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Element concentrations in rehabilitation species from thirteen coal-stripmines in five western states and Alaska

By

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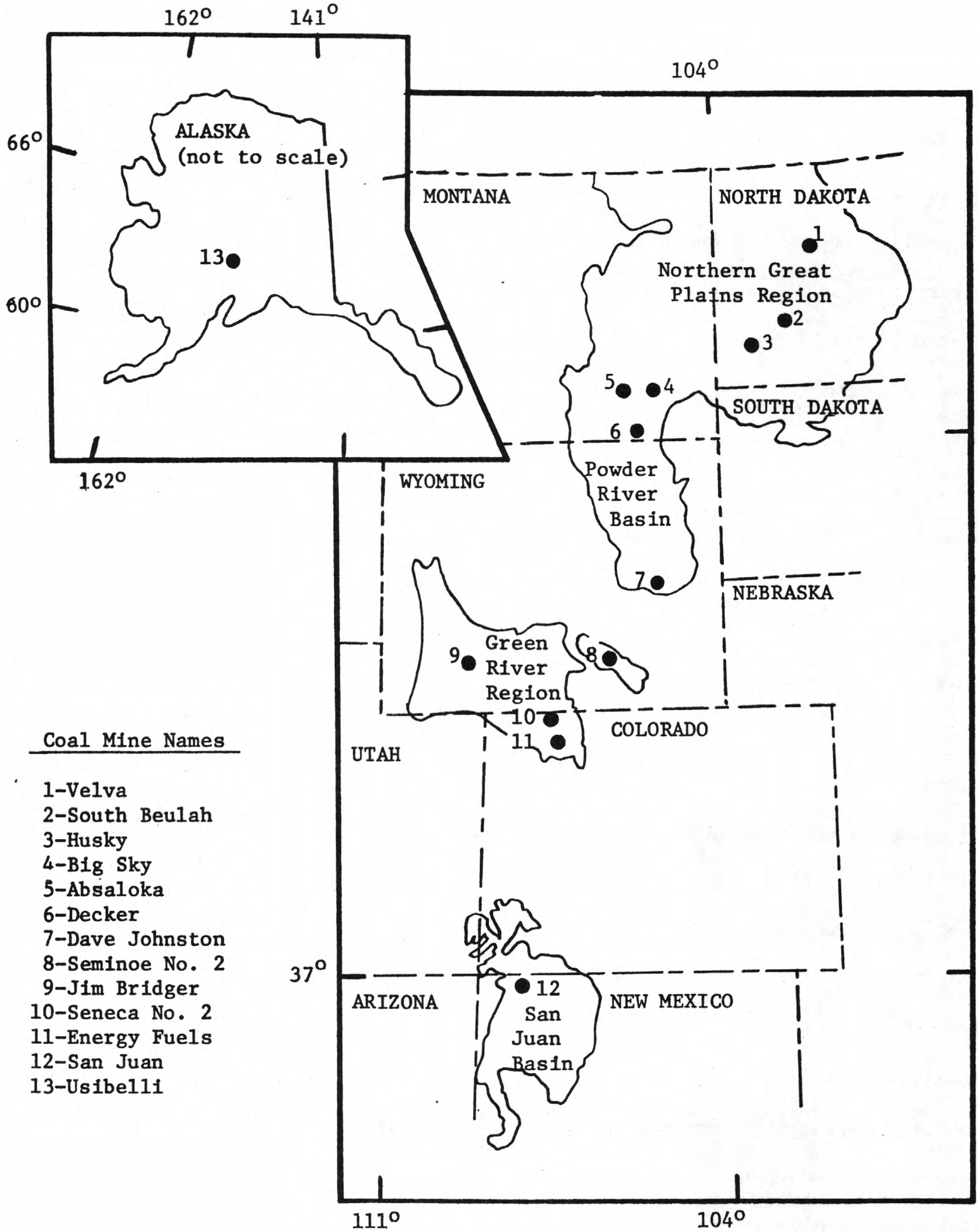
INTRODUCTION

The effects of the burning of coal on the mobilization and concentration in the environment of many of the potentially toxic trace elements has been extensively studied over the past 5 years. A question that has not been adequately investigated, however, is the effect that the surface mining of coal may have on the mobilization of elements in spoils and replaced topsoil and their absorption by rehabilitation species. In areas where overburden contains higher than normal levels of potentially toxic elements, it can be assumed that rehabilitation species will, in general, concentrate many elements in their tissues (Wallace and Berry, 1979). Whether or not such levels will prove to be toxic (either through frank intoxication or the production of subtle, chronic chemical imbalances, Erdman, 1978) needs to be examined.

This study was prompted by the preliminary results of earlier work by Erdman and Ebens (1975) who sampled sweetclover and associated spoils at eight coal-stripmines in the northern Great Plains. They found that the element content of sweetclover differed among mines and, in a strong way, represented the local (or mine-area) environment. Except for their report, there has not been any work that has examined the variability in the element content of rehabilitation species among mines over a broad geographic region. This kind of background information is critical to the formulation of regulations that set maximum allowable element concentrations in rehabilitation materials.

Our main objective was to obtain element-concentration data of commonly used species from a number of western coal-mine rehabilitated areas and to assess whether or not altered substrate chemistry was reflected in these species. Secondary objectives were: (1) to assess the variability in the concentration of elements in similar rehabilitation species among mines; and (2) to assess the variability in the element concentration of rehabilitation species within a mine. Because of the possible mobilization of environmentally important and potentially toxic elements by surface-mining methods, a knowledge of the chemistry of rehabilitation species is a useful estimate of soil or spoil element availability.

The mines studied were: Dave Johnston, Seminoe No. 2, and Jim Bridger (Wyoming); Seneca No. 2 and Energy Fuels (Colorado); South Beulah, Husky, and Velva (North Dakota); and Big Sky, Decker, and Absaloka (Sarpy Creek) (Montana) (fig. 1). All samples at these 11 mines were collected within a relatively short time by one individual, they received the same preparation, they were analyzed by one laboratory using consistent methods, and they were prepared and analyzed in a randomized sequence so that any systematic error in preparation and analysis would be converted to random error. Therefore, these data are useful for evaluating differences in the chemical composition of rehabilitation species among states (which are the basic regulatory units) and among mines, and should also indicate the amount of variability to be expected when small rehabilitated areas are sampled within a single mine. Similar information exists for the variability in the element content of native plants (Gough, Severson, and McNeal, 1979) and of cultivated wheat (Erdman and Gough,



Coal Mine Names

1-Velva
2-South Beulah
3-Husky
4-Big Sky
5-Absaloka
6-Decker
7-Dave Johnston
8-Seminoe No. 2
9-Jim Bridger
10-Seneca No. 2
11-Energy Fuels
12-San Juan
13-Usibelli

Figure 1. General locations of the coal strip mines sampled in this study.

1979) in the northern Great Plains.

In addition to the mines listed above, rehabilitation species were collected at the San Juan mine, New Mexico and at the Usibelli mine, Alaska (fig. 1). Even though these samples were collected by the same individual and prepared and analyzed by the same laboratory using the same methods as for the other 11 mines, continuity among all samples is lacking because they were collected with different objectives and at different seasons of the year. Therefore, comparisons of the chemistry of the plant materials at the San Juan mine, the Usibelli mine, and the 11 western mines should be made only with these qualifications in mind.

The selection and utilization of appropriate rehabilitation plant species at the various mine sites has not been standardized. Seed mixtures and their rates of application varied greatly from year to year and from mine to mine. This was true partly because inter-mine communication of ideas, successes, and failures usually was lacking (except among mines owned by the same company) and also because the laws governing rehabilitation are changing continually. This state of flux was of direct concern to us because we wanted to sample species that would most likely be used for some years in the future.

Increasing legislative pressure is causing the mines to utilize more and more of the so-called native species in their seed mixtures. Native is usually arbitrarily defined as anything that was not introduced from foreign sources with the expansion of the railroads and the cattle industry. Commonly used native species of semiarid regions include: bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith), slender wheatgrass (*A. trachycaulum* (Link) Malte), thickspike wheatgrass (*A. dasystachyum* (Hook.) Scribn.), green needlegrass (*Stipa viridula* Trin.) blue grama (*Bouteloua gracilis* (H.B.K.) Lag.), prairie sandreed (*Calamovilfa longifolia* (Hook.)

Scribn.), and skunkbush (Rhus trilobata Nutt.). Many introduced species have qualities that lend themselves well to use in reclamation, however, and a total elimination of them is probably not practical. Examples of some of the introduced species still in use include: alfalfa (Medicago sativa L.), sweetclover (Melilotus alba Desr. and M. officinalis (L.) Lam.), smooth brome (Bromus inermis Leys.), sandfain (Onobrychis viciaefolia Scop.), pubescent wheatgrass (Agropyron trichophorum (Link) Richt.), crested wheatgrass (A. cristatum (L.) Gaertn. or A. desertorum Fisch.) Schult), and intermediate wheatgrass (A. intermedium (Host) Beauv.).

The composition of the seeding mixture and the ability to pick and choose from many different rehabilitation species are luxuries enjoyed by mine managers only in the less arid areas. Thus, in general, the mines in North Dakota, Montana, and Colorado have rehabilitated sites that are relatively diverse in the species found. Mines in the arid areas of Wyoming and New Mexico, however, usually rely on the establishment of only a few species.

Both fall and spring planting schedules are being used by the various mines visited, and the different reseeding methods include broadcasting, hydroseeding, and drilling. The use of fertilizers and mulches also varies; however, mulch is rather universally used in the drier areas. Mines in the less arid areas commonly include an annual cereal grain in the seed mixture to serve as initial cover--in the more arid areas the rapid natural invasion of halogeton (Halogeton glomeratus Meyer) performs the same function. Halogeton, however, is highly undesireable because it is toxic to grazing sheep and once established it is hard to eradicate.

Comparisons of the element composition of plant species found on rehabilitation sites to those same species on native sites have revealed differences (Erdman and Ebens, 1975 and 1979; Munshower and others, 1979;

Erdman and Gough, 1979; and Gough and Severson, 1980). Where ever possible, therefore, we also collected 'control' samples from adjacent non-mine areas. Table 1 lists those mines and species for which control collections were made.

ACKNOWLEDGMENTS

The following persons were most cooperative either in granting us permission to collect samples of plant, soil, and spoil materials or in spending time in the field showing and explaining their rehabilitation efforts: D. Elberg and D. Bennick (Husky mine, Husky Industries, Inc.); G. Bierei, G. Herold, and T. Forney (Seminoe No. 2 mine, Arch Minerals Corp.); H. P. Meuret (Jim Bridger mine, Northern Energy Resources Co.); D. G. Deveraux, G. Peters, and J. R. Phillips (Dave Johnston mine, Northern Energy Resources Co.); A. F. Grandt and R. Karo (Seneca No. 2 mine, Peabody Coal Co.); W. L. Noud and K. A. Crofts (Energy Fuels mine, Energy Fuels Corp.); C. L. Blohm and D. Morman (South Beulah mine, Knife River Coal Mining Co.); G. M. L. Robinson and R. Hoff (Big Sky mine, Peabody Coal Co.); E. G. Robbins and D. Layton (Decker Coal mine, Peter Kiewit Sons' Co.); D. W. Simpson and W. Sullivan (Absaloka mine, Westmoreland Resources Inc.); R. W. Allen (San Juan mine, Western Coal Co.); C. P. Boddy (Usibelli mine, Usibelli Coal Mine Inc.); and Stan Weston (Usibelli mine, Weston Agricultural Consultants Limited). Line drawings by J. M. Bowles. Preparation and analyses of all samples were done in the U.S. Geological Survey Laboratories in Denver by T. F. Harms, R. Hope, K. King, J. G. McDade, C. S. E. Papp, K. C. Stewart, and M. L. Tuttle.

METHODS

Field

Major Mine Comparison Study. -- This study was designed to evaluate differences in: (1) the variability in the element composition of species among 11 mines; (2) the element composition of species within mines; and (3) the relations between plant element concentrations and extractable element concentrations in minesoils. Results of the last objective will be discussed separately. Of interest (but not part of the design) was a comparison of the composition of like species on both mine and non-mine (control) sites.

Based on the tabular information provided by Evans, Uhleman, and Eby (1978) for surface-mined lands, we selected a set of mines in Colorado, North Dakota, Montana, and Wyoming, that they judged as having successful rehabilitation according to current regulations. From these mines we selected three per state according to the following additional criteria: (1) the area had been rehabilitated in the past 3 to 5 years, (2) topsoil had been used in the rehabilitation process, and (3) a wheatgrass and a legume had been included in the seeding mixture. By limiting our sampling using these criteria we provided a basis for making comparisons among rehabilitated areas.

In practice, it was not possible to locate rehabilitated areas within the targeted mines that met all three criteria mentioned above. Mine-site differences required that we use some flexibility in the selection of suitable plant materials to be sampled. For example, we were unable to sample a legume at the Dave Johnston mine so we sampled instead two grasses; and, at the Jim Bridger mine, neither a grass nor a legume was available so we sampled the woody shrub fourwing saltbrush. At most mines, however, a non-rhyzomatous wheatgrass and either alfalfa or sandfain were collected (the latter are both legumes).

At each mine, the rehabilitation specialist was most cooperative in helping select a suitable site of about 5 to 10 hectares. Once a site had been selected, plants and soils were collected as follows: A random traverse across the site was made and at ten localities topsoil, spoil, and plant samples were collected. The actual sampling localities were dictated by the presence of acceptable plant material.

Table 1 lists the plant parts included in each sample and Figures 2 and 3 diagram the collection method. The grass samples were composed of the culms, leaves, and inflorescences clipped at about 10 cm above the ground. The collections consisted of one or two clonal clumps (for the bunchgrasses); however, the smooth brome collections were of numerous individuals (which may or may not have been clonal). The alfalfa collections consisted of the stems, leaves, and fruits from one or two individual plants. At the Husky and Big Sky mines, the occurrence of frost had hastened leaf-drop and the alfalfa samples consisted mostly of stems and fruits. Frost had also caused leaf-drop for sandfain collected at the Absaloka mine, and these collections consisted of dormant stem and fruit tissue from two plants (with bunch habits) per site. Fourwing saltbush samples consisted of all the leaf and woody stem material clipped at about 10 cm above the ground from one or two shrubs per site.

In addition, three samples of hard red winter wheat grain were obtained at the Big Sky and Dave Johnston mines. This material was not collected as part of the formal study, and therefore only concentrations of selected elements were obtained (Appendix table). The Big Sky material was from a rehabilitation area with 25-60 cm of replaced topsoil that was seeded in the fall of 1977. The Dave Johnston material was also planted in 1977 as a cover for an area whose topsoil (to a depth of about 15 cm) had been removed for placement over spoil elsewhere. The area with wheat, therefore, had not been

Table 1.--Specific collection notes for plant rehabilitation species collected at 11 western coal surface mines (major study) and two additional mines

[Stages of maturity are those defined in National Research Council, U.S., and Department of Agriculture, Canada (1971); c=culms, l=leaves, i=inflorescences, s=stems, and f=fruits; root penetration into spoil was subjectively classified as good, fair, or poor; control-site column refers to presence (+) or absence (-) of sampled material; n.a. in column means not applicable, (--) indicates no data]

Mine	State	Date collected	Plant name: Scientific	Plant name: Common	Number of sites/number of clumps or individuals per site [1]	Stage of maturity	Plant parts	Range in depth of topsoil (cm)	Degree of root penetration into spoil	Control site comparison material
Major Mine Comparison Study										
Dave Johnston	Wyoming	9/8-9/78	Bromus inermis	smooth brome	10/15	mature	c,l,i	0-30	good	-
			Agropyron cristatum	crested wheatgrass[2]	10/1	do.	do.	do.	do.	+
Seminoe No. 2		9/11/78	do.	do.	10/2	overripe	do.	none	good	-
Jim Bridger		9/12-13/78	Atriplex canescens	fourwing saltbush	10/1	n.a.	s,l	10-25	do.	-
Seneca No. 2	Colorado	9/14/78	Agropyron intermedium	intermediate wheatgrass	10/2	mature	c,l,i	none	do.	-
			Medicago sativa	alfalfa	10/1	dough	s,l,f	do.	do.	-
Energy Fuels		9/15-16/78	Agropyron intermedium	intermediate wheatgrass	do.	mature-overripe	c,l,i	20-40	poor	-
			Medicago sativa	alfalfa	do.	dough-mature	s,l,f	do.	fair	-
South Beulah	North Dakota	9/25/78	Agropyron intermedium	intermediate wheatgrass	10/2	overripe	c,l,i	10-20	good	-
			Medicago sativa	alfalfa	do.	mature	s,l,f	do.	do.	+
Velva		9/26/78	Agropyron intermedium	intermediate wheatgrass	do.	overripe	c,l,i	5-25	good	-
			Medicago sativa	alfalfa	do.	mature	s,l,f	do.	do.	+
Husky		9/27/78	Agropyron intermedium	intermediate wheatgrass	do.	mature-overripe	c,l,i	15-50	fair	-
			Medicago sativa	alfalfa	do.	overripe-dormant	s,f	do.	good	+
Big Sky	Montana	10/9/78	Agropyron trachycaulum	slender wheatgrass	10/1	mature-overripe	c,l,i	10-30	good	-
			Medicago sativa	alfalfa	10/2	overripe	s,f	do.	good	+
Decker West		10/10/78	Agropyron trachycaulum	slender wheatgrass	10/1	mature-overripe	c,l,i	>90	--	-
			Atriplex canescens	fourwing saltbush	10/2	n.a.	s,l	do.	--	-
Absaloka		10/12/78	Agropyron trachycaulum	slender wheatgrass	10/1	mature	c,l,i	25-40	good	-
			Onobrychis viciaefolia	sandfain	10/2	dormant	s,f	do.	good	-
Additional Mines										
San Juan	New Mexico	8/11/77	Sporobolus airoides	alkali sacaton	6/4	mature	c,l,i	~20	good	-
			Atriplex canescens	fourwing saltbush	6/1	n.a.	s,l	do.	good	+
Usibelli	Alaska	6/7/79	Alnus crispa	American green alder	3/5	n.a.	do.	none	good	+
			Salix pulchra	diamondleaf willow	3/3	n.a.	do.	none	good	+

[1] A clump is defined as a tight clone of numerous individuals (characteristic of bunchgrasses), whereas individuals are isolated grasses (as in smooth brome which may or may not be clonal), forbs, or shrubs.

FIGURE 2. The method used in the sampling of soils, wheatgrasses and smooth brome at various coal-surface mine rehabilitation sites. The grass samples were composed of the culms (stems), leaves, and inflorescences clipped from one or two clonal clumps at about 10 cm above the ground. Topsoil samples were composed of the material (topsoil where present, present, spoil, or a combination of both) that adhered to the root mat. Spoil samples consisted of the material collected between 20 and 30 cm directly below where the plant clump and topsoil had been removed.

FIGURE 3. The method used in the sampling of soils and shrubs or shrubby forbs at various coal-surface mine rehabilitation sites. Samples of alfalfa, sandfain, and fourwing saltbush consisted of all the material, from one or two individual plants, clipped at 10 cm above the ground. Topsoil samples were composed of the material (topsoil where present, spoil, or a combustion of both), to a depth of 10 cm, that was located within 20 cm of the plant sampled. Spoil samples consisted of the material collected between 20 and 30 cm directly below where the topsoil sample was taken.

FIGUIRE 4. The method used in the sampling of soil, willow, and alder at the Usibelli Mine, Alaska. The terminal 10-20 cm of willow and alder branches with leaves and inflorescences were collected at both native and rehabilitated sites. Topsoil samples were collected at a depth of 15-20 cm on the native sites (below a mat of organic material), and, because the rehabilitated sites were without replaced topsoil, consisted of surficial material to a depth of 15-20 cm.

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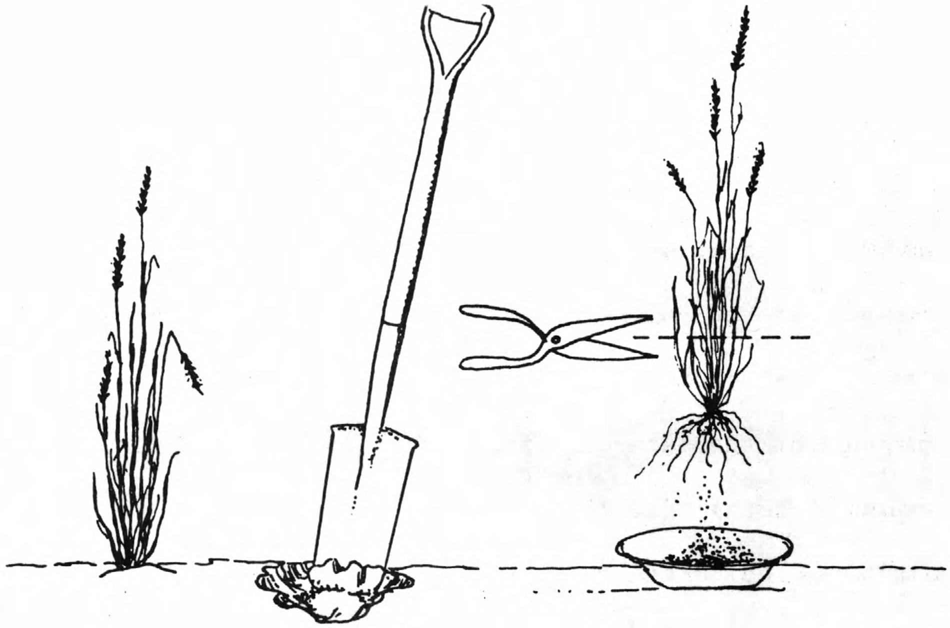

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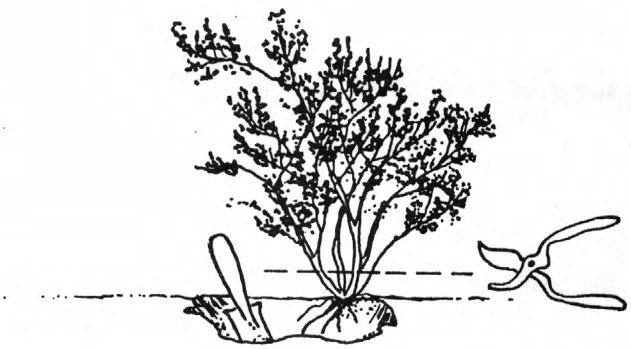

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mined of coal.

Additional Mines. -- Table 1 lists the collection details for plant material from the San Juan and Usibelli mines (New Mexico and Alaska, respectively). These two mines were sampled at different times and were not part of the major mine comparison study. Results of the element content of plants collected at the San Juan mine are given in Gough and Severson (1980a and 1980b).

Alkali sacaton and fourwing saltbush were sampled in the same manner as was described for the wheatgrasses and fourwing saltbush in the major mine comparison study. For alder and willow at the Usibelli mine, the terminal 15-20 cm of stems, with leaves and inflorescences were clipped as shown in Figure 4. Representative material from all species collected is housed, as voucher specimens, in the U.S. Geological Survey Herbarium in Denver, Colorado.

Laboratory

The sample preparation of the plant material from all 13 mines was the same. The samples were dried in a forced-air oven at 35°C, ground in a Wiley mill [1] to pass a 1.3-mm screen, and the homogenized ground material was either ashed by dry ignition at 500°C for 24 hours or by wet digestion (Harms, 1976). Because of excessive soil and dust contamination, samples of alfalfa, alkali sacaton, the wheatgrasses, and smooth brome, were washed prior to being dried and ground. (Samples of alder, fourwing saltbush, sandfain, and willow were not excessively contaminated and were not washed.) This process consisted of numerous tap-water rinses (until the rinse water was free of visible suspended and settled material) followed by a single distilled-water rinse. Ten percent of the samples from the major mine comparison study were

[1]Use of trade names in this report is for the convenience of the reader and does not constitute endorsement by the U.S. Geological Survey.

selected at random for splitting of the ground material and the analytical sequence of the entire suite of samples (plus splits), was randomized. Table 2 details the analytical method used for the determination of the concentration of each element in plant material. Samples from the San Juan and Usibelli mines were analyzed at a time different from the material from the 11 mines but the analytical methods were the same for all samples from all mines.

Statistical

For those elements analyzed in ash, the dry-weight-equivalent concentrations were calculated. This conversion was done because of the interest in dry-weight data by agronomists and others involved with reclamation studies.

Plant-element concentrations tend to exhibit positively skewed frequency distributions. Therefore, a logarithmic transformation of the data prior to statistical analysis improves the estimates of central tendency because the frequency distribution of the log-transformed data is more nearly normal. Some elements were approximately normally distributed; however, statistical tests for these elements, using both the transformed and original data, were similar. In order to simplify the discussion, therefore, all statistical results are based on log-transformed data.

The analysis of element concentrations usually found in trace amounts may result in values at or less than the lower limit of determination (LLD) of the method used. Elements with more than one-third of their values below the LLD were not included in the statistical tests. Elements with fewer than one-third LLD values were handled differently, depending on the statistical test as follows: (1) Because completely numeric data sets are required for the multiple-mean comparison test (Natrella, 1966), and for the calculation of

Table 2.--Analytical methods and their approximate lower limits of determination for the plant materials sampled

[All values are reported on an ash-weight basis, except where noted; LLD, lower limit of determination; ES, plate-reader emission spectrography; AA, flame atomic-absorption spectroscopy; SIE, selective ion electrode; FL-AA, flameless atomic-absorption spectroscopy; COLR, colorimetric; FLUR, fluorometric; TURB, turbidimetric]

Element	Analytical method	Approximate LLD (ppm)	Element	Analytical method	Approximate LLD (ppm)
Aluminum---	ES	200	Molybdenum------	ES	2
Arsenic[1]---	AA	.05	Nickel----------	ES	2
Barium-----	ES	4.4	Niobium---------	ES	9.2
Beryllium--	ES	2	Phosphorus------	COLR	100
Boron------	ES	10	Potassium-------	AA	100
Cadmium----	AA	.4	Selenium[1]-------	FLUR	.01
Calcium----	AA	100	Silver----------	ES	.92
Cerium-----	ES	93	Sodium----------	AA	25
Chromium---	AA	1	Strontium-------	ES	1
Cobalt-----	AA	1	Strontium-------	ES	[2]4,000
Copper-----	AA	1	Sulfur (total)[1]-	TURB	100
Fluorine[1]--	SIE	1	Titanium--------	ES	90
Germanium--	ES	2	Uranium---------	FLUR	.4
Iron-------	ES	200	Vanadium--------	ES	2
Lanthanum--	ES	9.2	Yttrium---------	ES	2
Lead-------	ES	4.4	Zinc------------	AA	1
Lithium----	AA	4	Zirconium-------	ES	4.4
Magnesium--	AA	20			
Manganese--	ES	2			
Mercury[1]---	FL-AA	.01			

[1]Analyses determined on dry material not ash.

[2]Upper limit of determination.

confidence intervals about the mean, a substitution of 0.7 times the LLD (ash-weight basis) was made for all censored values. The sequence of calculations was: (a) substitution of censored values; (b) dry-weight conversion of those element concentrations reported on an ash-weight basis; (c) log transformation; and (d) statistical tests. (2) The estimation of the geometric mean (GM) and geometric deviation (GD), for those elements with censored values, was performed using the technique of Cohen (1959) as detailed by Miesch (1967). This technique, however, requires a single LLD per element and the dry-weight conversion calculation often results in variable LLD values (due to differences in the ash yield of individual samples). Following dry-weight conversion, therefore, if variable LLD values were generated, a substitution was made that replaced the variable LLD values with a single LLD value equal to an average of the variable LLD values. The sequence of calculations was: (a) dry-weight conversion of those elements reported on an ash-weight basis; (b) calculation of an average LLD for those elements with censoring; (c) substitution of the variable LLD values (per element) with the average LLD value; (d) log-transformation; (e) calculation of the GM and GD. The analysis of the data was performed on a computer using the U.S. Geological Survey's STATPAC library (VanTrump and Miesch, 1977).

RESULTS AND DISCUSSION

Figure 1 shows the location of the thirteen coal-stripmines studied. Table 1 details the characteristics of the mine sites visited with emphasis on the rehabilitation species sampled. Additional mine-site details (time since rehabilitation was initiated, rehabilitation scheme, topsoil and spoil characteristics, unique features of the area studied, and type of mining operations) are reported in Severson and Gough (1981) and will not be repeated here.

The data that follow are discussed and summarized in four basic ways: (1) A listing, with no statistical interpretation, of the element-concentration data for each sample of rehabilitation plant material is given by mine and by state in the Appendix. (2) Several different species of wheatgrass were collected; figure 5 diagrams the geometric mean and confidence interval about the mean for the concentration of eighteen elements and plant-ash yield at the ten mines where they were sampled. (3) Tables 3-7 compare the geometric means of element concentrations in similar plant material collected at different mines. (4) Tables 9-28 give the summary statistics, by individual mines, for the concentration of elements in particular rehabilitation species.

Mine- and Control-Site Comparisons--Appendix

The element concentration data for each sample at the individual mines are given in the Appendix table. No summarization or statistical interpretation is presented. Concentrations of arsenic, fluorine, mercury, selenium, and total sulfur were reported by the analyst on a dry-weight basis and are listed as received. Concentrations of all other elements were reported by the analyst on an ash-weight basis; however, in the Appendix table we list the dry-weight converted values. As discussed under the Statistical

Table 3.--Multiple-mean comparison test for concentrations of 34 elements (and ash) in dry material of crested wheatgrass collected at two surface-coal mines in Wyoming.

[Mean values followed by the same small letter are not significantly different at the 0.05 probability level; ppm, parts per million; %, percent; leaders (---) mean no date]

Element or ash	Dave Johnston		Seminoe Number 2	
Ash, %-----	4.9	a	5.1	a
Al, ppm----	410	a	500	a
As, ppm----	.46	a	.37	a
B, ppm-----	14	a	6.8	b
Ba, ppm----	5.1	a	5.8	a
Be, ppm----	.11	a	.10	a
Ca, %------	.19	b	.27	a
Cd, ppm----	.052	a	.027	b
Co, ppm----	.062	a	.066	a
Cr, ppm----	.41	a	.45	a
Cu, ppm----	1.3	b	3.4	a
F, ppm-----	6.5	b	8.0	a
Fe, ppm----	120	b	180	a
Ge, ppm----	.10	a	.11	a
Hg, ppm----	.019	a	.017	a
K, %-------	.64	b	1.1	a
La, ppm----	---		1.8	
Li, ppm----	.71	a	.47	a
Mg, %------	.073	a	.088	a
Mn, ppm----	19	a	22	a
Mo,ppm-----	.22	a	.23	a
Na, ppm----	26	b	34	a
Nb, ppm----	.42		---	
Ni, ppm----	.19	b	.24	a
P, %-------	.063	a	.064	a
Pb, ppm----	.86	a	.71	a
S, ppm-----	1,000	b	1,200	a
Se, ppm----	.21	a	.054	b
Sr, ppm----	7.2	a	6.6	a
Ti, ppm----	9.7	a	9.0	a
U, ppm-----	.056	a	.057	a
V, ppm-----	.55	a	.60	a
Y, ppm-----	.28	a	.26	a
Zn, ppm----	15	a	9.5	b
Zr, ppm----	.78	a	.70	a

Table 4.--Mulitple-mean comparison test for concentrations of 34 elements (and ash) in the dry material of intermediate wheatgrass collected at five surface-coal mines in Colorado and North Dakota.

[Mean values followed by the same small letter are not significantly different at the 0.05 probability level; ppm, parts per million; %, percent; leaders (---) mean no data]

Element or ash	Colorado: Energy Fuels	Colorado: Seneca Number 2	North Dakota: Husky	North Dakota: South Beulah	North Dakota: Velva
Ash, %----	5.6 c	6.8 b	4.6 c	5.4 c	7.5 a
Al, ppm---	360 bc	270 c	660 a	480 b	130 d
As, ppm---	.16 c	.33 b	.38 b	.66 a	.21 c
B, ppm----	6.4 c	5.1 c	13 a	7.7 bc	9.2 b
Ba, ppm---	9.0 c	6.7 d	38 a	15 b	11 bc
Be, ppm---	.13 b	.15 b	.18 b	.13 b	.25 a
Ca, %-----	.19 a	.18 a	.20 a	.18 a	.18 a
Cd, ppm---	.060 a	.036 b	.039 b	.030 b	.039 b
Co, ppm---	.048 b	.051 ab	.059 ab	.076 a	---
Cr, ppm---	.55 b	.47 b	.70 a	.49 b	.30 c
Cu, ppm---	1.0 b	1.1 b	1.1 b	1.0 b	1.5 a
F, ppm----	6.2 b	7.5 a	5.7 b	6.3 b	4.8 c
Fe, ppm---	150 c	100 d	280 a	200 b	54 e
Ge, ppm---	.14 b	.13 b	.11 b	.12 b	.18 a
Hg, ppm---	.013 b	.010 b	.019 a	.013 b	.016 a
K, %------	.56 b	1.2 a	.33 c	.21 d	.22 d
La, ppm---	---	---	.66 b	1.4 a	1.1 a
Li, ppm---	.30 a	.27 ab	.21 b	---	---
Mg, %-----	.073 b	.10 a	.072 b	.055 c	.044 d
Mn, ppm---	19 b	16 b	39 a	30 a	44 a
Mo, ppm---	.25 a	.36 a	.31 a	.27 a	.36 a
Na, ppm---	23 c	40 b	59 a	30 c	24 c
Nb, ppm---	.52 a	---	.65 a	---	.63 a
Ni, ppm---	.24 ab	.14 b	.36 a	.25 a	.13 b
P, %------	.064 a	.051 b	.023 d	.039 c	.045 bc
Pb, ppm---	.76 c	.84 bc	1.2 ab	1.0 b	1.5 a
S, ppm----	810 a	890 a	620 b	440 c	440 c
Se, ppm---	.17 a	.19 a	.054 c	.088 b	.098 b
Sr, ppm---	6.9 d	5.0 e	19 a	15 b	10 c
Ti, ppm---	7.4 b	6.4 b	16 a	9.2 b	---
U, ppm----	.022 d	.030 c	.038 bc	.047 ab	.058 a
V, ppm----	.37 bc	.25 c	.76 a	.43 b	.21 c
Y, ppm----	.24 c	.21 c	.46 a	.30 b	.22 c
Zn, ppm---	10 c	11 bc	9.6 c	12 b	15 a
Zr, ppm---	.70 b	.63 b	1.2 a	.76 b	.64 b

Table 5.--Multiple-mean comparison test for concentrations of 34 elements (and ash) in the dry material of slender wheatgrass collected at three surface-coal mines in Montana.

[Mean values followed by the same small letter are not significantly different at the 0.05 probability level; ppm, parts per million; %, percent; leaders (---) mean no data]

Element or ash	Absaloka		Big Sky		Decker	
Ash, %----	3.7	b	3.5	b	5.5	a
Al, ppm---	260	b	510	a	440	a
As, ppm---	.26	a	.29	a	.23	a
B, ppm----	5.5	b	14	a	3.6	c
Ba, ppm---	8.4	b	8.7	b	18	a
Be, ppm---	.075	c	.11	b	.17	a
Ca, %-----	.17	a	.19	a	.18	a
Cd, ppm---	.017	b	.027	a	.019	ab
Co, ppm---	.040	b	.057	a	.052	a
Cr, ppm---	.32	b	.48	a	.41	ab
Cu, ppm---	.78	b	1.1	a	.87	b
F, ppm----	5.1	b	6.6	a	5.6	b
Fe, ppm---	95	b	180	a	170	a
Ge, ppm---	.075	c	.10	b	.22	a
Hg, ppm---	.022	a	.021	a	.014	b
K, %------	.26	b	.36	a	.22	b
La, ppm---	.50	a	.56	a	.40	a
Li, ppm---	---		.21	b	.34	a
Mg, %-----	.055	b	.070	a	.079	a
Mn, ppm---	22	b	26	b	61	a
Mo, ppm---	.20	c	.60	a	.33	b
Na, ppm---	23	c	32	b	72	a
Nb, ppm---	---		.37	a	.43	a
Ni, ppm---	.14	b	.27	a	.32	a
P, %------	.021	b	.021	b	.027	a
Pb, ppm---	.72	b	1.1	b	.74	a
S, ppm----	490	a	470	ab	440	b
Se, ppm---	.025	c	.13	a	.057	b
Sr, ppm---	6.1	c	8.2	b	24	a
Ti, ppm---	5.0	b	9.9	a	7.9	ab
U, ppm----	.024	c	.050	b	.061	a
V, ppm----	.15	b	.43	a	.45	a
Y, ppm----	.16	b	.29	a	.27	a
Zn, ppm---	12	b	14	a	8.7	c
Zr, ppm---	.52	b	.81	a	.80	a

Table 6.--Multiple-mean comparison test for concentrations of 32 elements (and ash) in the dry material of alfalfa collected at six surface-coal mines in three western states

[Mean values followed by the same small letter are not significantly different at the 0.05 probability level; ppm, parts per million; %, percent; leaders (---) mean no data]

Element or ash	Colorado		Montana	North Dakota		
	Energy Fuels	Seneca Number 2	Big Sky	Husky	South Beulah	Velva
Ash, %----	9.0 a	6.8 b	5.2 c	4.8 c	6.4 b	6.7 b
Al, ppm---	560 a	440 b	660 a	460 b	540 a	150 c
As, ppm---	.31 c	.56 b	.31 c	.22 c	.95 a	.53 b
B, ppm----	54 ab	52 ab	48 b	27 c	48 b	66 a
Ba, ppm---	15 c	8.2 d	10 d	38 a	22 b	10 d
Ca, %-----	2.6 a	1.7 b	1.2 c	.94 d	1.6 b	1.6 b
Cd, ppm---	.12 b	.10 b	.040 d	.064 c	.20 a	.075 c
Co, ppm---	.084 bc	.061 c	.11 b	.081 bc	.28 a	---
Cr, ppm---	.56 a	.45 a	.55 a	.48 a	.56 a	.27 b
Cu, ppm---	5.6 b	5.3 b	7.6 ab	5.3 b	6.3 b	8.7 a
F, ppm----	6.6 a	6.6 a	7.2 a	6.3 a	6.3 a	5.0 b
Fe, ppm---	170 b	120 c	230 a	200 ab	240 a	75 d
Hg, ppm---	.015 b	.011 b	.022 a	.011 b	.018 a	.014 b
K, ppm---	.82 b	.70 b	.50 c	.80 b	.78 b	1.0 a
La, ppm---	1.8 a	1.2 ab	1.0 b	.75 b	.71 b	1.0 b
Li, ppm---	.76 c	.54 cd	.52 d	1.2 b	1.2 b	5.8 a
Mg, %-----	.38 b	.42 a	.47 a	.26 c	.30 bc	.25 c
Mn, ppm---	24 ab	17 b	28 ab	13 b	31 a	26 ab
Mo, ppm---	2.0 b	1.2 c	4.3 a	1.5 bc	1.6 bc	4.2 a
Na, ppm---	40 c	96 b	80 b	250 a	240 a	93 b
Nb, ppm---	.74 a	.49 b	.50 b	---	.58 b	.48 b
Ni, ppm---	.69 ab	.50 b	.82 ab	.52 b	1.0 a	.63 b
P, %------	.089 a	.067 b	.052 c	.060 bc	.060 bc	.088 a
Pb, ppm---	.97 a	.82 ab	.78 bc	.73 c	1.0 a	1.0 a
S, ppm----	2,600 a	1,700 b	1,300 c	1,200 bc	1,700 b	1,700 b
Se, ppm---	.39 a	.32 a	.10 b	.17 bc	.12 c	.37 a
Sr, ppm---	78 c	37 d	42 d	62 c	170 a	100 bc
Ti, ppm---	9.8 b	7.8 c	12 a	9.2 b	8.9 bc	---
U, ppm----	.029 b	.048 b	.048 b	.098 a	.041 b	.085 a
V, ppm----	.64 a	.34 ab	.49 ab	.41 ab	.51 ab	.18 b
Y, ppm----	.59 a	.35 b	.44 ab	.32 b	.37 b	.17 c
Zn, ppm---	18 bc	21 b	27 a	15 c	20 b	22 ab
Zr, ppm---	1.5 a	.97 b	1.4 a	.98 b	1.1 ab	.59 c

Table 7.--Multiple-mean comparison test for concentrations of 33 elements (and ash) in the dry material of fourwing saltbush collected at three surface-coal mines in three western states

[Mean values followed by the same small letter are not significantly different at the 0.05 probability level; ppm, parts per million; %, percent; n, number of samples collected; leaders (---) mean no data]

Element or ash	New Mexico San Juan (n=6)		Montana Decker (n=10)		Wyoming Jim Bridger (n=10)	
Ash, %----	13	a	9.9	b	10	b
Al, ppm---	1,200	a	440	b	460	b
As, ppm---	.24	a	.26	a	.24	a
B, ppm----	57	b	30	c	220	a
Ba, ppm---	26	a	8.1	b	4.4	c
Ca, %-----	1.0	a	.96	a	.94	a
Cd, ppm---	.17	a	.081	b	.099	b
Ce, ppm---	---		---		9.1	
Co, ppm---	.47	a	.27	b	.18	b
Cr, ppm---	2.1	a	.47	b	.49	b
Cu, ppm---	9.7	a	4.5	b	4.9	b
F, ppm----	20	a	7.6	b	8.2	b
Fe, ppm---	780	a	140	b	140	b
Hg, ppm---	.13	a	.009	b	.010	b
K, %------	2.6	b	3.1	a	2.8	ab
La, ppm---	1.1	a	1.5	a	1.5	a
Li, ppm---	1.7	a	1.8	a	.97	b
Mg, %-----	.72	a	.48	b	.82	a
Mn, ppm---	160	a	110	ab	68	b
Mo, ppm---	.73	a	.46	a	.72	a
Na, ppm---	7,400	a	420	c	2,600	b
Nb, ppm---	1.3		---		---	
Ni, ppm---	1.9	a	2.5	a	.79	b
P, %------	.084	b	.074	b	.11	a
Pb, ppm---	1.2	a	.90	b	1.0	ab
S, ppm----	4,500	a	3,600	b	3,500	b
Se, ppm---	.22	b	.32	b	.70	a
Sr, ppm---	48	b	88	a	21	c
Ti, ppm---	43	a	9.3	b	10	b
U, ppm----	.11	a	---		.038	b
V, ppm----	1.9	a	.30	b	.35	b
Y, ppm----	.81	a	.29	c	.43	b
Zn, ppm---	56	a	34	b	66	a
Zr, ppm---	5.1	a	.95	c	1.2	b

Table 8.--Silver concentrations (ash-weight basis) in alder and willow, Usibelli mine, Alaska

[ppm, parts per million; <, less than the analytical limit of determination; GM, geometric mean; ≈, approximately equal to]

Sample	Silver, ppm	
	American green alder, mine	
US1AS	<0.92	
US2AS	2.5	
US3AS	1.0	GM ≈ 1.2
	American green alder, control	
US1AN	3.6	
US2AN	2.1	
US3AN	3.2	GM = 2.9
	Diamondleaf willow, mine	
US1WS	< .92	
US2WS	1.5	
US3WS	1.4	GM ≈ 1.1
	Diamondleaf willow, control	
US1WN	.94	
US2WN	1.3	
US3WN	1.4	GM = 1.2

Table 9.--Summary statistics for the element content of dry material of smooth brome from the Dave Johnston mine, Wyoming

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	5.8	1.06	5.3-6.4
Aluminum (ppm)	10:10	290	1.86	160-960
Arsenic (ppm)	10:10	.46	1.82	.20-1.0
Barium (ppm)	9:10	[1]3.4	[1]1.90	<2.3-13
Beryllium (ppm)	5:10	[1].11	[1]2.01	<.12-.36
Boron (ppm)	10:10	24	1.47	14-36
Cadmium (ppm)	8:10	[1].038	[1]1.68	<.022-,064
Calcium (percent)	10:10	.23	1.21	.17-.34
Cerium (ppm)	0:10	--	--	<6.0- --
Chromium (ppm)	9:10	[1].30	[1]1.96	<.12-.96
Cobalt (ppm)	6:10	[1].054	[1]1.36	<.060-.11
Copper (ppm)	10:10	1.1	1.47	.53-2.4
Fluorine (ppm)	10:10	6.5	1.29	4-9
Germanium (ppm)	6:10	[1].12	[1]1.42	<.13-.23
Iron (ppm)	10:10	80	1.80	40-280
Lanthanum (ppm)	1:10	--	--	<.56-4.1
Lead (ppm)	10:10	.74	1.52	.50-1.9
Lithium (ppm)	10:10	1.8	2.25	.54-5.3
Magnesium (percent)	10:10	.082	1.32	.042-.11
Manganese (ppm)	10:10	59	1.68	29-170
Mercury (ppm)	10:10	.016	1.69	.01-.04
Molybdenum (ppm)	10:10	.24	1.75	.13-.72
Nickel (ppm)	3:10	--	--	<.12-.77
Niobium (ppm)	2:10	--	--	<.56-2.1
Phosphorus (percent)	10:10	.053	1.64	.030-.11
Potassium (percent)	10:10	.89	1.22	.60-1.2
Selenium (ppm)	10:10	.14	1.82	.06-.50
Sodium (ppm)	10:10	30	1.83	18-110
Strontium (ppm)	10:10	9.6	1.85	3.8-24
Sulfur (total)(ppm)	10:10	830	1.36	650-1,200
Titanium (ppm)	4:10	[1]4.2	[1]2.61	<5.6-21
Uranium (ppm)	10:10	.047	1.62	.022-.094
Vanadium (ppm)	8:10	[1].24	[1]3.24	<.11-1.8
Yttrium (ppm)	10:10	.24	1.71	.13-.77
Zinc (ppm)	10:10	8.6	1.45	4.8-17
Zirconium (ppm)	10:10	.67	1.81	.34-2.7

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 10.--Summary statistics for the element content of dry material of crested wheatgrass from the Dave Johnston mine, Wyoming

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	4.9	1.16	4.1-6.6
Aluminum (ppm)	10:10	410	2.26	110-1,200
Arsenic (ppm)	10:10	.46	1.41	.20-.65
Barium (ppm)	10:10	5.1	1.42	3.3-8.1
Beryllium (ppm)	8:10	[1].11	[1]1.37	<.13-.21
Boron (ppm)	10:10	14	1.48	8.1-24
Cadmium (ppm)	10:10	.052	1.74	.025-.13
Calcium (percent)	10:10	.19	1.30	.10-.29
Cerium (ppm)	0:10	--	--	<6.1- --
Chromium (ppm)	10:10	.41	1.74	.16-.86
Cobalt (ppm)	7:10	[1].062	[1]1.74	<.049-.13
Copper (ppm)	10:10	1.3	1.35	.88-2.2
Fluorine (ppm)	10:10	6.5	1.28	5-9
Germanium (ppm)	7:10	[1].10	[1]1.46	<.11-.20
Iron (ppm)	10:10	120	2.03	34-350
Lanthanum (ppm)	2:10	--	--	<.61-.60
Lead (ppm)	10:10	.86	1.49	.54-1.5
Lithium (ppm)	10:10	.71	1.84	.29-2.2
Magnesium (percent)	10:10	.066	1.37	.045-.13
Manganese (ppm)	10:10	19	2.16	7.0-79
Mercury (ppm)	10:10	.019	1.64	.01-.04
Molybdenum (ppm)	10:10	.22	1.79	.13-.88
Nickel (ppm)	8:10	[1].19	[1]2.38	<.10-.72
Niobium (ppm)	4:10	[1].42	[1]1.47	<.61-.92
Phosphorus (percent)	10:10	.063	1.40	.034-.086
Potassium (percent)	10:10	.64	1.31	.44-1.0
Selenium (ppm)	10:10	.21	1.78	.10-.45
Sodium (ppm)	10:10	26	1.29	16-35
Strontium (ppm)	10:10	7.2	1.66	4.1-18
Sulfur (total)(ppm)	10:10	1,000	1.16	850-1,400
Titanium (ppm)	8:10	[1]9.7	[1]1.88	<4.6-23
Uranium (ppm)	10:10	.056	1.88	.017-.16
Vanadium (ppm)	10:10	.55	2.52	.090-1.6
Yttrium (ppm)	10:10	.28	1.70	.11-.60
Zinc (ppm)	10:10	15	1.50	9.2-26
Zirconium (ppm)	10:10	.78	1.65	.39-1.6

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 11.--Summary statistics for the element content of dry material of crested wheatgrass from the Seminoe Number 2 mine, Wyoming

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	5.1	1.08	4.6-6.3
Aluminum (ppm)	10:10	500	1.41	280-740
Arsenic (ppm)	10:10	.37	1.67	.15-.70
Barium (ppm)	10:10	5.8	1.59	2.9-12
Beryllium (ppm)	6:10	[1].10	[1]1.46	<.11-.23
Boron (ppm)	10:10	6.8	1.44	3.1-10
Cadmium (ppm)	6:10	[1].027	[1]2.01	<.021-.083
Calcium (percent)	10:10	.27	1.13	.22-.33
Cerium (ppm)	1:10	--	--	<5.9-5.0
Chromium (ppm)	9:10	[1].45	[1]1.90	<.10-.88
Cobalt (ppm)	9:10	[1].066	[1]1.52	<.046-.11
Copper (ppm)	10:10	3.4	1.35	1.5-3.8
Fluorine (ppm)	10:10	8.0	1.36	5-14
Germanium (ppm)	8:10	[1].11	[1]1.37	<.11-.21
Iron (ppm)	10:10	180	1.26	140-260
Lanthanum (ppm)	5:10	[1]1.8	[1]1.67	<.49-1.5
Lead (ppm)	10:10	.71	1.24	.58-1.2
Lithium (ppm)	10:10	.47	2.16	.21-1.5
Magnesium (percent)	10:10	.088	1.20	.068-.11
Manganese (ppm)	10:10	22	1.60	12-63
Mercury (ppm)	10:10	.017	1.66	.01-.04
Molybdenum (ppm)	10:10	.23	1.35	.15-.40
Nickel (ppm)	10:10	.24	1.43	.15-.50
Niobium (ppm)	3:10	--	--	<.49-.82
Phosphorus (percent)	10:10	.064	1.16	.048-.080
Potassium (percent)	10:10	1.1	1.14	.95-1.4
Selenium (ppm)	10:10	.054	1.45	.04-.10
Sodium (ppm)	10:10	34	1.22	25-45
Strontium (ppm)	10:10	6.6	1.60	4.0-22
Sulfur (total)(ppm)	10:10	1,200	1.18	900-1,500
Titanium (ppm)	10:10	9.0	1.40	5.4-15
Uranium (ppm)	10:10	.057	1.21	.039-.076
Vanadium (ppm)	10:10	.60	1.47	.34-1.2
Yttrium (ppm)	10:10	.26	1.47	.15-.48
Zinc (ppm)	10:10	9.5	1.14	7.8-11
Zirconium (ppm)	10:10	.60	1.38	.36-.95

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 12.--Summary statistics for the element content of dry material of intermediate wheatgrass from the Energy Fuels mine, Colorado

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	5.6	1.13	4.7-7.1
Aluminum (ppm)	10:10	360	1.66	160-640
Arsenic (ppm)	10:10	.16	1.72	.10-.40
Barium (ppm)	10:10	9.0	1.56	4.5-18
Beryllium (ppm)	6:10	[1].13	[1]1.70	<.14-.35
Boron (ppm)	10:10	6.4	1.92	1.6-18
Cadmium (ppm)	9:10	[1].060	[1]2.56	<.019-.39
Calcium (percent)	10:10	.19	1.17	.15-.26
Cerium (ppm)	0:10	--	--	<6.6- --
Chromium (ppm)	10:10	.55	1.42	.33-1.0
Cobalt (ppm)	4:10	[1].048	[1]1.43	<.071-.11
Copper (ppm)	10:10	1.0	1.16	.76-1.3
Fluorine (ppm)	10:10	6.2	1.13	6-8
Germanium (ppm)	7:10	[1].14	[1]1.70	<.13-.32
Iron (ppm)	10:10	150	1.51	91-260
Lanthanum (ppm)	2:10	--	--	<.66-1.6
Lead (ppm)	10:10	.76	1.48	.43-1.6
Lithium (ppm)	8:10	[1].30	[1]1.73	<.26-.68
Magnesium (percent)	10:10	.073	1.28	.047-.11
Manganese (ppm)	10:10	19	2.14	7.0-55
Mercury (ppm)	9:10	[1].013	[1]1.59	<.01-.03
Molybdenum (ppm)	10:10	.25	2.10	.12-1.7
Nickel (ppm)	9:10	[1].24	[1]1.97	<.10-.64
Niobium (ppm)	5:10	[1].52	[1]1.55	<.66-1.1
Phosphorus (percent)	10:10	.064	1.38	.029-.087
Potassium (percent)	10:10	.56	1.38	.26-.80
Selenium (ppm)	10:10	.17	1.45	.10-.25
Sodium (ppm)	10:10	23	1.34	16-37
Strontium (ppm)	10:10	6.9	2.05	3.3-24
Sulfur (total)(ppm)	10:10	810	1.32	550-1,300
Titanium (ppm)	7:10	[1]7.4	[1]1.74	<6.0-14
Uranium (ppm)	6:10	[1].022	[1]1.54	<.028-.068
Vanadium (ppm)	9:10	[1].37	[1]2.08	<.10-1.1
Yttrium (ppm)	9:10	[1].24	[1]1.66	<.10-.49
Zinc (ppm)	10:10	10	1.43	5.2-16
Zirconium (ppm)	10:10	.70	1.65	.39-1.8

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 13.--Summary statistics for the element content of dry material of intermediate wheatgrass from the Seneca Number 2 mine, Colorado

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	6.8	1.16	5.8-9.9
Aluminum (ppm)	10:10	270	1.64	130-480
Arsenic (ppm)	10:10	.33	2.00	.15-1.0
Barium (ppm)	10:10	6.7	1.64	3.0-20
Beryllium (ppm)	7:10	[1].15	[1]1.44	<.20-.26
Boron (ppm)	10:10	5.1	1.26	3.5-7.3
Cadmium (ppm)	8:10	[1].036	[1]1.86	<.040-.11
Calcium (percent)	10:10	.18	1.22	.14-.24
Cerium (ppm)	0:10	--	--	<9.2- --
Chromium (ppm)	10:10	.47	1.39	.30-.77
Cobalt (ppm)	4:10	[1].051	[1]1.61	<.099-.13
Copper (ppm)	10:10	1.1	1.62	.69-3.5
Fluorine (ppm)	10:10	7.5	1.22	6-10
Germanium (ppm)	5:10	[1].13	[1]1.61	<.20-.25
Iron (ppm)	10:10	100	1.52	57-190
Lanthanum (ppm)	3:10	--	--	<.92-2.0
Lead (ppm)	10:10	.84	1.23	.69-1.3
Lithium (ppm)	6:10	[1].27	[1]1.23	<.40-.38
Magnesium (percent)	10:10	.10	1.27	.075-.16
Manganese (ppm)	10:10	16	1.51	8.0-37
Mercury (ppm)	8:10	[1].010	[1]1.33	<.01-.02
Molybdenum (ppm)	10:10	.36	1.76	.19-1.2
Nickel (ppm)	6:10	[1].14	[1]1.61	<.20-30
Niobium (ppm)	2:10	--	--	<.92-.77
Phosphorus (percent)	10:10	.051	1.20	.041-.069
Potassium (percent)	10:10	1.2	1.36	.64-2.0
Selenium (ppm)	10:10	.19	1.77	.06-.45
Sodium (ppm)	10:10	40	1.22	29-59
Strontium (ppm)	10:10	5.0	1.47	3.1-9.0
Sulfur (total)(ppm)	10:10	890	1.42	500-2,000
Titanium (ppm)	6:10	[1]6.4	[1]1.50	<9.2-11
Uranium (ppm)	9:10	[1].030	[1]1.52	<.023-.086
Vanadium (ppm)	9:10	[1].25	[1]1.60	<.20-.50
Yttrium (ppm)	10:10	.21	1.44	.12-.36
Zinc (ppm)	10:10	11	1.34	7.9-18
Zirconium (ppm)	10:10	.63	1.37	.38-.90

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 14.--Summary statistics for the element content of dry material of intermediate wheatgrass from the Husky mine, North Dakota

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	4.6	1.10	4.0-5.3
Aluminum (ppm)	10:10	660	1.60	320-1,200
Arsenic (ppm)	10:10	.38	1.38	.25-.65
Barium (ppm)	10:10	38	1.68	16-87
Beryllium (ppm)	9:10	[1].18	[1]1.46	<.094-.31
Boron (ppm)	10:10	13	1.26	9.0-18
Cadmium (ppm)	10:10	.039	1.68	.018-.10
Calcium (percent)	10:10	.20	1.15	.15-.23
Cerium (ppm)	5:10	[1]4.0	[1]1.35	<4.9-6.2
Chromium (ppm)	10:10	.70	1.41	.48-1.3
Cobalt (ppm)	9:10	[1].059	[1]1.50	<.051-.11
Copper (ppm)	10:10	1.1	1.44	.51-1.7
Fluorine (ppm)	10:10	5.7	1.18	5-8
Germanium (ppm)	6:10	[1].11	[1]1.58	<.10-.21
Iron (ppm)	10:10	280	1.61	120-510
Lanthanum (ppm)	6:10	[1].66	[1]2.14	<.48-2.3
Lead (ppm)	10:10	1.2	1.47	.61-2.4
Lithium (ppm)	8:10	[1].21	[1]1.38	<.21-.38
Magnesium (percent)	10:10	.072	1.14	.057-.091
Manganese (ppm)	10:10	39	1.77	12-69
Mercury (ppm)	10:10	.019	1.30	.01-.03
Molybdenum (ppm)	10:10	.31	1.48	.14-.58
Nickel (ppm)	10:10	.36	2.02	.090-.83
Niobium (ppm)	8:10	[1].65	[1]1.65	<.47-1.4
Phosphorus (percent)	10:10	.023	1.12	.020-.027
Potassium (percent)	10:10	.33	1.37	.22-.58
Selenium (ppm)	10:10	.054	1.51	.04-.15
Sodium (ppm)	10:10	59	1.91	36-310
Strontium (ppm)	10:10	19	1.52	9.9-32
Sulfur (total)(ppm)	10:10	620	1.24	450-800
Titanium (ppm)	10:10	16	2.07	5.2-44
Uranium (ppm)	10:10	.038	1.34	.018-.053
Vanadium (ppm)	10:10	.76	2.06	.24-1.8
Yttrium (ppm)	10:10	.46	1.54	.23-.78
Zinc (ppm)	10:10	9.6	1.18	7.3-12
Zirconium (ppm)	10:10	1.2	1.69	.56-2.6

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 15.--Summary statistics for the element content of dry material of intermediate wheatgrass from the South Beulah mine, North Dakota

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	5.4	1.13	4.6-6.8
Aluminum (ppm)	10:10	480	1.42	280-840
Arsenic (ppm)	10:10	.66	2.25	.25-2.5
Barium (ppm)	10:10	15	1.43	11-35
Beryllium (ppm)	7:10	[1].13	[1]1.75	<.11-.40
Boron (ppm)	10:10	7.7	1.50	4.0-16
Cadmium (ppm)	9:10	[1].030	[1]1.55	<.021-.060
Calcium (percent)	10:10	.18	1.08	.16-.21
Cerium (ppm)	1:10	--	--	<6.3-6.6
Chromium (ppm)	10:10	.49	1.30	.38-.84
Cobalt (ppm)	10:10	.076	1.41	.046-.12
Copper (ppm)	10:10	1.0	1.26	.69-1.5
Fluorine (ppm)	10:10	6.3	1.17	5-8
Germanium (ppm)	8:10	[1].12	[1]1.38	<.12-.20
Iron (ppm)	10:10	200	1.40	130-480
Lanthanum (ppm)	6:10	[1]1.4	[1]1.68	<.63-1.5
Lead (ppm)	10:10	1.0	1.37	.75-2.2
Lithium (ppm)	3:10	--	--	<.24-.34
Magnesium (percent)	10:10	.055	1.09	.049-.067
Manganese (ppm)	10:10	30	1.58	18-90
Mercury (ppm)	10:10	.013	1.43	.01-.02
Molybdenum (ppm)	10:10	.27	1.46	.18-.66
Nickel (ppm)	10:10	.25	1.71	.14-.78
Niobium (ppm)	3:10	--	--	<.52-1.5
Phosphorus (percent)	10:10	.039	1.26	.023-.050
Potassium (percent)	10:10	.21	1.20	.17-.31
Selenium (ppm)	10:10	.088	1.31	.06-.15
Sodium (ppm)	10:10	30	1.17	25-40
Strontium (ppm)	10:10	15	1.36	9.5-32
Sulfur (total)(ppm)	10:10	440	1.10	400-500
Titanium (ppm)	10:10	9.2	1.55	5.4-20
Uranium (ppm)	10:10	.047	1.19	.0370.060
Vanadium (ppm)	10:10	.43	1.86	.18-1.6
Yttrium (ppm)	10:10	.30	1.52	.17-.66
Zinc (ppm)	10:10	12	1.12	9.7-15
Zirconium (ppm)	10:10	.76	1.46	.52-1.7

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 16.--Summary statistics for the element content of dry material of intermediate wheatgrass from the Velva mine, North Dakota

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	7.5	1.10	6.6-8.9
Aluminum (ppm)	10:10	130	1.54	86-220
Arsenic (ppm)	10:10	.21	2.35	.050-.80
Barium (ppm)	10:10	11	1.67	4.1-22
Beryllium (ppm)	9:10	[1].25	[1]1.59	<.18-.46
Boron (ppm)	10:10	9.2	1.58	4.4-20
Cadmium (ppm)	6:10	[1].039	[1]1.80	<.036-.090
Calcium (percent)	10:10	.18	1.11	.16-.21
Cerium (ppm)	2:10	--	--	<8.3-8.7
Chromium (ppm)	10:10	.30	1.56	.18-.53
Cobalt (ppm)	3:10	--	--	<.081-.20
Copper (ppm)	10:10	1.5	1.24	1.2-2.2
Fluorine (ppm)	10:10	4.8	1.30	4-8
Germanium (ppm)	7:10	[1].18	[1]1.79	<.17-.41
Iron (ppm)	10:10	54	1.50	31-98
Lanthanum (ppm)	5:10	[1]1.1	[1]2.42	<.83-3.8
Lead (ppm)	10:10	1.5	1.38	.98-2.4
Lithium (ppm)	1:10	--	--	<.36-.32
Magnesium (percent)	10:10	.044	1.13	.036-.053
Manganese (ppm)	10:10	44	2.06	13-100
Mercury (ppm)	10:10	.016	1.60	.01-.04
Molybdenum (ppm)	10:10	.36	2.25	.19-2.4
Nickel (ppm)	4:10	[1].13	[1]2.74	<.18-.48
Niobium (ppm)	5:10	[1].63	[1]2.30	<.83-1.7
Phosphorus (percent)	10:10	.045	1.21	.038-.058
Potassium (percent)	10:10	.22	1.11	.19-.27
Selenium (ppm)	10:10	.098	1.50	.06-.20
Sodium (ppm)	10:10	24	1.25	18-39
Strontium (ppm)	10:10	10	1.53	5.6-26
Sulfur (total)(ppm)	10:10	440	1.14	400-680
Titanium (ppm)	2:10	--	--	<8.3-8.3
Uranium (ppm)	10:10	.058	1.32	.028-.080
Vanadium (ppm)	7:10	[1].21	[1]1.77	<.18-.83
Yttrium (ppm)	7:10	[1].22	[1]1.74	<.18-.48
Zinc (ppm)	10:10	15	1.11	12-28
Zirconium (ppm)	10:10	.64	1.32	.36-.95

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 17.--Summary statistics for the element content of dry material of slender wheatgrass from the Absaloka mine, Montana

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	3.7	1.26	2.7-5.1
Aluminum (ppm)	10:10	260	1.93	100-920
Arsenic (ppm)	10:10	.26	1.91	.15-1.2
Barium (ppm)	10:10	8.4	1.49	5.2-22
Beryllium (ppm)	5:10	[1].075	[1]1.86	<.10-.32
Boron (ppm)	10:10	5.5	1.73	2.3-16
Cadmium (ppm)	7:10	[1].017	[1]2.04	<.016-.096
Calcium (percent)	10:10	.17	1.12	.13-.20
Cerium (ppm)	1:10	--	--	<4.7-5.6
Chromium (ppm)	10:10	.32	1.30	.22-.56
Cobalt (ppm)	6:10	[1].040	[1]1.55	<.051-.080
Copper (ppm)	10:10	.78	1.22	.58-1.0
Fluorine (ppm)	10:10	5.1	1.22	4-7
Germanium (ppm)	7:10	[1].075	[1]1.30	<.10-.11
Iron (ppm)	10:10	95	1.73	38-260
Lanthanum (ppm)	6:10	[1].50	[1]1.85	<.45-1.2
Lead (ppm)	10:10	.72	1.44	.55-1.8
Lithium (ppm)	3:10	--	--	<.20-.16
Magnesium (percent)	10:10	.055	1.25	.049-.082
Manganese (ppm)	10:10	22	1.73	13-87
Mercury (ppm)	10:10	.022	1.46	.01-.04
Molybdenum (ppm)	10:10	.20	1.65	.10-.61
Nickel (ppm)	9:10	[1].14	[1]1.75	<.10-.51
Niobium (ppm)	1:10	--	--	<.46-1.4
Phosphorus (percent)	10:10	.021	1.40	.010-.030
Potassium (percent)	10:10	.26	1.37	.17-.42
Selenium (ppm)	10:10	.025	1.40	.02-.04
Sodium (ppm)	10:10	23	1.22	19-32
Strontium (ppm)	10:10	6.1	1.47	3.5-11
Sulfur (total)(ppm)	10:10	490	1.17	400-650
Titanium (ppm)	8:10	[1]5.0	[1]1.65	<4.7-14
Uranium (ppm)	10:10	.024	1.44	.014-.046
Vanadium (ppm)	9:10	[1].15	[1]1.54	<.10-1.0
Yttrium (ppm)	10:10	.16	1.63	.07-.43
Zinc (ppm)	10:10	12	1.38	7.0-21
Zirconium (ppm)	10:10	.52	1.68	.25-1.5

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 18.--Summary statistics for the element content of dry material of slender wheatgrass from the Big Sky mine, Montana

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	3.7	1.17	3.2-5.0
Aluminum (ppm)	10:10	510	1.37	280-740
Arsenic (ppm)	10:10	.29	1.55	.15-.70
Barium (ppm)	10:10	8.7	1.42	5.8-17
Beryllium (ppm)	9:10	[1].11	[1]1.51	<.072-.20
Boron (ppm)	10:10	14	1.73	6.0-36
Cadmium (ppm)	9:10	[1].027	[1]1.53	<.020-.044
Calcium (percent)	10:10	.19	1.09	.17-.22
Cerium (ppm)	3:10	--	--	<4.7-5.2
Chromium (ppm)	10:10	.48	1.55	.20-.78
Cobalt (ppm)	10:10	.057	1.43	.033-.096
Copper (ppm)	10:10	1.1	1.36	.70-2.0
Fluorine (ppm)	10:10	6.6	1.21	5-9
Germanium (ppm)	7:10	[1].10	[1]1.62	<.096-.20
Iron (ppm)	10:10	180	1.31	110-270
Lanthanum (ppm)	8:10	[1].56	[1]2.21	<.33-1.9
Lead (ppm)	10:10	.74	1.31	.46-1.1
Lithium (ppm)	9:10	[1].21	[1]1.51	<.20-.43
Magnesium (percent)	10:10	.079	1.27	.056-.11
Manganese (ppm)	10:10	26	1.77	16-110
Mercury (ppm)	10:10	.021	1.38	.01-.03
Molybdenum (ppm)	10:10	.60	2.25	.19-1.5
Nickel (ppm)	10:10	.27	1.46	.14-.38
Niobium (ppm)	5:10	[1].37	[1]1.80	<.45-.88
Phosphorus (percent)	10:10	.021	1.19	.017-.031
Potassium (percent)	10:10	.36	1.34	.22-.58
Selenium (ppm)	10:10	.13	1.71	.04-.25
Sodium (ppm)	10:10	32	1.27	21-48
Strontium (ppm)	10:10	8.2	1.48	4.9-15
Sulfur (total)(ppm)	10:10	470	1.22	400-700
Titanium (ppm)	10:10	9.9	1.49	5.0-15
Uranium (ppm)	10:10	.050	1.33	.026-.079
Vanadium (ppm)	10:10	.43	1.76	.18-.85
Yttrium (ppm)	10:10	.29	1.53	.15-.45
Zinc (ppm)	10:10	14	1.41	8.1-26
Zirconium (ppm)	10:10	.81	1.70	.39-1.7

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 19.--Summary statistics for the element content of dry material of slender wheatgrass from the Decker mine, Montana

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	5.5	1.22	4.0-8.2
Aluminum (ppm)	10:10	440	1.36	290-810
Arsenic (ppm)	10:10	.23	1.52	.15-.45
Barium (ppm)	10:10	18	1.53	7.2-33
Beryllium (ppm)	9:10	[1].17	[1]1.55	<.11-.30
Boron (ppm)	10:10	3.6	1.60	1.4-5.8
Cadmium (ppm)	5:10	[1].019	[1]2.13	<.024-.054
Calcium (percent)	10:10	.18	1.18	.13-.22
Cerium (ppm)	3:10	--	--	<7.6-7.5
Chromium (ppm)	9:10	[1].41	[1]1.77	<.12-.87
Cobalt (ppm)	6:10	[1].052	[1]1.53	<.060-.18
Copper (ppm)	10:10	.87	1.35	.40-1.2
Fluorine (ppm)	10:10	5.6	1.34	3-8
Germanium (ppm)	10:10	.22	1.45	.12-.41
Iron (ppm)	10:10	170	1.45	110-350
Lanthanum (ppm)	5:10	[1].40	[1]2.86	<.76-2.2
Lead (ppm)	10:10	1.1	1.47	.64-1.9
Lithium (ppm)	8:10	[1].34	[1]2.11	<.23-1.3
Magnesium (percent)	10:10	.070	1.32	.048-.12
Manganese (ppm)	10:10	61	1.73	31-160
Mercury (ppm)	10:10	.014	1.44	.01-.02
Molybdenum (ppm)	10:10	.33	2.32	.12-2.2
Nickel (ppm)	10:10	.32	1.72	.18-.70
Niobium (ppm)	5:10	[1].43	[1]2.10	<.76-1.1
Phosphorus (percent)	10:10	.027	1.27	.019-.045
Potassium (percent)	10:10	.22	1.36	.16-.36
Selenium (ppm)	10:10	.057	1.41	.04-.10
Sodium (ppm)	10:10	72	2.01	37-240
Strontium (ppm)	10:10	24	1.58	13-44
Sulfur (total)(ppm)	10:10	440	1.12	400-500
Titanium (ppm)	9:10	[1]7.9	[1]1.48	<7.6-17
Uranium (ppm)	10:10	.061	1.30	.033-.080
Vanadium (ppm)	10:10	.45	1.81	.20-1.2
Yttrium (ppm)	10:10	.27	1.50	.13-.51
Zinc (ppm)	10:10	8.7	1.28	6.6-14
Zirconium (ppm)	10:10	.80	1.41	.48-1.3

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 20.--Summary statistics for the element content of dry material of alfalfa from the Energy Fuels mine, Colorado

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	9.0	1.20	6,7-13
Aluminum (ppm)	10:10	560	1.29	400-950
Arsenic (ppm)	10:10	.31	1.39	.15-.45
Barium (ppm)	10:10	15	1.30	10-28
Beryllium (ppm)	0:10	--	--	<.26- --
Boron (ppm)	10:10	54	1.49	29-92
Cadmium (ppm)	10:10	.12	1.71	.060-.26
Calcium (percent)	10:10	2.6	1.21	2.0-4.0
Cerium (ppm)	2:10	--	--	< 10- 13
Chromium (ppm)	10:10	.56	1.26	.46-1.0
Cobalt (ppm)	6:10	[1].084	[1]1.78	<.093-.19
Copper (ppm)	10:10	5.6	1.22	3.9-7.2
Fluorine (ppm)	10:10	6.6	1.25	5-9
Germanium (ppm)	1:10	--	--	<.26-.21
Iron (ppm)	10:10	170	1.24	120-220
Lanthanum (ppm)	10:10	1.8	1.86	.87-4.2
Lead (ppm)	10:10	.97	1.21	.74-1.3
Lithium (ppm)	10:10	.76	2.01	.46-3.8
Magnesium (percent)	10:10	.38	1.81	.16-.86
Manganese (ppm)	10:10	24	1.48	15-56
Mercury (ppm)	10:10	.015	1.53	.01-.03
Molybdenum (ppm)	10:10	2.0	1.81	.54-4.3
Nickel (ppm)	10:10	.69	2.00	.36-3.1
Niobium (ppm)	6:10	[1].74	[1]1.66	<1.0-1.4
Phosphorus (percent)	10:10	.089	1.38	.054-.14
Potassium (percent)	10:10	.82	1.25	.59-1.0
Selenium (ppm)	10:10	.39	1.81	.20-1.4
Sodium (ppm)	10:10	40	1.56	22-70
Strontium (ppm)	10:10	78	1.52	48-190
Sulfur (total)(ppm)	10:10	2,600	1.46	1,600-4,700
Titanium (ppm)	9:10	[1]9.8	[1]1.30	<10-14
Uranium (ppm)	8:10	[1].029	[1]1.32	<.052-.069
Vanadium (ppm)	10:10	.64	1.31	.49-1.0
Yttrium (ppm)	10:10	.59	1.54	.34-1.6
Zinc (ppm)	10:10	18	1.46	11-40
Zirconium (ppm)	10:10	1.5	1.28	1.0-2.0

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 21.--Summary statistics for the element content of dry material of alfalfa from the Seneca Number 2 mine, Colorado

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash weight basis to a dry weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	6.8	1.26	4.4-10
Aluminum (ppm)	10:10	440	1.71	170-1,100
Arsenic (ppm)	10:10	.56	2.26	.25-3.0
Barium (ppm)	10:10	8.2	2.13	3.3-47
Beryllium (ppm)	0:10	--	--	<.20- --
Boron (ppm)	10:10	52	1.46	29-84
Cadmium (ppm)	9:10	[1].10	[1]2.22	<.040-.43
Calcium (percent)	10:10	1.7	1.44	.88-2.9
Cerium (ppm)	2:10	--	--	<9.3-7.2
Chromium (ppm)	10:10	.45	1.46	.25-.72
Cobalt (ppm)	5:10	[1].061	[1]1.46	<.10-.11
Copper (ppm)	10:10	5.3	1.78	1.1-8.0
Fluorine (ppm)	10:10	6.6	1.25	4-8
Germanium (ppm)	1:10	--	--	<.20-.19
Iron (ppm)	10:10	120	1.42	79-250
Lanthanum (ppm)	9:10	[1]1.2	[1]1.91	<.59-3.4
Lead (ppm)	10:10	.82	1.38	.54-1.4
Lithium (ppm)	9:10	[1].54	[1]1.72	<.18-1.1
Magnesium (percent)	10:10	.42	1.51	.21-.64
Manganese (ppm)	10:10	17	1.65	9.0-33
Mercury (ppm)	9:10	[1].011	[1]1.37	<.01-.02
Molybdenum (ppm)	10:10	1.2	1.48	.50-1.9
Nickel (ppm)	10:10	.50	1.56	.22-1.1
Niobium (ppm)	4:10	[1].49	[1]1.87	<.83-1.3
Phosphorus (percent)	10:10	.067	1.25	.063-.088
Potassium (percent)	10:10	.70	1.30	.46-.97
Selenium (ppm)	10:10	.32	2.06	.10-.90
Sodium (ppm)	10:10	96	2.77	35-630
Strontium (ppm)	10:10	37	1.46	20-72
Sulfur (total)(ppm)	10:10	1,700	1.38	950-2,800
Titanium (ppm)	7:10	[1]7.8	[1]1.66	<7.1-20
Uranium (ppm)	10:10	.048	1.68	.023-.12
Vanadium (ppm)	10:10	.34	1.95	.13-1.3
Yttrium (ppm)	10:10	.35	1.52	.19-.66
Zinc (ppm)	10:10	21	1.43	12-35
Zirconium (ppm)	10:10	.97	1.74	.47-2.8

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 22.--Summary statistics for the element content of dry material of alfalfa from the Husky mine, North Dakota

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	4.8	1.10	4.3-5.6
Aluminum (ppm)	10:10	460	1.53	230-990
Arsenic (ppm)	10:10	.22	1.28	.15-.30
Barium (ppm)	10:10	38	1.49	20-85
Beryllium (ppm)	1:10	--	--	<.11-.13
Boron (ppm)	10:10	27	1.36	19-47
Cadmium (ppm)	10:10	.064	1.26	.044-.10
Calcium (percent)	10:10	.94	1.14	.83-1.2
Cerium (ppm)	1:10	--	--	<5.1-5.1
Chromium (ppm)	10:10	.48	1.35	.33-.85
Cobalt (ppm)	10:10	.081	1.43	.046-.13
Copper (ppm)	10:10	5.3	1.18	4.2-7.2
Fluorine (ppm)	10:10	6.3	1.19	5-8
Germanium (ppm)	0:10	--	--	<.11- --
Iron (ppm)	10:10	200	1.47	120-450
Lanthanum (ppm)	9:10	[1].75	[1]1.87	<.49-2.4
Lead (ppm)	10:10	.73	1.45	.44-1.6
Lithium (ppm)	10:10	1.2	1.66	.58-2.4
Magnesium (percent)	10:10	.26	1.19	.21-.35
Manganese (ppm)	10:10	13	1.76	7.0-44
Mercury (ppm)	10:10	.011	1.34	.01-.02
Molybdenum (ppm)	10:10	1.5	1.93	.88-5.5
Nickel (ppm)	10:10	.52	1.58	.35-1.2
Niobium (ppm)	3:10	--	--	<.51-.71
Phosphorus (percent)	10:10	.060	1.24	.047-.088
Potassium (percent)	10:10	.80	1.15	.66-1.0
Selenium (ppm)	10:10	.17	1.70	.10-.45
Sodium (ppm)	10:10	250	1.82	120-700
Strontium (ppm)	10:10	62	1.63	38-160
Sulfur (total)(ppm)	10:10	1,200	1,20	850-1,400
Titanium (ppm)	10:10	9.2	1.64	5.3-26
Uranium (ppm)	10:10	.098	1.44	.062-.20
Vanadium (ppm)	10:10	.41	2.08	.12-1.8
Yttrium (ppm)	10:10	.32	1.54	.15-.70
Zinc (ppm)	10:10	15	1.17	12-18
Zirconium (ppm)	10:10	.98	1.63	.44-2.8

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 23.--Summary statistics for the element content of dry material of alfalfa from the South Beulah mine, North Dakota

[ppm, parts per million; <, less than; >, greater than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest lower limit and the smallest upper limit values are reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	6.4	1.16	4.8-7.7
Aluminum (ppm)	10:10	540	1.63	260-1,400
Arsenic (ppm)	10:10	.95	1.78	.40-2.5
Barium (ppm)	10:10	22	1.41	12-35
Beryllium (ppm)	2:10	--	--	<.15-.21
Boron (ppm)	10:10	48	1.60	31-120
Cadmium (ppm)	10:10	.20	1.98	.087-.88
Calcium (percent)	10:10	1.6	1.24	1.1-2.2
Cerium (ppm)	3:10	--	--	<6.9-12
Chromium (ppm)	10:10	.56	1.44	.38-1.2
Cobalt (ppm)	9:10	[1].28	[1]3.82	<.060-2.0
Copper (ppm)	10:10	6.3	1.21	4.9-9.0
Fluorine (ppm)	10:10	6.3	1.12	5-7
Germanium (ppm)	0:10	--	--	<.15- --
Iron (ppm)	10:10	240	1.55	140-560
Lanthanum (ppm)	6:10	[1].71	[1]2.94	<.69-4.3
Lead (ppm)	10:10	1.0	1.47	.60-2.2
Lithium (ppm)	10:10	1.2	2.32	.48-4.5
Magnesium (percent)	10:10	.30	1.19	.22-.38
Manganese (ppm)	10:10	31	2.34	11-160
Mercury (ppm)	10:10	.018	1.53	.01-.03
Molybdenum (ppm)	10:10	1.6	2.02	.43-5.8
Nickel (ppm)	10:10	1.0	3.04	.30-6.6
Niobium (ppm)	5:10	[1].58	[1]2.24	<.6 9-2.3
Phosphorus (percent)	10:10	.060	1.11	.053-.074
Potassium (percent)	10:10	.78	1.13	.60-.92
Selenium (ppm)	10:10	.12	1.37	.08-.20
Sodium (ppm)	10:10	240	1.62	110-390
Strontium (ppm)	[2] 7:10	170	1.76	77->220
Sulfur (total)(ppm)	10:10	1,700	1.32	1,300-2,800
Titanium (ppm)	9:10	[1]8.9	[1]1.66	6.7-25
Uranium (ppm)	10:10	.041	1.70	.022-.11
Vanadium (ppm)	10:10	.51	1.97	.23-2.3
Yttrium (ppm)	10:10	.37	1.80	.14-1.4
Zinc (ppm)	10:10	20	1.52	12-57
Zirconium (ppm)	10:10	1.1	1.60	.66-3.6

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

[2]Ratios for the number of values below the upper limit of determination to the number of samples analyzed.

Table 24.--Summary statistics for the element content of dry material of alfalfa from the Velva mine, North Dakota

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	6.7	1.10	5.9-7.8
Aluminum (ppm)	10:10	150	1.85	72-380
Arsenic (ppm)	10:10	.53	1.74	.30-1.1
Barium (ppm)	10:10	10	1.81	3.9-20
Beryllium (ppm)	4:10	[1].12	[1]1.67	<.14-.27
Boron (ppm)	10:10	66	1.65	28-130
Cadmium (ppm)	10:10	.075	1.57	.046-.18
Calcium (percent)	10:10	1.6	1.20	1.2-2.3
Cerium (ppm)	3:10	--	--	<7.3-11
Chromium (ppm)	10:10	.27	1.71	.12-.58
Cobalt (ppm)	2:10	--	--	<.077-.16
Copper (ppm)	10:10	8.7	1.29	6.1-12
Fluorine (ppm)	10:10	5.0	1.19	4-6
Germanium (ppm)	2:10	--	--	<.16-.21
Iron (ppm)	10:10	75	1.72	33-170
Lanthanum (ppm)	7:10	[1]1.0	[1]3.54	<.58-4.6
Lead (ppm)	10:10	1.0	1.64	.48-2.6
Lithium (ppm)	10:10	5.8	1.33	3.9-9.4
Magnesium (percent)	10:10	.25	1.26	.19-.37
Manganese (ppm)	10:10	26	1.82	13-77
Mercury (ppm)	10:10	.014	1.62	.01-.03
Molybdenum (ppm)	10:10	4.2	1.75	1.9-9.0
Nickel (ppm)	10:10	.63	1.70	.23-1.3
Niobium (ppm)	4:10	[1].48	[1]2.93	<.66-2.2
Phosphorus (percent)	10:10	.088	1.26	.059-.12
Potassium (percent)	10:10	1.0	1.16	.78-1.3
Selenium (ppm)	10:10	.37	1.34	.25-.55
Sodium (ppm)	10:10	93	1.93	38-270
Strontium (ppm)	10:10	100	1.67	54-210
Sulfur (total) (ppm)	10:10	1,700	1.28	1,200-2,700
Titanium (ppm)	2:10	--	--	<7.3-7.7
Uranium (ppm)	10:10	.085	2.00	.050-.23
Vanadium (ppm)	6:10	[1].18	[1]3.70	<.16-1.2
Yttrium (ppm)	8:10	[1].17	[1]1.71	<.13-.45
Zinc (ppm)	10:10	22	1.32	15-33
Zirconium (ppm)	10:10	.59	1.60	.42-1.6

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 25.--Summary statistics for the element content of dry material of alfalfa from the Big Sky mine, Montana

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	5.2	1.12	4.6-6.3
Aluminum (ppm)	10:10	660	1.61	290-1,400
Arsenic (ppm)	10:10	.31	1.66	.20-.85
Barium (ppm)	10:10	10	1.74	3.5-20
Beryllium (ppm)	1:10	--	--	<.13-.12
Boron (ppm)	10:10	48	1.58	26-90
Cadmium (ppm)	9:10	[1].040	[1]1.53	<.025-.62
Calcium (percent)	10:10	1.2	1.14	.99-1.4
Cerium (ppm)	4:10	[1]4.2	[1]1.36	<5.9-8.4
Chromium (ppm)	10:10	.55	1.42	.35-.95
Cobalt (ppm)	10:10	.11	1.48	.056-.18
Copper (ppm)	10:10	7.6	1.25	4.7-10
Fluorine (ppm)	10:10	7.2	1.16	5-8
Germanium (ppm)	1:10	--	--	<.13-.13
Iron (ppm)	10:10	230	1.41	160-430
Lanthanum (ppm)	10:10	1.0	1.72	.50-3.0
Lead (ppm)	10:10	.78	1.41	.46-1.3
Lithium (ppm)	10:10	.52	1.34	.30-.73
Magnesium (percent)	10:10	.47	1.32	.28-.69
Manganese (ppm)	10:10	28	2.69	8.0-97
Mercury (ppm)	10:10	.022	2.06	.01-.09
Molybdenum (ppm)	10:10	4.3	1.66	2.3-12
Nickel (ppm)	10:10	.82	1.91	.37-2.0
Niobium (ppm)	5:10	[1].50	[1]1.61	<.59-1.2
Phosphorus (percent)	10:10	.052	1.45	.023-.095
Potassium (percent)	10:10	.50	1.32	.34-.73
Selenium (ppm)	10:10	.20	1.61	.10-.45
Sodium (ppm)	10:10	80	1.66	38-150
Strontium (ppm)	10:10	42	1.52	25-100
Sulfur (total)(ppm)	10:10	1,300	1.18	950-1,500
Titanium (ppm)	10:10	12	1.61	5.1-22
Uranium (ppm)	10:10	.048	1.42	.021-.067
Vanadium (ppm)	10:10	.49	2.03	.14-1.4
Yttrium (ppm)	10:10	.44	1.56	.18-.75
Zinc (ppm)	10:10	27	1.38	14-40
Zirconium (ppm)	10:10	1.4	1.58	.60-3.1

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 26.--Summary statistics for the element content of dry material of sandfain from the Absaloka mine, Montana

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	3.4	1.16	2.6-3.8
Aluminum (ppm)	10:10	230	1.98	65-580
Arsenic (ppm)	10:10	.59	2.24	.10-1.2
Barium (ppm)	10:10	24	1.59	15-56
Beryllium (ppm)	3:10	--	--	<.084-.11
Boron (ppm)	10:10	20	1.59	11-43
Cadmium (ppm)	10:10	.081	1.71	.031-.17
Calcium (percent)	10:10	.78	1.18	.59-.94
Cerium (ppm)	3:10	--	--	<3.9-5.8
Chromium (ppm)	10:10	.25	1.51	.11-.43
Cobalt (ppm)	10:10	.064	1.30	.039-.099
Copper (ppm)	10:10	2.0	1.22	1.5-2.9
Fluorine (ppm)	10:10	5.2	1.13	4-6
Germanium (ppm)	2:10	--	--	<.084-.086
Iron (ppm)	10:10	76	1.72	24-140
Lanthanum (ppm)	8:10	[1].61	[1]2.53	<.35-2.3
Lead (ppm)	10:10	.64	1.56	.29-1.3
Lithium (ppm)	5:10	[1].12	[1]1.33	<.16-.20
Magnesium (percent)	10:10	.26	1.28	.15-.37
Manganese (ppm)	10:10	47	1.79	18-100
Mercury (ppm)	10:10	.016	1.51	.01-.03
Molybdenum (ppm)	10:10	1.6	2.35	.36-5.5
Nickel (ppm)	9:10	[1].19	[1]2.02	<.060-.43
Niobium (ppm)	6:10	[1].35	[1]1.67	<.36-.86
Phosphorus (percent)	10:10	.017	1.16	.015-.023
Potassium (percent)	10:10	.39	1.60	.18-.65
Selenium (ppm)	10:10	.029	1.53	.02-.06
Sodium (ppm)	10:10	41	1.53	22-79
Strontium (ppm)	10:10	40	1.67	19-86
Sulfur (total)(ppm)	10:10	1,000	1.87	400-3,600
Titanium (ppm)	7:10	[1]4.1	[1]1.70	<3.6-8.4
Uranium (ppm)	10:10	.030	1.58	.010-.050
Vanadium (ppm)	9:10	[1].20	[1]2.44	<.060-.68
Yttrium (ppm)	10:10	.19	1.78	.070-.40
Zinc (ppm)	10:10	8.9	1.68	4.5-23
Zirconium (ppm)	10:10	.70	1.89	.30-2.0

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 27.--Summary statistics for the element content of dry material of fourwing saltbush from the Jim Bridger mine, Wyoming

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	10	1.12	8.1-12
Aluminum (ppm)	10:10	460	1.46	240-910
Arsenic (ppm)	10:10	.24	1.61	.10-.40
Barium (ppm)	10:10	4.4	1.57	2.3-12
Beryllium (ppm)	0:10	--	--	<.24- --
Boron (ppm)	10:10	220	1.72	110-610
Cadmium (ppm)	10:10	.099	2.21	.032-.30
Calcium (percent)	10:10	.94	1.28	.57-1.4
Cerium (ppm)	4:10	[1]9.1	[1]1.23	<11-12
Chromium (ppm)	10:10	.49	1.45	.22-.86
Cobalt (ppm)	10:10	.18	1.77	.081-.44
Copper (ppm)	10:10	4.9	1.22	4.4-7.0
Fluorine (ppm)	10:10	8.2	1.21	6-10
Germanium (ppm)	1:10	--	--	<.24-.30
Iron (ppm)	10:10	140	1.48	63-290
Lanthanum (ppm)	6:10	[1]1.5	[1]2.00	<2.2-4.1
Lead (ppm)	10:10	1.0	1.48	.51-1.8
Lithium (ppm)	10:10	.97	1.59	.32-1.5
Magnesium (percent)	10:10	.82	1.25	.63-1.0
Manganese (ppm)	10:10	68	2.82	10-330
Mercury (ppm)	7:10	[1].010	[1]1.36	<.01-.02
Molybdenum (ppm)	10:10	.72	2.46	.23-5.1
Nickel (ppm)	9:10	[1].79	[1]2.12	<.16-1.8
Niobium (ppm)	3:10	--	--	<1.1-1.4
Phosphorus (percent)	10:10	.11	1.20	.081-.14
Potassium (percent)	10:10	2.8	1.19	1.9-3.6
Selenium (ppm)	10:10	.70	1.63	.25-1.2
Sodium (ppm)	10:10	2,600	3.80	230-7,700
Strontium (ppm)	10:10	21	1.47	9.0-41
Sulfur (total)(ppm)	10:10	3,500	1.17	2,600-4,400
Titanium (ppm)	7:10	[1]10	[1]1.50	<10-20
Uranium (ppm)	7:10	[1].038	[1]1.25	<.048-.048
Vanadium (ppm)	8:10	[1].35	[1]2.14	<.22-1.3
Yttrium (ppm)	10:10	.43	1.48	.24-.84
Zinc (ppm)	10:10	66	1.33	52-110
Zirconium (ppm)	10:10	1.2	1.43	.66-2.3

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Table 28.--Summary statistics for the element content of dry material of fourwing saltbush from the Decker mine, Montana

[ppm, parts per million; <, less than; leaders (--), mean no data; ratio is the proportion of the number of analyses having values above the lower limit of determination to the total number of analyses; variable lower limits of determination are obtained when converting concentrations on an ash-weight basis to a dry-weight basis, however only the largest value is reported]

Element or ash	Ratio	Geometric mean	Geometric deviation	Observed range
Ash (percent)	10:10	9.9	1.24	6.1-13
Aluminum (ppm)	10:10	440	1.53	200-910
Arsenic (ppm)	10:10	.26	1.70	.10-.50
Barium (ppm)	10:10	8.1	1.51	3.7-14
Beryllium (ppm)	2:10	--	--	<.26-.25
Boron (ppm)	10:10	30	1.36	18-53
Cadmium (ppm)	9:10	[1].081	[1]1.76	<.048-.18
Calcium (percent)	10:10	.96	1.43	.55-1.2
Cerium (ppm)	0:10	--	--	<12- --
Chromium (ppm)	10:10	.47	1.33	.28-.61
Cobalt (ppm)	10:10	.27	1.58	.12-.52
Copper (ppm)	10:10	4.5	1.33	3.0-6.6
Fluorine (ppm)	10:10	7.6	1.18	6-9
Germanium (ppm)	1:10	--	--	<.26-.19
Iron (ppm)	10:10	140	1.30	98-220
Lanthanum (ppm)	9:10	[1]1.5	[1]1.77	<1.1-3.8
Lead (ppm)	10:10	.90	1.20	.80-1.3
Lithium (ppm)	10:10	1.8	1.53	.82-3.8
Magnesium (percent)	10:10	.48	1.46	.30-.94
Manganese (ppm)	10:10	110	1.47	65-210
Mercury (ppm)	6:10	[1].009	[1]1.38	<.01-.02
Molybdenum (ppm)	10:10	.46	1.47	.29-1.0
Nickel (ppm)	10:10	2.5	1.48	1.4-4.7
Niobium (ppm)	3:10	--	--	<1.2-1.3
Phosphorus (percent)	10:10	.074	1.38	.052-.16
Potassium (percent)	10:10	3.1	1.20	2.2-3.8
Selenium (ppm)	10:10	.32	1.75	.15-.90
Sodium (ppm)	10:10	420	2.70	130-2,500
Strontium (ppm)	10:10	88	1.49	51-210
Sulfur (total)(ppm)	10:10	3,600	1.25	2,400-4,700
Titanium (ppm)	6:10	[1]9.3	[1]1.38	<12-16
Uranium (ppm)	2:10	--	--	<.052-.039
Vanadium (ppm)	9:10	[1].30	[1]1.41	<.19-.47
Yttrium (ppm)	9:10	[1].29	[1]1.27	<.19-.41
Zinc (ppm)	10:10	34	1.57	19-86
Zirconium (ppm)	10:10	.95	1.25	.67-1.2

[1]The technique of Cohen (1959) was used to calculate the mean and deviation because there were one or more concentration values outside of the limits of determination of the analytical method used.

Methods section, the dry-weight conversion results in some variable LLD values.

For many of the mines, control samples of alfalfa were collected in nearby hay fields. Three samples of the control material are presented for comparison with the mine material. Where available, therefore, these data follow one another in the Appendix. Observations concerning these sets of data follow: (1) The alfalfa collected in a field 2 km east of the Big Sky mine has lower concentrations of aluminum, calcium, cobalt, copper, manganese, molybdenum, nickel, selenium, sulfur, titanium, uranium, zinc, and zirconium, and higher concentrations of barium, than did mine samples. (2) Control samples of alfalfa collected 4 km west of the Husky mine were higher in arsenic, boron, and lead than were samples collected at the mine (none of the elements were lower in concentration in the control samples when compared with the mine samples). (3) Alfalfa control samples collected 2 km southeast of the South Beulah mine had a lower concentration of sodium than did mine samples; however, the control samples were higher in barium (order of magnitude), lanthanum, niobium, phosphorus (order of magnitude), and selenium. The higher ash yield of the control samples, compared to the mine samples, may be responsible for these differences; however, the reason for such a large discrepancy in ash yield is not apparent. Also, the high mercury value of 0.10 ppm in one of the control samples is also difficult to explain--it may be analytical error. (4) Samples of alfalfa collected in a field 5 km north of the Velva mine showed no concentration of elements lower than what was found in the mine samples. The control samples were higher, however, in aluminum, iron, lithium, sodium, phosphorus, and sulfur.

Crested wheatgrass was collected not only on a rehabilitation site at the Dave Johnston mine, but also at an area whose topsoil had been removed to a depth of several inches for use elsewhere. Data on the crested wheatgrass samples from this altered topsoil 'borrow' area is presented in the Appendix table as 'control' samples. The control samples and mine samples were similar in their concentrations of most elements; however, the control samples were higher in barium and lower in cadmium, potassium, and manganese. These comparisons, between control- and mine-samples, differ somewhat from element levels in similar materials collected in 1974 (Erdman and Ebens, 1979). Concentrations of cadmium, cobalt, fluorine, manganese, uranium, vanadium, and zinc in wheatgrass from mine sites were found by these authors to be from 3 to 20 times higher than those grown in the 'borrow' areas. Variables such as time since reclamation, degree of topsoil depth (reclamation methods), and minesoil heterogeneity from site-to-site probably contribute to these differences between studies.

Samples of green alder and diamondleaf willow were sampled both on and away from a rehabilitation area at the Usibelli mine, Alaska. The Appendix table lists the analytical results for the six samples of each of these woody species. Essentially no difference was observed in the concentration of 34 elements and ash yield in alder between the control- and mine-samples. The willow samples were also similar, except for lanthanum which appeared to be somewhat higher in concentration in mine samples than in control samples. Of particular interest, however, were the concentrations of silver in the two species both on and off the rehabilitation site (table 8). Although silver was analyzed for in all of the samples listed in the Appendix, only the alder and willow samples from the Usibelli mine had detectable amounts (the LLD in ash, by the emission spectrographic method, was 0.92 ppm). Table 8 also shows that about twice as much silver was found in control samples of alder as in mine-sampled alder. Diamondleaf willow samples did not show this same difference. These levels of silver, although anomalous for this data set, are not unusually high when compared to samples of plants growing in soils that are slightly acidic (Connor and Shacklette, 1975).

Comparison of Mine-Sampled Wheatgrasses

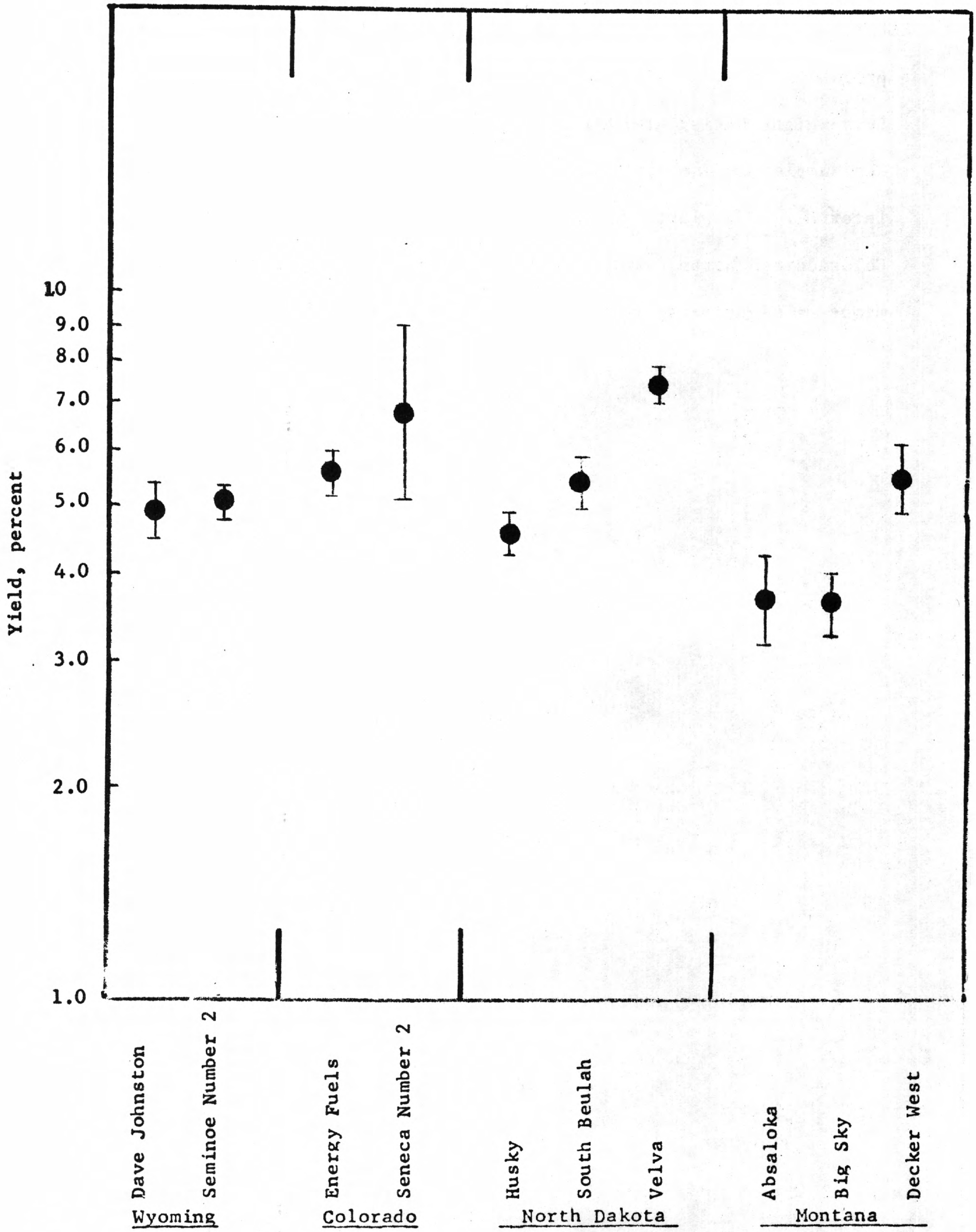
Figure 5 diagrams the geometric mean of ten samples of wheatgrass collected at each of ten different mine rehabilitation sites in four western states. Also shown are the confidence intervals about the mean. The width of the confidence interval defines the specific region within which the population mean (μ) occurs with a probability of 95 percent. Because both the geometric mean (GM) and geometric deviation (GD) were used in the calculation, instead of the mean and standard deviation, the following equation defines the confidence limits:

$$\log_{10} GM - \frac{1.96 \times \log_{10} GD}{\sqrt{n}} < \mu < \log_{10} GM + \frac{1.96 \times \log_{10} GD}{\sqrt{n}}.$$

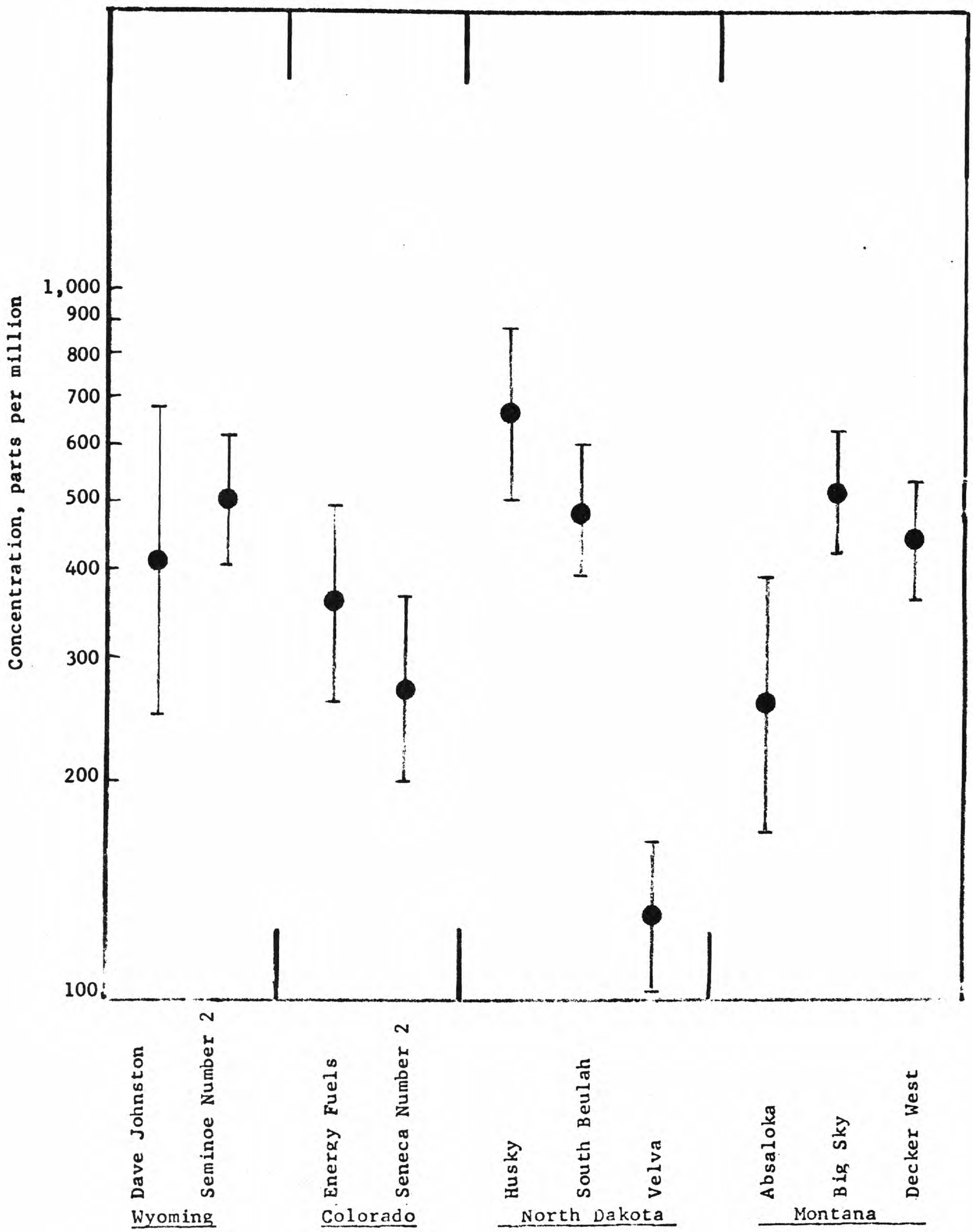
Following the above calculation, the antilog of the confidence limits was determined and then plotted. A resampling of the same material at the same site would generate new GM and GD values and thus different confidence limits; however, 95 percent of the time the theoretical μ would fall within these limits.

Data for three species of wheatgrasses are plotted together in Figure 5. Crested wheatgrass was sampled at the two Wyoming mines. The five mines in Colorado and North Dakota represent collections of intermediate wheatgrass, whereas slender wheatgrass was sampled at the three mines in Montana. Although interspecific physiological differences in element uptake may occur, Figure 5 shows that for most elements, the effects due to differences among

FIGURE 5. Geometric means (solid circles) and their confidence intervals (0.05 probability level) for the element content and ash yield of wheatgrass (dry-weight basis) at 10 western surface-mined coal rehabilitation sites. Ten samples at each site were used in the calculation of the mean and interval. The plants sampled were: Wyoming mines -- crested wheatgrass; Colorado and North Dakota mines -- intermediate wheatgrass; and Montana mines -- slender wheatgrass.

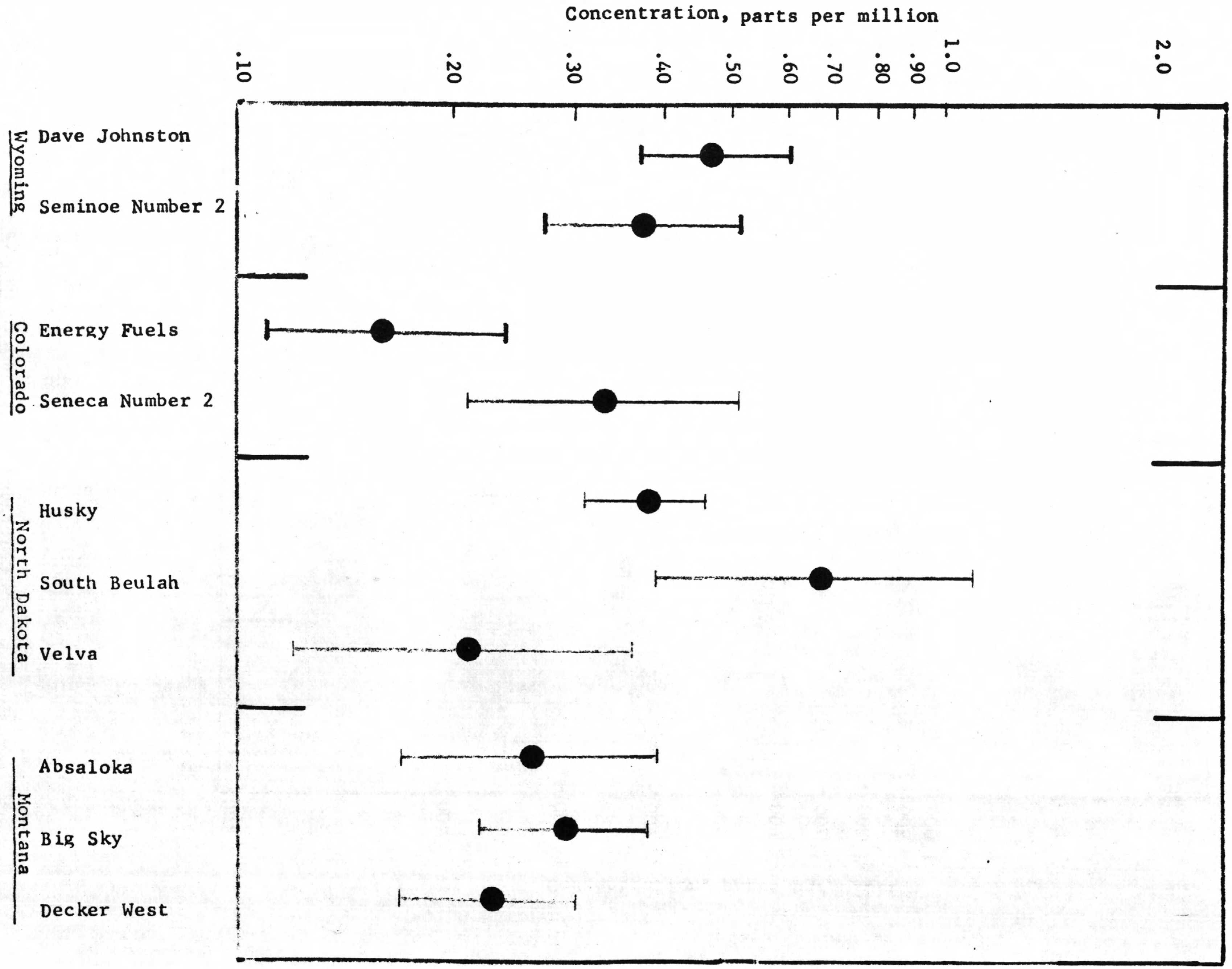

Yield, percent
10
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
Dave Johnston
Seminoe Number 2
Wyoming
Energy Fuels
Seneca Number 2
Colorado
Husky
South Beulah
Velva
North Dakota
Absaloka
Big Sky
Decker West
Montana

5A. Ash yield.

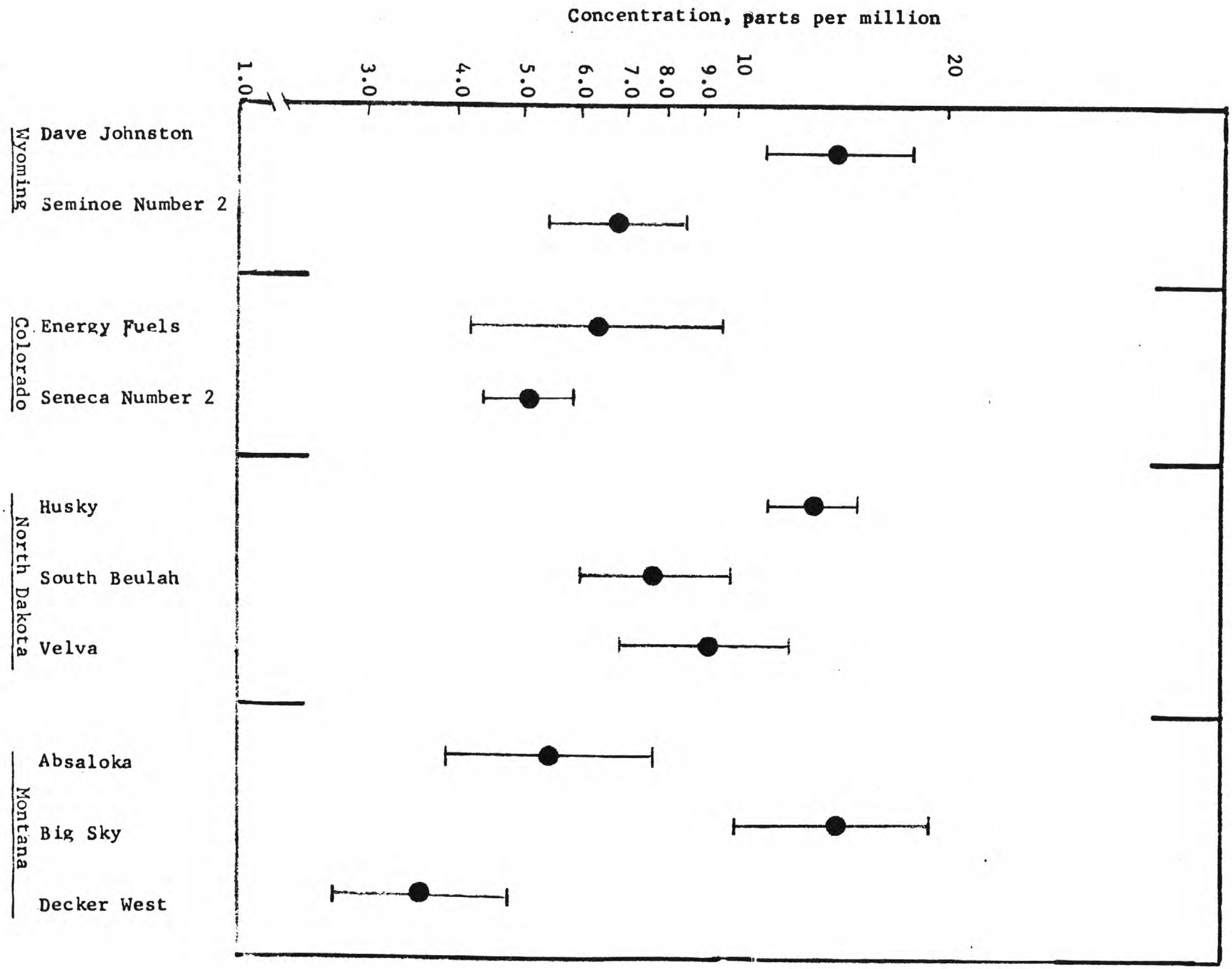


Concentration, parts per million
1,000
900
800
700
600
500
400
300
200
100
Dave Johnston
Seminoe Number 2
Wyoming
Energy Fuels
Seneca Number 2
Colorado
Husky
South Beulah
Velva
North Dakota
Absaloka
Big Sky
Decker West
Montana

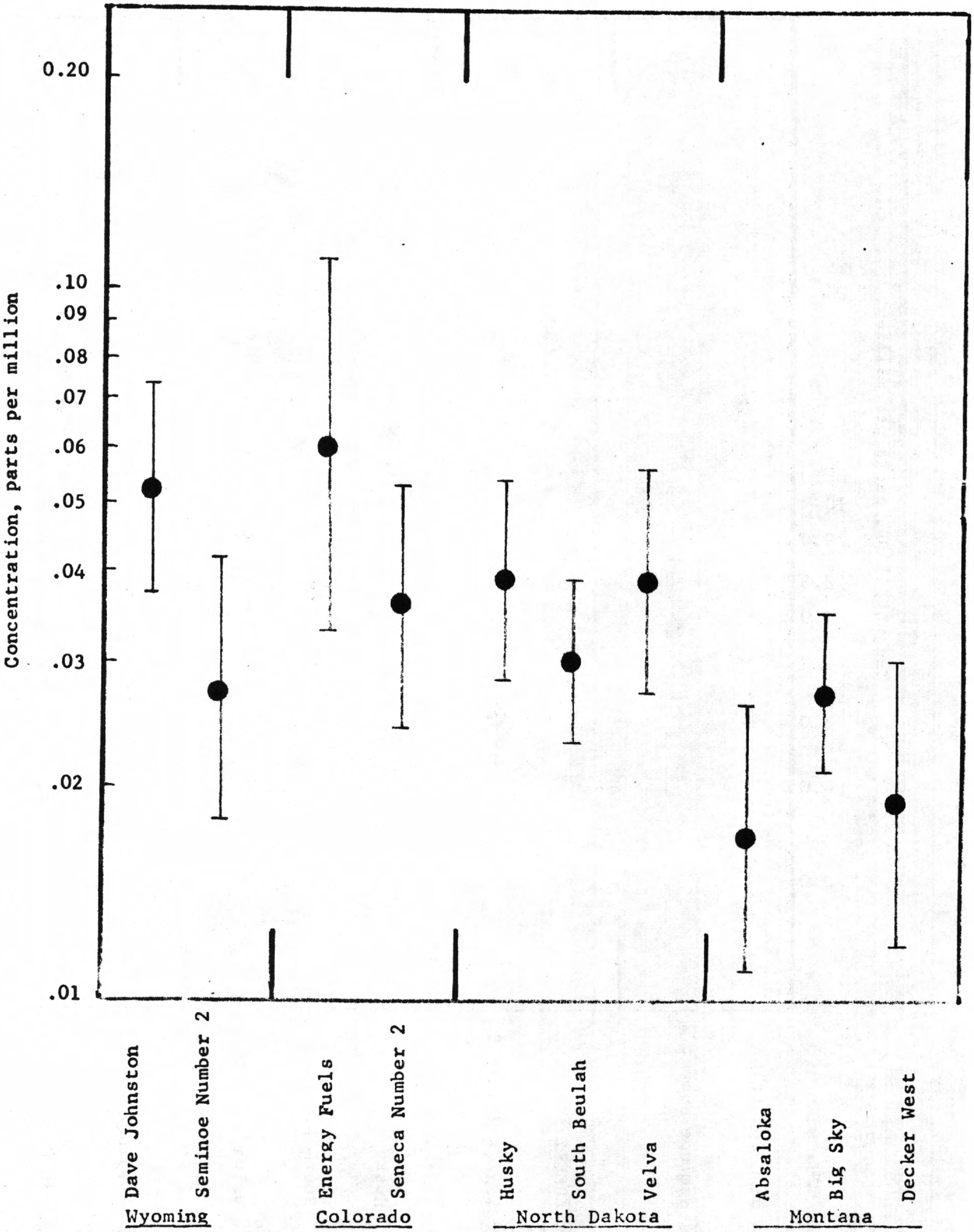
5B. Aluminum.


Concentration, parts per million
.10
.20
.30
.40
.50
.60
.70
.80
.90
1.0
2.0
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

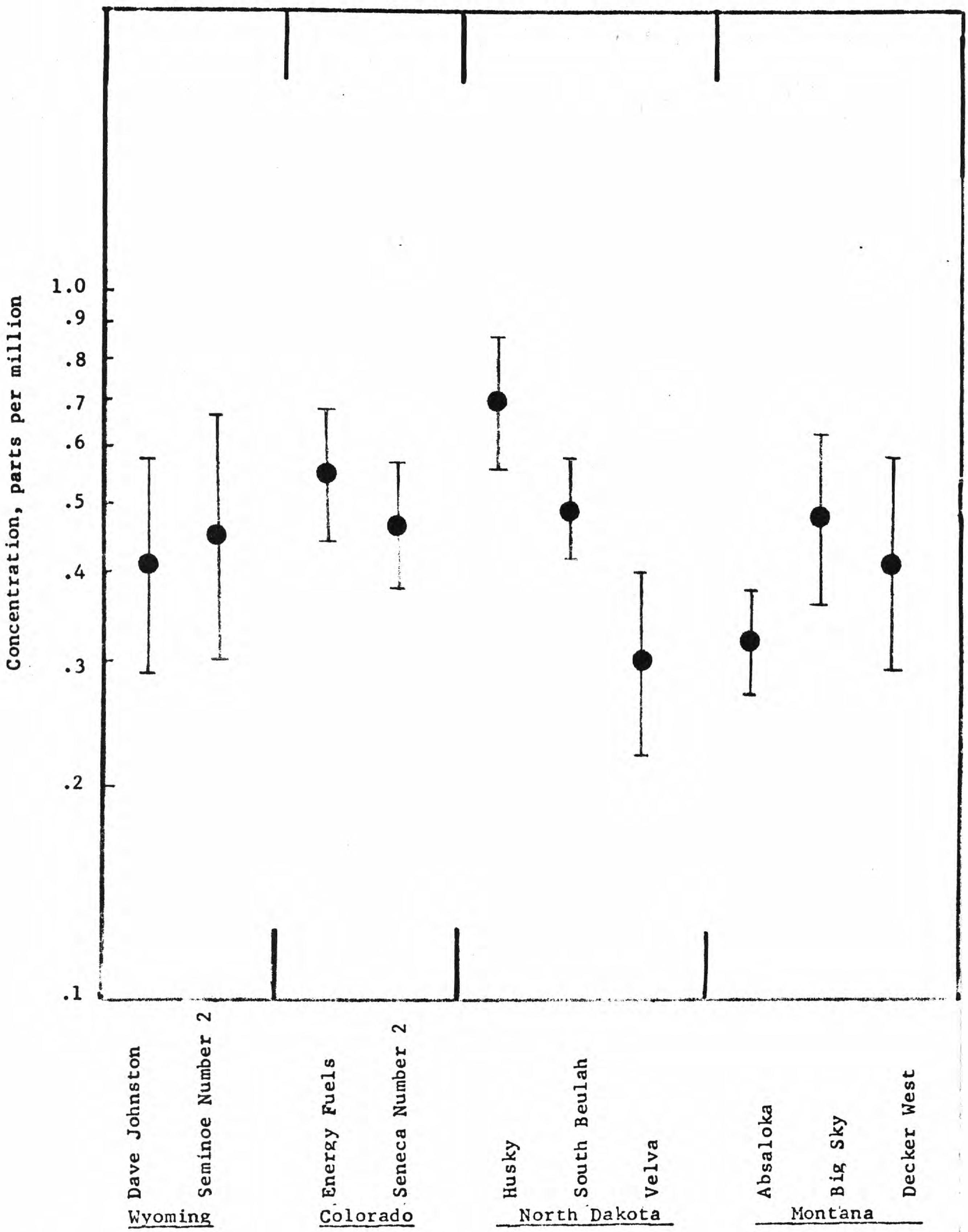
5C. Arsenic.


Concentration, parts per million
1.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10
20
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

5D. Boron.

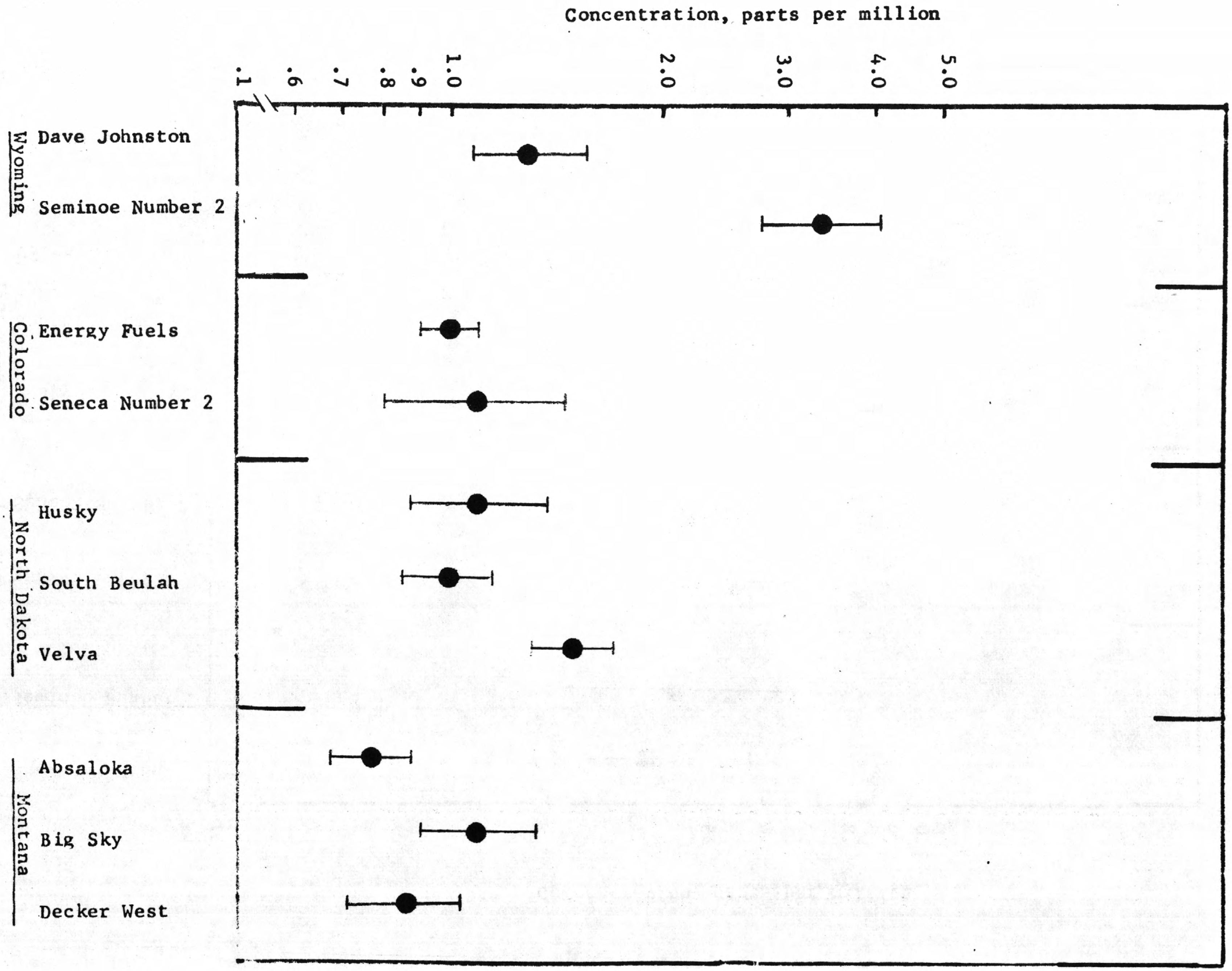

Concentration, parts per million
0.20
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
Dave Johnston
Seminoe Number 2
Energy Fuels
Seneca Number 2
Husky
South Beulah
Velva
Absaloka
Big Sky
Decker West
Wyoming
Colorado
North Dakota
Montana

5E. Cadmium.



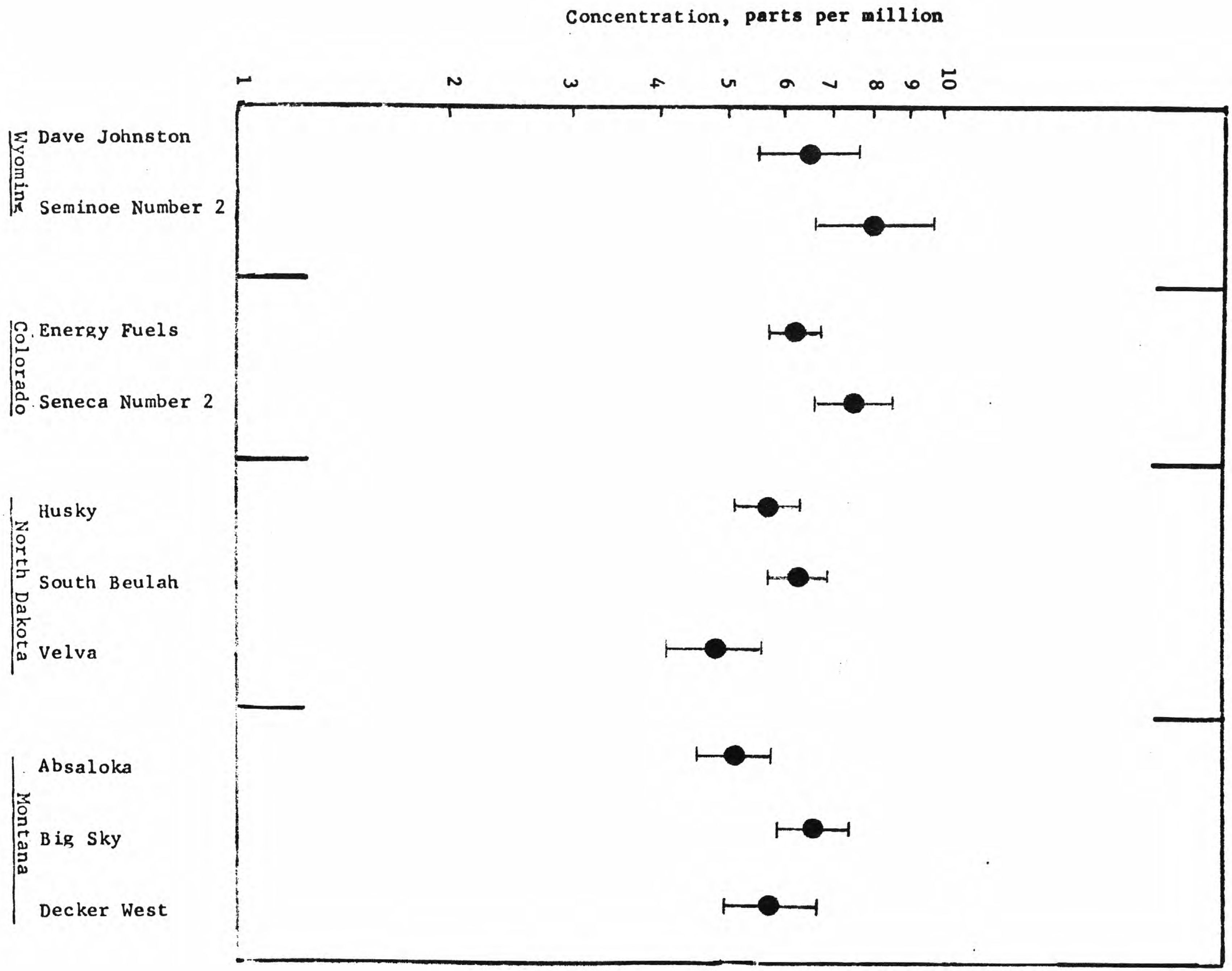
Concentration, parts per million
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
Dave Johnston
Seminoe Number 2
Wyoming
Energy Fuels
Seneca Number 2
Colorado
Husky
South Beulah
Velva
North Dakota
Absaloka
Big Sky
Decker West
Montana

5F. Chromium.

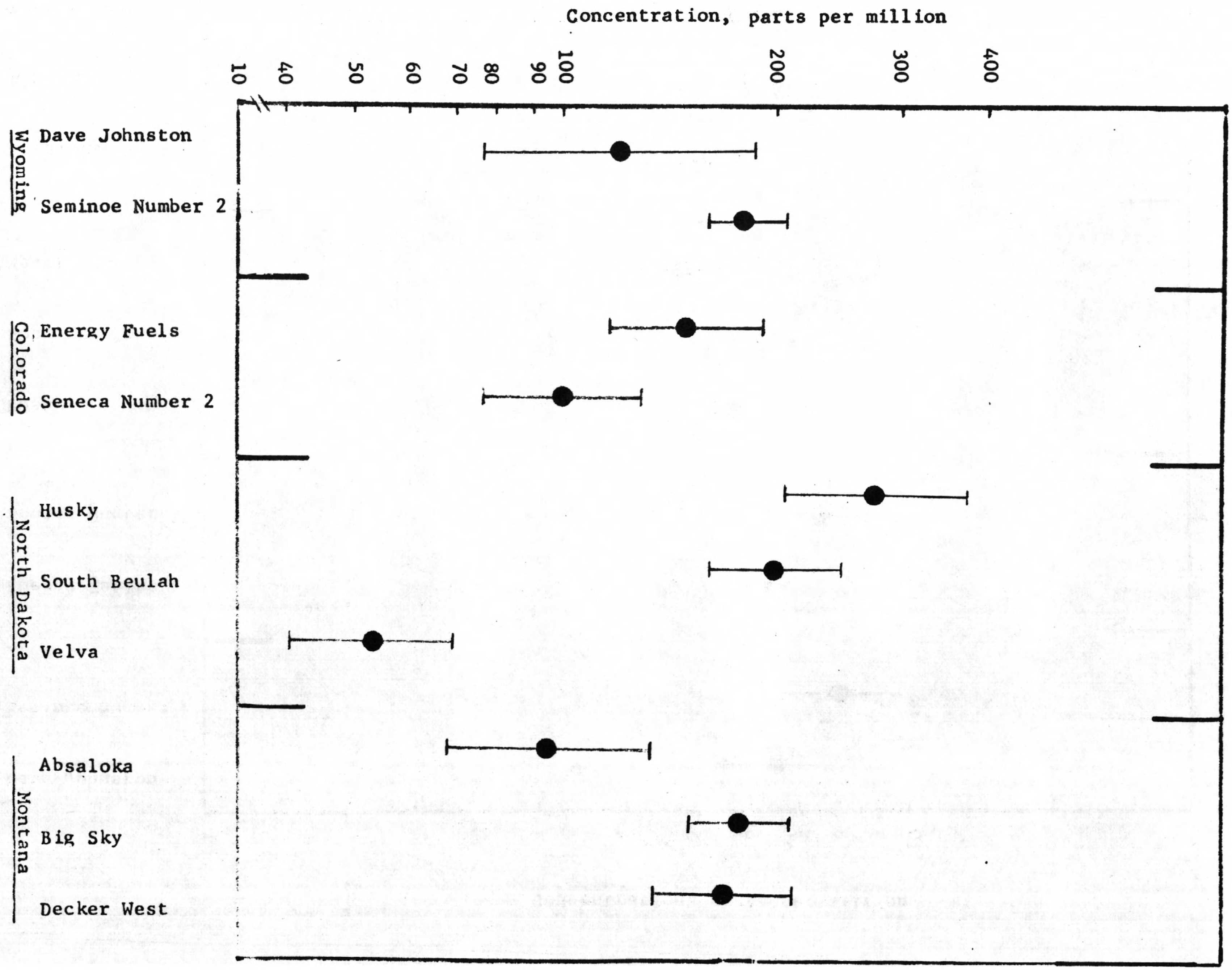

Concentration, parts per million
.1
.6
.7
.8
.9
1.0
2.0
3.0
4.0
5.0
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

5G. Copper.

5H. Fluorine.

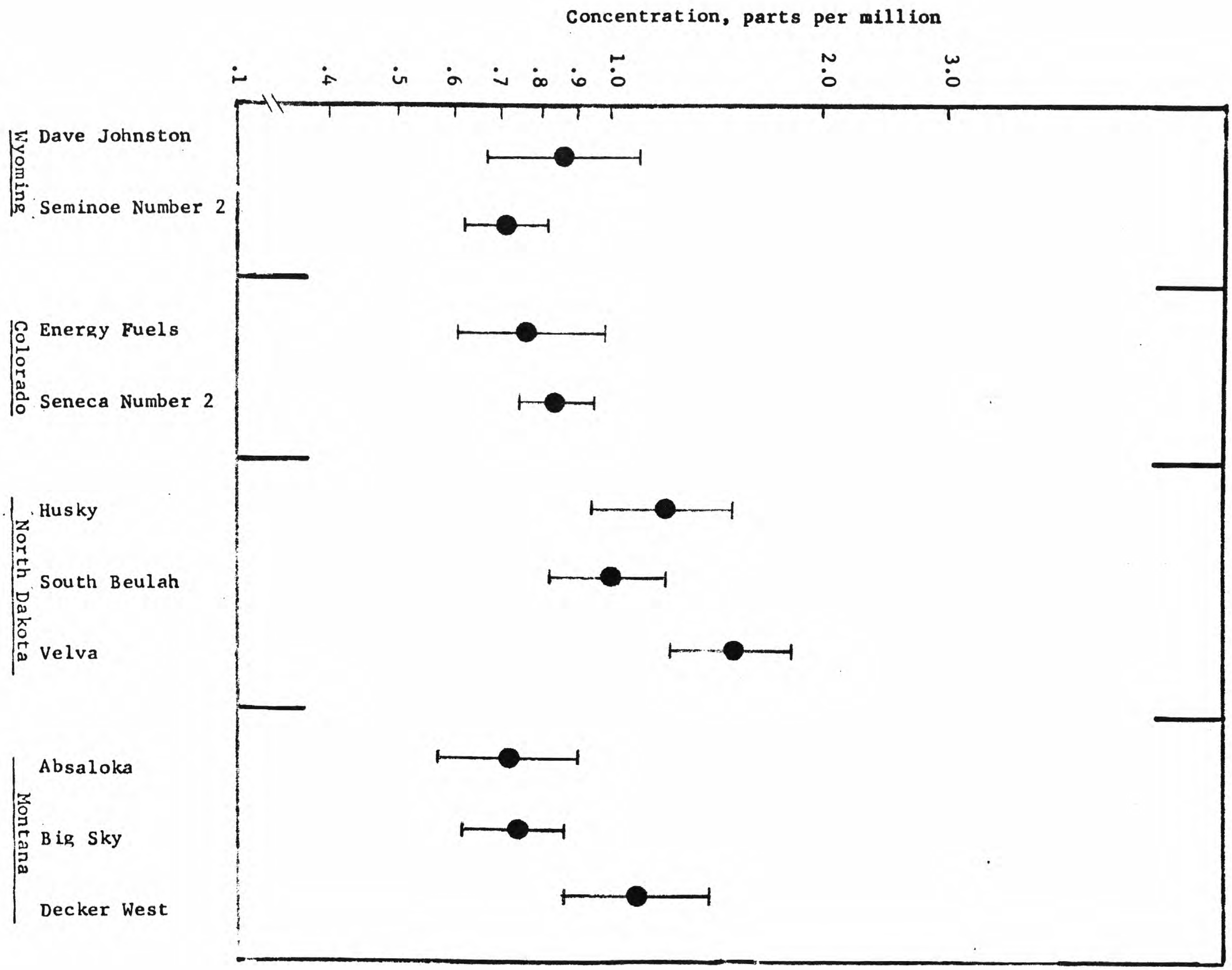


Concentration, parts per million
1
2
3
4
5
6
7
8
9
10
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

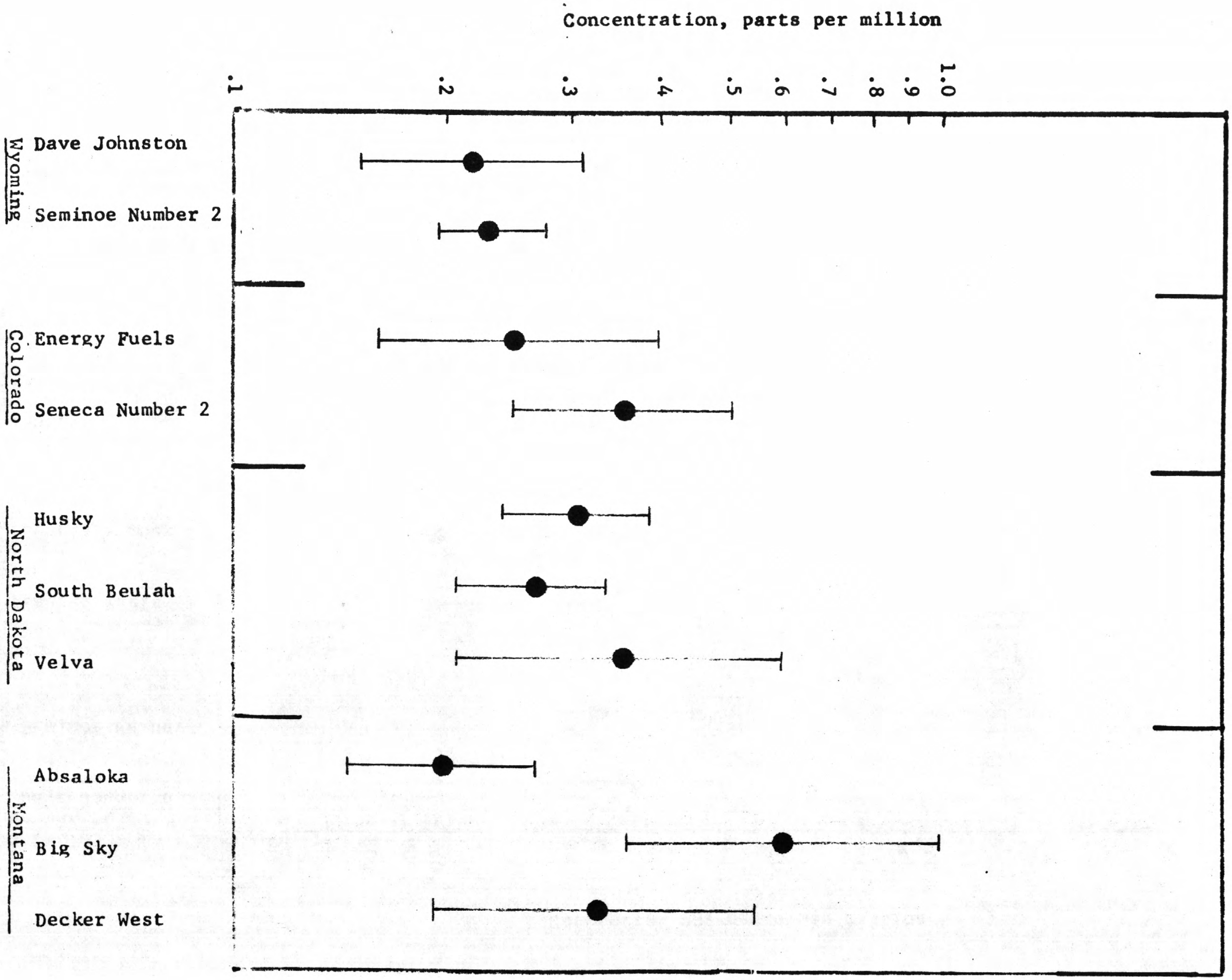

Concentration, parts per million
10
40
50
60
70
80
90
100
200
300
400
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

5I. Iron.

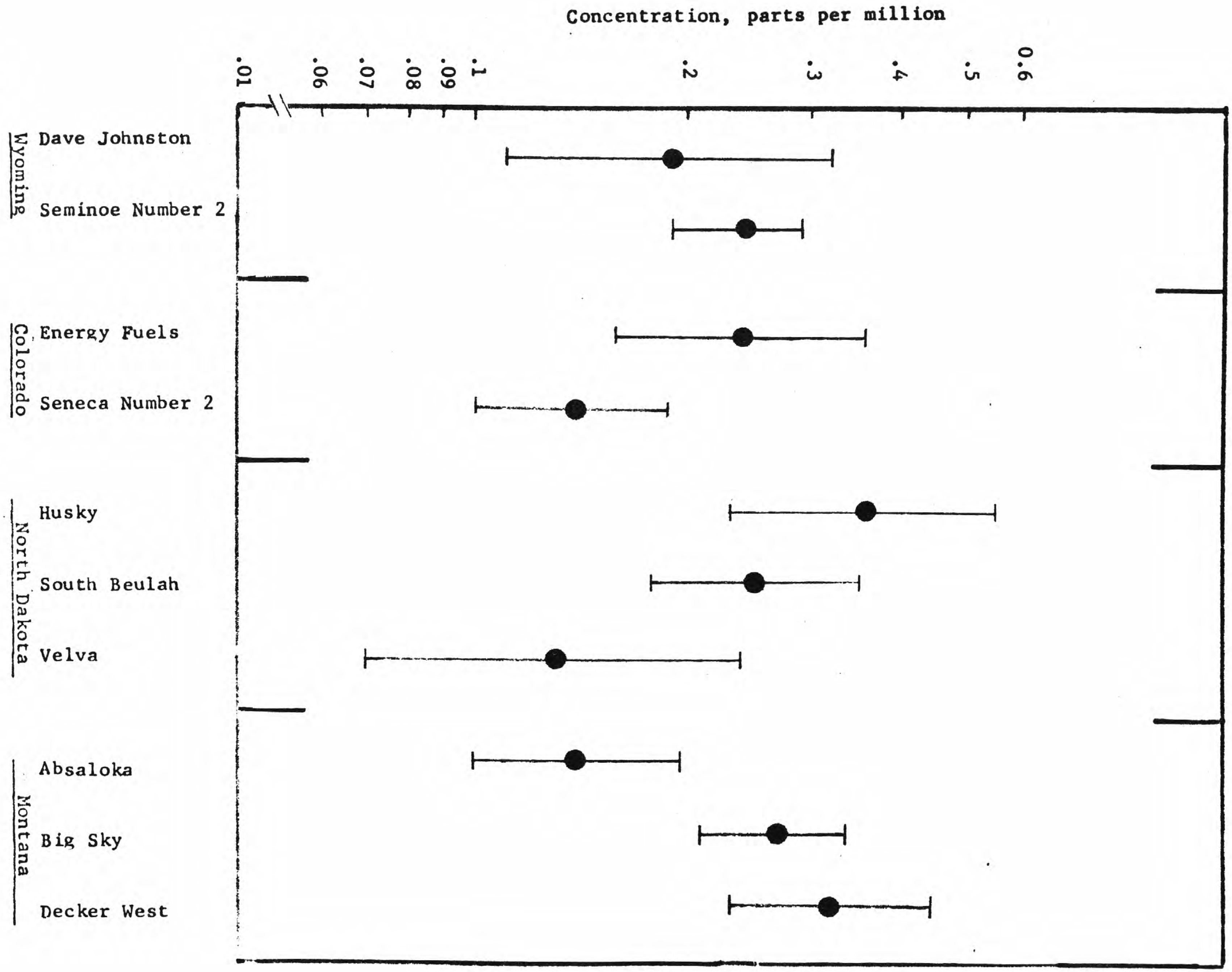
5J. Lead.



Concentration, parts per million
.1
.4
.5
.6
.7
.8
.9
1.0
2.0
3.0
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

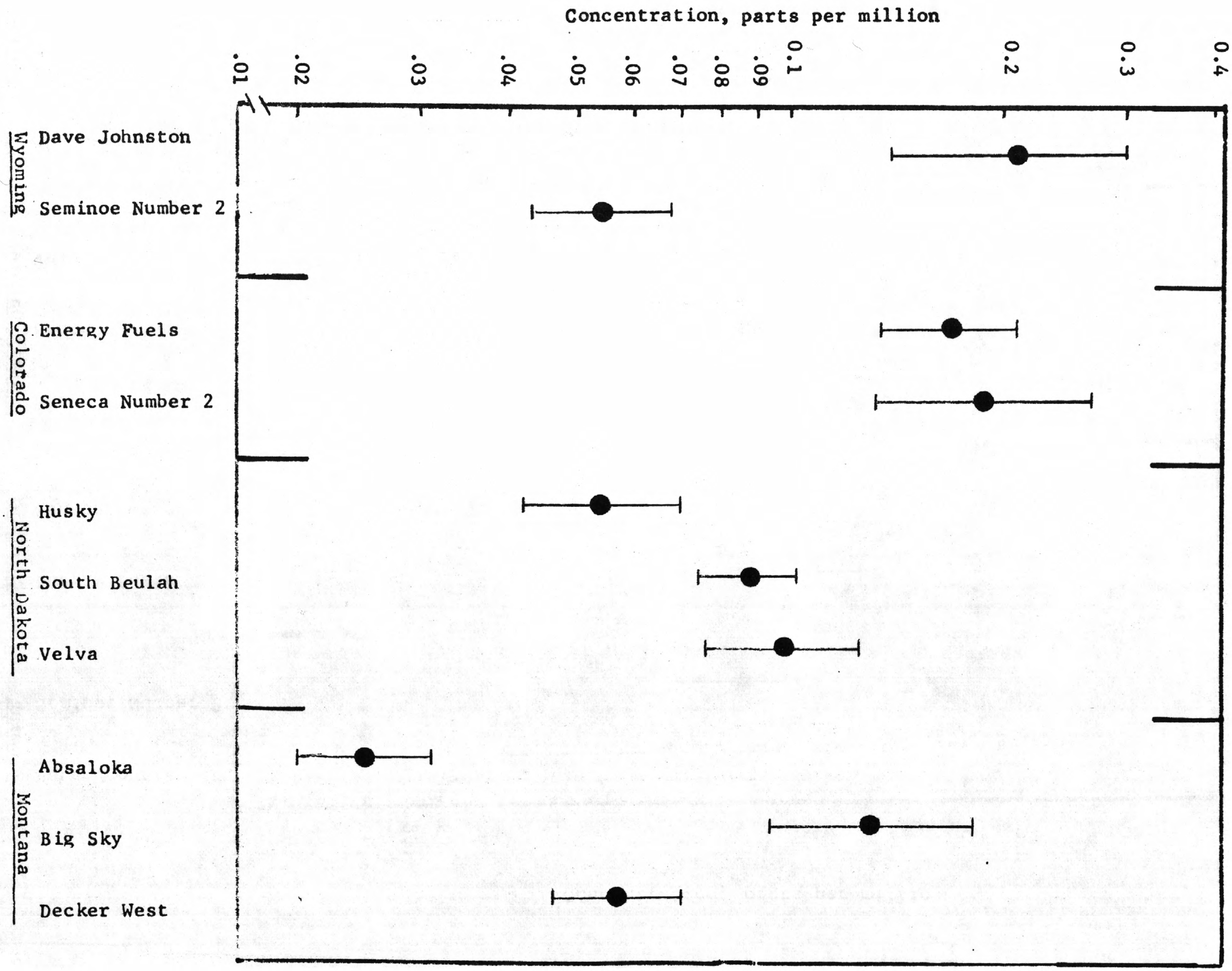


5M. Molybdenum.

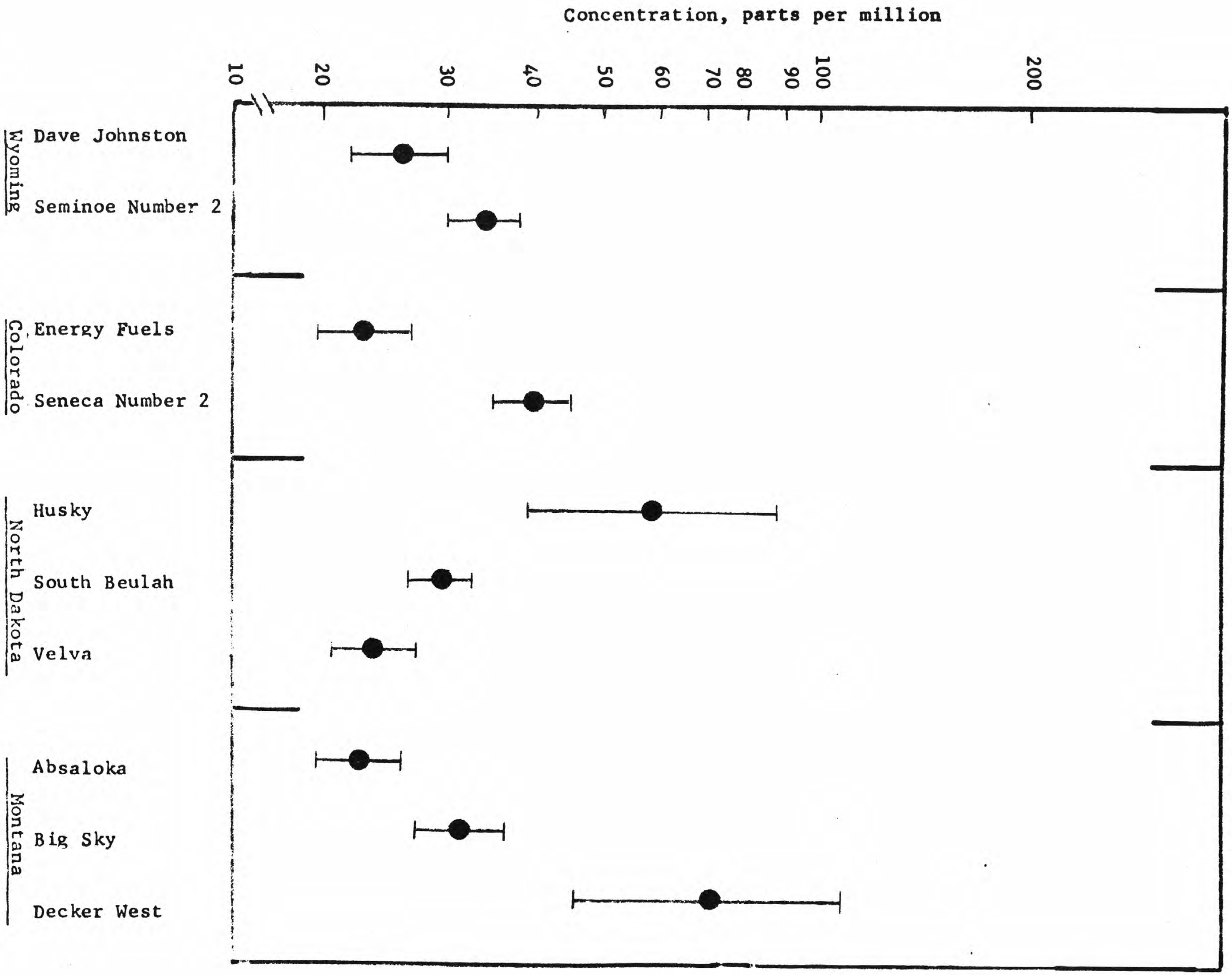


Concentration, parts per million
.01
.06
.07
.08
.09
.1
.2
.3
.4
.5
0.6
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

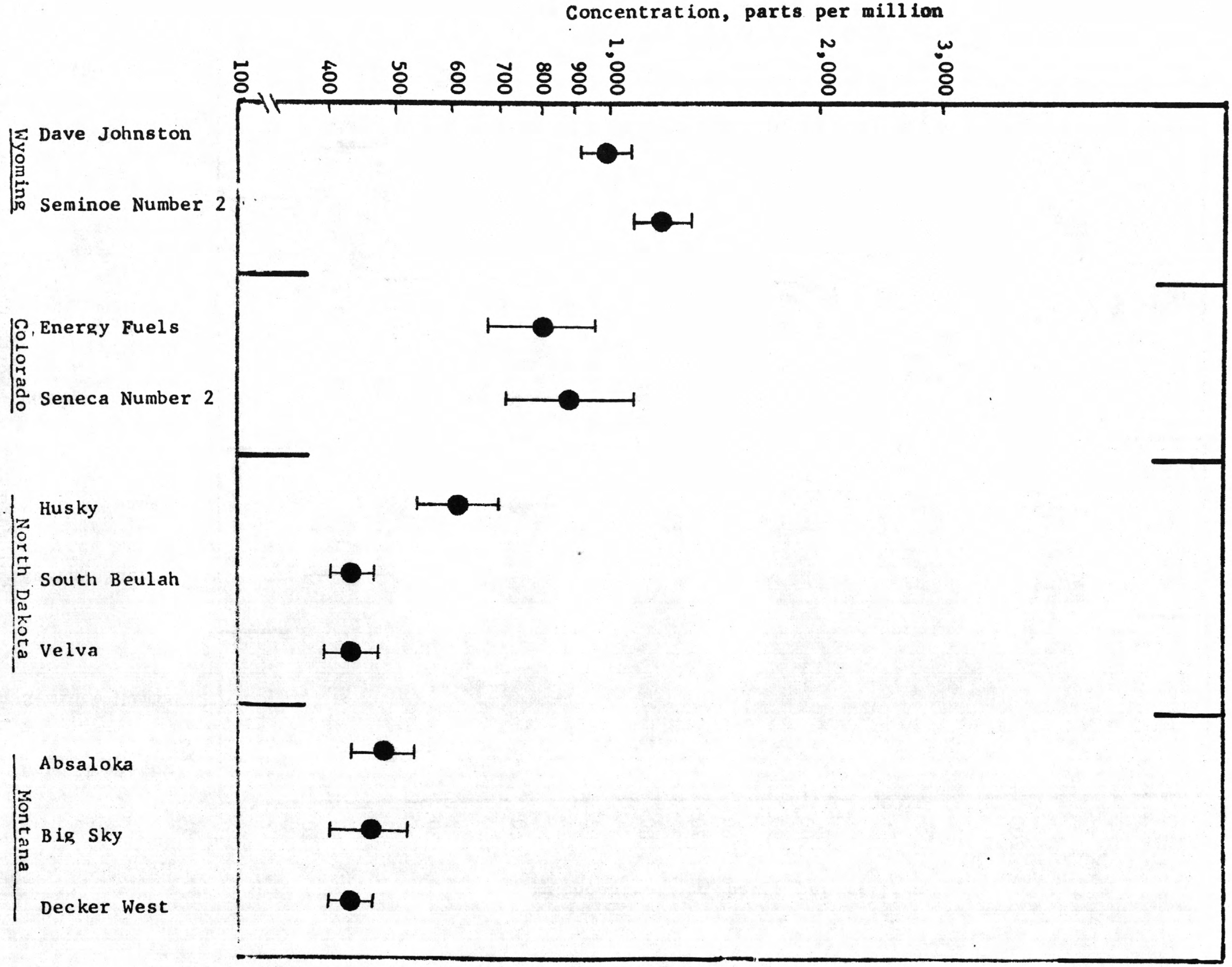
5N. Nickel.


Concentration, parts per million
.01
.02
.03
.04
.05
.06
.07
.08
.09
0.1
0.2
0.3
0.4
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

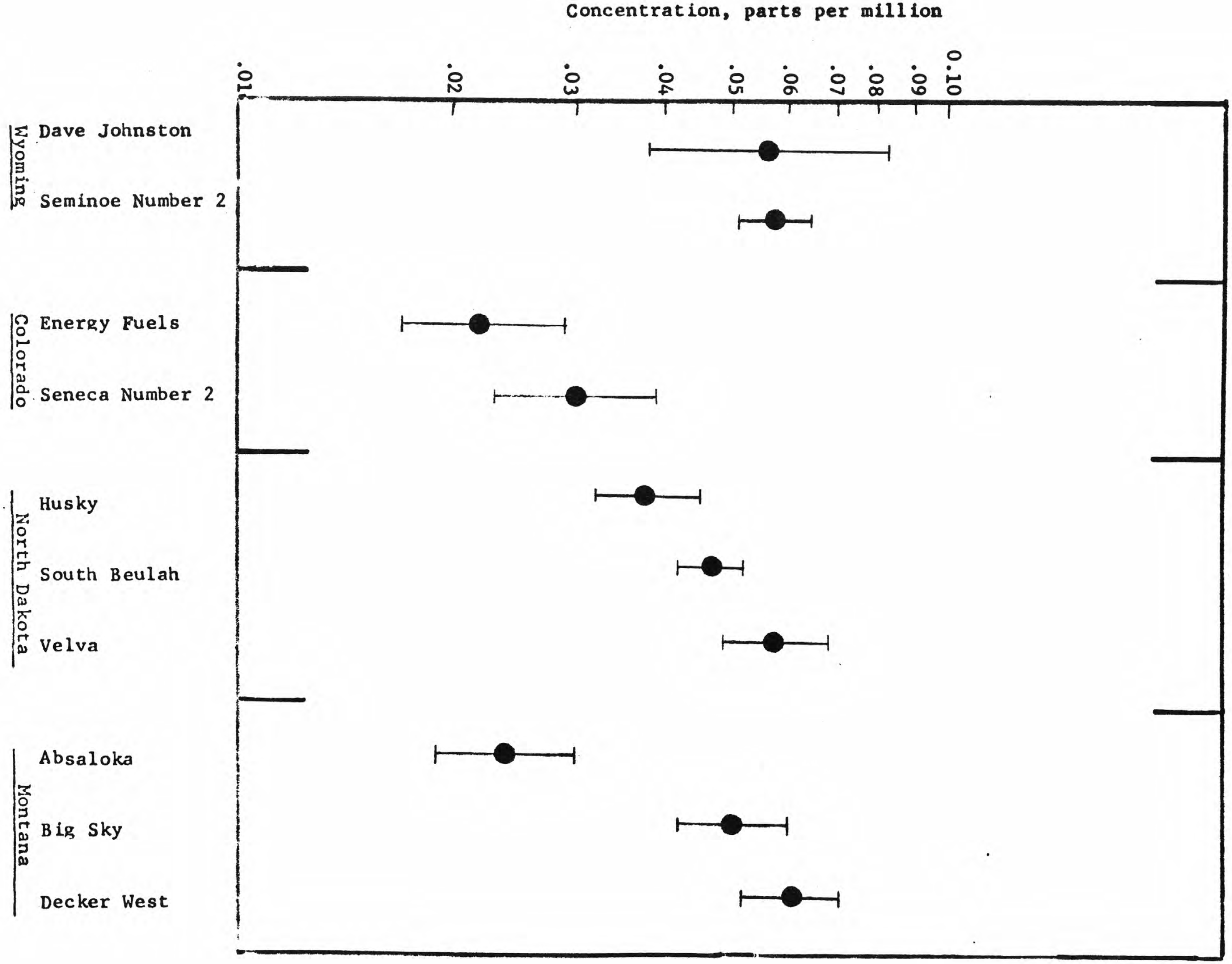
50. Selenium.


Concentration, parts per million
10
20
30
40
50
60
70
80
90
100
200
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

5P. Sodium.


Concentration, parts per million
100
400
500
600
700
800
900
1,000
2,000
3,000
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

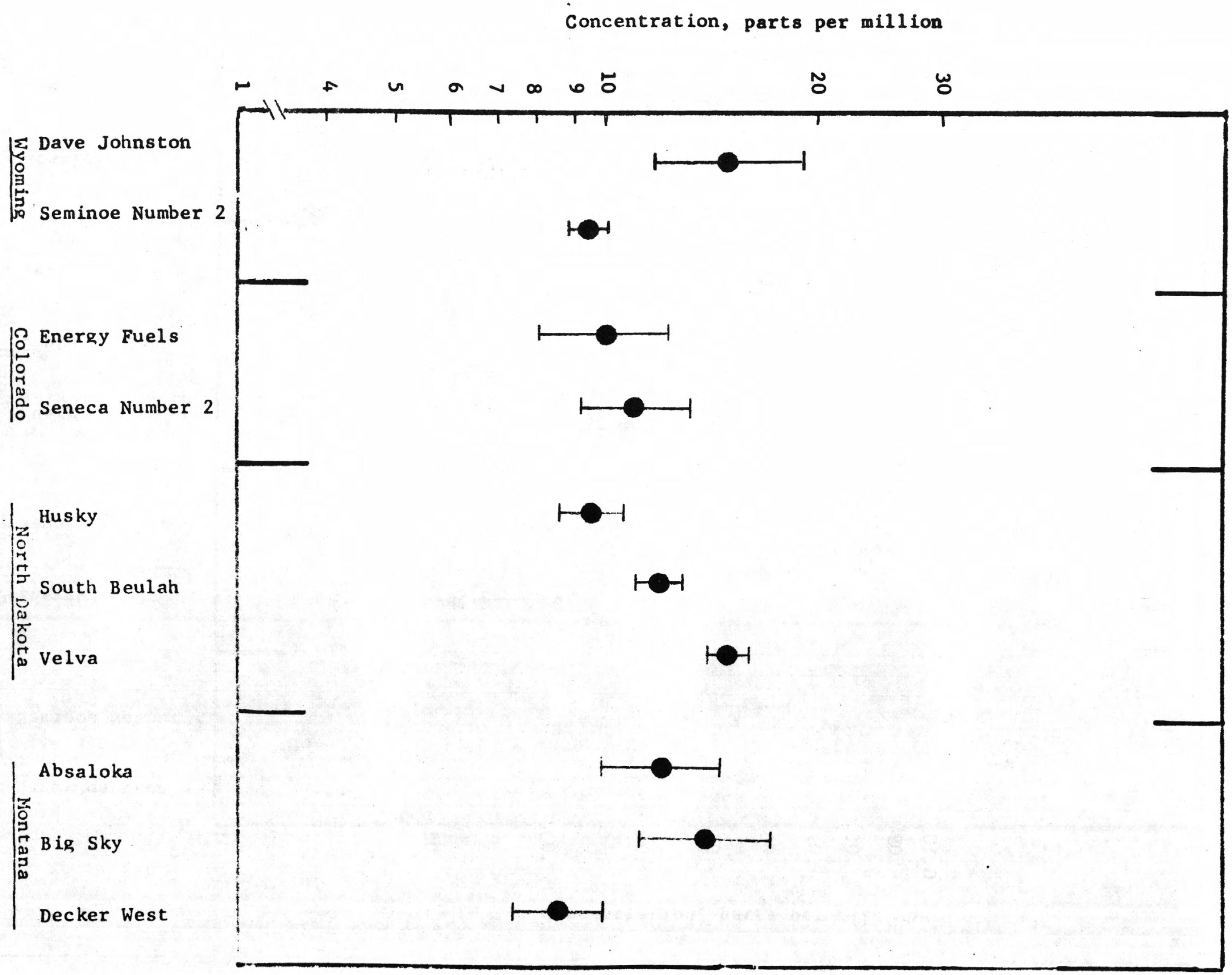
5Q. Sulfur.



Concentration, parts per million
.01
.02
.03
.04
.05
.06
.07
.08
.09
0.10
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

5R. Uranium.

5S. Zinc.



Concentration, parts per million
1
4
5
6
7
8
9
10
20
30
Wyoming
Dave Johnston
Seminoe Number 2
Colorado
Energy Fuels
Seneca Number 2
North Dakota
Husky
South Beulah
Velva
Montana
Absaloka
Big Sky
Decker West

mines apparently overwhelm any differences due to species. Good examples are the plots of boron, selenium, and sodium (fig. 5D, 5O, and 5P) that show little interspecific overlap among mines, whereas intermine differences are pronounced.

Assuming, then, that the local or mine-area environment is more important in determining the element composition of the wheatgrasses than is the inherent uptake characteristics of the three species, an examination of figure 5 reveals major compositional differences among mines. A qualitative assessment of high or low levels (concentrations) of selected elements at each mine (based on intermine comparisons) follows: Dave Johnston--boron, cadmium, selenium, sulfur, and uranium (high); Seminoe No. 2--copper, sulfur, and uranium (high); Energy Fuels--cadmium and selenium (high), arsenic and uranium (low); Seneca No. 2--selenium (high), nickel (low); Husky--boron, iron, lead, manganese, and sodium (high), nickel (low); South Beulah--arsenic and aluminum (high), sulfur (low); Velva--ash yield, lead, manganese, and uranium (high), aluminum, fluorine, iron, and sulfur (low); Absaloka--ash yield, nickel, selenium, sulfur, and uranium (low); Big Sky--boron, molybdenum, selenium, and uranium (high), ash yield and sulfur (low); Decker--lead, manganese, sodium, and uranium (high), boron and sulfur (low). High molybdenum was also found at the Big Sky mine (1.2-1.8 ppm, dry material) in the wheat grain samples (Appendix). This material was from an area that had 25-60 cm of topsoil placed over spoil previously reported to be high in available molybdenum (Erdman and others, 1978). The molybdenum levels in our wheat samples were similar to samples collected in 1974 (Erdman and Gough, 1979) from an area at the same mine but with only 10-15 cm of topsoil. It would appear, therefore, that increasing topsoil depth has not ameliorated the tendency of wheat to assimilate molybdenum.

The following elements showed only small differences among most of the mines: cadmium, chromium, fluorine, mercury, and zinc. There were no obvious element groupings by state, by wheatgrass species, or by mine; however, an analysis of the results of a Q-mode factor analysis, to examine further possible sample-site groupings, is pending.

Between-Mine Multiple-Mean Comparisons

Tables 3-7 list the geometric means for the concentration of 32, 33, or 34 elements (and ash yield) in plant materials sampled at 11 coal-stripmines. Each table shows the concentration means that are significantly different from one another for the same rehabilitation species among mines. Differences among mines, using like species, is assumed to reflect differences in the mine environment--specifically, differences in spoil and topsoil (minesoil) mineralogy, lithology, and bioavailability.

Crested Wheatgrass

Table 3 is a comparison of the concentrations of 34 elements in crested wheatgrass collected at two mines in Wyoming. Little difference between mines was noted for most (about 60 percent) of the elements. The wheatgrass at the Dave Johnston mine was highest in the concentration of boron, cadmium, selenium, and zinc, whereas the Seminoe No. 2 mine wheatgrass was highest in calcium, copper, fluorine, iron, nickel, potassium, sodium, and sulfur. The reason for the slight increase in the number of elements found to be at higher concentrations in the wheatgrass from the Seminoe No. 2 mine is unknown; however, the latter mine had no topsoil at the rehabilitation site visited.

Intermediate Wheatgrass

A comparison of the element content of intermediate wheatgrass collected at five mines in Colorado and North Dakota is given in Table 4. Although all the elements, except calcium, molybdenum, and niobium, showed significant differences in their means between at least two of the mines, these differences were usually only a factor of two or three. For example, although four of the five zinc means were found to be significantly different, the difference between the lowest and highest mean was less than a factor of two. A few elements did show substantial differences in their concentration levels among mines as is demonstrated by the following extreme high and low mine values (ppm dry material): aluminum--660 (Husky), 130 (Velva); potassium--12,000 (Seneca No. 2), 2,100 (South Beulah); iron--280 (Husky), 54 (Velva); magnesium--1,000 (Seneca No. 2), 440 (Velva); and selenium--0.19 (Seneca No. 2), 0.054 (Husky). The concentrations of such environmentally important elements as arsenic, boron, cadmium, cobalt, fluorine, lead, mercury, molybdenum, nickel, and uranium did not vary greatly between mines, and also did not occur in concentrations usually considered to be potentially toxic to plants or grazing animals (Gough, Shacklette, and Case, 1979).

Slender Wheatgrass

Table 5 gives the mean concentration of 34 elements in samples of slender wheatgrass collected at three coal-stripmines in Montana. A comparison of these means shows that over 90 percent of the elements show significant differences between at least two of the mines. The elements boron, beryllium, germanium, molybdenum, sodium, selenium, strontium, and uranium show large enough intermine differences to be segregated into three groups. Intermine differences in the element concentration means were always less than an order-of-magnitude. In general, concentrations of most elements were highest in samples from the Big Sky and Decker mines and lowest in samples from the Absaloka mine. The concentrations of potentially harmful elements in slender wheatgrass all appear to be well within acceptable (non-toxic) ranges.

Nutritional diseases in grazing cattle associated with a low macronutrient content of forage grown on rehabilitated areas is a potential problem in stripmine management (Erdman and Ebens, 1979). These authors report from the literature a minimum critical phosphorus level in dry forage material of about 0.13 percent. In another study Mayland and Grunes (1974) report from the literature a minimum critical level for magnesium in grasses to be about 0.2 percent. The concentrations of both these elements in crested, intermediate, and slender wheatgrass (tables 3, 4, and 5, respectively) are below the critical levels by factors of two to six. These levels should be re-evaluated earlier in the season by a resampling because the amount of phosphorus and magnesium are known to decrease as the plant undergoes senescence (Rittenhouse and Vavra, 1979). In any event, a nutritional supplement for cattle, grazing predominantly over rehabilitated areas, should be a management consideration at all the mines in this study.

Alfalfa

Alfalfa was collected at six mines in three states--Energy Fuels and Seneca No. 2 (Colorado); Big Sky (Montana); and Husky, South Beulah, and Velva (North Dakota). Table 6 gives the results of the multiple-mean comparison test for the concentration of 32 elements and ash yield. The ash yield of alfalfa ranged from a low of 4.8 percent for the Husky mine samples to a high of 9.0 percent for the Energy Fuels mine material. This rather large variability was due to the percentage of low ash-yielding stem to high ash-yielding leaf material in samples from individual mines. Table 1 reflects the fact that the samples from the Big Sky and Husky mines (low ash-yield mines) were composed mostly of stems and fruits (due to early frost-initiated leaf-drop), whereas samples from the other mines included leaf material. Because the Table 6 data are reported on a dry-weight basis, some of the concentration among between mines are due to ash yield-differences which in turn is due to the plant-material composition of the alfalfa collected.

The multiple-mean test of the six mines produced four or fewer concentration groupings per element--for most elements, the segregation was accomplished with only two or three groups. About 90 percent of the elements were segregated when the difference between means was less than a factor of five. The chemistry of alfalfa is fairly uniform among mines; however, differences shown by alfalfa are generally larger than those observed for wheatgrass. Large variability among mines was observed for alfalfa in the concentration of aluminum, cadmium, lithium, and sodium. The difference between the largest and smallest means among mines for each of these elements ranged between a factor of about five to ten. For example, samples of alfalfa from the Velva mine were an order-of-magnitude higher in their lithium concentrations than the lowest mean recorded at the Big Sky mine. Similar high lithium values in alfalfa sampled at the Velva mine were also found by J. A. Erdman (U.S. Geological Survey, Denver, unpub. data, 1974). Of interest is the fact that lithium was much higher in samples from all the North Dakota mines when compared to the other mines. Other pronounced intrastate or interstate trends, however, are not common.

The concentration of several of the environmentally important elements were considerably higher in alfalfa when compared to their concentration in wheatgrass. For example, boron and molybdenum were about five and ten times higher, respectively. A mean boron concentration of 66 ppm at the Velva mine may be borderline phytotoxic (Gupta, 1979), especially when one considers that individual values were as high as 130 ppm. Also, whereas molybdenum at concentrations of 1-3 ppm is not particularly unusual for dicots in the northern Great Plains, values of greater than 4 ppm, observed at the Big Sky and Velva mines, are unusual (Appendix table). Similar high molybdenum concentrations in sweetclover and alfalfa at the Big Sky mine, and their potential health effects on grazing cattle, have already been discussed by Erdman and Ebens (1979) and J. A. Erdman (U.S. Geological Survey, Denver, unpub. data, 1974). A reiteration of these considerations will not be presented here except to emphasize that a similar condition for potential molybdenum problems may exist at the Velva mine.

Fourwing Saltbush

Table 1 shows that whereas samples of fourwing saltbush from the Jim Bridger and Decker mines (Wyoming and Montana, respectively) were collected in September and October 1978, the samples from the San Juan mine, New Mexico, were collected as part of a separate study in August 1977. Some intermine differences, reported in Table 7, therefore, may be due to somewhat different sample handling procedures. Also, the number of samples varied among mines--the multiple-mean test, however, allowed for this difference.

Table 7 gives the results of the multiple-mean test for 33 elements and ash yield in fourwing saltbush. Except for concentrations of boron, phosphorus, selenium, and perhaps zinc (which were highest in samples from the Jim Bridger mine), the majority of the high element means were found in samples from the San Juan mine. For some elements the difference was considerable--for example, the means for barium, iron, mercury, vanadium, and zirconium were five to ten times greater. Of special note were the sodium concentrations in saltbush at the San Juan mine that were nearly twenty times greater than the Decker mine samples. The Jim Bridger samples were also high in sodium. The saline-sodic minesoil conditions of the more arid mine-sites (San Juan and Jim Bridger mines) were undoubtedly responsible for this pronounced difference (Severson and Gough, 1981).

The concentration means for the elements in fourwing saltbush show that only one potentially phytotoxic condition exists at these mines. The extremely high boron levels found at the Jim Bridger mine are of concern. Although the mean value was 220 ppm, the range of ten samples was from 110-610 ppm (Appendix table). This mean is two times greater than the high boron mean recorded for samples of alfalfa from the Velva mine. We reported (Severson and Gough, 1981) that the hot-water-extractable boron levels in both replaced topsoil and spoil at the Jim Bridger mine were about five times greater than levels at the other mines. Extractable boron in topsoil ranged from 2.5 to 9.5 ppm and in spoil from 8.0 to 26 ppm. These water-soluble boron levels must be considered detrimental to all but the most boron-tolerant species. Further, the unusually high boron levels in fourwing saltbush is evidence that the boron in the minesoils is in an form available for plant assimilation.

Rehabilitation Species Summary Data

Tables 9 through 28 list the summary statistics for the concentration of elements in the rehabilitation species sampled. Only data for the 11 mines that made up the major mine comparison study (table 1) are given. These data are presented to aid those most interested in assessing the individual composition of a given species at a given mine, and basically they summarize the information presented in the Appendix table. For those elements with variable lower limits of analytical determination (see the Appendix table) we took a most conservative approach, and, in Tables 9 through 28, list only the largest less-than values. For example, in Table 9, a lower limit of determination value for cobalt of <0.060 ppm is given even though the Appendix table lists four values that range from 0.054 to 0.060 ppm. In some instances this results in the unusual circumstance (for example, see lanthanum in table 10) where the less-than value is larger than a non-less-than value. Only one instance of variable upper limits of determination is given (strontium in alfalfa at the South Beulah mine) and only the lowest greater-than value is listed (table 23).

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APPENDIX TABLE

APPENDIX

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska

Sample	Latitude	Longitude	Ash %	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Ca %	Cd ppm
				Slender wheatgrass, Big Sky Mine, Montana						
BS01AE	45 49 15	106 36 15	3.3	594	.20	36.3	6.6	.109	.18	.033
BS02AE	45 49 15	106 36 15	5.0	650	.40	21.0	7.0	.170	.19	<.020
BS03AE	45 49 15	106 36 15	3.3	627	.30	23.8	8.3	.073	.20	.013
BS04AE	45 49 15	106 36 15	3.2	480	.20	9.3	7.4	.109	.17	.026
BS05AE	45 49 15	106 36 15	3.6	284	.40	9.0	10.1	<.072	.22	.022
BS06AE	45 49 15	106 36 15	3.4	408	.30	11.6	5.8	.122	.20	.027
BS07AE	45 49 15	106 36 15	3.7	740	.25	12.2	13.3	.159	.19	.044
BS08AE	45 49 15	106 36 15	3.5	329	.15	6.0	6.3	.088	.17	.042
BS09AE	45 49 15	106 36 15	4.0	640	.25	14.8	17.2	.200	.19	.040
BS10AE	45 49 15	106 36 15	4.8	528	.70	22.1	10.1	.110	.22	.029
				Alfalfa, Big Sky Mine, Montana						
BS01MS	45 49 15	106 36 15	4.7	470	.40	70.5	8.9	<.094	1.08	.056
BS02MS	45 49 15	106 36 15	5.0	500	.85	65.0	10.0	<.100	1.15	.030
BS03MS	45 49 15	106 36 15	5.0	1,400	.20	75.0	19.5	<.100	1.10	.050
BS04MS	45 49 15	106 36 15	5.2	936	.20	39.0	16.6	<.104	.99	.062
BS05MS	45 49 15	106 36 15	5.6	1,176	.20	89.6	17.4	.123	1.18	.056
BS06MS	45 49 15	106 36 15	4.7	611	.40	32.9	6.1	<.094	1.03	.047
BS07MS	45 49 15	106 36 15	5.6	442	.20	30.8	7.3	<.112	1.34	.034
BS08MS	45 49 15	106 36 15	4.6	294	.20	25.8	3.5	<.092	1.10	.055
BS09MS	45 49 15	106 36 15	6.1	793	.40	33.6	17.1	<.122	1.40	.024
BS10MS	45 49 15	106 36 15	6.3	693	.45	69.3	8.8	<.126	1.45	<.025
				Alfalfa control, Big Sky Mine, Montana						
BS11MS	45 49 15	106 36 15	4.6	143	.10	23.0	30.4	<.092	.78	.037
BS12MS	45 49 15	106 36 15	4.0	180	.20	31.2	44.0	<.080	.60	.024
BS13MS	45 49 15	106 36 15	4.8	211	.35	48.0	44.6	<.096	.82	<.019
				Winter wheat, Big Sky Mine, Montana						
BS01TA	45 49 15	106 36 15	1.5	--	--	--	--	--	--	.075
BS02TA	45 49 15	106 36 15	1.3	--	--	--	--	--	--	.143
BS03TA	45 49 15	106 36 15	1.5	--	--	--	--	--	--	.060
				Slender wheatgrass, Decker Mine, Montana						
DE01AE	45 2 30	106 49 8	8.2	287	.15	3.8	22.1	.189	.21	.033
DE02AE	45 2 30	106 49 8	6.1	403	.40	3.8	26.8	.140	.20	<.024
DE03AE	45 2 30	106 49 8	4.0	396	.20	2.6	15.6	.100	.16	<.016
DE04AE	45 2 30	106 49 8	4.5	495	.30	4.1	18.9	.248	.15	.054
DE05AE	45 2 30	106 49 8	5.4	443	.15	4.1	15.7	.189	.16	<.022
DE06AE	45 2 30	106 49 8	4.7	564	.20	5.2	19.7	.211	.13	.023
DE07AE	45 2 30	106 49 8	5.5	424	.20	2.3	12.1	.127	.18	.055
DE08AE	45 2 30	106 49 8	6.0	528	.15	6.6	19.2	.300	.18	.024
DE09AE	45 2 30	106 49 8	5.5	292	.45	1.4	7.2	<.110	.21	<.022
DE10AE	45 2 30	106 49 8	5.8	812	.35	5.8	33.1	.261	.22	<.023

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska

Sample	Ce ppm	Co ppm	Cr ppm	Cu ppm	F ppm	Fe ppm	Ge ppm	Hg ppm	K %	La ppm
Slender wheatgrass, Big Sky Mine, Montana										
BS01AE	<3.1	.033	.63	1.16	8	198	.109	.03	.32	.43
BS02AE	<4.7	.050	.34	1.00	7	275	.170	.02	.32	1.90
BS03AE	3.6	.066	.66	1.98	9	185	.106	.02	.28	.46
BS04AE	<3.0	.064	.54	.96	7	189	.099	.01	.35	<.30
BS05AE	<3.3	.072	.32	1.44	6	115	<.072	.02	.58	.54
BS06AE	<3.2	.068	.41	.85	5	160	.197	.03	.41	.34
BS07AE	5.2	.074	.78	1.48	5	233	.185	.02	.44	1.89
BS08AE	<3.3	.035	.20	.70	7	119	.098	.03	.22	<.33
BS09AE	4.8	.040	.68	1.00	6	188	<.080	.02	.52	.40
BS10AE	<4.5	.096	.62	.96	7	211	<.096	.02	.35	1.10
Alfalfa, Big Sky Mine, Montana										
BS01MS	4.4	.094	.47	6.58	8	155	<.094	.01	.61	.61
BS02MS	<4.7	.100	.41	6.50	7	160	<.100	.03	.55	.50
BS03MS	5.0	.100	.85	7.75	7	375	<.100	.04	.34	2.00
BS04MS	5.0	.156	.78	4.68	8	265	<.104	.01	.73	.83
BS05MS	8.4	.168	.95	10.08	7	431	<.112	.04	.73	3.08
BS06MS	<4.4	.094	.47	8.93	8	235	<.094	.02	.42	.70
BS07MS	<5.2	.056	.35	7.84	7	174	<.112	.09	.36	1.18
BS08MS	<4.3	.184	.38	9.20	5	193	<.092	.01	.42	1.01
BS09MS	<5.7	.122	.57	7.32	8	220	.128	.02	.57	.85
BS10MS	<5.9	.063	.61	8.82	8	221	<.126	.02	.48	1.01
Alfalfa control, Big Sky Mine, Montana										
BS11MS	<4.3	.046	.21	2.76	7	69	<.092	.01	.83	.74
BS12MS	<3.7	<.040	.36	2.40	5	104	<.080	.02	.64	.92
BS13MS	<4.5	<.048	.40	4.08	8	115	<.096	.01	.72	1.44
Winter wheat, Big Sky Mine, Montana										
BS01TA	--	--	--	--	--	--	--	--	--	--
BS02TA	--	--	--	--	--	--	--	--	--	--
BS03TA	--	--	--	--	--	--	--	--	--	--
Slender wheatgrass, Decker Mine, Montana										
DE01AE	<7.6	.082	.37	.82	6	107	.410	.01	.36	<.76
DE02AE	<5.7	.183	.45	.92	6	140	.214	.02	.20	<.57
DE03AE	<3.7	<.040	.38	.40	6	124	.176	.02	.16	<.37
DE04AE	5.4	.045	.63	1.13	5	239	.252	.01	.16	.45
DE05AE	<5.0	.108	.53	.81	8	162	.227	.01	.19	1.73
DE06AE	5.2	.047	.66	.94	3	216	.249	.01	.18	2.16
DE07AE	<5.1	<.055	.36	1.10	7	149	.138	.02	.24	.51
DE08AE	<5.6	<.060	<.12	.90	4	192	.324	.02	.34	.60
DE09AE	<5.1	<.055	.36	.83	6	116	.121	.01	.33	<.51
DE10AE	7.5	.058	.87	1.16	7	354	.278	.02	.20	<.54

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska

Sample	Li ppm	Mg %	Mn ppm	Mo ppm	Na ppm	Nb ppm	Ni ppm	P %	Pb ppm
				Slender wheatgrass, Big Sky Mine, Montana					
BS01AE	.26	.092	16	.73	46	.33	.36	.018	.73
BS02AE	<.20	.095	25	.37	30	.85	.34	.023	.85
BS03AE	.30	.092	22	1.02	28	<.31	.33	.023	.76
BS04AE	.13	.058	21	.23	32	.30	.30	.019	.77
BS05AE	.29	.072	28	.40	31	<.33	.14	.022	.54
BS06AE	.14	.068	15	.68	27	<.32	.18	.017	.58
BS07AE	.19	.104	36	1.48	31	.81	.37	.031	.89
BS08AE	.14	.056	19	.19	21	<.33	.15	.019	.46
BS09AE	.20	.068	108	2.56	34	.88	.38	.020	1.08
BS10AE	.43	.106	24	.53	48	<.45	.32	.019	.96
				Alfalfa, Big Sky Mine, Montana					
BS01MS	.56	.282	8	2.26	141	<.44	.75	.061	.70
BS02MS	.30	.370	9	11.50	50	<.46	.39	.050	.65
BS03MS	.45	.455	80	7.00	38	1.15	1.30	.050	1.25
BS04MS	.73	.364	52	3.64	99	.62	.51	.047	1.09
BS05MS	.56	.538	62	6.72	151	.90	1.96	.095	1.34
BS06MS	.42	.517	8	3.57	47	.42	1.27	.075	.61
BS07MS	.62	.672	16	3.36	123	.73	2.02	.056	.67
BS08MS	.37	.451	97	2.44	55	<.43	.87	.023	.46
BS09MS	.67	.512	36	3.42	73	<.57	.46	.043	.67
BS10MS	.69	.693	38	4.66	120	<.59	.37	.057	.76
				Alfalfa control, Big Sky Mine, Montana					
BS11MS	.23	.423	6	.46	21	<.43	<.09	.060	.64
BS12MS	.56	.560	12	3.32	76	.39	.10	.040	.80
BS13MS	.96	.576	9	1.73	38	.53	.13	.067	.77
				Winter wheat, Big Sky Mine, Montana					
BS01TA	--	--	--	1.3	--	--	--	.249	--
BS02TA	--	--	--	1.2	--	--	--	.192	--
BS03TA	--	--	--	1.8	--	--	--	.204	--
				Slender wheatgrass, Decker Mine, Montana					
DE01AE	1.31	.123	31	2.21	37	<.76	.22	.045	.98
DE02AE	.24	.061	31	.16	40	<.57	.18	.027	1.16
DE03AE	<.16	.048	34	.12	40	<.37	.22	.024	.64
DE04AE	.32	.054	86	.43	171	.59	.59	.027	1.35
DE05AE	.27	.059	50	.26	162	.70	.33	.027	1.24
DE06AE	.52	.066	94	.38	240	1.08	.52	.021	1.79
DE07AE	.61	.066	66	.18	66	<.51	.19	.019	.77
DE08AE	.48	.090	162	.53	42	.96	.58	.033	1.38
DE09AE	.39	.088	61	.18	61	<.51	.20	.028	.66
DE10AE	<.23	.070	87	.50	55	.93	.70	.023	1.91

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska

Sample	Se ppm	Sr ppm	S ppm	Ti ppm	U ppm	V ppm	Y ppm	Zn ppm	Zr ppm
Slender wheatgrass, Big Sky Mine, Montana									
BS01AE	.20	9.9	550	10.9	.079	.53	.31	25.7	.82
BS02AE	.10	9.0	400	13.0	.040	.65	.45	12.0	1.05
BS03AE	.20	8.6	700	14.8	.026	.59	.40	17.2	1.29
BS04AE	.15	7.0	400	9.6	.051	.32	.26	16.0	.51
BS05AE	.08	5.0	550	5.0	.058	.21	.15	15.5	.47
BS06AE	.15	5.8	400	7.5	.054	.25	.21	19.7	.48
BS07AE	.10	14.1	450	14.4	.044	.85	.44	9.6	1.30
BS08AE	.04	4.9	400	5.3	.056	.18	.15	8.1	.39
BS09AE	.15	15.2	400	12.4	.048	.68	.40	12.0	1.72
BS10AE	.25	8.6	500	13.0	.058	.67	.38	16.3	1.10
Alfalfa, Big Sky Mine, Montana									
BS01MS	.30	32.0	1,200	8.9	.038	.56	.39	40.4	1.17
BS02MS	.10	26.0	1,200	9.5	.060	.41	.39	14.5	1.50
BS03MS	.30	100.0	1,400	22.0	.040	1.30	.75	38.5	3.10
BS04MS	.20	35.4	1,000	19.2	.021	.88	.57	28.6	2.13
BS05MS	.10	51.0	1,400	21.8	.067	1.40	.67	29.1	2.13
BS06MS	.15	25.4	1,500	9.9	.056	.30	.33	28.7	1.03
BS07MS	.20	38.6	1,500	7.8	.067	.30	.36	32.5	1.12
BS08MS	.20	39.1	950	5.1	.055	.14	.18	29.0	.60
BS09MS	.20	44.5	1,200	12.2	.049	.41	.73	17.1	1.40
BS10MS	.45	63.0	1,400	12.0	.050	.39	.40	24.6	1.39
Alfalfa control, Big Sky Mine, Montana									
BS11MS	.06	17.0	650	<4.3	<.018	.16	.19	8.7	.51
BS12MS	.10	30.4	650	4.4	<.016	.24	.19	4.0	.48
BS13MS	.08	31.7	950	5.8	.019	.30	.24	10.6	.62
Winter wheat, Big Sky Mine, Montana									
BS01TA	--	--	1,600	--	.001	--	--	42.8	--
BS02TA	--	--	1,500	--	.002	--	--	33.2	--
BS03TA	--	--	1,600	--	.002	--	--	35.3	--
Slender wheatgrass, Decker Mine, Montana									
DE01AE	.04	15.6	500	<7.6	.033	.34	.29	7.4	.55
DE02AE	.04	17.1	400	6.7	.073	.31	.26	7.3	.67
DE03AE	.04	13.6	500	5.6	.080	.27	.19	8.0	.48
DE04AE	.06	25.6	400	10.3	.054	.72	.37	11.3	.95
DE05AE	.06	20.5	450	7.6	.065	.53	.28	10.3	.81
DE06AE	.08	44.2	400	11.3	.075	.75	.39	10.8	1.32
DE07AE	.10	38.5	400	7.2	.066	.24	.18	13.8	.94
DE08AE	.04	39.0	500	9.0	.048	.72	.31	6.6	1.02
DE09AE	.06	14.9	500	6.1	.066	.20	.13	7.7	.55
DE10AE	.08	37.1	400	16.8	.070	1.16	.51	7.0	1.16

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Latitude	Longitude	Ash %	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Ca %	Cd ppm
				Fourwing saltbush, Decker Mine, Montana						
DE01FS	45 2 30	106 49 8	9.7	378	.35	26.2	5.1	<.194	1.07	.175
DE02FS	45 2 30	106 49 8	6.1	305	.30	18.3	9.8	<.122	.55	.098
DE03FS	45 2 30	106 49 8	9.8	461	.25	28.4	10.8	<.196	.96	.078
DE04FS	45 2 30	106 49 8	11.0	198	.50	52.8	14.3	<.220	1.01	.110
DE05FS	45 2 30	106 49 8	10.0	470	.10	38.0	11.0	.210	1.50	.160
DE06FS	45 2 30	106 49 8	13.0	416	.15	23.4	7.7	<.260	1.56	.104
DE07FS	45 2 30	106 49 8	9.5	675	.30	25.6	8.5	<.190	.64	.038
DE08FS	45 2 30	106 49 8	8.2	902	.15	28.7	10.7	<.164	.63	.082
DE09FS	45 2 30	106 49 8	12.0	564	.45	37.2	6.0	<.240	1.08	<.048
DE10FS	45 2 30	106 49 8	12.0	348	.40	40.8	3.7	.252	1.19	.048
				Crested wheatgrass, Dave Johnston Mine, Wyoming						
DJ01AC	43 3 0	105 50 0	4.4	378	.50	13.2	3.3	<.088	.18	.044
DJ02AC	43 3 0	105 50 0	6.6	1,056	.20	23.8	4.4	<.132	.21	.106
DJ03AC	43 3 0	105 50 0	5.4	340	.50	8.1	8.1	.119	.21	.043
DJ04AC	43 3 0	105 50 0	5.0	1,200	.60	20.5	6.0	.110	.17	.050
DJ05AC	43 3 0	105 50 0	4.8	418	.45	17.8	3.3	.130	.18	.038
DJ06AC	43 3 0	105 50 0	4.4	660	.65	23.8	8.4	.101	.19	.026
DJ07AC	43 3 0	105 50 0	4.9	108	.35	12.2	4.9	.108	.22	.059
DJ08AC	43 3 0	105 50 0	4.1	111	.45	10.7	3.4	.094	.21	.025
DJ09AC	43 3 0	105 50 0	4.2	391	.50	16.8	6.7	.210	.10	.134
DJ10AC	43 3 0	105 50 0	5.5	605	.60	8.8	5.5	.127	.29	.077
				Crested wheatgrass control, Dave Johnston Mine, Wyoming						
DJ11AC	43 3 0	105 50 0	6.0	780	.90	12.6	11.4	<.120	.22	.024
DJ12AC	43 3 0	105 50 0	6.7	476	.80	18.8	11.4	.194	.20	<.027
DJ13AC	43 3 0	105 50 0	7.2	1,008	.55	15.1	12.2	.209	.22	<.029
				Smooth brome, Dave Johnston Mine, Wyoming						
DJ01BI	43 3 0	105 50 0	6.4	960	.90	35.8	12.8	.358	.24	.064
DJ02BI	43 3 0	105 50 0	6.0	564	.60	23.4	2.8	<.120	.19	.048
DJ03BI	43 3 0	105 50 0	5.6	319	1.00	18.5	3.8	<.112	.19	<.022
DJ04BI	43 3 0	105 50 0	5.9	336	.20	31.9	2.9	.130	.22	.035
DJ05BI	43 3 0	105 50 0	5.9	466	.35	31.3	3.5	<.118	.25	.071
DJ06BI	43 3 0	105 50 0	5.4	200	.80	36.7	2.7	<.108	.24	.032
DJ07BI	43 3 0	105 50 0	5.4	157	.65	12.4	<2.3	<.103	.25	<.022
DJ08BI	43 3 0	105 50 0	6.0	168	.30	28.2	7.2	.246	.27	.036
DJ09BI	43 3 0	105 50 0	5.3	159	.20	13.8	1.5	.186	.17	.032
DJ10BI	43 3 0	105 50 0	5.9	189	.40	23.0	2.8	.136	.34	.024

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Ce ppm	Co ppm	Cr ppm	Cu ppm	F ppm	Fe ppm	Ge ppm	Hg ppm	K %	La ppm
				Fourwing saltbush, Decker Mine, Montana						
DE01FS	<9.0	.291	.28	4.85	6	107	<.194	<.01	2.72	1.07
DE02FS	<5.7	.183	.32	3.05	9	110	<.122	<.01	2.20	1.40
DE03FS	<9.1	.392	.60	5.39	7	147	<.196	.01	3.43	.98
DE04FS	<10.2	.440	.67	6.05	7	98	<.220	.01	3.19	3.30
DE05FS	<9.3	.300	.51	3.00	9	130	<.200	<.01	2.80	2.50
DE06FS	<12.1	.520	.51	4.55	9	143	<.260	.01	3.64	3.77
DE07FS	<8.8	.285	.55	5.70	6	200	<.190	.01	3.51	1.99
DE08FS	<7.6	.164	.61	6.56	8	221	.189	.02	2.62	.82
DE09FS	<11.2	.240	.41	3.60	9	144	<.240	<.01	3.72	<1.12
DE10FS	<11.2	.120	.43	3.60	7	120	<.240	.01	3.84	1.18
				Crested wheatgrass, Dave Johnston Mine, Wyoming						
DJ01AC	<4.1	.088	.42	.88	7	123	<.088	.01	.66	<.41
DJ02AC	<6.1	.132	.86	1.98	9	185	.158	.01	.51	<.61
DJ03AC	<5.0	.054	.39	1.08	5	130	.113	.02	.59	<.50
DJ04AC	<4.7	.100	.75	1.75	9	350	.115	.02	.47	.60
DJ05AC	<4.5	.096	.53	1.20	7	187	.101	.01	.72	<.45
DJ06AC	<4.1	.088	.57	1.10	8	185	<.088	.03	.44	.57
DJ07AC	<4.6	<.049	.17	1.47	5	41	.098	.04	.88	<.46
DJ08AC	<3.8	<.041	.16	1.03	5	34	.086	.03	.57	<.38
DJ09AC	<3.9	<.042	.41	1.26	5	147	.202	.02	.67	<.39
DJ10AC	<5.1	.055	.34	2.20	7	121	<.110	.02	1.05	<.51
				Crested wheatgrass control, Dave Johnston Mine, Wyoming						
DJ11AC	<5.6	.060	.72	1.20	8	234	<.120	.03	.29	.59
DJ12AC	6.7	<.067	.47	1.34	7	161	.181	.03	.32	<.62
DJ13AC	6.9	.072	.72	1.08	10	274	.223	.03	.29	<.67
				Smooth brome, Dave Johnston Mine, Wyoming						
DJ01BI	<6.0	.064	.96	1.28	7	282	<.128	.03	.83	4.10
DJ02BI	<5.6	<.060	<.12	.90	9	96	.162	.01	.60	<.56
DJ03BI	<5.2	.056	.37	1.12	6	101	<.112	.02	1.23	<.52
DJ04BI	<5.5	.059	.58	1.18	7	83	.118	.01	1.00	<.55
DJ05BI	<5.5	.059	.48	.89	9	136	.124	.01	.94	<.55
DJ06BI	<5.0	.108	.29	1.08	8	59	<.108	.04	.81	<.50
DJ07BI	<5.0	<.054	.22	1.35	5	42	<.108	.02	.86	<.50
DJ08BI	<5.6	<.060	.34	1.50	6	60	.234	.02	.84	<.56
DJ09BI	<4.9	.053	.19	.53	6	40	.154	.01	.85	<.49
DJ10BI	<5.5	<.059	.19	2.36	4	58	.118	.01	1.12	<.55

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Li ppm	Mg %	Mn ppm	Mo ppm	Na ppm	Nb ppm	Ni ppm	P %	Pb ppm
Fourwing saltbush, Decker Mine, Montana									
DE01FS	1.55	.407	146	.29	310	1.26	1.75	.068	.79
DE02FS	1.22	.317	79	.54	348	<.57	1.40	.052	.73
DE03FS	1.96	.353	137	.32	235	<.91	2.25	.073	.76
DE04FS	3.85	.770	100	.56	2,530	<1.02	3.41	.165	.91
DE05FS	2.00	.400	130	1.00	220	.99	3.00	.070	1.10
DE06FS	2.60	.572	208	.35	2,340	<1.21	4.68	.078	.99
DE07FS	1.71	.437	61	.29	266	<.88	1.52	.066	.80
DE08FS	.82	.303	123	.52	131	<.76	3.61	.090	.82
DE09FS	2.40	.936	96	.49	288	<1.12	2.64	.060	.89
DE10FS	1.68	.588	65	.54	564	1.32	2.76	.060	1.32
Crested wheatgrass, Dave Johnston Mine, Wyoming									
DJ01AC	.44	.062	12	.22	22	<.41	.10	.079	.62
DJ02AC	1.06	.046	79	.28	33	<.61	.17	.086	.99
DJ03AC	.54	.065	12	.14	35	.54	.15	.070	.81
DJ04AC	.90	.070	23	.18	30	.47	.60	.070	1.35
DJ05AC	1.44	.067	15	.36	24	<.45	.72	.082	.72
DJ06AC	.48	.048	7	.15	31	.57	.29	.037	1.54
DJ07AC	2.20	.073	7	.88	32	<.46	<.10	.034	.54
DJ08AC	.29	.045	25	.13	16	<.38	<.08	.049	.57
DJ09AC	.63	.129	46	.21	19	.92	.36	.076	1.43
DJ10AC	.55	.083	27	.17	25	<.51	.13	.077	.66
Crested wheatgrass control, Dave Johnston Mine, Wyoming									
DJ11AC	<.24	.054	8	.34	33	.66	.28	.042	1.56
DJ12AC	.27	.067	8	.33	27	.87	.19	.064	1.34
DJ13AC	.50	.086	8	1.08	32	.62	.27	.050	1.73
Smooth brome, Dave Johnston Mine, Wyoming									
DJ01BI	3.71	.109	109	.44	26	2.11	.77	.115	1.86
DJ02BI	1.80	.066	168	.29	21	<.56	<.12	.090	.66
DJ03BI	1.23	.078	42	.15	62	<.52	<.11	.048	.50
DJ04BI	1.77	.083	54	.21	112	<.55	<.12	.032	.65
DJ05BI	5.31	.083	46	.21	35	<.55	.17	.035	.65
DJ06BI	5.13	.108	40	.12	38	<.50	<.11	.043	.70
DJ07BI	.54	.103	54	.31	19	<.50	<.11	.030	.49
DJ08BI	2.58	.084	78	.72	18	1.20	.32	.039	1.32
DJ09BI	1.17	.042	29	.13	24	<.49	<.11	.058	.69
DJ10BI	.59	.094	54	.22	18	<.55	<.12	.100	.65

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Se ppm	Sr ppm	S ppm	Ti ppm	U ppm	V ppm	Y ppm	Zn ppm	Zr ppm
Fourwing saltbush, Decker Mine, Montana									
DE01FS	.25	97.0	3,400	<9.0	<.039	<.19	<.19	41.7	.91
DE02FS	.20	51.2	2,400	6.0	.024	.20	.28	18.9	.67
DE03FS	.30	68.6	3,000	10.8	.039	.22	.24	34.3	1.18
DE04FS	.80	81.4	4,300	<10.2	<.044	.39	.31	85.8	1.21
DE05FS	.35	130.0	3,900	11.0	<.040	.38	.26	25.0	1.10
DE06FS	.90	208.0	4,700	<12.1	<.052	.29	.34	36.4	.73
DE07FS	.25	76.9	3,000	12.4	<.038	.29	.29	29.4	.79
DE08FS	.30	98.4	3,000	15.6	<.033	.47	.40	49.2	1.15
DE09FS	.30	58.8	4,700	11.9	<.048	.40	.41	33.6	.82
DE10FS	.15	88.8	4,000	<11.2	<.048	.36	.28	19.2	1.15
Crested wheatgrass, Dave Johnston Mine, Wyoming									
DJ01AC	.10	5.3	1,100	6.2	.053	.38	.21	18.0	.39
DJ02AC	.45	5.5	1,000	21.8	.158	1.45	.38	26.4	1.45
DJ03AC	.15	16.2	900	7.6	.086	.59	.31	17.8	1.08
DJ04AC	.30	5.5	1,000	23.0	.100	1.60	.60	18.0	1.55
DJ05AC	.15	4.1	1,400	12.5	.058	.72	.20	26.4	.58
DJ06AC	.10	5.7	1,000	16.3	.070	1.10	.48	8.8	1.19
DJ07AC	.15	17.6	850	<4.6	.039	.18	.15	17.1	.42
DJ08AC	.35	5.7	850	<3.8	.033	.09	.11	10.3	.53
DJ09AC	.20	5.9	1,100	10.1	.017	.80	.34	9.2	.80
DJ10AC	.45	10.5	900	9.9	.044	.47	.31	11.6	.72
Crested wheatgrass control, Dave Johnston Mine, Wyoming									
DJ11AC	.25	7.2	650	15.0	.096	1.14	.60	9.6	1.80
DJ12AC	.30	6.2	650	9.4	.107	.74	.41	6.0	1.34
DJ13AC	.50	6.3	900	19.4	.086	1.44	.54	13.0	1.37
Smooth brome, Dave Johnston Mine, Wyoming									
DJ01BI	.10	24.3	1,000	20.5	.077	1.79	.77	9.0	2.69
DJ02BI	.50	20.4	450	12.0	.048	.96	.24	16.8	1.02
DJ03BI	.06	5.3	1,100	6.7	.067	.19	.21	7.8	.62
DJ04BI	.10	7.7	1,100	<5.5	.047	.25	.29	8.3	.65
DJ05BI	.10	6.5	1,200	8.3	.094	.38	.34	11.2	.94
DJ06BI	.15	8.6	750	<5.0	.022	<.11	.13	13.0	.34
DJ07BI	.25	9.2	650	<5.0	.022	.11	.13	8.6	.44
DJ08BI	.15	19.8	650	<5.6	.048	.52	.32	6.0	.57
DJ09BI	.10	3.8	750	<4.9	.042	<.11	.22	4.8	.43
DJ10BI	.20	8.9	950	<5.5	.047	.14	.14	6.5	.50

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Latitude	Longitude	Ash %	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Ca %	Cd ppm
Winter wheat, Dave Johnston Mine, Wyoming										
DJ01TA	43 3 0	105 50 0	1.7	--	--	--	--	--	--	.119
DJ02TA	43 3 0	105 50 0	2.0	--	--	--	--	--	--	.200
DJ03TA	43 3 0	105 50 0	1.9	--	--	--	--	--	--	.209
Intermediate wheatgrass, Energy Fuels Mine, Colorado										
EN01AC	40 20 15	107 3 30	4.7	202	.20	4.7	7.5	.108	.18	<.019
EN02AC	40 20 15	107 3 30	5.1	260	.20	5.1	10.2	.158	.18	.051
EN03AC	40 20 15	107 3 30	5.7	319	.15	1.6	6.8	<.114	.17	.125
EN04AC	40 20 15	107 3 30	6.5	247	.10	5.9	11.1	.143	.21	.065
EN05AC	40 20 15	107 3 30	5.5	605	.10	10.5	18.2	.347	.22	.055
EN06AC	40 20 15	107 3 30	5.7	627	.35	5.5	5.1	<.114	.19	.023
EN07AC	40 20 15	107 3 30	5.1	423	.10	18.4	10.2	.214	.17	.092
EN08AC	40 20 15	107 3 30	7.1	490	.40	6.8	9.2	<.142	.26	.071
EN09AC	40 20 15	107 3 30	5.2	156	.10	5.7	4.5	<.104	.15	.031
EN10AC	40 20 15	107 3 30	5.8	638	.10	11.6	15.7	.238	.19	.394
Alfalfa, Energy Fuels Mine, Colorado										
EN01MS	40 20 15	107 3 30	8.6	946	.45	47.3	15.5	<.172	2.32	.103
EN02MS	40 20 15	107 3 30	9.3	698	.30	28.8	14.9	<.186	2.32	.223
EN03MS	40 20 15	107 3 30	9.4	395	.30	75.2	18.8	<.188	2.44	.263
EN04MS	40 20 15	107 3 30	9.1	628	.30	43.7	13.6	<.182	2.64	.055
EN05MS	40 20 15	107 3 30	9.2	589	.45	36.8	27.6	<.184	2.76	.202
EN06MS	40 20 15	107 3 30	13.0	650	.30	81.9	16.9	<.260	3.90	.156
EN07MS	40 20 15	107 3 30	11.0	473	.25	92.4	13.2	<.220	3.19	.066
EN08MS	40 20 15	107 3 30	6.7	456	.45	36.9	14.7	<.134	2.01	.080
EN09MS	40 20 15	107 3 30	7.8	484	.15	68.6	12.5	<.156	2.26	.094
EN10MS	40 20 15	107 3 30	7.9	498	.30	67.9	10.3	<.158	2.29	.126
Intermediate wheatgrass, Husky Mine, North Dakota										
HU01AI	46 51 0	102 41 0	4.7	320	.65	9.9	16.0	<.094	.19	.019
HU02AI	46 51 0	102 41 0	4.6	350	.30	13.3	22.5	.124	.20	.018
HU03AI	46 51 0	102 41 0	4.4	748	.45	12.8	48.4	.246	.20	.053
HU04AI	46 51 0	102 41 0	5.2	624	.30	12.0	33.8	.198	.15	.052
HU05AI	46 51 0	102 41 0	5.3	583	.55	9.0	30.7	.164	.20	.032
HU06AI	46 51 0	102 41 0	4.8	1,104	.40	13.9	40.3	.158	.17	.038
HU07AI	46 51 0	102 41 0	4.0	760	.45	>16.0	52.0	.188	.22	.048
HU08AI	46 51 0	102 41 0	4.6	1,196	.25	17.0	87.4	.313	.21	.046
HU09AI	46 51 0	102 41 0	5.1	459	.25	11.2	29.1	.122	.23	.031
HU10AI	46 51 0	102 41 0	4.0	1,040	.40	18.4	72.0	.272	.18	.104

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Ce ppm	Co ppm	Cr ppm	Cu ppm	F ppm	Fe ppm	Ge ppm	Hg ppm	K %	La ppm
Winter wheat, Dave Johnston Mine, Wyoming										
DJ01TA	--	--	--	--	--	--	--	--	--	--
DJ02TA	--	--	--	--	--	--	--	--	--	--
DJ03TA	--	--	--	--	--	--	--	--	--	--
Intermediate wheatgrass, Energy Fuels Mine, Colorado										
EN01AC	<4.4	.047	.52	.94	6	103	.103	.01	.80	1.46
EN02AC	<4.7	<.051	.49	.76	7	107	.153	.01	.61	1.58
EN03AC	<5.3	<.057	.45	.86	5	108	<.114	.02	.63	<.53
EN04AC	<6.0	.065	.34	.98	6	91	<.130	<.01	.62	<.60
EN05AC	<5.1	<.055	1.05	1.10	6	264	.319	.02	.44	<.51
EN06AC	<5.3	.114	.54	1.14	6	200	<.114	.02	.68	<.53
EN07AC	<4.7	<.051	.76	1.27	6	199	.240	.01	.71	<.47
EN08AC	<6.6	<.071	.60	1.07	8	185	.163	.03	.26	<.66
EN09AC	<4.8	.052	.33	1.04	6	94	.109	.01	.52	<.48
EN10AC	<5.4	<.058	.70	1.16	6	226	.302	.01	.58	<.54
Alfalfa, Energy Fuels Mine, Colorado										
EN01MS	<8.0	.086	.57	6.45	5	215	<.172	.02	1.03	4.21
EN02MS	<8.6	<.093	.51	4.65	8	223	<.186	.01	1.02	1.02
EN03MS	9.3	.188	.56	6.11	5	169	<.188	.03	.64	1.41
EN04MS	<8.5	<.091	.63	5.46	8	200	.209	.01	1.00	3.28
EN05MS	<8.6	.184	.49	5.52	8	147	<.184	.01	.81	.91
EN06MS	12.7	.130	1.00	7.15	9	221	<.260	.02	1.01	2.08
EN07MS	<10.2	.110	.64	6.60	5	154	<.220	.01	.88	3.96
EN08MS	<6.2	<.067	.46	4.36	7	154	<.134	.01	.59	1.21
EN09MS	<7.3	<.078	.48	3.90	6	117	<.156	.02	.75	2.89
EN10MS	<7.3	.079	.46	6.32	7	166	<.158	.02	.62	.87
Intermediate wheatgrass, Husky Mine, North Dakota										
HU01AI	<4.4	.047	.52	.94	5	122	<.094	.02	.29	<.44
HU02AI	4.5	.046	.51	.92	5	166	.110	.01	.30	<.43
HU03AI	6.2	.044	.84	1.10	5	286	.180	.02	.22	.48
HU04AI	5.7	.052	.83	1.04	6	291	<.104	.02	.24	<.48
HU05AI	<4.9	.106	.58	.80	8	249	.148	.02	.58	1.27
HU06AI	<4.5	.096	.96	1.68	5	432	<.096	.02	.53	2.30
HU07AI	<3.7	.080	.48	1.60	7	480	.172	.02	.35	1.56
HU08AI	5.5	.092	1.29	1.61	6	506	<.092	.02	.35	1.10
HU09AI	<4.7	<.051	.49	.51	6	179	.117	.03	.31	<.47
HU10AI	4.4	.040	.88	1.20	5	336	.208	.02	.27	.60

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Li ppm	Mg %	Mn ppm	Mo ppm	Na ppm	Nb ppm	Ni ppm	P %	Pb ppm
				Winter wheat, Dave Johnston Mine, Wyoming					
DJ01TA	--	--	--	.43	--	--	--	.292	--
DJ02TA	--	--	--	.50	--	--	--	.380	--
DJ03TA	--	--	--	.95	--	--	--	.331	--
				Intermediate wheatgrass, Energy Fuels Mine, Colorado					
EN01AC	.19	.047	7	.14	28	<.44	.40	.061	.61
EN02AC	<.20	.056	10	.24	20	.51	.18	.087	.66
EN03AC	.29	.063	19	.23	31	<.53	.13	.057	.68
EN04AC	<.26	.072	27	1.69	26	.60	.14	.072	.72
EN05AC	.22	.083	55	.31	17	1.10	.55	.055	1.59
EN06AC	.68	.074	12	.17	37	<.53	.20	.029	.63
EN07AC	.25	.097	36	.24	18	.87	.43	.082	1.07
EN08AC	.43	.107	23	.17	28	<.66	.23	.071	.57
EN09AC	.52	.068	7	.12	16	<.48	<.10	.073	.43
EN10AC	.58	.087	52	.30	20	.81	.64	.081	1.16
				Alfalfa, Energy Fuels Mine, Colorado					
EN01MS	.52	.163	26	1.63	65	1.12	.55	.112	1.03
EN02MS	1.02	.595	37	.54	70	1.02	.88	.065	1.02
EN03MS	3.76	.865	26	1.79	47	<.87	1.41	.085	1.13
EN04MS	.46	.182	19	3.19	55	1.00	.52	.109	1.00
EN05MS	.37	.294	24	2.39	28	1.01	.86	.064	.75
EN06MS	1.56	.806	56	2.34	59	1.43	3.12	.143	1.30
EN07MS	.55	.572	21	4.29	22	<1.02	.36	.132	1.08
EN08MS	.60	.375	15	1.07	27	<.62	.36	.054	.74
EN09MS	.55	.234	19	2.03	23	.94	.37	.078	.76
EN10MS	.71	.356	17	3.08	43	<.73	.50	.095	1.03
				Intermediate wheatgrass, Husky Mine, North Dakota					
HU01AI	.23	.070	21	.14	38	<.44	.09	.021	.61
HU02AI	<.18	.064	31	.28	37	.46	.28	.025	1.01
HU03AI	.18	.066	62	.35	40	1.14	.48	.020	1.63
HU04AI	<.21	.057	57	.30	49	.83	.37	.026	1.35
HU05AI	.27	.080	12	.24	74	.51	.27	.027	.95
HU06AI	.38	.091	38	.48	312	.72	.67	.024	1.34
HU07AI	.24	.080	52	.36	76	.80	.56	.020	1.48
HU08AI	.23	.078	69	.51	55	1.43	.83	.023	2.35
HU09AI	.20	.071	38	.22	36	<.47	.14	.025	.82
HU10AI	.16	.068	64	.40	56	.76	.60	.020	1.40

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Se ppm	Sr ppm	S ppm	Ti ppm	U ppm	V ppm	Y ppm	Zn ppm	Zr ppm
Winter wheat, Dave Johnston Mine, Wyoming									
DJ01TA	--	--	1,100	--	.003	--	--	19.5	--
DJ02TA	--	--	1,400	--	.003	--	--	26.0	--
DJ03TA	--	--	1,000	--	.003	--	--	29.4	--
Intermediate wheatgrass, Energy Fuels Mine, Colorado									
EN01AC	.10	3.3	600	6.6	.019	.41	.22	5.2	.89
EN02AC	.15	5.0	950	5.6	.020	.30	.18	7.6	.39
EN03AC	.10	4.4	550	<5.3	.023	.21	.18	9.7	.63
EN04AC	.15	4.3	900	<6.0	<.026	.30	.25	11.7	.50
EN05AC	.25	6.6	1,300	14.3	<.022	1.05	.48	7.2	1.38
EN06AC	.25	4.9	550	10.3	.068	.32	.19	9.7	.52
EN07AC	.15	16.8	900	11.2	.020	.71	.31	16.3	.82
EN08AC	.25	15.6	850	9.9	<.028	.24	.25	14.2	.57
EN09AC	.20	3.7	900	<4.8	<.021	<.10	<.10	9.9	.44
EN10AC	.25	24.4	900	14.5	.023	1.10	.49	14.5	1.80
Alfalfa, Energy Fuels Mine, Colorado									
EN01MS	.20	103.2	1,700	12.9	.069	.95	.57	15.5	1.72
EN02MS	.55	53.0	1,600	12.1	<.037	.70	.68	22.3	1.77
EN03MS	.45	69.6	2,800	9.3	.038	.66	.70	39.5	1.03
EN04MS	.30	48.2	2,700	11.8	.036	.76	.60	14.6	1.36
EN05MS	.25	77.3	1,600	10.1	.037	.49	.58	11.0	1.38
EN06MS	1.40	67.6	4,700	14.3	<.052	.99	1.56	26.0	1.95
EN07MS	.60	187.0	4,100	<10.2	.044	.58	.67	14.3	1.98
EN08MS	.40	54.3	2,400	8.0	.027	.49	.40	14.1	1.01
EN09MS	.20	117.0	2,800	7.7	.031	.50	.34	14.8	1.25
EN10MS	.30	73.5	3,200	8.7	.032	.51	.36	20.5	1.58
Intermediate wheatgrass, Husky Mine, North Dakota									
HU01AI	.06	9.9	450	5.2	.038	.24	.23	8.5	.56
HU02AI	.06	12.0	650	6.4	.018	.51	.33	11.5	.78
HU03AI	.04	31.2	450	14.5	.053	.84	.48	8.8	1.01
HU04AI	.04	17.2	500	13.0	.042	.78	.43	7.3	1.09
HU05AI	.15	13.8	800	12.7	.042	.52	.37	9.5	1.33
HU06AI	.04	20.6	650	29.3	.038	1.49	.72	10.1	1.92
HU07AI	.04	24.0	600	44.0	.032	1.80	.72	12.0	2.56
HU08AI	.04	32.2	750	36.3	.046	1.66	.78	9.7	2.25
HU09AI	.06	14.8	750	9.2	.041	.29	.30	11.7	.71
HU10AI	.06	29.6	700	25.6	.048	1.28	.68	8.4	1.96

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Latitude	Longitude	Ash %	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Ca %	Cd ppm
					Alfalfa, Husky Mine, North Dakota					
HU01MS	46 51 0	102 41 0	5.3	376	.25	22.3	30.7	<.106	1.17	.053
HU02MS	46 51 0	102 41 0	4.3	340	.25	23.7	26.2	<.086	.86	.060
HU03MS	46 51 0	102 41 0	4.4	392	.30	24.6	33.9	<.088	.84	.062
HU04MS	46 51 0	102 41 0	5.0	700	.30	42.0	85.0	.130	.95	.100
HU05MS	46 51 0	102 41 0	4.4	484	.15	29.5	41.4	<.088	.84	.044
HU06MS	46 51 0	102 41 0	5.1	474	.15	47.4	40.3	<.102	1.17	.061
HU07MS	46 51 0	102 41 0	5.5	990	.25	29.7	55.0	<.110	.88	.077
HU08MS	46 51 0	102 41 0	4.6	690	.20	19.8	33.6	<.092	.83	.055
HU09MS	46 51 0	102 41 0	5.2	369	.20	32.2	39.5	<.104	.99	.062
HU10MS	46 51 0	102 41 0	4.4	229	.20	18.9	19.8	<.088	1.01	.079
					Alfalfa control, Husky Mine, North Dakota					
HU11MS	46 51 0	102 41 0	5.8	568	.70	63.8	87.0	<.116	.99	.023
HU12MS	46 51 0	102 41 0	6.2	397	1.20	51.5	49.6	<.124	1.18	.050
HU13MS	46 51 0	102 41 0	6.1	409	.90	42.7	52.5	<.122	1.40	.024
					Fourwing saltbush, Jim Bridger Mine, Wyoming					
JB01FS	41 46 0	108 45 0	11.0	385	.30	187.0	4.7	<.220	1.21	.154
JB02FS	41 46 0	108 45 0	8.1	243	.15	113.4	2.3	<.162	.97	.032
JB03FS	41 46 0	108 45 0	10.0	540	.40	140.0	4.8	<.200	1.00	.300
JB04FS	41 46 0	108 45 0	12.0	696	.35	192.0	6.0	<.240	1.44	.048
JB05FS	41 46 0	108 45 0	10.0	340	.35	260.0	3.8	<.200	.84	.060
JB06FS	41 46 0	108 45 0	11.0	528	.30	253.0	3.6	<.220	.86	.110
JB07FS	41 46 0	108 45 0	11.0	429	.20	418.0	4.5	<.220	.81	.110
JB08FS	41 46 0	108 45 0	12.0	456	.15	612.0	4.6	<.240	1.08	.240
JB09FS	41 46 0	108 45 0	11.0	913	.10	275.0	12.1	<.220	.88	.198
JB10FS	41 46 0	108 45 0	9.5	352	.35	114.0	2.8	<.190	.57	.038
					Intermediate wheatgrass, So. Beulah Mine, North Dakota					
SB01AI	47 14 0	101 46 0	5.5	281	.25	7.7	11.0	<.110	.20	.022
SB02AI	47 14 0	101 46 0	4.6	506	.70	6.4	13.3	.097	.16	.028
SB03AI	47 14 0	101 46 0	5.3	355	1.10	9.5	11.7	.122	.19	<.021
SB04AI	47 14 0	101 46 0	4.9	539	.25	4.9	11.8	<.098	.18	.029
SB05AI	47 14 0	101 46 0	5.0	465	.65	7.0	21.5	<.100	.20	.030
SB06AI	47 14 0	101 46 0	4.6	782	.30	10.6	14.3	.166	.19	.028
SB07AI	47 14 0	101 46 0	5.9	502	.70	10.0	17.7	.177	.18	.059
SB08AI	47 14 0	101 46 0	6.0	840	.45	16.2	35.4	.402	.17	.060
SB09AI	47 14 0	101 46 0	5.6	336	2.00	4.0	14.6	.118	.21	.022
SB10AI	47 14 0	101 46 0	6.8	422	2.50	6.3	12.2	.211	.19	.041

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Ce ppm	Co ppm	Cr ppm	Cu ppm	F ppm	Fe ppm	Ge ppm	Hg ppm	K %	La ppm
Alfalfa, Husky Mine, North Dakota										
HU01MS	<4.9	.053	.47	5.04	6	217	<.106	.01	.90	<.49
HU02MS	<4.0	.086	.36	4.51	5	155	<.086	.01	.77	.52
HU03MS	<4.1	.132	.33	5.72	6	176	<.088	.01	.75	.44
HU04MS	<4.7	.100	.85	6.50	7	445	<.100	.02	.85	1.50
HU05MS	<4.1	.088	.43	5.72	8	172	<.088	.01	.75	.44
HU06MS	5.1	.051	.61	5.10	7	214	<.102	.01	.71	2.45
HU07MS	<5.1	.110	.61	7.15	7	336	<.110	.01	1.05	.72
HU08MS	<4.3	.046	.51	4.60	7	216	<.092	.01	.92	1.33
HU09MS	<4.8	.104	.52	4.16	5	151	<.104	.02	.73	.73
HU10MS	<4.1	.088	.34	4.84	5	123	<.088	.01	.66	.66
Alfalfa control, Husky Mine, North Dakota										
HU11MS	<5.4	.058	.35	5.22	4	209	<.116	.02	1.04	1.68
HU12MS	<5.8	.062	.50	7.75	7	223	<.124	.01	1.05	1.74
HU13MS	<5.7	<.061	.73	6.71	7	232	<.122	.01	.85	<.57
Fourwing saltbush, Jim Bridger Mine, Wyoming										
JB01FS	<10.2	.220	.40	4.40	9	97	<.220	<.01	2.86	<1.02
JB02FS	<7.5	.081	.22	4.86	8	63	<.162	.01	2.59	<.75
JB03FS	<9.3	.300	.55	7.00	10	130	<.200	.02	3.00	<.93
JB04FS	<11.2	.120	.47	6.60	6	168	<.240	.01	2.52	2.40
JB05FS	10.0	.300	.65	5.00	6	150	<.200	.01	2.80	1.80
JB06FS	<10.2	.110	.47	4.40	9	154	<.220	<.01	2.97	1.65
JB07FS	12.1	.220	.57	4.40	7	165	<.220	.01	1.87	<2.20
JB08FS	11.8	.240	.64	3.60	9	156	.300	.01	3.60	3.60
JB09FS	11.0	.440	.86	4.95	10	286	<.220	<.01	2.97	4.07
JB10FS	<8.8	.095	.38	4.75	9	114	<.190	.01	3.04	2.38
Intermediate wheatgrass, So. Beulah Mine, North Dakota										
SB01AI	<5.1	.110	.38	1.10	5	127	.121	.02	.24	<.51
SB02AI	<4.3	.046	.51	1.38	5	198	.106	.01	.20	1.10
SB03AI	<4.9	.053	.40	1.06	6	159	.122	.01	.25	<.49
SB04AI	<4.6	.098	.48	1.22	6	206	.127	.02	.21	<.46
SB05AI	<4.7	.100	.41	1.00	7	220	.105	.01	.18	1.10
SB06AI	<4.3	.092	.69	.69	7	285	.179	.01	.18	.69
SB07AI	<5.5	.118	.50	.89	7	201	.183	.01	.17	1.48
SB08AI	6.6	.060	.84	1.50	6	396	<.120	.02	.22	.78
SB09AI	<5.2	.056	.38	.84	7	134	<.112	.02	.31	1.18
SB10AI	<6.3	.068	.48	1.02	8	197	.197	.01	.22	<.63

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Li ppm	Mg %	Mn ppm	Mo ppm	Na ppm	Nb ppm	Ni ppm	P %	Pb ppm
				Alfalfa, Husky Mine, North Dakota					
HU01MS	.58	.212	15	.95	143	<.49	.37	.074	.69
HU02MS	.69	.206	7	1.25	120	<.40	.35	.047	.52
HU03MS	1.14	.251	7	.88	264	.42	.53	.066	.53
HU04MS	2.35	.350	44	5.50	700	<.46	1.25	.060	1.60
HU05MS	.70	.255	7	.97	207	<.41	.27	.070	.66
HU06MS	1.78	.296	14	1.22	321	.71	.56	.061	.92
HU07MS	2.20	.314	15	4.40	660	<.51	.94	.088	.94
HU08MS	1.61	.225	12	1.93	253	<.43	.55	.051	.74
HU09MS	.83	.302	20	1.25	166	.49	.45	.047	.83
HU10MS	1.06	.255	11	.97	172	<.41	.48	.048	.44
				Alfalfa control, Husky Mine, North Dakota					
HU11MS	2.32	.545	13	2.61	267	<.54	.58	.064	1.10
HU12MS	1.86	.508	12	4.34	868	<.58	1.12	.087	1.30
HU13MS	.85	.403	9	2.50	397	<.57	.56	.061	1.04
				Fourwing saltbush, Jim Bridger Mine, Wyoming					
JB01FS	.88	.902	79	.54	2,750	<1.02	.58	.099	.81
JB02FS	.32	.632	15	.32	235	<.75	<.16	.081	.51
JB03FS	.90	.680	150	.23	5,300	<.93	1.50	.130	.69
JB04FS	1.44	.816	89	.82	7,680	<1.12	1.80	.120	1.44
JB05FS	.80	.920	66	1.30	2,200	<.93	1.10	.090	1.10
JB06FS	.77	.946	84	.87	231	1.32	.65	.132	1.21
JB07FS	1.54	1.034	85	5.06	7,480	1.32	1.02	.110	1.54
JB08FS	1.44	1.008	95	.53	3,840	1.44	.59	.108	1.32
JB09FS	1.10	.902	330	1.21	7,040	<1.02	1.54	.094	1.76
JB10FS	1.33	.532	10	.32	4,940	<.88	.76	.143	.85
				Intermediate wheatgrass, So. Beulah Mine, North Dakota					
SB01AI	<.22	.052	26	.18	25	<.51	.15	.041	.94
SB02AI	<.18	.051	38	.28	25	<.43	.27	.046	.83
SB03AI	<.21	.053	34	.21	29	<.49	.16	.050	.85
SB04AI	<.20	.049	29	.23	32	<.46	.24	.044	.88
SB05AI	<.20	.055	22	.20	40	<.46	.19	.023	.75
SB06AI	.18	.055	18	.29	25	.46	.46	.032	1.20
SB07AI	.24	.053	21	.24	30	.55	.23	.047	1.18
SB08AI	<.24	.060	90	.66	30	1.50	.78	.039	2.22
SB09AI	<.22	.067	37	.38	36	<.52	.14	.039	.90
SB10AI	.34	.054	24	.22	31	.63	.31	.041	1.16

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Se ppm	Sr ppm	S ppm	Ti ppm	U ppm	V ppm	Y ppm	Zn ppm	Zr ppm
				Alfalfa, Husky Mine, North Dakota					
HU01MS	.15	38.2	1,400	7.4	.085	.37	.24	15.9	.90
HU02MS	.10	41.3	1,100	5.6	.120	.22	.26	11.6	.90
HU03MS	.10	48.4	1,000	6.6	.106	.25	.25	18.5	.79
HU04MS	.15	155.0	1,400	26.0	.200	1.85	.70	16.0	2.85
HU05MS	.15	48.4	1,100	8.4	.106	.43	.35	13.2	1.19
HU06MS	.10	61.2	1,400	9.7	.061	.61	.36	14.3	1.02
HU07MS	.45	126.5	1,400	15.9	.110	.66	.53	17.0	1.38
HU08MS	.35	82.8	1,300	12.0	.129	.41	.32	16.6	.87
HU09MS	.25	44.2	1,000	7.8	.062	.43	.35	12.0	.68
HU10MS	.15	48.4	850	5.3	.070	.12	.15	13.6	.44
				Alfalfa control, Husky Mine, North Dakota					
HU11MS	.15	98.6	1,400	8.7	.070	.37	.24	18.0	.58
HU12MS	.50	74.4	1,600	8.7	.099	.46	.24	18.0	.56
HU13MS	.90	73.2	1,400	6.7	.098	.33	.20	14.0	.67
				Fourwing saltbush, Jim Bridger Mine, Wyoming					
JB01FS	1.20	20.9	3,100	<10.2	.044	<.22	.40	55.0	1.06
JB02FS	.55	16.2	3,300	<7.5	<.032	<.16	.24	48.6	.66
JB03FS	.50	21.0	3,200	<9.3	.040	.24	.36	110.0	1.50
JB04FS	.25	28.8	3,800	13.2	.048	.32	.42	96.0	1.32
JB05FS	.90	22.0	3,400	10.0	.040	.47	.44	89.0	1.50
JB06FS	.90	19.8	4,400	14.3	.044	.35	.29	62.7	.95
JB07FS	.50	24.2	4,000	10.9	<.044	.65	.76	68.2	1.43
JB08FS	.90	20.4	4,100	13.2	<.048	.71	.54	57.6	1.68
JB09FS	1.20	40.7	3,100	19.8	.044	1.32	.84	55.0	2.31
JB10FS	.80	9.0	2,600	8.8	.038	.24	.36	52.3	.91
				Intermediate wheatgrass, So. Beulah Mine, North Dakota					
SB01AI	.10	12.7	450	5.4	.044	.20	.17	11.0	.52
SB02AI	.06	15.2	450	9.2	.037	.35	.31	14.7	1.20
SB03AI	.06	13.3	400	6.4	.042	.32	.21	11.7	.58
SB04AI	.15	16.2	400	9.8	.059	.42	.31	12.7	.93
SB05AI	.10	17.0	450	8.5	.060	.45	.36	11.0	.65
SB06AI	.08	15.2	400	20.2	.037	.74	.46	9.7	.83
SB07AI	.08	15.9	400	8.9	.047	.53	.33	13.0	.65
SB08AI	.10	32.4	500	18.6	.048	1.56	.66	10.8	1.68
SB09AI	.08	14.0	500	6.2	.045	.18	.18	11.8	.53
SB10AI	.10	9.5	500	8.2	.054	.46	.28	12.2	.66

Concentrations of elements (dry-weight basis) in samples cf vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Latitude	Longitude	Ash %	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Ca %	Cd ppm
				Alfalfa, So. Beulah Mine, North Dakota						
SB01MS	47 14 0	101 46 0	6.9	504	2.50	47.6	26.9	<.138	1.86	.290
SB02MS	47 14 0	101 46 0	7.7	924	2.40	92.4	34.7	.208	2.16	.139
SB03MS	47 14 0	101 46 0	6.0	264	.80	42.0	18.6	<.120	1.68	.120
SB04MS	47 14 0	101 46 0	4.8	384	1.20	47.0	20.6	<.096	1.10	.134
SB05MS	47 14 0	101 46 0	7.2	540	.95	63.4	18.7	<.144	1.73	.115
SB06MS	47 14 0	101 46 0	6.2	533	.75	26.7	11.8	<.124	1.49	.087
SB07MS	47 14 0	101 46 0	7.3	1,387	.60	116.8	34.3	.204	1.83	.876
SB08MS	47 14 0	101 46 0	7.4	474	.90	42.2	25.2	<.148	2.00	.222
SB09MS	47 14 0	101 46 0	5.6	728	.40	30.8	29.1	<.112	1.23	.347
SB10MS	47 14 0	101 46 0	6.1	336	.70	34.8	16.5	<.122	1.40	.232
				Alfalfa control, So. Beulah Mine, North Dakota						
SB11MS	47 14 0	101 46 0	12.0	936	.25	109.2	276.0	<.240	3.12	.144
SB12MS	47 14 0	101 46 0	13.0	767	.65	89.7	195.0	<.260	3.51	.182
SB13MS	47 14 0	101 46 0	15.0	435	2.50	60.0	285.0	<.300	4.50	.120
				Slender wheatgrass, Absaloka Mine, Montana						
SC01AE	45 49 0	107 6 0	2.9	189	.25	8.4	5.2	.078	.17	<.012
SC02AE	45 49 0	107 6 0	5.0	110	.25	7.5	6.0	<.100	.18	.020
SC03AE	45 49 0	107 6 0	4.8	259	.30	7.7	8.6	.106	.18	.096
SC04AE	45 49 0	107 6 0	2.7	405	.15	5.1	7.8	<.054	.13	.016
SC05AE	45 49 0	107 6 0	4.0	252	.15	5.2	6.0	.108	.18	<.016
SC06AE	45 49 0	107 6 0	3.4	476	.15	2.3	10.9	.071	.16	.014
SC07AE	45 49 0	107 6 0	5.1	918	.15	15.8	21.9	.316	.20	.031
SC08AE	45 49 0	107 6 0	3.5	102	.40	4.6	8.1	<.070	.18	<.014
SC09AE	45 49 0	107 6 0	3.0	237	.30	3.3	8.4	<.060	.17	.012
SC10AE	45 49 0	107 6 0	3.5	263	1.20	3.9	9.1	<.070	.20	.014
				Sandfain, Absaloka Mine, Montana						
SC01SF	45 49 0	107 6 0	3.1	65	.80	17.4	15.2	<.062	.59	.031
SC02SF	45 49 0	107 6 0	4.2	307	1.00	28.6	16.4	<.084	.92	.160
SC03SF	45 49 0	107 6 0	3.8	198	1.20	16.3	15.2	<.076	.84	.046
SC04SF	45 49 0	107 6 0	2.9	580	.95	15.7	31.9	<.058	.70	.174
SC05SF	45 49 0	107 6 0	3.6	468	.10	43.2	39.6	.108	.72	.108
SC06SF	45 49 0	107 6 0	3.9	429	.95	28.9	25.0	.105	.82	.062
SC07SF	45 49 0	107 6 0	2.6	187	.40	10.9	31.2	<.052	.62	.062
SC08SF	45 49 0	107 6 0	3.2	227	1.20	12.8	17.9	<.064	.83	.109
SC09SF	45 49 0	107 6 0	3.9	98	.25	16.4	15.6	<.078	.94	.078
SC10SF	45 49 0	107 6 0	3.3	238	.50	36.3	56.1	.073	.92	.086

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Ce ppm	Co ppm	Cr ppm	Cu ppm	F ppm	Fe ppm	Ge ppm	Hg ppm	K %	La ppm
Alfalfa, So. Beulah Mine, North Dakota										
SB01MS	<6.4	1.035	.56	8.97	6	242	<.138	.03	.76	.83
SB02MS	8.5	.077	.85	6.16	6	400	<.154	.02	.92	4.31
SB03MS	<5.6	<.060	.38	5.10	5	138	<.120	.01	.60	<.56
SB04MS	4.6	.096	.53	5.76	6	144	<.096	.03	.77	.62
SB05MS	<6.7	.144	.50	6.12	7	252	<.144	.01	.86	1.87
SB06MS	<5.8	.124	.47	5.89	7	229	<.124	.02	.81	<.58
SB07MS	12.4	1.971	1.17	7.30	6	562	<.146	.01	.88	2.34
SB08MS	<6.9	.518	.41	8.14	7	200	<.148	.02	.72	<.69
SB09MS	<5.2	.840	.67	5.88	6	252	<.112	.02	.84	.73
SB10MS	<5.7	.732	.38	4.88	7	165	<.122	.02	.73	<.57
Alfalfa control, So. Beulah Mine, North Dakota										
SB11MS	15.6	.120	.96	8.40	6	300	.300	.02	1.68	9.60
SB12MS	<12.1	.130	.77	8.45	2	247	<.260	.01	1.43	5.07
SB13MS	14.3	<.150	.72	6.75	8	195	<.300	.10	.95	3.45
Slender wheatgrass, Absaloka Mine, Montana										
SC01AE	<2.7	.029	.29	.58	4	84	.075	.01	.29	<.27
SC02AE	<4.7	<.050	.22	1.00	6	38	<.100	.02	.27	1.20
SC03AE	<4.5	<.048	.35	.96	4	91	.115	.03	.26	<.45
SC04AE	<2.5	.027	.38	.81	6	143	.065	.03	.17	.84
SC05AE	<3.7	.080	.33	.60	5	100	.096	.02	.30	1.00
SC06AE	<3.2	.068	.34	.85	5	129	.088	.02	.18	.44
SC07AE	5.6	<.051	.56	1.02	7	265	<.102	.04	.17	.51
SC08AE	<3.3	.070	.23	.70	5	46	.074	.02	.39	.81
SC09AE	<2.8	.030	.29	.75	4	93	<.060	.02	.25	<.28
SC10AE	<3.3	<.035	.34	.70	6	98	.077	.03	.42	<.33
Sandfain, Absaloka Mine, Montana										
SC01SF	<2.9	.062	.11	1.55	6	24	<.062	.01	.53	.56
SC02SF	<3.9	.084	.26	2.94	4	71	<.084	.02	.50	.50
SC03SF	<3.5	.076	.22	2.09	6	80	<.076	.01	.65	<.35
SC04SF	<2.7	.087	.35	2.32	6	145	<.058	.02	.21	.46
SC05SF	5.8	.072	.40	2.16	5	130	.086	.02	.61	2.34
SC06SF	4.7	.039	.43	1.95	5	137	<.078	.02	.55	2.22
SC07SF	<2.4	.052	.18	1.56	5	55	<.052	.03	.24	.29
SC08SF	<3.0	.064	.27	1.60	5	83	<.064	.01	.32	<.30
SC09SF	<3.6	.039	.21	1.95	5	55	<.078	.01	.47	.38
SC10SF	3.6	.099	.29	2.14	5	73	.102	.02	.18	1.98

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Li ppm	Mg %	Mn ppm	Mo ppm	Na ppm	Nb ppm	Ni ppm	P %	Pb ppm
				Alfalfa, So. Beulah Mine, North Dakota					
SB01MS	2.07	.262	42	2.21	200	.90	2.41	.062	.97
SB02MS	.62	.308	72	1.54	254	1.46	1.54	.054	1.69
SB03MS	.54	.300	11	.90	390	<.56	.16	.060	.60
SB04MS	.48	.221	12	1.54	154	<.45	.30	.053	.91
SB05MS	1.15	.338	18	3.10	194	.70	.66	.065	1.01
SB06MS	.50	.236	19	.43	112	<.58	.45	.062	.81
SB07MS	.84	.380	161	5.84	387	2.26	6.64	.062	2.19
SB08MS	3.33	.355	41	1.85	370	<.69	1.18	.074	.89
SB09MS	4.48	.297	46	1.85	420	.78	2.35	.056	1.06
SB10MS	2.44	.293	21	1.10	140	<.57	1.28	.055	.73
				Alfalfa control, So. Beulah Mine, North Dakota					
SB11MS	.72	.552	116	4.80	72	1.80	7.56	.168	2.40
SB12MS	1.30	.741	72	3.12	195	1.56	2.99	.156	1.43
SB13MS	.90	.960	36	2.40	98	1.80	3.15	.150	1.65
				Slender wheatgrass, Absaloka Mine, Montana					
SC01AE	<.12	.049	15	.23	32	<.27	.14	.020	.70
SC02AE	<.20	.075	29	.26	20	<.46	<.10	.023	.55
SC03AE	<.19	.058	24	.22	19	<.45	.11	.026	.86
SC04AE	<.11	.051	15	.19	19	<.25	.24	.026	.59
SC05AE	.16	.060	23	.24	22	<.37	.14	.026	.72
SC06AE	<.14	.037	17	.14	19	<.32	.15	.010	.82
SC07AE	<.20	.082	87	.61	23	1.43	.51	.015	1.84
SC08AE	<.14	.049	13	.10	28	<.33	.08	.030	.60
SC09AE	.12	.051	23	.17	20	<.28	.14	.019	.57
SC10AE	.14	.053	16	.13	30	<.33	.13	.030	.56
				Sandfain, Absaloka Mine, Montana					
SC01SF	<.12	.260	18	1.83	22	<.29	<.06	.015	.29
SC02SF	.17	.319	46	5.46	76	.39	.25	.023	.76
SC03SF	<.15	.281	25	.36	42	<.35	.12	.015	.53
SC04SF	.15	.218	41	3.77	46	.35	.22	.017	.67
SC05SF	<.14	.281	104	3.60	79	.86	.43	.014	1.26
SC06SF	.20	.367	86	1.60	47	.55	.36	.018	1.01
SC07SF	.10	.148	36	2.29	23	<.24	.09	.018	.42
SC08SF	.13	.211	35	.67	32	.38	.17	.021	.58
SC09SF	<.16	.281	62	1.72	39	<.36	.21	.016	.47
SC10SF	<.13	.271	96	.73	43	.59	.40	.018	.96

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Se ppm	Sr ppm	S ppm	Ti ppm	U ppm	V ppm	Y ppm	Zn ppm	Zr ppm
				Alfalfa, So. Beulah Mine, North Dakota					
SB01MS	.20	151.8	1,700	9.0	.028	.46	.35	24.8	1.24
SB02MS	.08	>308.0	1,300	16.2	.031	1.08	.59	15.4	1.62
SB03MS	.08	126.0	1,500	<5.6	.048	.23	.14	12.0	.66
SB04MS	.10	76.8	1,300	6.7	.038	.44	.29	14.4	1.01
SB05MS	.15	223.2	2,600	7.1	.115	.48	.42	20.2	1.15
SB06MS	.15	105.4	1,700	8.1	.074	.33	.34	20.5	.93
SB07MS	.10	>292.0	2,800	24.8	.058	2.26	1.39	56.9	3.58
SB08MS	.15	155.4	2,000	8.1	.030	.34	.38	20.0	.96
SB09MS	.15	>224.0	1,300	10.1	.022	.67	.43	20.2	1.12
SB10MS	.15	109.8	1,500	7.3	.024	.31	.28	20.7	.73
				Alfalfa control, So. Beulah Mine, North Dakota					
SB11MS	.40	168.0	2,500	15.6	.048	1.56	1.06	19.2	3.60
SB12MS	.70	130.0	3,200	18.2	.052	.75	1.05	23.4	2.34
SB13MS	.80	130.5	2,500	<14.0	.060	.89	.80	18.0	1.29
				Slender wheatgrass, Absaloka Mine, Montana					
SC01AE	.04	4.9	550	4.1	.046	.12	.13	21.2	.38
SC02AE	.04	5.0	650	<4.7	.020	<.10	.11	12.0	.41
SC03AE	.02	5.3	500	4.7	.038	.22	.21	16.3	.58
SC04AE	.02	7.0	400	6.7	.022	.23	.21	12.7	.62
SC05AE	.04	10.8	500	4.8	.016	.22	.17	14.8	.39
SC06AE	.02	10.2	400	7.5	.027	.20	.22	10.9	.92
SC07AE	.02	8.2	450	14.3	.020	1.02	.43	11.2	1.53
SC08AE	.02	3.5	550	<3.3	.014	.09	.07	7.0	.25
SC09AE	.02	6.6	450	3.9	.024	.16	.14	8.7	.36
SC10AE	.02	3.9	550	4.6	.028	.13	.13	9.1	.56
				Sandfain, Absaloka Mine, Montana					
SC01SF	.02	24.2	1,000	<2.9	.025	<.06	.07	7.4	.30
SC02SF	.04	50.4	3,600	4.2	.050	.16	.16	18.1	.71
SC03SF	.02	19.4	900	<3.5	.030	.15	.16	12.9	.38
SC04SF	.04	52.2	400	8.4	.035	.29	.41	22.6	2.00
SC05SF	.06	86.4	1,400	8.3	.029	.68	.40	9.0	1.44
SC06SF	.04	78.0	1,200	7.8	.047	.51	.32	8.2	1.13
SC07SF	.02	33.8	650	3.1	.010	.15	.15	6.2	.47
SC08SF	.04	23.7	550	3.8	.026	.14	.14	4.5	.64
SC09SF	.02	30.8	1,800	<3.6	.047	.09	.12	6.6	.36
SC10SF	.02	49.5	900	4.3	.026	.59	.33	5.6	.99

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Latitude	Longitude	Ash %	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Ca %	Cd ppm
				Intermediate wheatgrass, Seneca No. 2 Mine, Colorado						
SE01AC	40 26 15	107 6 20	6.9	304	.35	6.8	7.6	<.138	.21	<.028
SE02AC	40 26 15	107 6 20	6.9	435	.25	4.6	4.9	.173	.19	.110
SE03AC	40 26 15	107 6 20	6.4	454	.25	5.7	8.3	.160	.18	.064
SE04AC	40 26 15	107 6 20	6.1	262	1.00	7.3	6.1	.140	.20	.031
SE05AC	40 26 15	107 6 20	7.0	483	.95	5.0	19.6	.238	.21	.070
SE06AC	40 26 15	107 6 20	9.9	347	.65	3.5	7.8	<.198	.20	<.040
SE07AC	40 26 15	107 6 20	6.8	143	.20	5.9	7.5	<.136	.24	.027
SE08AC	40 26 15	107 6 20	6.3	132	.15	4.9	3.0	.151	.14	.038
SE09AC	40 26 15	107 6 20	5.8	145	.20	4.1	4.3	.186	.14	.035
SE10AC	40 26 15	107 6 20	7.2	245	.20	4.3	6.9	.259	.14	.029
				Alfalfa, Seneca No. 2 Mine, Colorado						
SE01MS	40 26 15	107 6 20	5.7	410	.30	39.3	9.7	<.114	1.14	.114
SE02MS	40 26 15	107 6 20	7.7	570	.25	53.1	5.1	<.154	2.00	.431
SE03MS	40 26 15	107 6 20	6.3	284	.40	36.5	3.3	<.126	1.45	.151
SE04MS	40 26 15	107 6 20	6.7	489	.30	80.4	7.4	<.134	1.61	.107
SE05MS	40 26 15	107 6 20	10.0	770	.60	55.0	47.0	<.200	2.90	<.040
SE06MS	40 26 15	107 6 20	7.6	312	3.00	66.1	11.4	<.152	1.98	.106
SE07MS	40 26 15	107 6 20	6.0	1,140	1.30	84.0	13.8	<.120	1.38	.060
SE08MS	40 26 15	107 6 20	4.4	374	.90	29.9	4.4	<.088	.88	.053
SE09MS	40 26 15	107 6 20	6.6	172	.65	35.6	4.9	<.132	1.65	.172
SE10MS	40 26 15	107 6 20	8.9	543	.25	79.2	7.5	<.178	2.67	.107
				Crested wheatgrass, Seminoe No. 2 Mine, Wyoming						
SM01AC	41 53 0	106 32 0	4.9	284	.40	7.3	2.8	.108	.24	<.020
SM02AC	41 53 0	106 32 0	4.6	506	.30	8.3	5.5	<.092	.22	<.018
SM03AC	41 53 0	106 32 0	5.0	470	.15	7.5	7.5	.110	.29	.040
SM04AC	41 53 0	106 32 0	5.3	742	.25	4.1	5.3	<.106	.24	.021
SM05AC	41 53 0	106 32 0	5.3	689	.60	3.1	12.2	<.106	.29	<.021
SM06AC	41 53 0	106 32 0	5.0	650	.20	7.0	6.5	<.100	.29	.030
SM07AC	41 53 0	106 32 0	5.2	468	.70	7.8	5.0	.140	.27	.083
SM08AC	41 53 0	106 32 0	5.0	295	.60	10.5	4.0	.105	.30	<.020
SM09AC	41 53 0	106 32 0	6.3	693	.40	8.2	11.3	.227	.33	.063
SM10AC	41 53 0	106 32 0	5.0	455	.50	7.5	4.0	.105	.27	.050
				Intermediate wheatgrass, Velva Mine, North Dakota						
VE01AI	47 57 0	101 0 0	8.9	73	.65	4.4	6.9	<.178	.20	<.036
VE02AI	47 57 0	101 0 0	7.9	150	.20	5.4	4.1	.269	.19	.047
VE03AI	47 57 0	101 0 0	7.1	142	.80	9.2	11.4	.213	.16	.071
VE04AI	47 57 0	101 0 0	6.9	104	.10	14.5	13.8	.173	.19	<.028
VE05AI	47 57 0	101 0 0	6.7	80	.10	9.4	8.7	.188	.20	.027
VE06AI	47 57 0	101 0 0	6.6	172	.05	19.8	13.2	.363	.21	.066
VE07AI	47 57 0	101 0 0	7.5	218	.30	11.3	18.8	.458	.17	.090
VE08AI	47 57 0	101 0 0	8.1	219	.15	11.3	21.9	.381	.16	.065
VE09AI	47 57 0	101 0 0	7.8	86	.30	5.9	9.4	.226	.17	<.031
VE10AI	47 57 0	101 0 0	7.9	221	.20	9.5	18.2	.363	.16	<.032

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Ce ppm	Co ppm	Cr ppm	Cu ppm	F ppm	Fe ppm	Ge ppm	Hg ppm	K %	La ppm
				Intermediate wheatgrass, Seneca No. 2 Mine, Colorado						
SE01AC	<6.4	<.069	.54	.69	8	138	.200	.02	1.03	<.64
SE02AC	<6.4	.069	.69	.69	9	186	.200	<.01	1.17	<.64
SE03AC	<6.0	.128	.49	.96	6	122	<.128	.01	.64	<.60
SE04AC	<5.7	.061	.51	1.22	7	134	.165	.01	1.10	<.57
SE05AC	<6.5	.070	.77	3.50	6	154	<.140	.01	2.03	<.65
SE06AC	<9.2	<.099	.56	.99	10	109	<.198	.01	1.68	<.92
SE07AC	<6.3	<.068	.32	1.36	7	61	<.136	.01	1.22	<.63
SE08AC	<5.9	<.063	.32	1.26	10	57	.164	<.01	1.45	1.95
SE09AC	<5.4	<.058	.30	.87	6	64	<.116	.01	1.22	1.22
SE10AC	<6.7	<.072	.41	.72	7	94	.252	.01	1.15	1.94
				Alfalfa, Seneca No. 2 Mine, Colorado						
SE01MS	<5.3	.114	.68	4.85	7	120	<.114	.01	.97	3.36
SE02MS	<7.2	.077	.47	5.39	6	154	<.154	.01	.49	1.93
SE03MS	<5.9	<.063	.35	7.56	7	101	<.126	.01	.76	<.59
SE04MS	6.7	.067	.55	8.04	9	161	<.134	.01	.80	2.35
SE05MS	<9.3	<.100	.55	7.00	8	150	<.200	.01	.74	1.40
SE06MS	<7.1	<.076	.40	6.84	6	91	<.152	.01	.56	.84
SE07MS	7.2	.060	.72	5.40	6	252	.192	.02	.90	1.32
SE08MS	<4.1	<.044	.25	1.10	4	88	<.088	.01	.88	.66
SE09MS	<6.1	<.066	.26	5.28	6	79	<.132	<.01	.66	.63
SE10MS	<8.3	.089	.58	7.12	8	134	<.178	.02	.46	1.07
				Crested wheatgrass, Seminoe No. 2 Mine, Wyoming						
SM01AC	<4.6	.098	<.10	1.47	7	147	.098	.01	1.03	<.46
SM02AC	<4.3	<.046	.42	2.53	7	170	.115	.01	1.01	1.38
SM03AC	5.0	.050	.55	3.00	10	175	.115	.01	1.30	1.10
SM04AC	<4.9	.106	.64	2.12	12	260	<.106	.04	1.06	<.49
SM05AC	<4.9	.106	.80	1.86	14	254	.154	.01	.95	1.54
SM06AC	<4.7	.050	.50	2.75	7	195	.105	.02	1.05	<.46
SM07AC	<4.8	.052	.49	2.08	8	166	<.104	.02	1.20	1.35
SM08AC	<4.7	.100	.46	1.75	7	145	.105	.03	1.05	<.46
SM09AC	<5.9	.063	.88	3.78	5	227	.214	.02	1.45	.76
SM10AC	<4.7	.050	.39	3.25	7	140	.105	.02	1.10	<.46
				Intermediate wheatgrass, Velva Mine, North Dakota						
VE01AI	<8.3	.089	.18	1.33	4	31	<.178	.02	.27	<.83
VE02AI	<7.3	<.079	.20	1.19	5	45	.269	.01	.19	2.45
VE03AI	<6.6	<.071	.31	1.42	6	50	.199	.02	.21	1.56
VE04AI	<6.4	<.069	.23	1.38	5	41	.221	.01	.21	<.64
VE05AI	<6.2	.201	.21	1.34	5	34	.168	.01	.23	1.47
VE06AI	<6.1	<.066	.40	1.32	3	73	<.132	.02	.24	<.61
VE07AI	<7.0	<.075	.55	2.25	4	98	.413	.04	.21	3.53
VE08AI	8.1	<.081	.53	2.03	5	89	.356	.02	.23	<.75
VE09AI	<7.3	.078	.21	1.56	8	46	.218	.01	.19	3.82

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Se ppm	Sr ppm	S ppm	Ti ppm	U ppm	V ppm	Y ppm	Zn ppm	Zr ppm
Intermediate wheatgrass, Seneca No. 2 Mine, Colorado									
SE01AC	.15	7.6	900	6.9	.028	.23	.17	8.3	.90
SE02AC	.25	4.1	900	11.0	.028	.50	.32	9.0	.83
SE03AC	.15	9.0	500	9.0	.026	.29	.27	12.8	.83
SE04AC	.20	4.3	950	6.7	.024	.27	.16	15.3	.60
SE05AC	.06	7.0	2,000	11.2	.028	.51	.36	8.4	.77
SE06AC	.15	7.0	900	<9.2	.040	<.20	.29	11.9	.74
SE07AC	.15	3.1	1,000	<6.3	.027	.20	.22	17.7	.42
SE08AC	.20	3.3	750	<5.9	.025	.17	.14	12.6	.38
SE09AC	.40	3.4	700	<5.4	<.023	.14	.12	8.1	.44
SE10AC	.45	4.5	850	6.8	.086	.34	.18	7.9	.63
Alfalfa, Seneca No. 2 Mine, Colorado									
SE01MS	.10	21.7	1,400	7.4	.023	.29	.26	14.8	.86
SE02MS	.35	34.7	1,300	10.0	.031	.35	.44	35.4	1.16
SE03MS	.15	20.2	1,500	<5.9	.050	.13	.21	30.9	.47
SE04MS	.35	35.5	2,800	10.1	.027	.52	.48	14.1	1.27
SE05MS	.80	72.0	2,400	12.0	.120	.65	.60	18.0	1.60
SE06MS	.25	37.2	2,000	<7.1	.061	.27	.30	23.6	.84
SE07MS	.20	54.0	2,200	20.4	.072	1.26	.66	22.8	2.82
SE08MS	.25	35.6	950	5.7	.035	.23	.19	12.3	.53
SE09MS	.90	37.0	1,600	<6.1	.053	.16	.27	18.5	.55
SE10MS	.65	45.4	2,000	8.9	.071	.37	.35	28.5	1.16
Crested wheatgrass, Seminoe No. 2 Mine, Wyoming									
SM01AC	.10	4.0	1,200	5.4	.039	.44	.17	11.3	.41
SM02AC	.06	6.4	1,300	9.7	.055	.41	.23	8.3	.60
SM03AC	.04	6.0	1,500	10.5	.060	.70	.34	8.0	.75
SM04AC	.10	6.9	950	12.2	.064	.80	.32	9.5	.64
SM05AC	.04	5.8	900	15.4	.042	1.17	.48	10.6	.90
SM06AC	.04	7.5	1,100	10.0	.060	.65	.25	10.5	.65
SM07AC	.04	4.6	1,200	8.8	.062	.57	.25	7.8	.44
SM08AC	.06	5.0	1,300	5.5	.060	.45	.15	9.0	.36
SM09AC	.04	22.0	1,500	10.1	.076	.88	.39	10.7	.95
SM10AC	.06	7.0	1,200	7.0	.060	.34	.18	10.0	.55
Intermediate wheatgrass, Velva Mine, North Dakota									
VE01AI	.08	8.3	500	<8.3	.071	<.18	<.18	15.1	.60
VE02AI	.20	6.4	450	<7.3	.063	<.16	.17	18.2	.95
VE03AI	.06	9.9	400	<6.6	.028	<.14	<.14	13.5	.63
VE04AI	.10	8.3	450	<6.4	.055	.30	.30	12.4	.61
VE05AI	.08	11.4	400	<6.2	.080	.13	<.13	16.8	.36
VE06AI	.08	26.4	450	<6.1	.053	.34	.30	15.8	.60
VE07AI	.08	11.3	600	8.3	.060	.83	.48	14.3	.83
VE08AI	.20	11.3	400	<7.5	.065	.61	.37	14.6	.73

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Latitude	Longitude	Ash %	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Ca %	Cd ppm
				Alfalfa, Velva Mine, North Dakota						
VE01MS	47 57 0	101 0 0	6.9	242	.20	110.4	20.7	.173	1.73	.179
VE02MS	47 57 0	101 0 0	6.8	245	1.00	115.6	20.4	.272	1.70	.054
VE03MS	47 57 0	101 0 0	7.7	385	.60	130.9	16.2	.223	2.31	.046
VE04MS	47 57 0	101 0 0	6.1	183	.60	53.7	18.9	<.122	1.46	.049
VE05MS	47 57 0	101 0 0	7.1	121	.30	62.5	9.2	<.142	1.92	.071
VE06MS	47 57 0	101 0 0	7.8	257	.55	78.0	10.9	.164	2.03	.109
VE07MS	47 57 0	101 0 0	6.4	77	.30	36.5	5.7	<.128	1.54	.102
VE08MS	47 57 0	101 0 0	6.2	74	.60	27.9	6.8	<.124	1.43	.062
VE09MS	47 57 0	101 0 0	6.5	72	.80	56.6	3.9	<.130	1.50	.052
VE10MS	47 57 0	101 0 0	5.9	100	1.10	64.9	7.1	<.118	1.24	.106
				Alfalfa control, Velva Mine, North Dakota						
VE11MS	47 57 0	101 0 0	7.9	340	.75	67.1	7.4	<.158	1.50	.063
VE12MS	47 57 0	101 0 0	8.6	542	.75	58.5	24.9	<.172	1.72	.086
VE13MS	47 57 0	101 0 0	7.8	390	.60	54.6	10.9	<.156	1.40	.062
				American green alder, Usibelli Mine, Alaska						
US1AS	63 51 0	148 44 0	3.6	115	<.05	11.9	8.3	<.072	.65	.018
US2AS	63 51 0	148 44 0	3.6	194	<.05	11.9	23.8	<.072	.58	.054
US3AS	63 51 0	148 44 0	3.4	85	<.05	10.9	8.2	<.068	.54	.034
				American green alder control, Usibelli Mine, Alaska						
US1AN	63 51 0	148 44 0	3.3	241	<.05	13.9	16.8	<.066	.53	.033
US2AN	63 51 0	148 44 0	3.0	129	<.05	9.6	20.7	<.060	.48	.030
US3AN	63 51 0	148 44 0	2.7	116	.15	8.6	12.7	<.054	.43	.014
				Diamondleaf willow, Usibelli Mine, Alaska						
US1WS	63 51 0	148 44 0	4.5	198	<.05	10.8	6.8	<.090	.77	3.735
US2WS	63 51 0	148 44 0	3.7	115	<.05	13.3	4.8	<.074	.55	2.590
US3WS	63 51 0	148 44 0	3.5	95	<.05	11.2	8.8	<.070	.60	1.995

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Ce ppm	Co ppm	Cr ppm	Cu ppm	F ppm	Fe ppm	Ge ppm	Hg ppm	K %	La ppm
Alfalfa, Velva Mine, North Dakota										
VE01MS	9.7	<.069	.49	10.35	4	131	.200	.02	1.03	4.42
VE02MS	8.8	<.068	.44	9.18	4	116	<.136	.03	.95	3.47
VE03MS	10.8	<.077	.58	9.24	4	169	.208	.01	.92	4.62
VE04MS	<5.7	<.061	.27	6.10	5	67	<.122	.01	1.04	<.57
VE05MS	<6.6	<.071	.23	11.36	5	78	<.142	.01	.78	<.66
VE06MS	<7.3	.156	.37	10.92	6	117	<.156	.01	1.17	3.59
VE07MS	<6.0	<.064	.13	6.40	5	48	<.128	.02	1.02	.77
VE08MS	<5.8	.062	.12	6.82	6	33	<.124	.03	1.18	<.58
VE09MS	<6.0	<.065	.18	12.35	6	51	<.130	.01	1.30	.65
VE10MS	<5.5	<.059	.24	7.38	6	44	<.118	.01	1.18	.65
Alfalfa control, Velva Mine, North Dakota										
VE11MS	<7.3	.158	.33	7.90	4	205	<.158	<.01	1.26	2.05
VE12MS	<8.0	<.086	.38	6.45	4	206	<.172	.02	1.72	1.20
VE13MS	<7.3	.078	.34	7.80	8	179	<.156	.01	1.48	1.09
American green alder, Usibelli Mine, Alaska										
US1AS	<3.3	.144	.17	9.36	7	83	<.072	.01	.72	1.15
US2AS	<3.3	.072	.25	9.36	8	130	<.072	.02	.79	1.26
US3AS	<3.2	.068	.14	8.84	6	92	<.068	.02	.71	1.16
American green alder control, Usibelli Mine, Alaska										
US1AN	<3.1	.099	.19	7.26	7	115	<.066	.01	.59	1.12
US2AN	<2.8	.120	.13	5.70	6	81	<.060	.01	.63	.81
US3AN	<2.5	.054	.13	7.56	8	89	<.054	.01	.57	.73
Diamondleaf willow, Usibelli Mine, Alaska										
US1WS	<4.2	.180	.50	6.75	7	95	<.090	.02	.95	1.22
US2WS	<3.4	.148	.15	6.66	6	74	<.074	.02	.85	1.33
US3WS	<3.3	.245	.22	7.35	7	74	<.070	.01	.77	1.12

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Li ppm	Mg %	Mn ppm	Mo ppm	Na ppm	Nb ppm	Ni ppm	P %	Pb ppm
				Alfalfa, Velva Mine, North Dakota					
VE01MS	3.86	.221	47	8.97	38	1.38	1.17	.104	1.59
VE02MS	7.48	.286	39	8.16	272	1.63	.68	.109	1.22
VE03MS	5.93	.370	77	6.08	46	2.16	1.00	.077	1.46
VE04MS	5.49	.238	13	2.44	73	<.57	.23	.085	2.62
VE05MS	3.91	.284	26	2.41	71	<.66	.50	.106	.85
VE06MS	5.07	.250	31	5.69	62	1.01	1.33	.125	1.17
VE07MS	7.68	.192	13	1.92	141	<.60	.38	.070	.70
VE08MS	5.89	.198	27	2.48	105	<.58	.62	.093	.48
VE09MS	9.43	.364	14	5.27	247	<.60	.62	.078	.72
VE10MS	5.90	.212	18	5.02	89	<.55	.53	.059	.77
				Alfalfa control, Velva Mine, North Dakota					
VE11MS	18.17	.411	27	8.69	1,817	<.73	.63	.205	1.11
VE12MS	4.30	.344	50	4.21	688	1.03	1.81	.215	1.20
VE13MS	10.92	.499	40	3.90	1,014	.72	1.01	.203	.94
				American green alder, Usibelli Mine, Alaska					
US1AS	<.14	.180	137	.11	14	<.33	3.96	.209	.43
US2AS	<.14	.166	576	.11	5	<.33	2.88	.216	.36
US3AS	<.14	.163	218	.08	10	<.32	4.08	.224	.37
				American green alder control, Usibelli Mine, Alaska					
US1AN	<.13	.205	>660	.16	25	<.31	2.51	.172	.40
US2AN	<.12	.162	420	.07	14	<.28	2.19	.150	.21
US3AN	<.11	.151	540	.16	19	<.25	2.16	.173	.30
				Diamondleaf willow, Usibelli Mine, Alaska					
US1WS	<.18	.180	284	.09	18	<.42	3.87	.203	.41
US2WS	<.15	.185	333	.11	15	<.34	4.44	.192	.29
US3WS	<.14	.144	315	.15	21	<.33	3.85	.168	.33

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Se ppm	Sr ppm	S ppm	Ti ppm	U ppm	V ppm	Y ppm	Zn ppm	Zr ppm
Alfalfa, Velva Mine, North Dakota									
VE01MS	.30	151.8	1,900	6.9	.055	.76	.23	33.1	1.03
VE02MS	.30	204.0	1,800	<6.3	.054	.82	.20	19.0	.63
VE03MS	.50	215.6	1,800	7.7	.092	1.16	.45	20.8	1.62
VE04MS	.30	128.1	1,500	<5.7	.024	.30	.13	14.6	.52
VE05MS	.35	78.1	1,500	<6.6	.227	.20	.16	34.1	.44
VE06MS	.55	109.2	2,700	<7.3	.218	<.16	.32	27.3	.78
VE07MS	.30	60.8	1,200	<6.0	.102	<.13	<.13	16.6	.42
VE08MS	.25	58.9	1,500	<5.8	.050	<.12	<.12	21.7	.46
VE09MS	.55	54.0	2,400	<6.0	.130	<.13	.20	23.4	.42
VE10MS	.45	76.7	1,400	<5.5	.094	.14	.12	20.7	.39
Alfalfa control, Velva Mine, North Dakota									
VE11MS	.40	71.9	4,000	7.3	.356	.24	.20	17.4	.73
VE12MS	.35	74.8	4,000	8.4	.069	.64	.34	20.6	1.03
VE13MS	.70	77.2	4,600	<7.3	.187	.37	.31	22.6	.94
American green alder, Usibelli Mine, Alaska									
US1AS	.01	12.6	1,300	<3.3	<.014	<.07	.09	66.6	.79
US2AS	.01	18.4	1,700	<3.3	<.014	.09	.10	61.2	2.23
US3AS	.01	9.9	1,500	<3.2	<.014	<.07	.07	62.9	.95
American green alder control, Usibelli Mine, Alaska									
US1AN	.01	16.8	1,100	4.0	.013	.10	.14	54.4	2.90
US2AN	.01	12.9	1,100	<2.8	<.012	.10	.07	46.5	1.44
US3AN	.01	8.9	1,100	<2.5	.022	.08	.11	37.8	2.00
Diamondleaf willow, Usibelli Mine, Alaska									
US1WS	.02	18.0	1,300	<4.2	<.018	.09	.11	173.3	1.26
US2WS	.02	13.7	1,800	<3.4	<.015	<.07	.13	144.3	1.48
US3WS	.01	13.0	1,700	<3.3	<.014	.11	<.07	199.5	1.47

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Latitude	Longitude	Ash %	Al ppm	As ppm	B ppm	Ba ppm	Be ppm	Ca %	Cd ppm
				Diamondleaf willow control, Usibelli Mine, Alaska						
US1WN	63 51 0	148 44 0	3.1	121	<.05	13.3	7.8	<.062	.46	.124
US2WN	63 51 0	148 44 0	4.1	209	<.05	7.0	10.7	<.082	.57	3.936
US3WN	63 51 0	148 44 0	3.4	323	.10	10.5	7.8	<.068	.54	2.380
				Alkali sacaton, San Juan Mine, New Mexico						
SJ111AO	36 45 0	108 22 30	5.1	454	.10	10.2	11.7	<.102	.42	.153
SJ112AO	36 45 0	108 22 30	5.6	246	.10	7.8	<.2	<.112	.40	.056
SJ121AO	36 45 0	108 25 20	5.7	1,026	.15	8.5	17.1	<.114	.44	.034
SJ211AO	36 45 0	108 25 20	4.1	320	.10	7.8	10.7	<.082	.36	.057
SJ212AO	36 45 0	108 25 20	4.6	552	.15	12.0	14.3	<.092	.37	.032
SJ221AO	36 45 0	108 22 30	5.6	728	.15	9.0	16.8	<.112	.46	.022
				Fourwing saltbush, San Juan Mine, New Mexico						
SJ111FO	36 45 0	108 22 30	15.0	1,395	.25	55.5	33.0	<.300	.99	.240
SJ112FO	36 45 0	108 22 30	14.0	938	.25	51.8	18.2	<.280	.92	.140
SJ121FO	36 45 0	108 22 30	13.0	1,118	.25	40.3	19.5	<.260	.91	.260
SJ211FO	36 45 0	108 25 20	12.0	1,440	.20	>60.0	33.6	<.240	1.44	.264
SJ212FO	36 45 0	108 25 20	13.0	1,690	.30	>65.0	41.6	<.260	.99	.052
SJ221FO	36 45 0	108 22 30	14.0	882	.20	51.8	16.8	<.280	1.15	.224

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Ce ppm	Co ppm	Cr ppm	Cu ppm	F ppm	Fe ppm	Ge ppm	Hg ppm	K %	La ppm
Diamondleaf willow control, Usibelli Mine, Alaska										
US1WN	<2.9	.155	.19	3.72	6	84	<.062	.01	.68	.87
US2WN	<3.8	2.870	.24	6.15	8	115	<.082	.03	1.07	<.82
US3WN	<3.2	.272	.34	5.10	5	126	<.068	.01	.78	.34
Alkali sacaton, San Juan Mine, New Mexico										
SJ111AO	<4.7	.255	.47	2.80	8	326	.102	.20	.16	<.47
SJ112AO	<5.2	.168	.90	1.96	8	213	<.052	.25	.24	2.35
SJ121AO	<5.3	.342	.91	2.56	9	513	.074	.20	.26	1.03
SJ211AO	<3.8	.164	.49	2.05	6	217	.074	.15	.20	<.38
SJ212AO	4.5	.276	.74	2.30	8	322	<.042	.15	.25	.69
SJ221AO	<5.2	.224	.90	2.80	8	381	<.052	.25	.35	1.12
Fourwing saltbush, San Juan Mine, New Mexico										
SJ111FO	<14.0	.600	2.40	12.00	19	915	<.138	.10	2.55	<1.39
SJ112FO	<13.0	.560	1.96	9.80	21	714	<.129	.10	2.10	<1.30
SJ121FO	<12.1	.650	2.47	9.10	18	767	<.120	.20	2.99	<1.21
SJ211FO	<11.2	.360	1.92	10.20	19	708	<.110	.08	2.64	1.56
SJ212FO	<12.1	.520	1.82	8.45	34	1,066	.169	.20	2.08	1.82
SJ221FO	<13.0	.280	1.96	9.10	15	616	<.129	.15	3.22	<1.30

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Li ppm	Mg %	Mn ppm	Mo ppm	Na ppm	Nb ppm	Ni ppm	P %	Pb ppm
Diamondleaf willow control, Usibelli Mine, Alaska									
US1WN	<.12	.217	192	.15	14	<.29	3.41	.149	.34
US2WN	<.16	.230	340	.11	21	<.38	3.03	.164	.30
US3WN	.14	.163	303	.07	31	<.32	1.12	.150	.41
Alkali sacaton, San Juan Mine, New Mexico									
SJ111AO	.46	.082	56	.76	1,275	.97	.66	.031	1.53
SJ112AO	.22	.112	56	.90	1,120	.53	.73	.034	1.01
SJ121AO	.23	.097	74	.74	912	1.31	1.08	.029	1.65
SJ211AO	.16	.119	31	.57	4,510	.26	.49	.033	1.23
SJ212AO	.37	.101	55	.87	1,380	.69	.64	.037	1.38
SJ221AO	.39	.112	38	.48	1,680	.62	.78	.039	1.79
Fourwing saltbush, San Juan Mine, New Mexico									
SJ111FO	1.80	.750	165	.78	19,500	3.00	3.15	.120	1.22
SJ112FO	2.10	.840	133	.74	19,600	2.52	1.37	.084	1.08
SJ121FO	1.82	.702	169	.66	6,500	1.25	3.38	.078	1.18
SJ211FO	1.20	.672	240	1.32	540	<.52	1.68	.084	.96
SJ212FO	2.47	.611	208	.53	11,700	<.56	1.95	.065	1.69
SJ221FO	1.12	.784	90	.57	10,500	1.18	1.11	.084	.99

Concentrations of elements (dry-weight basis) in samples of vegetation from thirteen surface coal-mine reclamation sites in five western states and Alaska--continued

Sample	Se ppm	Sr ppm	S ppm	Ti ppm	U ppm	V ppm	Y ppm	Zn ppm	Zr ppm
				Diamondleaf willow control, Usibelli Mine, Alaska					
US1WN	.01	10.9	1,200	<2.9	<.012	<.06	.08	133.3	.90
US2WN	.01	18.9	1,700	3.9	.033	.16	.18	164.0	1.68
US3WN	.01	13.6	1,200	6.5	.014	.22	.15	180.2	1.46
				Alkali sacaton, San Juan Mine, New Mexico					
SJ111A0	.10	17.8	1,300	12.7	.122	1.02	.49	16.3	1.73
SJ112A0	.08	17.4	1,600	5.3	.146	.62	.30	12.3	.54
SJ121A0	.10	23.9	1,200	44.5	.125	1.37	.68	12.5	3.31
SJ211A0	.10	17.6	1,800	10.7	.139	.66	.37	11.1	1.15
SJ212A0	.10	23.9	1,500	18.9	.156	.97	.46	17.0	2.30
SJ221A0	.10	26.9	1,600	29.1	.101	1.23	.62	13.4	5.26
				Fourwing saltbush, San Juan Mine, New Mexico					
SJ111F0	.15	42.0	5,200	61.5	.120	2.10	.95	55.5	8.55
SJ112F0	.15	35.0	4,000	33.6	.112	1.68	.60	60.2	3.92
SJ121F0	.10	41.6	4,200	44.2	.130	1.69	.65	61.1	4.03
SJ211F0	.30	70.8	4,400	43.2	.072	2.04	1.03	86.4	5.28
SJ212F0	.45	53.3	5,200	63.7	.104	2.73	1.26	68.9	8.19
SJ221F0	.35	53.2	4,100	25.2	.112	1.54	.60	26.6	3.08