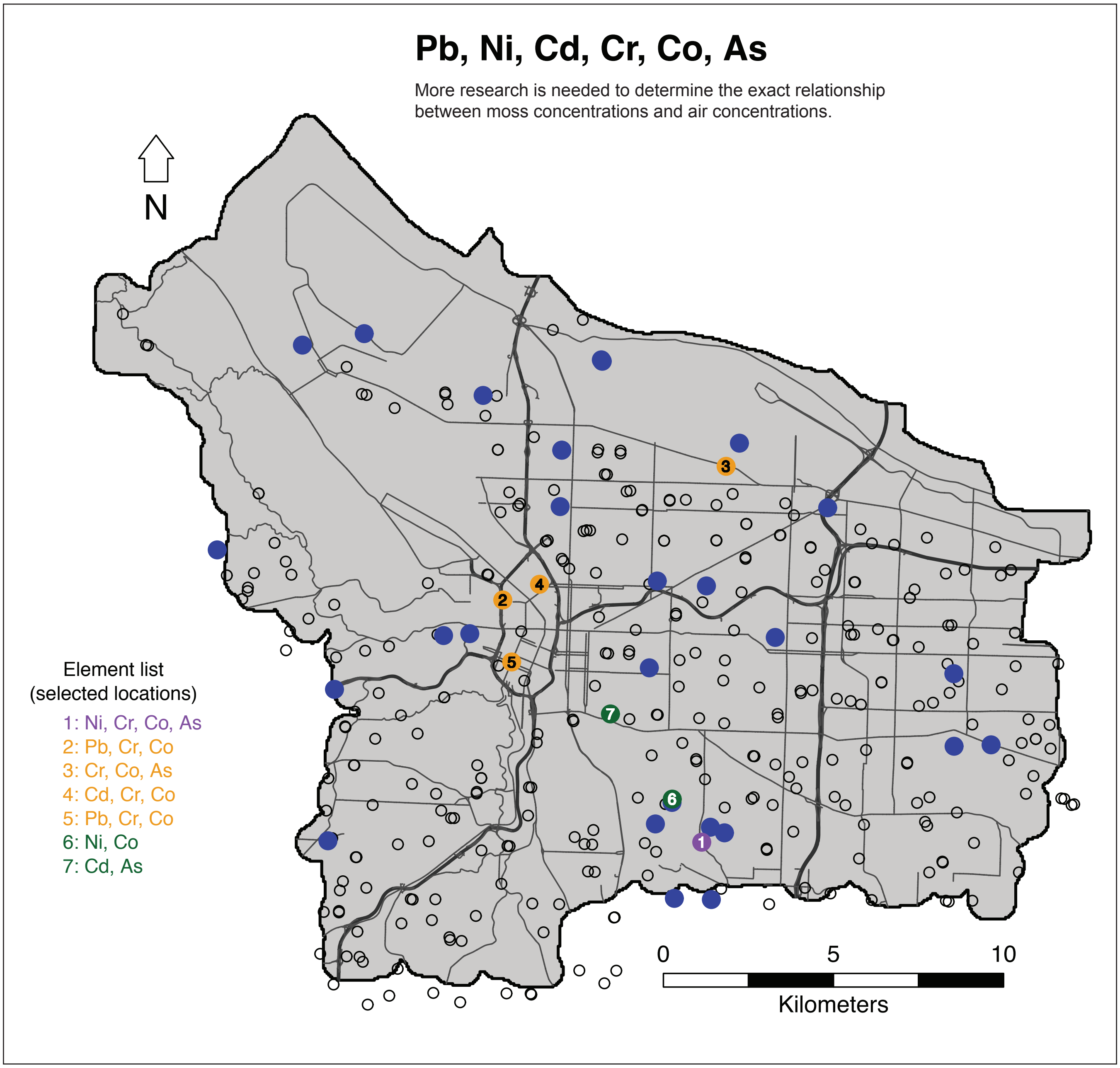

Figure 4—Sample locations with elevated concentrations for several of the six most toxic metals in our dataset (Pb, Ni, Cd, Cr, Co, and As). Filled points show the locations where the concentration of one or more of those elements was among the top 8. Numbers in filled circles link locations to the element list in the lower left corner. Blue circles indicate that the concentration of just one element was among the top 8 concentrations.

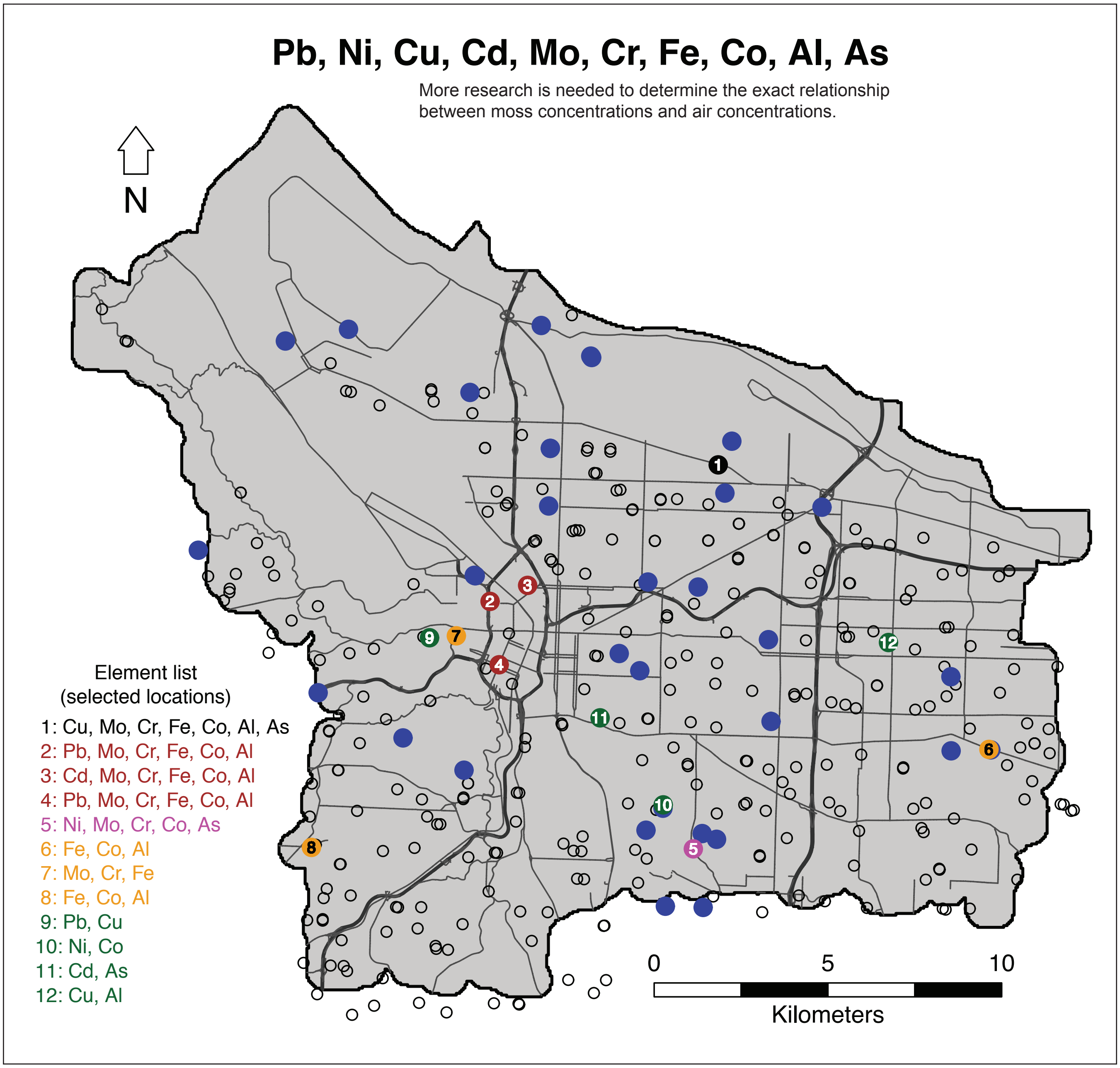

Figure 5—Sample locations with elevated concentrations for several of the 10 most toxic metals in our dataset (Pb, Ni, Cu, Cd, Mo, Cr, Fe, Co, Al, and As). Filled points show the locations where the concentration of one or more of those elements was among the top 8. Numbers in filled circles link locations to the element list in the lower left corner. Blue circles indicate that the concentration of just one element was among the top 8 concentrations.

Limitations and Guidelines

At this stage in the research, the moss data should be regarded as a screening tool to identify possible problem areas for followup with actual air quality measurements. Even with a casual look at the element concentration dot maps in figure 3, the reader can identify many samples positioned very close to each other but with highly contrasting concentration values. This observation is both encouraging and concerning. It is encouraging because it suggests that the dispersion distance of most elements is relatively short and an isolated pollution point source will affect only those in its immediate vicinity, ultimately a very small percentage of an urban area's population. It is concerning because a pollution point source can remain undetected for a long time if relying exclusively on sparse air monitoring networks. To reduce the probability of missing a hotspot, the mean distance between neighboring samples will need to be shorter than the one used in this study, and the spatial allocation of the sample free of sizeable gaps. Ensuring the latter can be logistically challenging, while the former would be costly.

A key unknown is how accurately metal concentrations in the moss we used, *Orthotrichum lyellii,* reflect levels in the air. Donovan et al. (2016) found a very high correlation between moss Cd and atmospheric Cd measured by the Department of Environmental Quality (DEQ) (0.991 or 99.1 percent), but this relationship was based on only four data points and is thus not considered statistically significant. Otherwise, no calibration work (comparing moss-to-instrument values) has been done yet with *Orthotrichum* as this is the first time it has been used as a bioindicator.

It is likely that the strength of relationships between moss and atmospheric concentrations will vary by element. This is because elements differ in how strongly they bind to moss cells, how long they are retained in the moss, and how susceptible they are to displacement by other co-occurring elements (Gonzalez and Pokrovsky 2014, Rühling and Tyler 1970). Additionally, moss cells regulate the uptake of elements with physiological roles, such as some of the plant essential nutrients (table 1) (Bates 1992), potentially weakening relationships with atmospheric concentrations. Also, emissions from natural sources of elements (e.g., soils, leachates from overstory vegetation, marine aerosols) can contribute to levels measured in moss. Therefore, it is likely that some *Orthotrichum*-based maps will portray air quality more accurately than others.

Most past research calibrating moss-based concentrations with air quality data focused on comparing ground-dwelling moss species against bulk deposition measurements (Aboal et al. 2010). This may not accurately represent the epiphytic species we used and the DEQ's high-volume particulate monitors used by Donovan et al. (2016) to calibrate our Cd data. Calibrating *Orthotrichum* is a top research priority. It is only possible to convert moss concentrations to health thresholds and regulatory standards if relationships are sufficiently strong. Otherwise, validation of moss hotspots using monitoring instruments is required to make inferences about health risks and absolute concentrations in the atmosphere.

The time period represented by metals in *Orthotrichum* is unknown, but it likely ranges between several months to a few years. This means moss concentrations may indicate emissions sources that no longer exist and that repeat sampling over short time intervals may not accurately portray declining emissions after pollution abatement measures are taken. We analyzed elemental concentrations in only the upper two-thirds of moss stems and estimate that our samples could represent, at maximum, 3 years of exposure. In the reciprocal transplant study of Boquete et al. (2013), it took over 1.5 years for transplants from polluted environments to reach background concentrations of metals. Conversely, it took 240 days for transplants from "clean" sites to reflect metal concentrations at a polluted site. As it is well known that different species have different accumulation and retention capacities (Castello 2007, Gonzalez and Pokrovsky 2014, Halleraker et al. 1998), determining what timeframe *Orthotrichum* represents is another research priority.

Environmental conditions, such as precipitation intensity, pH, and temperature, may affect element concentrations in moss tissues although results seem to vary across studies (Čeburnis and Valiulis 1999, Gjengedal and Steinnes 1990). Effects on *Orthotrichum* concentrations are another unknown that could potentially affect both timeframe and strength of relationships to atmospheric concentrations. Annual and daily temperature, humidity, and precipitation were not significant predictors of Cd in moss (Donovan et al. 2016). However, we intentionally sampled within a short timeframe (2.5 weeks) to minimize variability in weather conditions so results are not definitive.

Conclusions

Mosses are a useful screening tool for atmospheric pollutants. They can be used to inexpensively and quickly identify areas for the placement of pollution monitoring instruments. Moss and lichen bioindicators have provided valuable low-cost information on pollution levels in hundreds of other studies from dozens of countries across the world (e.g., Ares et al. 2012, Fuga et al. 2008, Garty Ha2001, Nguyen Viet et al. 2010, Zvěřina et al. 2014).

While monitoring instruments are expensive and require one or more months to yield results for a single location, they provide real-time, accurate measurements of pollutant concentrations in the air without the uncertainties of working with living organisms like moss bioindicators. The complementary use of both techniques has the potential to revolutionize how we monitor air quality in urban areas, helping to more efficiently and effectively inform about pollution levels and sources, an excellent example being current monitoring activities taking place in Portland, Oregon.

Moss monitoring research based on our Cd data helped identify two major, unregulated sources of Cd in Portland. Placement of an air monitor near one hotspot measured Cd and As levels that greatly exceeded health benchmarks (Donovan et al. 2016). These findings led to the installation of new pollution controls at both facilities, reexamination of regulatory exemptions for the stained-glass industry, and the creation of "Cleaner Air Oregon."[4] This new state program will provide more resources for air monitoring and mandates the development of risk-based standards for air toxics. Hotspots identified in this study may likewise assist in uncovering additional unknown or unregulated pollution sources; the provision of our raw data (app., table 6) will enable others to carry forward such investigations.

English Equivalents

When you know:	Multiply by:	To get:
Meters (m)	3.27	Feet
Square kilometers (km^2)	0.386	Square miles
Milliliters (mL)	0.061	Cubic inches
Grams (g)	0.0352	Ounces
Degrees Celsius (°C)	1.8 °C (+ 32)	Degrees Fahrenheit

[4] Cleaner Air Oregon. http://cleaneraíroregon.org/. (May 2016).

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Appendix

Table 6—Moss-derived element concentration data

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					mg / kg of dry moss																
1	45.54782	-122.60665	0.186	0.542	0.105	0.826	0.121	0.130	61.5	671.0	1.91	10.23	50.91	32.03	112.8	58.0	42.2	371.7	451.3	1.77	0.395	0.430	14.23	BD[b]
2	45.57009	-122.64356	0.172	0.568	0.162	0.465	0.124	0.700	37.7	943.2	1.93	25.79	61.63	13.74	183.2	29.5	31.0	433.6	515.7	2.11	0.525	0.320	7.59	0.270
3	45.54787	-122.53965	0.209	0.479	0.198	0.481	0.134	0.580	53.0	1313.5	2.93	13.68	72.81	12.65	170.3	48.5	62.6	673.4	657.0	3.14	0.870	0.240	4.24	BD
4	45.45384	-122.51577	0.258	0.565	0.180	0.551	0.079	0.410	31.6	627.2	1.37	12.04	35.00	20.91	152.5	25.8	40.2	383.3	478.6	1.38	0.440	0.125	1.78	BD
5	45.46631	-122.58462	0.163	0.410	0.115	0.455	0.096	0.935	36.0	971.6	3.74	11.99	37.20	6.68	111.7	29.4	48.3	553.0	415.4	1.79	0.730	0.105	4.82	0.295
6	45.51493	-122.68193	0.339	0.677	0.185	0.620	0.179	1.165	175.0	1144.5	3.04	23.12	83.11	32.75	153.0	34.1	42.3	443.4	432.2	3.75	0.565	0.385	6.18	BD
7	45.53501	-122.79052	0.225	0.573	0.221	0.525	0.120	0.420	59.6	974.7	1.42	7.57	42.44	22.57	142.0	34.8	34.5	381.8	445.2	2.24	0.500	0.165	2.36	BD
8	45.55557	-122.68132	0.214	0.432	0.135	0.579	0.143	0.635	102.3	1385.5	3.15	18.88	94.61	15.75	98.8	37.7	60.3	553.9	460.4	3.39	0.775	0.360	12.52	0.250
9	45.51080	-122.60269	0.246	0.512	0.133	0.349	0.133	0.655	101.8	1038.6	3.71	14.66	44.50	4.78	171.9	15.1	36.8	550.0	434.3	2.08	0.570	0.245	10.70	BD
10	45.46616	-122.71173	0.155	0.398	0.135	0.402	0.090	0.615	380.3	1086.1	1.38	7.52	51.75	6.99	119.1	21.7	51.1	488.1	595.7	1.68	0.645	0.160	3.58	BD
11	45.57014	-122.68977	0.132	0.442	0.174	0.739	0.153	1.165	56.2	1121.7	2.94	48.19	94.73	31.95	148.6	34.3	35.2	485.1	481.1	3.41	0.565	0.330	15.65	0.390
12	45.52379	-122.55503	0.194	0.455	0.153	0.784	0.119	0.175	30.8	857.0	2.06	11.48	35.45	39.79	117.3	58.9	85.5	433.4	432.7	1.74	0.535	0.190	3.20	0.315
13	45.45338	-122.73467	0.180	0.349	0.099	0.457	0.094	0.485	99.8	814.1	1.26	6.95	43.71	4.93	81.7	27.3	52.5	411.1	499.3	1.49	0.450	0.240	5.06	BD
14	45.54930	-122.65667	0.158	0.365	0.092	0.393	0.110	0.365	51.1	1030.5	2.26	18.58	89.66	3.47	98.0	24.8	35.3	468.5	454.2	2.37	0.635	0.275	13.29	BD
15	45.52254	-122.58347	0.284	0.502	0.159	0.706	0.178	0.625	84.7	1618.5	8.93	23.26	79.51	28.00	148.7	49.6	45.0	827.4	782.0	3.43	1.010	0.225	12.47	0.385
16	45.55561	-122.66570	0.317	0.630	0.198	0.672	0.169	0.295	56.5	1069.5	2.27	19.98	101.91	55.43	111.0	43.7	62.2	505.9	570.0	2.59	0.595	0.745	26.19	0.380
17	45.56018	-122.60090	0.346	0.606	0.195	0.580	0.159	1.435	64.7	2741.2	3.40	30.98	165.63	26.75	135.5	48.9	65.7	1042.8	518.2	3.81	1.270	0.250	17.50	0.520
18	45.47962	-122.69420	0.238	0.562	0.155	0.651	0.153	0.960	53.5	1167.1	1.39	14.66	68.70	65.44	155.4	43.2	79.1	475.5	509.2	2.25	0.630	0.250	4.67	BD
19	45.42759	-122.74598	0.200	0.355	0.083	0.442	0.121	0.670	40.8	1079.1	1.48	8.15	72.25	3.73	104.1	30.3	33.1	449.2	257.3	2.00	0.515	0.080	3.64	BD
20	45.44416	-122.72103	0.154	0.382	0.139	0.398	0.098	0.725	130.6	747.6	1.24	7.11	50.00	5.76	183.4	28.2	54.0	421.1	356.7	1.48	0.520	0.215	3.56	0.265
21	45.50859	-122.57343	0.222	0.633	0.095	0.417	0.073	0.455	76.3	689.6	1.91	5.89	30.54	7.56	92.8	19.1	20.2	366.2	368.3	1.30	0.370	0.075	2.78	BD
22	45.55619	-122.68085	0.236	0.515	0.120	0.431	0.168	1.070	83.2	1738.5	2.94	26.95	231.56	5.36	116.6	37.9	71.9	617.4	520.5	3.56	0.895	0.385	12.22	BD
23	45.50800	-122.57326	0.216	0.616	0.182	0.492	0.111	0.485	102.5	632.1	1.52	8.47	27.37	28.06	180.9	37.7	59.0	344.2	455.8	1.41	0.325	0.100	4.07	BD
24	45.54732	-122.62629	0.235	0.603	0.150	0.574	0.140	0.205	156.6	1282.0	2.31	18.51	66.16	21.52	136.1	33.4	44.8	606.4	683.5	2.40	0.770	0.370	14.29	BD
25	45.52816	-122.62103	0.214	0.706	0.223	0.475	0.146	0.210	26.9	869.0	2.21	25.54	43.14	30.39	200.3	33.6	48.6	445.3	561.5	1.98	0.520	0.340	9.99	BD
26	45.52351	-122.63601	0.165	0.435	0.185	0.421	0.141	0.320	34.8	894.5	2.22	16.69	65.56	22.98	167.6	35.7	38.9	418.6	452.6	1.94	0.595	0.625	10.05	0.240
27	45.52381	-122.55393	0.169	0.440	0.132	0.552	0.105	0.170	33.1	672.5	2.18	10.15	41.41	13.66	162.5	37.2	56.4	364.5	469.3	1.56	0.505	0.155	3.26	BD
28	45.51711	-122.63833	0.209	0.524	0.115	0.445	0.135	0.135	91.2	753.5	2.08	12.04	44.96	17.68	155.0	17.4	26.6	361.6	545.0	1.84	0.435	0.795	9.92	BD

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					- - - mg / kg of dry moss - - -																
29	45.46202	-122.48968	0.164	0.363	0.164	0.418	0.092	0.410	42.5	1003.7	1.76	6.25	41.24	8.06	131.1	28.1	46.8	615.8	482.7	1.95	0.710	0.080	4.19	0.300
30	45.57365	-122.59888	0.212	0.521	0.201	0.629	0.119	0.630	27.1	798.2	3.21	19.14	67.48	50.12	118.2	26.4	38.8	380.9	476.6	1.81	0.505	1.830	4.97	0.320
31	45.50634	-122.52350	0.211	0.486	0.189	0.418	0.119	0.665	31.8	731.1	1.67	7.38	32.66	11.33	164.8	31.1	21.4	417.9	490.4	1.36	0.460	0.095	2.69	BD
32	45.53835	-122.65159	0.313	1.132	0.136	0.485	0.124	0.095	173.9	737.5	2.73	25.11	51.11	36.35	185.2	21.3	37.2	450.2	658.0	1.94	0.480	0.190	11.26	BD
33	45.47915	-122.69419	0.164	0.357	0.120	0.540	0.101	0.835	60.4	934.1	1.29	10.99	184.15	11.83	129.7	31.6	38.1	410.2	421.0	2.03	0.540	0.165	5.86	BD
34	45.58456	-122.71014	0.197	0.465	0.132	0.374	0.119	1.350	90.9	871.7	2.56	11.91	55.73	6.29	165.0	22.0	32.8	334.2	372.4	2.83	0.420	0.210	3.65	0.260
35	45.60231	-122.67037	0.215	0.534	0.262	0.743	0.193	1.980	75.5	2249.7	4.05	85.05	162.08	55.12	166.1	34.6	44.1	787.3	634.2	5.65	1.110	1.090	14.07	0.630
36	45.51134	-122.54302	0.136	0.338	0.113	0.355	0.088	0.630	43.0	812.6	2.29	9.66	50.90	4.34	130.9	28.0	36.3	449.5	330.8	1.45	0.550	0.135	4.14	0.265
37	45.58499	-122.71017	0.267	0.572	0.190	0.701	0.150	1.660	235.5	1292.7	3.16	14.96	65.28	30.44	117.8	47.1	154.3	548.8	442.6	4.11	0.580	0.250	5.56	0.395
38	45.50124	-122.62694	0.153	0.448	0.104	0.380	0.090	0.590	75.0	1176.1	2.89	12.26	53.90	8.27	159.9	21.6	35.9	630.0	525.7	1.83	0.785	0.265	10.83	0.335
39	45.48577	-122.74040	0.186	0.526	0.124	0.428	0.095	0.495	119.3	672.7	1.30	7.96	51.18	8.55	139.6	28.1	37.6	309.0	358.3	1.55	0.405	0.210	3.23	BD
40	45.49453	-122.71698	0.178	0.437	0.126	0.652	0.104	0.430	33.6	610.6	0.82	357.25	43.93	16.38	108.2	48.6	56.1	320.4	394.7	1.37	0.305	0.145	4.95	0.255
41	45.54184	-122.66452	0.192	0.472	0.173	0.762	0.150	0.600	38.3	1153.0	2.25	18.17	79.26	43.36	117.9	50.1	50.7	538.4	540.5	2.74	0.735	0.660	12.01	BD
42	45.51748	-122.72871	0.180	0.383	0.136	0.404	0.093	0.080	60.4	663.5	1.48	6.41	44.91	4.57	132.9	29.7	31.8	248.7	291.6	1.70	0.340	0.165	3.57	BD
43	45.57101	-122.65191	0.151	0.501	0.147	0.441	0.120	0.760	73.4	992.2	1.85	22.25	56.23	11.25	142.6	30.7	36.4	429.0	371.4	2.18	0.530	0.225	10.84	0.300
44	45.50127	-122.62727	0.197	0.535	0.125	0.524	0.095	0.515	84.0	1114.1	2.77	10.62	46.80	26.35	147.5	27.3	31.3	601.0	482.1	1.78	0.710	0.300	7.87	0.440
45	45.46667	-122.58467	0.270	0.579	0.180	0.596	0.101	0.755	28.4	784.1	2.56	9.75	28.97	32.56	123.9	31.9	38.8	441.8	450.2	1.70	0.575	0.115	3.04	0.260
46	45.45405	-122.51686	0.221	0.675	0.160	0.379	0.092	0.510	292.8	759.2	1.79	8.91	47.28	9.38	382.6	17.9	27.9	446.0	552.7	1.68	0.535	0.135	2.27	BD
47	45.47129	-122.57483	0.248	0.547	0.193	0.538	0.123	0.635	33.4	896.6	3.14	8.82	57.65	26.60	224.3	35.9	41.0	496.0	547.7	1.74	0.670	0.135	8.39	BD
48	45.54122	-122.66386	0.233	0.618	0.152	0.396	0.143	0.255	202.3	901.5	3.48	13.67	139.91	18.42	205.4	23.6	43.3	424.3	416.1	2.21	0.650	0.550	10.62	BD
49	45.53746	-122.56834	0.401	0.653	0.220	0.779	0.189	0.480	60.8	1222.0	2.62	20.62	68.41	26.10	109.6	54.0	175.0	572.9	495.0	2.69	0.745	1.075	5.06	0.295
50	45.52763	-122.62106	0.312	0.590	0.188	0.826	0.164	0.365	76.3	1010.5	2.15	14.25	67.76	45.97	123.2	44.5	64.5	516.9	626.0	1.99	0.540	0.335	13.76	BD
51	45.54196	-122.49547	0.237	0.601	0.164	0.673	0.128	1.120	33.0	1312.2	2.14	16.91	83.63	33.54	152.5	54.6	64.2	637.3	478.2	3.02	0.745	0.300	3.69	0.420
52	45.52538	-122.49338	0.223	0.431	0.131	0.491	0.096	0.550	35.8	880.2	1.71	23.83	115.58	8.73	95.3	34.0	30.9	477.7	433.5	1.91	0.515	0.100	7.27	BD
53	45.43309	-122.65384	0.186	0.469	0.144	0.380	0.093	0.605	38.2	511.1	1.57	9.32	41.08	9.64	124.4	21.2	33.9	258.9	369.1	1.16	0.365	0.180	2.92	BD
54	45.51209	-122.51412	0.181	0.424	0.110	0.490	0.137	0.490	40.7	847.6	1.45	7.95	30.00	9.42	101.8	37.6	38.9	471.9	319.0	1.44	0.460	0.075	6.11	0.290
55	45.54732	-122.62629	0.265	0.468	0.198	0.586	0.167	0.510	90.0	1411.5	4.88	16.11	72.76	20.55	127.5	27.8	57.7	719.4	714.5	3.12	0.885	0.210	14.40	0.335
56	45.45569	-122.60137	0.175	0.496	0.209	0.395	0.083	0.775	94.2	516.2	6.47	7.48	44.43	7.01	127.2	25.4	28.6	311.6	391.8	1.81	0.820	0.165	2.58	BD
57	45.49625	-122.48980	0.223	0.357	0.120	0.444	0.092	0.460	72.0	1047.1	1.27	8.79	47.20	10.44	116.8	31.4	40.0	647.5	402.0	1.46	0.565	0.080	4.85	BD

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					mg / kg of dry moss																
58	45.54196	-122.49547	0.268	0.569	0.200	0.637	0.155	1.545	52.9	2241.2	3.32	23.88	116.43	27.13	161.1	57.7	82.7	1078.8	644.7	4.66	1.210	0.450	6.51	0.450
59	45.45495	-122.74360	0.167	0.497	0.140	0.278	0.123	0.645	145.4	1557.6	1.85	14.93	194.15	4.76	176.4	22.5	46.4	665.5	623.2	1.95	0.800	0.340	8.65	BD
60	45.51789	-122.63825	0.172	0.431	0.216	0.780	0.118	BD	84.2	518.0	1.56	78.85	161.16	60.23	61.8	45.7	37.1	287.0	388.7	1.26	0.285	0.555	4.82	0.275
61	45.57019	-122.65226	0.180	0.489	0.130	0.723	0.133	0.870	53.7	1289.7	2.21	27.57	60.23	29.07	152.1	46.9	81.2	670.3	560.2	2.67	0.640	0.305	8.22	0.320
62	45.54775	-122.60657	0.280	0.604	0.197	0.411	0.133	BD	33.3	792.0	1.94	11.96	77.46	7.55	127.6	25.4	22.4	423.6	475.2	1.63	0.500	0.350	6.30	BD
63	45.53133	-122.61123	0.377	0.646	0.189	0.866	0.180	0.175	34.5	883.0	1.63	19.84	49.81	65.23	133.4	40.6	79.2	524.9	627.5	1.82	0.535	0.705	7.26	BD
64	45.50535	-122.55064	0.197	0.439	0.220	0.667	0.112	0.450	181.9	753.1	1.75	7.32	45.35	45.71	79.7	35.5	81.9	449.2	598.7	1.70	0.725	0.145	3.56	0.445
65	45.47364	-122.54831	0.147	0.352	0.184	0.613	0.126	0.850	35.9	1313.1	2.52	52.25	69.60	32.95	113.5	64.1	74.6	691.0	299.9	2.21	0.755	0.165	5.88	BD
66	45.53931	-122.66169	0.310	0.929	0.153	0.589	0.145	1.140	64.0	1675.5	2.87	26.83	118.71	44.01	200.9	43.0	74.8	694.4	750.5	3.86	0.885	0.570	17.05	BD
67	45.50851	-122.65086	0.181	0.570	0.097	0.349	0.087	0.655	57.7	729.6	2.27	10.25	64.05	12.98	190.4	20.1	32.7	357.2	358.0	1.93	0.520	0.795	13.22	BD
68	45.47747	-122.51351	0.139	0.323	0.140	0.461	0.110	0.680	77.4	1225.1	1.78	20.26	112.30	9.89	146.3	113.8	58.5	688.5	423.7	1.79	0.785	0.145	5.23	BD
69	45.52259	-122.56967	0.306	0.700	0.211	0.499	0.138	0.400	52.4	1101.0	2.75	11.61	73.86	22.97	198.4	40.9	56.7	547.9	743.0	2.15	0.660	0.225	6.01	BD
70	45.46438	-122.51847	0.275	0.575	0.171	0.465	0.107	0.445	120.9	472.9	1.61	5.93	46.32	7.94	97.9	61.5	66.0	260.9	317.9	1.22	0.550	0.215	1.22	BD
71	45.54170	-122.79429	0.196	0.434	0.173	0.642	0.092	0.345	51.2	447.2	0.68	5.78	82.35	23.65	111.6	45.8	60.2	220.3	263.8	1.07	0.500	1.130	1.11	BD
72	45.52217	-122.50902	0.189	0.388	0.106	0.399	0.105	0.770	77.8	1048.3	1.70	15.04	70.60	6.78	34.0	28.8	43.4	539.9	341.3	1.67	0.585	0.140	4.57	BD
73	45.49989	-122.74090	0.286	0.478	0.201	0.544	0.186	1.675	256.8	1657.7	2.23	22.49	118.71	18.83	143.5	51.4	86.9	666.2	505.0	3.10	0.865	0.285	7.66	0.270
74	45.51653	-122.49275	0.131	0.346	0.087	0.798	0.135	0.395	21.0	833.6	1.55	9.18	31.06	22.47	102.1	61.8	49.6	538.0	424.3	1.51	0.485	0.185	2.85	0.475
75	45.52884	-122.78434	0.235	0.505	0.140	0.339	0.101	0.405	104.2	773.6	1.05	6.36	48.20	6.44	149.7	22.5	32.5	392.8	408.4	1.57	0.410	0.140	2.91	BD
76	45.42611	-122.70844	0.210	0.356	0.152	0.395	0.096	0.710	35.2	727.6	1.63	8.14	44.90	6.64	89.0	39.0	57.1	376.7	472.6	1.52	0.385	0.140	3.25	BD
77	45.53195	-122.78238	0.179	0.347	0.144	0.563	0.092	0.575	53.5	656.1	1.09	7.41	40.64	19.46	63.7	52.4	45.4	249.0	125.2	1.49	0.435	0.100	1.80	BD
78	45.51745	-122.47676	0.171	0.456	0.148	0.430	0.116	0.970	103.7	1733.1	2.19	14.22	121.00	5.30	151.8	31.4	54.6	731.0	385.3	2.57	0.960	0.195	5.00	0.395
79	45.55684	-122.77936	0.179	0.474	0.144	0.284	0.126	0.735	109.2	1051.8	1.80	8.06	54.60	3.03	159.4	21.7	39.7	410.3	407.7	2.06	0.555	0.140	5.23	BD
80	45.43512	-122.73654	0.232	0.402	0.170	0.529	0.089	0.415	54.5	689.5	0.98	6.70	36.71	9.71	81.3	40.9	46.8	345.5	326.8	1.33	0.390	0.075	2.12	BD
81	45.51417	-122.74843	0.189	0.416	0.158	0.360	0.113	0.680	162.9	1062.1	1.86	9.75	47.10	6.68	112.9	23.7	34.2	426.1	463.6	2.72	0.480	0.320	4.57	BD
82	45.44006	-122.69839	0.203	0.541	0.163	0.381	0.136	0.770	76.1	1200.3	2.42	10.00	62.60	9.88	216.2	31.1	40.3	516.4	369.6	2.51	0.675	0.150	4.63	BD
83	45.48572	-122.74066	0.184	0.531	0.111	0.434	0.096	0.425	197.8	795.6	1.20	7.22	48.00	7.73	125.0	23.1	29.7	315.5	140.1	1.58	0.455	0.145	3.68	BD
84	45.51024	-122.49779	0.111	0.300	0.099	0.717	0.113	0.480	27.0	1056.3	1.93	9.64	41.37	17.58	36.4	46.2	67.0	743.9	504.3	1.85	0.605	0.185	3.46	0.435
85	45.48183	-122.47439	0.234	0.553	0.151	0.535	0.119	0.480	382.9	869.8	1.76	8.50	31.34	7.13	86.1	25.8	41.3	480.0	331.3	1.78	0.575	0.085	2.21	BD
86	45.49397	-122.61742	0.298	0.664	0.212	0.752	0.144	0.655	38.3	732.7	2.51	25.39	86.56	38.80	69.3	40.0	73.8	447.9	603.0	1.62	0.540	0.685	5.08	BD

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					- - - mg / kg of dry moss - - -																
87	45.47044	-122.60066	0.228	0.572	0.188	0.587	0.119	1.415	43.6	1113.6	7.09	15.10	62.15	27.09	157.8	38.7	86.1	651.0	381.0	2.26	0.830	0.400	6.40	0.715
88	45.55903	-122.68497	0.167	0.342	0.114	0.709	0.151	0.500	37.0	1098.5	3.74	15.38	129.41	20.60	82.7	46.0	90.8	465.6	444.5	2.88	0.585	0.260	15.22	0.285
89	45.42639	-122.67166	0.189	0.414	0.163	0.446	0.088	0.495	55.6	958.1	1.92	6.71	35.14	10.20	90.4	32.0	38.2	427.1	343.2	1.60	0.545	0.095	4.17	BD
90	45.45090	-122.70862	0.285	0.441	0.208	0.571	0.128	0.550	52.9	855.0	1.61	12.27	55.82	31.30	114.8	37.2	49.8	420.6	652.5	1.84	0.510	0.175	3.30	0.385
91	45.49054	-122.56085	0.193	0.405	0.143	0.317	0.136	0.870	86.1	1685.2	5.19	17.16	77.31	5.73	163.0	20.1	46.0	811.7	601.5	3.19	1.145	0.195	7.44	0.275
92	45.51144	-122.54308	0.142	0.358	0.123	0.372	0.098	0.710	43.8	1034.8	2.50	12.03	58.20	4.04	43.9	30.8	40.0	558.4	348.1	1.73	0.675	0.160	5.16	BD
93	45.53101	-122.78244	0.240	0.506	0.156	0.391	0.112	0.840	84.6	702.1	1.29	9.83	71.10	7.45	198.3	34.8	45.1	295.9	266.6	1.58	0.385	0.125	2.71	BD
94	45.46651	-122.65024	0.175	0.515	0.158	0.540	0.109	0.565	30.9	762.0	1.91	9.72	41.78	24.37	144.5	32.5	37.7	391.3	334.0	1.52	0.455	0.240	5.48	BD
95	45.51303	-122.68735	0.228	0.458	0.139	0.569	0.178	1.300	254.8	1516.7	3.21	20.76	148.21	9.18	84.1	45.6	75.6	657.7	452.9	3.35	0.705	0.235	11.76	0.250
96	45.48173	-122.47323	0.255	0.657	0.228	0.572	0.095	0.340	38.1	533.3	0.99	9.49	26.10	39.70	132.5	49.4	71.8	314.4	266.2	1.21	0.390	0.115	1.03	BD
97	45.50257	-122.48744	0.204	0.651	0.193	0.382	0.088	0.455	67.2	1133.7	1.50	6.71	30.31	19.90	148.5	27.0	55.1	684.2	616.0	1.72	0.630	0.100	2.98	BD
98	45.57014	-122.68977	0.132	0.443	0.182	0.685	0.162	1.350	73.1	1564.7	3.73	59.10	119.28	28.72	164.3	32.9	37.7	688.3	595.2	4.86	0.810	0.400	19.93	0.460
99	45.46148	-122.73864	0.198	0.588	0.155	0.443	0.095	0.445	244.0	708.0	1.12	10.89	60.22	8.15	152.1	25.9	42.0	328.1	443.2	1.24	0.470	0.240	3.17	BD
100	45.46417	-122.51832	0.235	0.592	0.211	0.509	0.102	0.425	62.3	530.0	1.45	5.56	29.10	28.53	128.2	51.2	90.9	312.9	365.9	1.26	0.365	0.080	1.17	BD
101	45.45049	-122.66206	0.180	0.343	0.206	0.542	0.128	0.705	70.9	1841.7	2.65	19.54	104.98	16.23	126.9	31.5	59.9	682.2	423.7	2.81	1.045	0.240	4.64	0.310
102	45.57088	-122.64357	0.215	0.605	0.163	0.422	0.124	0.620	31.5	799.7	1.76	19.21	59.83	14.65	199.1	23.6	31.1	368.5	445.1	1.82	0.440	0.330	5.91	0.290
103	45.54786	-122.50154	0.265	0.492	0.159	0.438	0.131	0.150	59.7	1100.0	1.95	10.28	61.96	6.29	157.7	24.4	40.7	546.4	392.6	2.23	0.675	0.125	3.25	BD
104	45.47822	-122.58279	0.211	0.514	0.225	0.505	0.088	0.650	24.7	748.0	2.75	24.45	33.53	31.61	116.3	35.9	53.7	403.1	411.8	1.64	0.605	0.120	4.27	0.320
105	45.53053	-122.68639	0.284	0.469	0.191	0.751	0.224	3.440	142.2	3883.0	6.34	52.20	250.06	38.00	166.0	70.7	97.6	1497.4	714.5	8.80	2.015	0.670	35.03	0.455
106	45.58448	-122.69078	0.174	0.548	0.175	0.419	0.144	1.160	156.9	1477.7	3.00	23.32	85.63	11.06	218.3	27.6	42.1	530.8	545.2	4.61	0.725	0.185	7.33	0.260
107	45.52073	-122.70823	0.168	0.254	0.124	0.517	0.128	0.645	59.0	1497.0	2.83	341.70	107.96	5.08	116.3	37.3	75.7	547.9	475.2	3.76	0.745	0.295	27.09	0.355
108	45.58446	-122.69588	0.204	0.491	0.135	0.825	0.150	0.925	54.3	1360.7	2.82	20.97	84.38	33.71	107.2	64.8	82.9	617.8	540.7	4.49	0.705	0.270	128.95	BD
109	45.49158	-122.49444	0.225	0.510	0.186	0.316	0.078	0.455	80.1	1293.1	1.33	6.23	33.40	3.28	147.1	27.3	29.0	717.5	443.2	1.89	0.735	BD	1.91	BD
110	45.50086	-122.50851	0.108	0.276	0.077	0.704	0.101	0.355	22.6	854.1	1.27	7.64	48.10	13.79	86.5	56.5	48.5	633.0	342.4	1.45	0.490	0.130	2.77	0.595
111	45.53910	-122.76841	0.217	0.525	0.191	0.384	0.098	0.730	216.0	795.8	2.81	7.53	175.75	9.06	112.7	19.3	32.2	364.5	295.9	2.34	0.420	0.115	3.47	BD
112	45.51667	-122.51843	0.166	0.380	0.172	0.407	0.100	0.555	80.1	926.3	1.77	9.54	49.00	8.84	32.6	28.1	48.7	493.1	257.5	1.56	0.625	0.140	3.85	BD
113	45.47862	-122.55556	0.248	0.641	0.208	0.523	0.102	0.935	34.1	1130.0	3.53	9.45	39.37	28.87	146.0	25.2	35.8	532.1	418.5	2.09	0.780	0.165	3.79	BD
114	45.52609	-122.55619	0.153	0.338	0.122	0.350	0.107	1.150	57.8	1332.3	2.59	17.31	148.85	6.67	48.2	34.1	50.9	650.9	525.8	2.20	0.810	0.180	7.22	BD
115	45.51611	-122.73759	0.187	0.428	0.108	0.358	0.088	0.475	65.2	470.3	0.70	5.70	39.62	3.56	34.7	23.9	43.7	233.6	331.5	1.06	0.270	0.255	2.33	BD

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					mg / kg of dry moss																
116	45.49994	-122.63753	0.265	0.671	0.164	0.502	0.128	0.665	42.9	892.2	2.49	22.69	92.31	36.81	168.8	36.0	38.8	430.9	472.5	2.09	0.520	0.925	14.22	0.295
117	45.44103	-122.70295	0.178	0.502	0.151	0.353	0.136	0.565	294.4	849.8	2.27	7.75	45.20	3.77	156.9	16.1	31.7	439.0	359.5	1.57	0.525	0.185	2.69	BD
118	45.44673	-122.75043	0.189	0.410	0.153	0.354	0.093	0.465	226.4	702.3	1.06	6.22	43.64	4.21	96.8	22.1	27.6	327.6	347.0	1.30	0.445	0.100	2.39	0.320
119	45.45544	-122.68400	0.302	0.527	0.173	0.567	0.140	0.905	57.9	1159.0	1.92	12.60	88.57	26.31	159.8	41.1	48.6	518.1	588.5	2.49	0.600	0.250	4.83	BD
120	45.57914	-122.69473	0.184	0.582	0.202	0.394	0.125	1.050	44.2	1032.8	2.37	16.39	53.20	12.40	228.9	19.9	30.0	412.8	308.8	3.43	0.520	0.160	5.13	BD
121	45.45872	-122.62917	0.151	0.396	0.178	0.541	0.111	0.825	39.1	782.8	5.63	8.63	34.74	29.40	136.2	46.3	58.8	383.3	418.1	2.12	0.620	0.245	3.45	0.240
122	45.42651	-122.68099	0.192	0.397	0.125	0.502	0.098	0.405	29.9	605.6	1.71	5.36	31.70	9.77	84.3	30.8	17.7	299.7	282.4	1.36	0.415	0.100	1.66	BD
123	45.46142	-122.73889	0.245	0.502	0.156	0.422	0.101	0.340	121.8	505.5	0.93	7.40	38.38	8.06	102.5	25.4	32.8	250.2	361.3	1.72	0.300	0.215	2.05	0.365
124	45.42662	-122.67186	0.170	0.454	0.125	0.309	0.071	0.470	70.5	1048.1	1.72	5.70	42.02	6.12	184.5	20.4	44.7	401.4	362.2	1.69	0.700	0.135	3.13	BD
125	45.46837	-122.65695	0.316	0.607	0.176	0.420	0.153	0.990	306.6	1444.0	4.37	16.46	159.22	23.90	144.4	26.2	53.2	727.6	576.0	2.89	0.995	0.410	9.68	BD
126	45.51363	-122.63053	0.261	0.529	0.149	0.596	0.129	0.550	57.7	575.8	1.94	12.08	131.05	33.96	50.6	40.1	60.1	296.4	195.3	1.36	0.435	0.505	37.53	BD
127	45.54965	-122.58253	0.180	0.570	0.128	0.554	0.131	0.555	69.2	839.8	1.98	10.05	42.60	14.08	171.7	33.9	48.7	414.0	346.1	1.58	0.455	0.195	4.29	BD
128	45.45421	-122.50691	0.248	0.614	0.211	0.398	0.106	0.335	184.8	541.8	1.82	5.97	29.17	14.75	224.6	42.0	76.9	311.1	285.1	1.15	0.495	0.060	1.93	BD
129	45.51355	-122.63098	0.204	0.464	0.126	0.466	0.100	0.600	46.3	655.7	2.21	12.06	40.70	14.73	64.2	31.7	27.9	345.9	401.9	1.59	0.420	0.280	12.65	0.280
130	45.54356	-122.59542	0.141	0.474	0.114	0.506	0.104	0.515	52.2	715.3	1.76	21.46	51.10	7.51	102.7	28.6	39.9	395.6	316.6	1.34	0.400	0.305	8.89	BD
131	45.49736	-122.48450	0.247	0.501	0.180	0.536	0.146	0.870	76.6	1833.7	2.63	13.30	91.46	14.69	150.0	51.1	82.1	951.7	535.0	2.91	0.975	0.270	7.82	0.285
132	45.47773	-122.62313	0.180	0.426	0.097	0.738	0.125	0.870	28.4	1047.5	7.57	11.72	40.38	18.07	66.1	36.3	35.1	526.6	324.7	2.32	0.705	0.260	5.95	0.360
133	45.53765	-122.55401	0.310	0.559	0.190	0.607	0.134	0.670	32.8	848.3	2.27	14.94	45.00	39.26	42.6	41.7	61.9	416.9	299.0	1.69	0.545	0.410	3.86	BD
134	45.49941	-122.65885	0.196	0.477	0.189	0.691	0.164	1.165	59.8	1461.7	3.50	19.54	107.86	45.72	158.7	48.5	66.6	648.2	544.0	3.02	0.745	0.555	8.11	0.430
135	45.46518	-122.72329	0.307	0.635	0.210	0.592	0.132	1.180	54.9	1610.0	1.98	19.55	96.47	20.05	134.0	45.2	82.4	648.1	660.0	3.06	0.885	0.220	4.89	BD
136	45.46541	-122.68134	0.223	0.746	0.153	0.591	0.127	0.830	226.1	975.0	2.13	12.02	65.32	19.96	183.5	43.8	104.3	496.6	619.0	2.33	0.555	0.370	3.57	0.295
137	45.54397	-122.77282	0.222	0.587	0.196	0.340	0.099	0.505	166.4	651.3	1.87	6.47	41.70	3.74	119.6	37.5	37.8	307.0	271.2	1.66	0.525	0.070	3.25	BD
138	45.60333	-122.83238	0.160	0.393	0.114	0.324	0.095	0.350	124.4	851.3	1.53	6.11	30.53	4.66	102.7	26.7	32.9	332.0	250.8	1.60	0.475	0.115	3.85	0.265
139	45.52418	-122.75928	0.227	0.473	0.157	0.665	0.100	0.535	60.6	646.8	1.14	7.37	52.05	22.33	BD	61.4	57.7	274.6	275.9	1.77	0.405	0.335	2.37	BD
140	45.47721	-122.60086	0.258	0.636	0.212	0.501	0.095	0.995	23.7	657.5	7.96	16.27	29.17	18.58	127.7	32.4	48.1	379.4	396.2	1.83	0.615	0.120	3.93	0.290
141	45.46653	-122.65317	0.208	0.515	0.146	0.396	0.114	0.945	55.8	1350.5	2.96	17.73	90.12	11.53	225.9	26.8	44.0	674.6	720.0	2.73	0.760	0.255	10.01	0.270
142	45.54961	-122.58270	0.180	0.709	0.145	0.633	0.129	0.590	108.0	704.8	1.49	10.16	51.75	23.03	113.0	36.9	60.0	359.7	246.7	1.29	0.425	0.305	3.10	BD
143	45.48972	-122.57211	0.189	0.558	0.189	0.585	0.129	0.925	37.9	1362.7	3.04	17.13	59.61	25.98	174.5	38.9	58.8	702.2	406.5	2.38	0.800	0.200	4.67	0.540
144	45.45925	-122.64899	0.308	0.663	0.188	0.573	0.149	0.705	85.3	1011.3	2.63	15.06	60.90	22.47	176.3	42.4	39.6	503.4	477.7	2.08	0.610	0.325	6.66	0.450

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					- - - - - - mg / kg of dry moss - - - - - -																
145	45.52542	-122.54492	0.239	0.491	0.115	0.384	0.096	0.650	33.9	863.8	2.08	8.93	63.35	4.63	51.8	25.9	27.8	453.3	480.4	1.58	0.550	0.155	5.62	BD
146	45.54629	-122.67079	0.141	0.319	0.133	0.381	0.138	1.440	98.7	1840.8	3.14	19.23	87.25	18.67	114.0	22.9	36.4	697.4	432.8	3.21	0.840	0.560	13.00	BD
147	45.48214	-122.75006	0.132	0.359	0.088	0.466	0.086	0.425	27.0	719.8	1.37	6.84	40.99	6.17	96.3	31.5	37.3	315.9	238.0	1.51	0.410	0.100	2.39	BD
148	45.55714	-122.56502	0.302	0.617	0.153	0.518	0.171	0.920	91.8	1172.8	2.04	15.16	65.40	10.80	153.0	26.1	62.7	581.9	544.6	2.08	0.640	0.175	4.73	0.740
149	45.52809	-122.74974	0.154	0.443	0.170	0.296	0.109	0.710	70.8	856.7	1.62	16.69	68.53	5.51	6.6	20.2	55.5	422.1	564.2	2.15	0.500	0.210	4.99	BD
150	45.47357	-122.75056	0.135	0.576	0.271	0.449	0.096	0.485	49.9	540.3	0.77	6.46	25.24	29.81	159.3	26.8	21.3	253.3	330.4	1.02	0.295	0.095	1.16	BD
151	45.43513	-122.74133	0.191	0.386	0.124	0.390	0.116	0.805	75.5	1080.6	1.42	10.24	69.25	4.58	111.3	35.9	46.5	466.6	379.9	2.05	0.560	0.105	4.23	BD
152	45.50232	-122.58188	0.324	0.640	0.216	0.532	0.141	0.680	84.1	982.7	4.08	10.82	49.06	39.34	106.8	36.1	50.6	489.1	365.8	1.95	0.615	0.180	3.49	0.340
153	45.55831	-122.61845	0.269	0.869	0.201	0.326	0.138	0.560	143.7	752.3	1.96	11.72	93.60	25.68	258.6	20.6	39.6	360.0	251.7	1.58	0.520	0.280	6.07	0.240
154	45.56746	-122.60368	0.269	0.912	0.233	0.668	0.211	2.370	129.9	4802.8	8.10	88.50	203.05	34.26	230.1	66.2	98.4	1713.4	499.1	10.04	2.520	1.075	23.30	0.730
155	45.47369	-122.67464	0.116	0.349	0.094	0.576	0.117	0.990	38.3	1190.0	2.29	12.18	68.27	11.86	92.2	29.0	33.9	513.1	423.7	2.67	0.635	0.265	5.87	0.470
156	45.49560	-122.50134	0.244	0.635	0.176	0.422	0.139	0.935	139.1	2773.7	3.70	15.49	99.61	22.42	212.3	36.6	70.5	1419.2	452.1	4.69	1.345	0.230	8.18	0.280
157	45.54055	-122.51990	0.255	0.798	0.150	0.370	0.125	0.675	182.1	942.8	2.32	8.61	89.40	11.85	193.5	21.9	34.9	490.7	363.1	1.65	0.665	0.150	6.20	BD
158	45.46553	-122.68210	0.169	0.442	0.158	0.354	0.139	1.140	159.8	1470.0	2.83	16.75	91.37	8.32	170.9	23.8	62.4	664.6	647.5	3.08	0.805	0.230	6.58	BD
159	45.47240	-122.62719	0.194	0.478	0.140	0.408	0.076	0.605	27.6	516.0	5.24	10.13	40.45	5.37	108.1	21.8	16.1	280.9	370.6	1.64	0.455	0.220	3.07	BD
160	45.46626	-122.74806	0.196	0.464	0.149	0.433	0.107	0.765	57.9	1383.0	1.51	10.25	69.32	5.17	121.1	33.0	38.2	494.2	336.7	2.05	0.770	0.130	3.68	BD
161	45.49599	-122.74435	0.234	0.740	0.195	0.312	0.116	0.435	85.9	609.6	0.99	5.88	46.30	13.58	153.4	24.4	22.3	246.5	214.9	1.40	0.330	0.085	2.32	BD
162	45.58397	-122.74148	0.260	0.689	0.182	0.558	0.146	0.870	58.6	1357.8	2.46	16.64	67.15	17.47	178.8	24.4	34.0	527.9	439.3	4.42	0.660	0.265	10.31	BD
163	45.47476	-122.52541	0.171	0.487	0.153	0.668	0.136	0.415	26.1	983.0	2.16	40.09	157.42	16.17	160.4	52.9	48.2	850.1	23.9	1.95	0.525	0.140	3.74	0.490
164	45.49579	-122.74427	0.138	0.426	0.158	0.367	0.096	0.445	220.9	729.6	1.41	7.97	60.25	6.25	136.9	27.8	24.4	308.2	311.9	1.55	0.445	0.115	3.02	BD
165	45.47883	-122.70946	0.226	0.513	0.177	0.386	0.117	0.510	36.0	634.7	1.21	14.38	43.71	10.96	133.9	23.3	36.4	303.6	197.5	1.28	0.340	0.155	2.65	BD
166	45.44025	-122.70269	0.166	0.489	0.304	0.347	0.103	0.455	381.5	535.3	2.08	6.06	34.44	11.84	102.5	28.3	43.8	248.7	281.6	1.15	0.305	0.095	1.70	BD
167	45.43338	-122.63999	0.195	0.574	0.154	0.554	0.137	0.760	69.6	2110.3	3.33	11.72	86.95	17.54	153.7	39.0	47.1	888.9	631.1	2.50	1.120	0.305	6.14	BD
168	45.50064	-122.61130	0.189	0.656	0.142	0.595	0.146	0.935	122.2	1401.7	4.02	14.95	71.51	24.80	169.1	29.7	41.8	674.7	726.5	2.56	0.745	0.190	8.38	0.410
169	45.53769	-122.55425	0.296	0.717	0.210	0.526	0.148	0.740	35.6	1137.3	2.80	16.41	47.25	29.59	195.4	36.8	64.6	577.9	368.3	2.48	0.675	0.345	4.22	BD
170	45.52412	-122.59906	0.193	0.497	0.197	0.525	0.101	0.580	23.1	659.8	1.83	14.73	40.67	18.35	48.2	36.8	32.6	360.3	385.1	1.42	0.405	0.270	5.62	BD
171	45.49306	-122.67220	0.265	0.673	0.246	0.698	0.176	1.265	86.6	2382.7	3.12	22.83	86.46	65.47	157.5	32.7	43.8	1019.2	920.5	4.16	1.310	0.290	5.41	0.405
172	45.49290	-122.73293	0.224	0.632	0.139	0.398	0.106	0.460	202.8	926.7	1.65	8.21	49.71	6.33	184.1	34.4	62.5	487.8	622.5	2.15	0.495	0.170	3.67	BD
173	45.49339	-122.54821	0.172	0.524	0.137	0.562	0.120	0.655	81.4	1392.2	3.11	10.78	54.56	17.70	148.2	40.2	69.9	699.2	501.5	2.59	0.830	0.215	6.47	0.405

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					*- - - mg / kg of dry moss - - -*																
174	45.48123	-122.71861	0.114	0.333	0.093	0.540	0.093	0.395	28.3	786.5	1.41	6.18	41.26	10.93	75.0	34.5	37.8	406.3	349.3	1.76	0.435	0.120	3.80	BD
175	45.50905	-122.51736	0.224	0.924	0.181	0.311	0.104	0.340	140.3	756.8	1.44	8.53	85.90	19.48	216.9	25.8	43.9	432.7	335.2	1.24	0.505	0.175	4.05	BD
176	45.56034	-122.63946	0.182	0.641	0.175	0.519	0.118	0.575	27.5	661.3	1.33	13.53	79.60	18.88	166.1	27.5	30.4	327.8	316.8	1.39	0.435	0.280	6.44	BD
177	45.49884	-122.65847	0.200	0.495	0.153	0.530	0.150	1.305	88.2	1638.7	3.49	15.84	124.36	16.54	134.0	37.6	56.2	690.2	409.2	3.21	0.920	0.435	9.35	0.365
178	45.54955	-122.65420	0.240	0.563	0.150	0.726	0.158	0.870	41.1	1249.3	2.03	25.94	75.00	24.38	103.0	48.2	65.3	617.9	198.8	2.50	0.670	0.580	12.71	BD
179	45.54955	-122.65550	0.223	0.744	0.190	0.508	0.138	0.640	38.5	916.8	1.67	24.75	58.75	28.76	157.2	27.9	37.4	442.7	305.7	1.75	0.585	0.370	8.06	BD
180	45.54661	-122.67006	0.144	0.491	0.128	0.404	0.134	1.330	88.9	1434.8	2.50	15.18	73.45	23.75	116.0	26.6	42.6	569.4	551.8	2.35	0.685	0.650	12.21	BD
181	45.55684	-122.77936	0.155	0.450	0.139	0.299	0.119	0.675	106.3	1023.3	1.66	8.19	56.60	3.93	147.9	21.7	38.7	428.6	409.7	1.85	0.590	0.170	4.88	BD
182	45.52099	-122.52939	0.168	0.462	0.141	0.626	0.152	0.635	48.4	1069.3	2.40	14.40	52.75	23.75	60.9	43.2	47.6	678.9	534.8	2.07	0.640	0.180	6.16	BD
183	45.51567	-122.76734	0.234	0.608	0.231	0.435	0.078	0.400	21.9	615.6	0.83	16.75	24.08	20.84	139.3	31.3	28.7	286.8	310.9	1.23	0.340	0.070	1.38	BD
184	45.59534	-122.82330	0.257	0.558	0.155	0.349	0.119	0.420	135.9	910.3	1.73	8.71	36.09	3.11	156.0	29.0	39.8	511.4	504.1	1.50	0.565	0.105	2.44	BD
185	45.57382	-122.67631	0.313	0.670	0.162	0.630	0.190	1.320	91.1	1693.8	3.26	57.10	139.90	20.07	157.8	32.7	53.4	676.4	344.3	4.90	0.775	0.395	14.94	0.400
186	45.45042	-122.67220	0.182	0.439	0.152	0.433	0.112	0.655	121.3	836.0	1.90	10.41	65.17	8.88	108.0	25.0	44.4	397.8	458.3	2.06	0.485	0.330	4.88	BD
187	45.45076	-122.71790	0.176	0.597	0.225	0.417	0.105	0.550	25.7	732.0	1.32	15.77	30.01	18.38	161.8	34.6	29.8	365.7	504.5	1.64	0.445	0.110	2.11	BD
188	45.59650	-122.76447	0.222	0.550	0.217	0.469	0.158	1.230	97.4	1908.8	3.28	29.93	138.55	11.23	191.5	22.4	30.5	601.9	525.1	6.21	0.845	0.420	13.78	0.240
189	45.47902	-122.63369	0.173	0.427	0.184	0.450	0.119	0.765	102.0	878.7	3.81	11.50	52.56	25.49	90.1	21.0	41.6	433.3	381.9	1.99	0.580	0.335	4.17	BD
190	45.59518	-122.82254	0.201	0.551	0.143	0.345	0.104	0.455	208.1	666.8	1.41	7.31	26.11	4.22	153.7	35.7	37.2	331.5	384.5	1.34	0.390	0.075	2.42	BD
191	45.48082	-122.55965	0.167	0.440	0.112	0.540	0.113	0.695	32.5	1154.2	3.83	12.66	63.16	10.85	107.7	37.5	48.2	615.7	669.0	2.45	0.865	0.210	4.97	0.320
192	45.48571	-122.57693	0.171	0.523	0.125	0.648	0.126	0.760	65.6	1173.7	3.73	11.82	54.11	24.75	138.0	45.5	70.6	568.2	410.6	2.43	0.730	0.195	6.77	BD
193	45.49038	-122.53257	0.282	0.603	0.217	0.475	0.099	0.535	58.0	1000.2	2.18	8.79	184.56	21.70	130.5	34.6	46.1	555.2	624.5	1.82	0.635	0.225	4.91	0.265
194	45.53446	-122.71470	0.283	0.546	0.208	0.551	0.133	0.985	75.7	1186.8	2.85	16.32	113.45	25.84	65.5	32.9	72.0	474.3	506.3	3.38	0.645	0.370	12.87	BD
195	45.49498	-122.51519	0.161	0.363	0.232	0.475	0.095	0.480	52.9	1253.2	2.02	10.88	45.81	14.84	108.0	45.7	64.0	826.7	839.5	1.86	0.720	1.110	4.46	0.370
196	45.44293	-122.66765	0.177	0.415	0.128	0.409	0.102	0.750	79.7	1087.0	2.23	10.34	63.82	3.82	96.0	21.3	26.3	494.5	479.3	2.25	0.680	0.195	4.55	BD
197	45.55805	-122.58105	0.249	0.590	0.154	0.509	0.120	0.645	107.8	874.3	1.98	13.11	56.00	19.33	147.7	36.5	56.1	391.8	321.8	1.64	0.510	0.330	4.80	BD
198	45.50624	-122.55455	0.255	0.554	0.167	0.527	0.128	0.610	54.3	1231.7	3.51	10.54	58.66	13.89	125.2	31.7	44.5	640.2	460.3	2.49	0.885	0.315	3.82	BD
199	45.48894	-122.58215	0.160	0.560	0.198	0.382	0.114	0.815	132.2	1300.2	4.78	16.76	78.01	12.49	175.8	25.0	41.5	718.7	481.4	2.54	0.875	0.220	6.65	0.480
200	45.55537	-122.63473	0.280	0.635	0.186	0.624	0.169	1.065	40.5	1456.8	2.26	28.49	133.30	28.65	147.4	34.3	62.8	637.4	305.6	2.99	0.765	0.615	10.94	0.430
201	45.45931	-122.65157	0.234	0.497	0.150	0.628	0.109	0.730	30.3	862.0	2.11	10.62	72.12	22.25	114.5	39.6	48.8	476.6	556.0	2.03	0.490	0.395	15.17	BD
202	45.48274	-122.57410	0.244	0.502	0.182	0.429	0.111	0.715	52.3	1282.2	3.47	10.90	54.01	14.88	144.1	26.1	47.7	697.2	599.5	2.42	0.870	0.180	6.78	BD

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			Percent of dry moss weight					*mg / kg of dry moss*																
203	45.44538	-122.70971	0.203	0.444	0.135	0.409	0.110	0.615	152.6	1096.5	1.74	11.32	75.32	4.47	75.9	30.2	63.6	472.9	367.0	2.02	0.615	0.125	4.57	BD
204	45.50937	-122.67740	0.296	0.558	0.184	0.515	0.147	1.695	143.8	1739.2	3.27	23.69	129.86	16.53	104.1	32.9	58.5	662.7	458.6	4.07	0.850	0.355	7.41	0.245
205	45.47245	-122.70355	0.237	0.637	0.313	0.650	0.150	0.645	60.0	1775.5	2.01	10.04	46.77	46.03	86.5	53.6	57.2	625.1	539.0	2.93	0.995	0.230	3.49	0.305
206	45.54310	-122.59541	0.201	0.604	0.185	0.327	0.138	0.655	37.7	874.8	2.02	11.29	47.25	8.68	153.2	20.3	25.3	469.7	343.8	1.67	0.515	0.210	11.57	BD
207	45.53578	-122.63135	0.198	0.515	0.128	0.419	0.115	0.935	99.1	1062.8	2.14	15.70	79.15	9.31	64.3	28.1	43.6	476.9	269.8	2.10	0.560	0.290	7.07	0.270
208	45.45516	-122.56026	0.260	0.541	0.226	0.602	0.107	0.635	37.0	696.3	2.95	11.59	32.18	32.65	132.8	61.5	86.5	315.2	267.8	1.43	0.605	0.115	1.71	BD
209	45.49736	-122.48450	0.208	0.476	0.167	0.479	0.123	0.640	69.2	1376.7	2.02	10.60	80.31	12.04	137.6	44.9	72.7	735.2	425.6	2.36	0.805	0.260	6.51	0.350
210	45.55718	-122.60689	0.136	0.449	0.129	0.497	0.134	0.810	117.4	934.3	2.42	13.21	46.85	13.41	149.5	24.4	46.6	421.3	407.4	1.79	0.525	0.225	8.23	0.265
211	45.56016	-122.64085	0.210	0.443	0.132	0.363	0.137	0.755	44.2	1030.3	1.98	20.57	153.90	5.77	143.3	21.6	35.6	443.1	231.8	2.04	0.565	0.320	10.83	BD
212	45.52059	-122.69917	0.184	0.479	0.132	0.589	0.119	1.135	51.8	1078.8	2.09	14.68	144.15	11.66	64.8	34.0	60.2	475.0	457.9	2.89	0.555	0.200	7.92	BD
213	45.49545	-122.50062	0.265	0.598	0.184	0.491	0.138	0.810	124.1	2108.7	2.85	12.95	74.61	22.90	248.0	45.2	61.5	1147.7	925.0	3.68	1.040	0.180	6.07	0.250
214	45.50672	-122.55975	0.313	0.642	0.173	0.425	0.129	0.765	72.1	1027.8	2.42	12.11	49.75	15.76	115.2	34.7	57.5	570.4	391.5	1.79	0.645	0.175	4.66	BD
215	45.47032	-122.64999	0.151	0.378	0.108	0.447	0.104	0.785	41.6	1095.5	2.68	13.17	49.87	7.68	125.8	37.9	35.0	501.6	364.1	2.28	0.705	0.340	6.11	0.240
216	45.49011	-122.53269	0.292	0.688	0.247	0.482	0.095	0.445	43.4	739.7	2.01	8.68	33.08	13.87	108.5	31.4	40.0	445.0	552.5	1.56	0.525	0.105	2.63	BD
217	45.59994	-122.74126	0.239	0.576	0.241	0.558	0.149	2.130	147.9	1780.3	3.54	12.14	80.60	32.33	165.6	26.8	39.7	519.1	521.5	7.48	0.695	0.210	7.04	BD
218	45.45653	-122.56993	0.279	0.708	0.291	0.452	0.145	1.240	39.9	880.8	5.16	17.94	71.00	13.76	148.9	28.3	35.7	375.5	328.2	2.15	0.950	0.150	3.11	BD
219	45.43562	-122.75134	0.189	0.399	0.212	0.399	0.117	1.100	250.8	1319.8	1.88	13.05	114.65	12.78	137.9	22.7	43.8	503.6	517.0	2.52	0.695	0.130	3.71	BD
220	45.55375	-122.68817	0.241	0.603	0.190	0.590	0.134	1.185	99.3	1284.3	2.70	14.41	62.35	23.90	153.1	36.4	72.4	547.1	510.5	3.12	0.660	0.345	10.11	0.320
221	45.48013	-122.59011	0.243	0.570	0.104	0.463	0.131	0.470	24.5	609.2	4.00	7.72	34.90	6.73	108.5	28.7	21.5	310.6	197.9	1.58	0.515	0.145	3.66	BD
222	45.44671	-122.74477	0.223	0.745	0.154	0.460	0.100	0.555	222.2	682.2	1.30	7.14	42.71	13.65	197.9	30.9	47.1	313.2	199.2	1.53	0.400	0.185	1.92	0.565
223	45.49050	-122.62877	0.270	0.549	0.153	0.363	0.110	0.950	44.0	781.7	3.35	11.64	51.23	7.27	123.1	25.6	31.2	369.9	215.8	1.68	0.475	0.195	5.17	0.355
224	45.59107	-122.74757	0.210	0.596	0.136	0.576	0.140	0.970	97.6	1348.3	2.65	12.83	74.80	18.06	168.9	28.0	58.1	511.6	391.5	4.01	0.615	0.325	8.36	0.245
225	45.52137	-122.69840	0.433	0.623	0.240	0.739	0.241	2.255	102.8	2571.5	4.08	43.90	148.36	33.51	154.4	59.3	90.4	941.9	530.4	6.33	1.245	0.970	14.41	0.400
226	45.48665	-122.69424	0.098	0.380	0.109	0.598	0.114	0.865	53.3	952.7	1.89	249.50	44.98	12.67	110.1	41.6	49.7	486.0	144.6	2.15	0.480	0.275	5.25	0.625
227	45.44710	-122.74476	0.163	0.447	0.120	0.408	0.096	0.650	166.3	727.7	1.20	5.73	41.02	5.46	141.7	24.9	41.7	322.0	199.8	1.52	0.420	0.120	2.15	0.290
228	45.44681	-122.69329	0.207	0.511	0.145	0.301	0.090	0.545	149.2	618.7	1.64	6.34	35.41	6.24	104.5	22.2	25.8	296.8	137.4	1.47	0.365	0.105	2.50	BD
229	45.54810	-122.54804	0.227	0.586	0.226	0.655	0.164	1.040	54.2	1501.8	2.02	17.10	88.45	41.87	135.9	57.0	84.0	650.1	529.5	2.62	0.730	0.270	4.46	0.285
230	45.56447	-122.64840	0.288	0.677	0.225	0.585	0.131	0.720	53.8	876.3	1.33	15.01	35.66	38.66	102.9	92.2	45.8	567.6	487.2	1.84	0.380	0.190	5.48	0.360
231	45.58055	-122.72910	0.204	0.588	0.209	0.756	0.129	1.260	53.6	905.3	2.41	17.83	55.75	34.80	91.4	63.2	110.0	353.4	294.2	2.84	0.430	0.420	10.01	BD

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					mg / kg of dry moss																
232	45.55243	-122.59547	0.202	0.483	0.124	0.640	0.132	0.575	31.7	976.3	1.83	15.66	44.56	20.59	123.4	40.2	40.2	432.6	295.4	1.78	0.555	0.820	4.83	BD
233	45.55995	-122.66825	0.160	0.478	0.168	0.665	0.160	1.265	46.4	1652.3	2.88	37.95	94.05	29.00	143.7	42.0	51.2	652.6	409.7	3.84	0.845	0.515	10.84	0.350
234	45.48458	-122.60857	0.181	0.575	0.112	0.489	0.105	1.070	156.7	1051.2	7.81	13.40	56.68	10.85	134.0	28.9	54.2	470.5	247.1	2.81	0.765	0.130	6.68	0.285
235	45.45280	-122.61880	0.181	0.372	0.134	0.572	0.097	1.235	26.7	808.3	8.96	8.91	39.12	14.51	77.0	35.2	30.7	368.0	365.1	2.08	0.695	0.130	2.87	BD
236	45.50500	-122.73208	0.207	0.491	0.185	0.482	0.115	0.420	59.3	921.5	2.20	10.58	63.16	7.03	112.2	18.1	34.0	458.1	620.9	1.99	0.565	0.165	4.27	BD
237	45.44176	-122.73767	0.183	0.439	0.144	0.407	0.109	0.775	147.9	836.7	1.36	8.78	58.58	8.23	140.9	39.9	58.4	375.4	246.4	1.65	0.445	0.135	3.44	BD
238	45.53647	-122.62751	0.231	0.601	0.195	0.480	0.133	0.745	39.8	1230.0	1.93	15.99	65.41	22.70	136.2	32.4	42.0	562.9	591.4	2.48	0.660	0.390	10.16	BD
239	45.50890	-122.61925	0.340	0.684	0.229	0.606	0.159	0.535	179.4	915.0	2.63	13.33	53.36	44.96	143.3	41.1	79.2	525.4	669.9	2.08	0.590	0.220	10.65	BD
240	45.48285	-122.48777	0.115	0.283	0.084	0.700	0.099	0.460	39.9	1673.1	1.74	9.35	51.35	9.24	125.6	69.9	54.4	1041.0	697.2	2.11	0.905	0.155	5.10	BD
241	45.48326	-122.69262	0.199	0.519	0.160	0.678	0.144	0.730	68.1	1388.2	2.35	12.65	59.98	30.14	152.8	49.6	52.5	545.2	385.2	2.80	0.735	0.230	4.22	0.290
242	45.50440	-122.70728	0.184	0.515	0.171	0.446	0.143	0.745	50.1	1046.0	1.94	13.97	72.51	9.12	200.1	26.7	44.4	483.6	584.4	2.78	0.575	0.195	4.50	BD
243	45.45372	-122.54464	0.164	0.375	0.145	0.318	0.088	0.430	54.5	508.3	2.72	72.90	73.65	3.54	90.1	29.3	30.0	269.3	252.2	1.52	0.480	0.080	5.91	BD
244	45.53565	-122.76608	0.246	0.449	0.221	0.766	0.129	0.515	73.8	589.5	1.39	8.74	81.21	29.57	130.2	99.8	80.5	300.2	495.4	1.62	0.535	0.250	1.69	BD
245	45.48117	-122.67374	0.143	0.457	0.132	0.646	0.146	1.665	151.2	1810.7	2.70	21.06	109.58	21.95	151.7	37.4	58.8	698.2	416.6	3.64	0.920	0.245	6.46	0.380
246	45.49099	-122.59060	0.202	0.454	0.113	0.622	0.140	0.680	26.7	956.7	5.09	18.06	78.88	15.01	133.8	47.9	65.0	532.7	239.1	2.11	0.695	0.300	6.08	0.465
247	45.53711	-122.69246	0.283	0.629	0.217	0.760	0.159	2.840	101.1	2093.0	5.58	26.06	98.61	46.43	187.8	43.1	82.6	741.9	472.2	5.89	0.980	0.835	8.16	0.330
248	45.45190	-122.58316	0.128	0.400	0.115	0.611	0.100	0.665	151.3	1130.3	5.51	8.66	52.15	12.33	91.6	49.5	82.9	561.6	469.6	2.47	1.005	0.195	7.03	BD
249	45.45068	-122.71718	0.282	0.512	0.228	0.459	0.173	0.820	174.5	1557.2	2.66	12.75	73.08	18.94	164.3	42.4	62.3	859.2	501.3	3.05	0.940	0.325	4.06	0.325
250	45.49494	-122.47893	0.279	0.643	0.210	0.706	0.097	0.510	43.6	918.3	1.29	9.30	30.44	22.97	162.6	49.0	119.3	543.1	499.5	1.55	0.515	0.200	1.76	0.510
251	45.48127	-122.52397	0.216	0.468	0.168	0.464	0.102	0.560	31.0	885.7	1.99	8.79	45.13	9.25	116.3	81.0	49.9	496.3	338.0	1.64	0.605	0.190	3.10	0.370
252	45.54061	-122.56555	0.184	0.519	0.145	0.525	0.125	0.605	39.0	852.0	2.25	9.29	60.36	10.03	104.5	55.8	23.4	438.5	516.9	1.66	0.600	0.260	3.46	BD
253	45.47443	-122.70737	0.156	0.411	0.147	0.379	0.096	0.575	70.2	1585.2	1.80	8.06	47.68	7.07	148.3	26.0	29.9	656.2	360.4	2.43	0.975	0.190	3.73	BD
254	45.53584	-122.78024	0.232	0.561	0.130	0.309	0.084	0.500	216.0	629.6	0.92	8.89	58.94	2.76	218.9	12.8	27.2	293.5	549.3	1.20	0.440	0.160	1.98	0.330
255	45.51610	-122.60221	0.249	0.655	0.192	0.723	0.192	0.820	56.5	1449.0	3.95	23.44	63.86	45.92	211.9	46.6	68.8	710.9	748.9	3.18	0.820	0.920	8.49	0.375
256	45.47538	-122.73318	0.234	0.542	0.137	0.400	0.098	0.480	84.5	685.2	1.29	8.27	48.23	6.97	120.8	24.7	38.9	332.6	179.4	1.51	0.430	0.300	3.12	BD
257	45.50562	-122.74868	0.286	0.462	0.166	0.432	0.156	0.810	449.8	1258.8	3.11	12.97	115.20	18.51	139.8	28.2	42.7	565.1	454.9	2.75	0.880	0.250	6.57	0.665
258	45.54665	-122.57104	0.199	0.557	0.126	0.666	0.135	0.610	29.4	838.3	2.13	64.75	73.15	25.36	128.5	53.5	47.2	396.3	366.6	1.89	0.485	0.245	6.62	0.430
259	45.53662	-122.62843	0.280	0.589	0.195	0.564	0.144	0.760	81.1	1171.5	2.57	18.95	88.86	34.56	153.1	38.0	47.4	556.9	596.4	2.87	0.705	1.200	11.93	0.455
260	45.50535	-122.52877	0.268	0.512	0.170	0.475	0.106	0.390	30.3	704.5	1.79	11.44	48.11	13.30	149.7	30.4	40.5	445.4	593.4	1.50	0.515	0.220	2.60	0.535

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					- - - mg / kg of dry moss - - -																
261	45.54043	-122.49921	0.225	0.577	0.168	0.373	0.121	0.655	44.5	958.3	1.85	10.57	61.50	8.08	208.9	28.1	34.8	451.2	315.0	1.83	0.580	0.160	3.48	0.260
262	45.42379	-122.69823	0.206	0.581	0.255	0.509	0.121	1.150	47.1	1387.0	2.09	25.53	100.26	15.66	170.6	32.9	67.1	571.9	654.4	2.72	0.785	0.165	3.02	BD
263	45.60517	-122.65903	0.287	0.618	0.206	0.386	0.191	1.435	39.0	1111.8	2.43	28.15	61.45	15.96	153.8	18.3	21.6	410.3	429.3	2.25	0.540	0.420	5.77	BD
264	45.43382	-122.73524	0.228	0.497	0.147	0.441	0.101	0.550	191.0	676.8	1.56	6.89	52.00	7.11	105.7	28.7	41.3	298.7	258.3	1.41	0.430	0.190	2.20	BD
265	45.59477	-122.65171	0.270	0.594	0.287	0.851	0.181	1.450	67.8	1774.3	3.59	59.15	151.35	83.57	107.9	40.1	41.1	679.1	568.5	3.67	1.045	1.315	9.49	0.460
266	45.52682	-122.51866	0.211	0.491	0.274	0.753	0.147	0.550	43.1	1066.8	2.20	16.20	73.90	17.12	143.7	39.8	39.6	567.6	619.5	2.34	0.635	1.085	4.02	0.275
267	45.51716	-122.64627	0.155	0.629	0.216	0.453	0.143	0.750	88.3	1083.5	3.17	15.99	130.16	64.91	278.3	32.6	57.4	542.9	603.4	2.54	0.725	0.900	18.51	0.350
268	45.42505	-122.72501	0.233	0.517	0.214	0.519	0.107	0.575	35.2	725.8	1.39	14.26	36.71	20.11	140.4	47.9	36.6	321.4	286.9	1.40	0.380	0.125	1.83	0.280
269	45.58378	-122.73971	0.224	0.572	0.199	0.643	0.160	1.390	66.4	1590.8	2.96	16.96	68.15	26.33	150.7	37.6	103.7	623.6	594.0	4.61	0.705	0.255	7.92	0.465
270	45.46504	-122.62616	0.318	0.823	0.167	0.626	0.159	1.065	94.7	1530.7	6.74	16.05	70.03	53.38	135.3	31.0	61.6	775.2	423.4	3.32	1.000	0.780	7.15	0.285
271	45.48326	-122.69262	0.175	0.583	0.175	0.673	0.136	0.675	60.5	1179.2	1.99	10.35	54.33	31.83	198.1	48.9	44.9	474.3	342.2	2.13	0.640	0.195	3.27	BD
272	45.47962	-122.59075	0.140	0.448	0.191	0.493	0.125	1.140	61.0	1512.7	7.28	15.29	104.93	15.18	138.9	40.3	55.2	775.7	351.3	3.30	1.060	0.260	12.28	0.475
273	45.47973	-122.52852	0.227	0.434	0.120	0.416	0.099	0.475	58.7	776.7	2.35	6.69	43.73	4.58	106.8	30.6	46.7	467.1	303.0	1.86	0.565	0.295	4.17	0.400
274	45.45275	-122.60490	0.307	0.613	0.165	0.590	0.138	1.145	40.7	750.3	11.83	8.06	39.19	26.54	153.1	31.5	41.3	384.3	396.1	2.60	0.860	0.330	2.72	BD
275	45.46562	-122.74958	0.182	0.374	0.152	0.464	0.114	1.175	120.1	2528.8	2.84	16.25	141.40	5.37	100.0	35.7	63.6	1161.1	672.5	3.62	1.540	0.235	13.03	0.270
276	45.51722	-122.64707	0.293	0.689	0.151	0.711	0.167	0.855	51.3	1033.0	2.01	37.48	164.46	56.01	174.0	51.9	86.4	481.9	647.4	2.41	0.575	0.670	9.35	0.375
277	45.48037	-122.46949	0.157	0.446	0.162	0.327	0.096	0.570	55.4	1051.8	1.75	10.71	63.05	3.10	162.6	19.2	23.4	524.6	431.6	1.81	0.635	0.115	2.80	0.510
278	45.48019	-122.47050	0.303	0.697	0.250	0.594	0.136	0.825	37.9	1088.3	1.49	15.35	70.30	29.77	152.0	43.4	73.1	616.1	483.7	1.56	0.640	0.190	2.32	0.380
279	45.54647	-122.57101	0.347	0.694	0.177	0.544	0.152	0.680	63.2	890.3	2.39	13.23	57.00	31.52	149.9	30.9	46.0	408.3	365.6	1.86	0.480	0.550	3.58	0.345
280	45.55514	-122.63496	0.197	0.566	0.194	0.530	0.144	0.750	145.7	904.8	1.92	17.77	55.35	27.73	143.5	22.2	43.7	440.0	687.0	1.86	0.465	0.275	10.28	BD
281	45.50918	-122.58902	0.319	0.618	0.166	0.745	0.141	0.560	40.7	986.0	2.99	13.33	60.66	38.77	111.0	40.6	52.7	548.4	672.9	2.18	0.610	0.225	3.89	0.270
282	45.52237	-122.67912	0.240	0.478	0.168	0.579	0.170	1.790	93.2	1589.5	3.97	26.61	131.51	18.84	173.5	35.7	63.3	602.4	649.4	4.38	0.885	0.450	17.30	BD
283	45.47907	-122.62067	0.156	0.362	0.134	0.472	0.124	1.550	53.9	2012.7	13.81	18.17	105.68	5.18	138.5	30.0	41.9	901.2	325.3	4.40	1.350	0.260	20.00	0.295
284	45.46626	-122.74806	0.221	0.473	0.153	0.450	0.118	0.860	55.9	1483.5	1.66	11.38	72.62	5.65	124.7	35.1	39.1	543.1	511.0	2.48	0.815	0.150	3.84	BD
285	45.50117	-122.64471	0.220	0.517	0.147	0.760	0.158	0.975	39.5	1116.5	2.97	31.31	179.36	101.21	134.0	47.8	77.5	573.4	571.9	3.09	0.810	4.380	8.97	0.945
286	45.52084	-122.71061	0.254	0.512	0.192	0.516	0.123	0.680	52.5	1025.0	1.94	14.15	93.61	14.74	177.0	27.5	63.8	463.2	616.4	2.86	0.585	0.305	11.72	BD
287	45.53499	-122.67268	0.268	0.588	0.180	0.698	0.197	2.885	109.9	2819.5	5.18	26.58	159.86	44.17	234.7	40.4	70.7	1096.9	669.9	6.21	1.540	1.150	12.90	0.480
288	45.49927	-122.72348	0.252	0.526	0.167	0.474	0.147	0.630	175.2	1188.7	2.04	10.49	84.83	6.67	133.3	41.0	45.8	480.2	203.9	2.50	0.560	0.610	4.98	0.365
289	45.46725	-122.63049	0.203	0.563	0.155	0.578	0.100	0.735	26.0	819.7	3.82	8.77	29.43	12.09	92.0	32.0	30.9	462.3	356.4	1.75	0.535	0.180	4.16	BD

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					*mg / kg of dry moss*																
290	45.51413	-122.51594	0.132	0.288	0.108	0.708	0.131	0.330	34.0	1362.0	2.27	12.48	40.11	16.50	117.4	40.4	45.7	741.2	876.7	2.13	0.750	0.130	4.05	0.810
291	45.58185	-122.70919	0.230	0.594	0.142	0.406	0.141	1.640	114.3	1388.3	3.76	14.87	65.50	10.48	177.0	21.4	47.9	515.1	393.0	4.28	0.640	0.255	5.77	0.275
292	45.43225	-122.72210	0.240	0.420	0.152	0.364	0.147	0.760	252.1	1069.8	2.01	10.61	67.65	7.92	103.8	32.9	53.4	486.6	402.0	2.15	0.620	0.210	4.07	BD
293	45.49096	-122.59018	0.220	0.645	0.199	0.461	0.115	0.760	122.2	609.2	4.49	8.98	41.58	15.23	180.8	28.7	35.4	330.3	228.6	1.50	0.515	0.150	3.99	0.375
294	45.55170	-122.55247	0.190	0.555	0.153	0.589	0.121	0.580	29.2	945.3	1.51	10.99	37.11	28.97	144.6	48.0	69.5	431.0	388.6	1.71	0.540	0.235	3.80	BD
295	45.45253	-122.74459	0.166	0.371	0.171	0.402	0.114	0.495	98.1	799.3	1.27	6.47	52.75	12.51	89.2	30.6	43.4	352.7	375.2	1.72	0.415	0.330	2.84	0.330
296	45.42253	-122.73292	0.223	0.416	0.198	0.503	0.121	0.740	109.1	897.8	1.35	11.99	81.35	12.72	110.4	31.9	47.8	376.6	345.5	1.71	0.465	0.125	2.40	0.410
297	45.48117	-122.67463	0.203	0.540	0.137	0.621	0.110	0.860	74.5	864.2	1.86	39.25	114.23	20.89	104.3	36.4	40.8	351.1	166.6	2.10	0.495	0.330	4.52	0.270
298	45.50142	-122.58172	0.187	0.482	0.100	0.747	0.102	0.400	30.8	1219.0	3.00	124.90	49.91	15.55	102.1	48.6	59.3	681.4	803.4	2.41	0.795	0.210	4.28	0.275
299	45.49530	-122.67195	0.288	0.635	0.205	0.746	0.171	1.735	74.7	2054.5	3.73	23.53	131.81	31.70	152.6	46.5	56.3	819.4	521.4	4.53	1.105	0.430	7.19	BD
300	45.53427	-122.59669	0.229	0.502	0.188	0.465	0.139	0.725	45.3	1170.0	3.02	16.03	66.16	13.28	206.1	38.1	40.9	579.4	589.9	2.74	0.655	0.255	6.77	BD
301	45.42985	-122.64429	0.101	0.331	0.085	0.689	0.105	0.590	24.5	868.8	2.39	14.57	36.92	15.32	110.5	37.8	32.7	446.7	412.5	1.71	0.445	0.250	3.34	0.420
302	45.54741	-122.64209	0.255	1.212	0.145	0.450	0.133	0.525	101.8	656.8	1.55	18.12	57.90	26.34	186.8	23.8	18.7	292.2	301.2	1.58	0.360	0.290	6.04	BD
303	45.46416	-122.69178	0.172	0.341	0.126	0.388	0.119	0.750	65.3	1188.2	2.26	16.68	129.87	4.38	128.8	35.5	47.3	592.9	559.9	2.53	0.635	0.260	9.61	BD
304	45.56452	-122.64922	0.192	0.532	0.168	0.540	0.121	0.635	64.5	602.3	1.29	12.65	35.12	24.57	124.0	34.2	48.3	320.0	390.9	1.33	0.290	0.165	7.45	0.245
305	45.52666	-122.64997	0.165	0.383	0.124	0.520	0.151	1.230	140.5	1615.5	4.23	24.38	87.71	14.28	154.3	49.9	53.8	711.4	727.4	3.42	0.845	0.455	10.91	0.415
306	45.57057	-122.66571	0.171	0.749	0.133	0.642	0.158	0.860	86.9	967.3	2.02	25.57	58.60	31.96	228.3	31.3	52.6	414.2	446.8	2.59	0.475	0.365	26.45	0.380
307	45.53392	-122.53325	0.096	0.325	0.213	0.585	0.120	0.715	115.6	916.2	1.80	10.83	42.53	24.35	134.4	35.1	71.7	446.3	411.5	1.62	0.480	0.215	4.47	0.295
308	45.57057	-122.66571	0.172	0.554	0.105	0.686	0.128	0.720	56.6	624.8	1.56	15.87	49.90	23.13	153.5	33.1	51.4	278.6	338.6	1.66	0.315	0.240	32.75	0.265
309	45.50124	-122.47951	0.191	0.476	0.141	0.381	0.086	0.380	93.6	667.7	1.06	5.76	32.72	10.06	217.4	18.1	28.0	382.8	397.5	1.23	0.435	0.125	2.66	0.300
310	45.54995	-122.52736	0.273	0.602	0.129	0.501	0.123	0.795	30.9	1094.8	2.28	18.88	44.42	11.47	152.6	37.0	29.4	525.1	480.2	2.11	0.620	0.180	4.80	BD
311	45.55243	-122.59548	0.177	0.473	0.119	0.589	0.123	0.580	28.5	890.7	1.60	11.49	42.02	17.41	119.2	38.2	45.9	492.7	562.9	1.86	0.530	0.565	4.53	0.285
312	45.53392	-122.53325	0.099	0.344	0.208	0.646	0.122	0.545	88.8	823.5	1.60	10.32	42.57	28.62	141.1	39.1	72.4	438.6	664.9	1.79	0.415	0.250	3.30	0.500
313	45.47192	-122.60602	0.224	0.524	0.137	0.488	0.137	2.010	32.2	866.2	19.33	11.06	50.07	13.47	139.7	40.4	70.5	520.4	574.4	3.49	1.115	0.265	4.90	0.515
314	45.53703	-122.69205	0.324	0.608	0.204	0.728	0.170	3.105	107.1	1908.7	5.11	28.26	109.22	55.30	167.7	42.6	98.5	732.4	552.4	5.84	0.895	0.600	7.81	0.345
315	45.46789	-122.60908	0.237	0.623	0.238	0.567	0.148	3.770	125.6	1535.7	43.45	18.47	68.57	36.76	182.7	39.1	79.5	882.4	680.4	6.68	2.150	0.275	6.98	0.825
316	45.47247	-122.70244	0.221	0.564	0.198	0.460	0.124	0.620	54.5	1512.2	2.63	15.89	46.13	18.54	133.1	41.7	57.4	594.2	299.6	4.10	0.815	0.175	4.05	0.375
317	45.48983	-122.61204	0.129	0.433	0.152	0.356	0.106	0.670	155.4	933.2	4.25	23.68	175.67	9.26	155.9	17.2	28.0	512.9	449.0	2.10	0.685	0.320	6.00	0.415
318	45.53615	-122.53157	0.209	0.426	0.151	0.521	0.142	0.625	121.8	987.3	2.70	10.49	47.20	11.07	120.8	33.6	54.3	469.2	477.9	1.92	0.605	0.235	5.04	0.485

Table 6—Moss-derived element concentration data (continued)

	Latitude[a] (degrees)	Longitude[a] (degrees)	P	K	Mg	Ca	S	Mo	Mn	Fe	Ni	Cu	Zn	B	Na	Sr	Ba	Al	Si	Cr	Co	Cd	Pb	As
			- - Percent of dry moss weight - -					- - - mg / kg of dry moss - - -																
319	45.55498	-122.57764	0.251	0.592	0.200	0.734	0.146	0.730	56.4	964.7	2.15	15.96	71.77	37.37	142.3	59.3	121.1	539.4	604.4	1.92	0.560	0.605	5.33	BD
320	45.48927	-122.61191	0.207	0.534	0.179	0.506	0.123	0.765	32.2	829.7	4.88	12.84	42.15	15.17	134.4	27.8	33.7	403.3	214.7	1.91	0.530	0.225	4.77	0.375
321	45.44739	-122.64110	0.212	0.392	0.123	0.418	0.136	1.305	84.1	1301.2	6.79	14.48	103.87	8.61	92.0	27.9	50.2	594.9	513.4	3.55	0.880	0.445	7.44	BD
322	45.47818	-122.62070	0.160	0.435	0.136	0.451	0.113	1.250	50.2	1481.7	11.71	14.84	67.63	7.37	114.5	25.4	37.0	733.2	314.4	3.20	1.130	0.265	9.85	0.340
323	45.55817	-122.62454	0.216	0.567	0.153	0.485	0.147	0.730	38.7	1122.7	2.32	37.93	71.22	16.88	183.6	24.8	39.4	540.9	418.1	2.51	0.620	0.315	6.38	0.360
324	45.48758	-122.48510	0.221	0.631	0.173	0.432	0.120	0.550	189.0	1149.7	1.69	10.90	64.77	7.91	188.3	33.4	47.3	681.9	747.9	1.67	0.690	0.165	22.82	0.290
325	45.51420	-122.68235	0.190	0.482	0.198	0.661	0.229	3.395	122.9	3614.0	7.43	45.49	154.11	24.59	185.8	43.5	78.2	1168.9	685.9	8.07	1.410	0.430	34.75	0.320
326	45.52265	-122.53901	0.234	0.649	0.173	0.669	0.195	1.720	226.9	1776.2	2.61	30.00	115.52	26.72	178.6	53.3	89.6	888.9	811.9	2.73	0.955	0.215	7.09	0.370
327	45.51588	-122.61927	0.230	0.533	0.159	0.534	0.131	0.650	92.5	1012.2	3.17	15.04	66.77	17.93	170.8	35.4	54.0	542.9	624.9	2.22	0.580	0.450	10.26	0.290
328	45.51793	-122.61337	0.216	0.478	0.175	0.543	0.137	0.565	35.9	933.0	2.55	16.25	57.36	15.84	147.3	33.5	44.0	480.7	572.4	2.09	0.530	0.345	11.20	BD
329	45.49944	-122.60185	0.186	0.590	0.123	0.480	0.111	0.635	170.0	992.7	4.60	12.32	54.57	11.16	171.4	28.6	63.7	524.9	495.3	2.11	0.670	0.250	7.16	0.280
330	45.44731	-122.64137	0.191	0.412	0.124	0.473	0.168	1.860	129.0	1876.2	6.96	17.36	230.07	11.18	136.4	35.1	57.4	885.4	602.4	4.24	1.130	0.265	12.73	0.300
331	45.46143	-122.52337	0.209	0.406	0.147	0.343	0.107	0.535	54.7	702.7	2.04	9.60	46.57	5.24	169.3	35.7	53.0	396.1	433.0	1.66	0.525	0.120	2.09	BD
332	45.50440	-122.70728	0.181	0.429	0.151	0.395	0.129	0.735	44.3	870.2	1.52	11.72	63.47	9.22	168.7	23.3	41.7	388.7	451.0	1.90	0.465	0.195	3.94	BD
333	45.55797	-122.62457	0.200	0.566	0.146	0.463	0.138	0.660	34.3	892.1	1.78	37.65	52.69	17.83	155.5	26.6	38.9	470.6	646.2	1.92	0.540	0.290	5.19	BD
334	45.46461	-122.54997	0.166	0.780	0.198	0.260	0.116	0.620	235.0	703.2	2.66	8.66	79.32	11.19	270.6	18.1	34.0	421.8	468.3	1.39	0.650	0.180	3.27	0.380
335	45.52075	-122.76605	0.184	0.438	0.128	0.376	0.098	0.390	161.8	561.9	1.22	6.59	52.72	10.06	146.2	25.5	37.7	308.6	513.1	1.39	0.440	0.130	1.84	0.410
336	45.52694	-122.51728	0.196	0.524	0.291	0.517	0.132	0.460	190.7	992.4	2.67	8.85	35.10	25.73	136.8	41.1	83.1	593.1	1041.9	1.78	0.600	0.490	2.69	BD
337	45.47372	-122.52452	0.155	0.431	0.127	0.324	0.076	0.445	38.8	712.2	1.91	9.11	37.49	3.46	141.9	25.9	37.5	452.9	565.9	1.59	0.550	0.130	3.00	0.455
338	45.52257	-122.53930	0.219	0.501	0.141	0.512	0.181	2.100	305.9	2513.4	3.43	84.29	121.83	13.25	227.4	48.6	125.5	1141.9	1324.9	3.35	1.240	0.210	10.16	BD
339	45.51498	-122.51593	0.165	0.436	0.106	0.845	0.131	0.385	18.2	700.7	1.39	9.07	28.54	38.14	99.8	45.4	45.7	497.3	508.4	1.35	0.440	0.155	3.12	0.400
340	45.46950	-122.50686	0.128	0.528	0.172	0.350	0.084	0.610	191.5	786.2	1.61	8.44	41.56	7.01	178.6	27.9	34.8	482.7	558.4	1.35	0.540	0.165	2.38	0.470
341	45.54629	-122.67079	0.200	0.420	0.163	0.490	0.182	1.825	126.5	2323.2	4.62	25.41	97.47	18.20	146.7	28.6	49.6	873.4	713.9	4.59	1.035	0.810	18.16	0.270
342	45.53567	-122.60985	0.191	0.448	0.180	0.690	0.141	0.630	67.9	1023.4	1.84	15.16	49.80	26.06	99.5	41.9	87.3	628.0	882.5	2.98	0.590	0.330	9.50	0.770
343	45.59437	-122.65132	0.192	0.519	0.197	0.716	0.127	0.925	45.8	1026.8	2.18	33.04	113.90	44.22	108.2	31.8	28.8	415.9	396.0	2.17	0.640	1.125	5.46	0.535
344	45.54168	-122.51285	0.109	0.279	0.091	0.689	0.119	0.650	30.0	945.5	1.56	10.27	44.17	18.98	112.3	44.3	61.7	583.8	814.2	1.76	0.540	0.150	2.50	BD
345	45.50882	-122.56902	0.128	0.330	0.140	0.737	0.135	1.120	48.9	2146.2	4.86	21.24	90.42	15.43	118.9	61.3	82.1	1026.9	662.9	3.37	1.175	0.290	9.07	0.390
346	45.47240	-122.62679	0.239	0.555	0.161	0.520	0.118	1.120	42.3	1411.2	9.13	13.37	212.28	10.81	101.3	29.7	29.3	711.7	402.8	3.46	0.940	0.315	6.63	0.240

[a] Latitude and longitude of shifted locations. See the "Mapping" section in "Methods" for details.
[b] BD indicates concentration below detection limits.

```
GEOGCS[“WGS 84”,
    DATUM[“WGS_1984”,
        SPHEROID[“WGS 84”,6378137,298.257223563,
            AUTHORITY[“EPSG”,”7030”]],
        AUTHORITY[“EPSG”,”6326”]],
    PRIMEM[“Greenwich”,0,
        AUTHORITY[“EPSG”,”8901”]],
    UNIT[“degree”,0.01745329251994328,
        AUTHORITY[“EPSG”,”9122”]],
    AUTHORITY[“EPSG”,”4326”]
]
```

Figure 6—Global positioning system recorded sample coordinate system definition.

```
PROJCS[“NAD_1983_HARN_StatePlane_Oregon_North_FIPS_3601_Feet_Intl”,
    GEOGCS[“GCS_North_American_1983_HARN”,
        DATUM[“D_North_American_1983_HARN”,
            SPHEROID[“GRS_1980”,6378137.0,298.257222101]],
        PRIMEM[“Greenwich”,0.0],
        UNIT[“Degree”,0.0174532925199433]],
    PROJECTION[“Lambert_Conformal_Conic”],
    PARAMETER[“False_Easting”,8202099.737532808],
    PARAMETER[“False_Northing”,0.0],
    PARAMETER[“Central_Meridian”,-120.5],
    PARAMETER[“Standard_Parallel_1”,44.33333333333333],
    PARAMETER[“Standard_Parallel_2”,46.0],
    PARAMETER[“Latitude_Of_Origin”,43.66666666666666],
    UNIT[“Foot”,0.3048]
]
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Figure 7—Definition of sample coordinate system used in mapping.

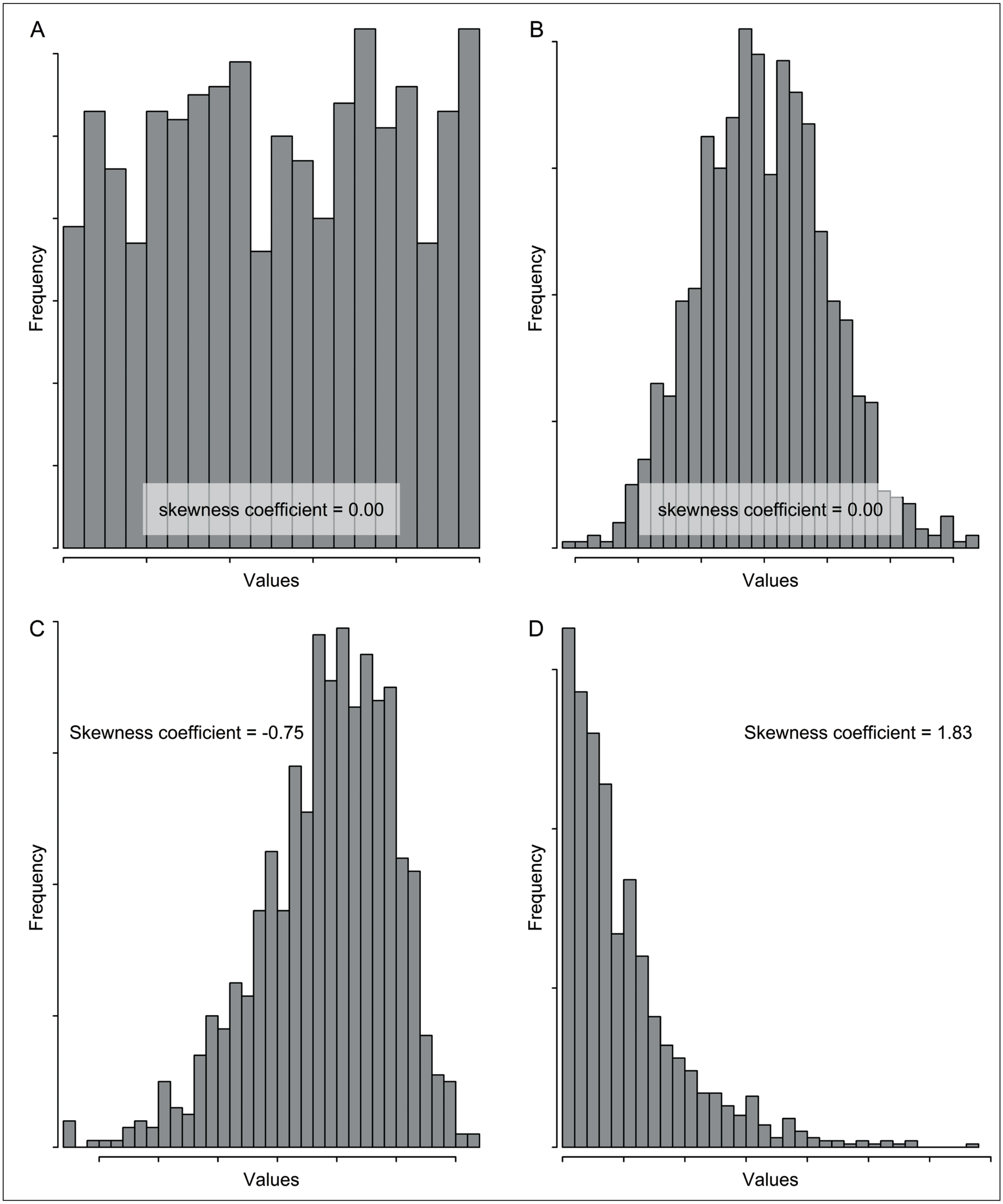

Figure 8—Skewness coefficients for a set of sample distributions: A and B are symmetric, C skewed to the left, and D skewed strongly to the right.

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