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BACA GEOTHERMAL DEMONSTRATION PROJECT
BASELINE ECOSYSTEM STUDIES OF
COOLING TOWER EMISSION EFFECTS

INTERIM REPORT

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ABSTRACT

Results of baseline studies for boron, arsenic, mercury, and fluorine in vegetation and soil near the Baca Geothermal Demonstration Power Plant are provided for the 1980 sampling season. Preliminary results of visual vegetation assessments and population density studies of soil invertebrate fauna are also provided.

Foliage samples were collected for chemical analysis on a total of 17 plots on 5 transects. Two to five plant species were sampled at each plot. Samples were collected in June-July and September. Soil samples were collected at each plot during September. Visual vegetation inspections were conducted along each transect. Eighty-eight soil samples were collected for soil invertebrate studies.

Boron, arsenic, mercury, and fluorine levels in vegetation were within normal range for natural vegetation and crops. Concentrations of soil arsenic and mercury were comparable to foliage concentrations. Boron concentrations were lower in soil than in foliage, whereas soil fluorine concentrations were considerably higher than foliage concentrations. With the exception of heavy insect infestations in June-July, no vegetation abnormalities were noted. Preliminary soil invertebrate analysis indicated an overall arthropod density of approximately 100,000/m² which appears within the normal range encountered in forest and meadow soil.

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SECTION 1.0

INTRODUCTION

This report summarizes preliminary results of 1980 ecological studies conducted at the site of the Baca Geothermal Demonstration Power Plant. These investigations were designed to provide baseline data for future monitoring of potential cooling tower drift effects.

Field sampling was carried out to (1) determine by visual examination the current condition of important vegetative species, (2) collect soil and foliage for chemical analysis, and (3) obtain soil cores for extraction of soil invertebrate fauna. Laboratory analysis of all soil and foliage samples has been accomplished; the visual assessment data has subjected to preliminary analysis; and population counts of soil invertebrates have been partially completed in order to determine trends. Full data will provided as an addendum to this report.

This report provides a detailed description of study methods. It also presents the results of chemical analysis of soils and foliage for boron, arsenic, mercury, and fluorine. General conclusions of the visual assessment study of vegetation are included. Representative population data for the soil invertebrate fauna are provided for a number of core samples. There is a discussion of several issues pertaining to sampling methods and procedures.

SECTION 2.0

METHODS

2.1 CHEMICAL ANALYSIS OF VEGETATION AND SOILS

2.1.1 Field Sampling

During the June-July sampling period, five transects were established radiating from the site of the power plant cooling tower. These transects were selected based on topography, access, and vegetation type. The locations of these transects are shown in Figure 2.1. A total of 17 sample plots were located at intervals on these transects. These plots are represented by circles on Figure 2.1, and the number associated with each plot indicates the measured distance to the cooling tower.

The center of each plot was identified with a "T"-drive iron post that was sprayed with bright orange paint and then marked with plastic survey flagging to facilitate relocation. Adjacent trees were also flagged. Individual specimens of each plant species to be sampled were then selected and marked within a 30 meter radius of the plot center post. Metal tags with individual numbers were attached to trees for permanent identification. Tree trunks were then sprayed with fluorescent paint as an additional identification and distances and compass bearings from the plot center were recorded.

The species of trees selected for study were generally the most abundant along the given transect (Table 2.1). Care was taken to sample species that were present at all or most of the plots on a transect. In addition, grasses were sampled on transects A and C where there were extensive meadows bordering the riparian zone. On the other transects, herbaceous species were not abundant enough to provide sufficient material for chemical analysis. No shrub species were found to be abundant enough for this purpose and, as a result, were not sampled.

Once tree specimens were selected and marked, foliage samples were taken by hand picking, hand pruner, or pole pruner. Needles or leaves were taken from the side of the tree facing the cooling tower site. Foliage was collected from at least five individual trees of a given species at each sample plot. The material was usually mixed into a single sample with a fresh weight of about 500 grams. At certain plots a series of replicate samples was taken for a particular species. The replicates were collected from individual trees and analyzed separately; in the case of replicate samples of grass, the material was simply cut from different areas near the plot center. All foliage samples were placed in plastic bags and carefully labelled with the plot designation and species name.

Folige samples for chemical analysis were taken both during the June 24-27 and July 9-11, 1980 sampling period and during the September 16-19, 1980 sampling period. Table 2.2 indicates the number of samples collected for each plant species at the 17 sample plots.

Table 2.1

LIST OF TREE SPECIES SAMPLED FOR CHEMICAL ANALYSIS
AND VISUAL DAMAGE ASSESSMENT

<u>COMMON NAME</u>	<u>SCIENTIFIC NAME</u>
Gambel Oak	<u>Quercus gambelii</u>
Quaking Aspen	<u>Populus tremuloides</u>
Alder	<u>Alnus tenuifolia</u>
Douglas Fir	<u>Pseudotsuga menziesii</u>
White Fir	<u>Abies concolor</u>
Ponderosa Pine	<u>Pinus ponderosa</u>

Table 2.2
PLANT SPECIES SAMPLED FOR CHEMICAL ANALYSIS OF FOLIAGE¹

Sample Plot	Grass	Gambel Oak	Quaking Aspen	Alder	Douglas Fir	White Fir	Ponderosa Pine
A 150	0/1	1/6	1/1	1/5	1/1		
300	0/1		1/5	1/1	0/1		
600	0/1		1/1	1/1	1/1		
1000	0/1		1/1	1/1	1/1		
B 150			1/1		1/1	1/1	
300			1/1		1/1	1/1	
600			1/1		1/1	1/1	
C 150	1/5			1/1		1/1	1/1
300	1/1			1/1		1/1	
600	0/1			1/1	1/1		1/1
1000	1/1			1/1	0/5		1/5
D 50		6/5				5/5	5/5
150		1/1				1/1	
300		1/1			1/1	1/1	
600		1/1			1/1	1/1	
E 150		1/1				1/1	
300		1/1				1/2	

1. Number before the slash indicates number of replicate samples taken in June and July 1980, while the number after the slash indicates replicates taken in September 1980.

Soil samples for chemical analysis were collected during the September 16-19, 1980 sampling period. These samples were taken with a coring tool near each plot center. Samples were obtained at each plot for shallow (0 to 7.5 cm) and deep (7.5 to 15 cm) layers of the mineral soil. Both shallow and deep samples were aggregated from five separate sampling points. Each sample was composed of about 500 grams of soil and was sealed in a labelled plastic bag.

2.1.2 Sample Preparation

After collection, foliage samples were double-rinsed, first in tap water and then in distilled water. This procedure served to remove surface dust and particulates. When possible, the plant material was allowed to air-dry following the rinse. All samples were kept chilled during transportation and delivery to the analytical laboratory in order to prevent microbial breakdown of plant tissues.

Both foliage and soil samples were delivered to the laboratory in plastic bags. They were then dried at 70°C, ground through 20 mesh screen, mixed thoroughly, and placed in sealed containers prior to analysis.

2.1.3 Analytical Procedures

2.1.3.1 Boron (B)

Approximately 0.5 g of the sample was ashed at 500°C and extracted with dilute HCl. Boron was determined colorimetrically on a suitable aliquot (2 to 4 ml) by azomethine-H reagent. Developed color solutions were measured at a wave length of 430 nm with a Perkin-Elmer Coleman Model 55 spectrophotometer utilizing a 10 mm flow-through cell. Duplicate tests were made on each sample.

2.1.3.2 Arsenic (As)

Approximately 2.5 to 3.5 g of the sample was wet-ashed in Kjeldahl flasks with concentrated HNO₃ and HClO₄ and then diluted with water. Arsenic was determined on suitable aliquots by atomic-absorption spectrophotometry using the gaseous hydride (sodium borohydride) method. A Varian Model 475 AA unit was used to measure arsenic levels. Duplicate tests were made on about one-third of the samples and several samples were rechecked.

2.1.3.3 Mercury (Hg)

The same solutions prepared for arsenic determinations were used for mercury analysis. Mercury was determined on these solutions by a cold vapor atomic absorption method using stannous chloride as reducing agent. A Varian Model 475 AA unit was used to measure mercury levels. Duplicate tests were made on about one-third of the samples and several samples were rechecked.

2.1.3.4 Fluorine (F)

Approximately 10 g of the prepared sample was mixed with a CaO slurry, dried at 100°C overnight, and ashed at 600°C for several hours. Ashed samples were then transferred to Calissen flasks with 35 ml of water. Twenty-five ml of concentrated H_2SO_4 was added to the sample flask and steam distilled. Fluorine concentrations were determined from the distillate by using a specific ion electrode (Orion probe and Corning meter) with TISAB reagent. Duplicate analysis was performed on about one sixth of the samples and several samples were rechecked.

The unused portion of each foliage and soil sample has been retained and will be made available to the Participant for additional chemical analysis if desired.

2.1.4 Visual Damage Assessment of Vegetation

Injury or damage to selected plant species was assessed by visual inspection of each of the 17 sample plots where foliage was taken for chemical analysis (Figure 2.1). The species surveyed at each plot were those listed in Table 2.2. The same individual trees from which foliage samples for chemical analysis were taken were also examined visually for possible damage due to insect activity, plant pathogens, and air-borne pollutants.

Samples of foliage were checked for spotting, discoloration, chlorosis, or necrosis. If these conditions were found, the percent of leaf or needle affected was estimated. The crown complement, conditions of branches and boles, and phenological stage were also noted. All data were taken in the field on a hand-held cassette recorder and transcribed in the office. Photographs were taken to document the general condition of the tree species surveyed and the extent of insect damage that was noted on certain plots.

This survey was carried out during the June-July sampling period and again in September. In addition to taking this data at the individual sample plots, visual assessment of vegetation condition was also made for the general study area and for the region as a whole.

2.2 SOIL INVERTEBRATE FAUNA

2.2.1 Sampling Procedures

The soil invertebrate fauna was sampled by taking a series of 8 replicate soil corings at 11 sample plots. These sample plots were located on the A, D, and E transects, as shown in Figure 2.2. The total of 88 soil corings were collected on August 25-26, 1980.

Soil corings were taken with a rectangular steel sampling tool, constructed of two overlapping pieces, and measuring when fitted together 5 cm by 7 cm in cross section. The coring tool thus enclosed a soil surface area of 35 cm². The plan was to take soil corings to a depth of 15 cm to obtain a volume of

FIGURE 2.2 TRANSECTS AND SAMPLING PLOTS FOR SOIL INVERTEBRATES

0 492 984 Feet
0 150 300 Meters

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525 cm³. However, because of the rocky nature of the soil on transects D and E and at sample plot A 150 (Forest), the depth to which the sampling tool could penetrate varied as indicated in Table 2.3. At the other 4 sample plots on transect A, the soil was not rocky and almost all corings penetrated to 15 cm.

The original sampling plan was to take replicate corings at each plot in a random manner. The locations of corings were to be selected by the use of two stakes, each with a free-spinning arrow mounted horizontally through a nail at the top of the stake. One stake was placed in the center of the plot and the other at its edge. The arrows were spun and allowed to come to rest; the point at which imaginary lines projected from the arrows intersected was chosen for a soil coring. Because of the rocky soil at a number of the sample plots, these randomly chosen sites were often too rocky to obtain a sample. As a result, corings were frequently taken at arbitrarily selected points near the intersection of the two imaginary lines where the coring tool could penetrate. This tended to bias the sampling, since rocky areas were excluded systematically.

Each replicate sample was placed in a plastic bag and carefully labelled. These bags were stored and then transported under refrigeration. A reservoir of air was maintained in each bag. Each bag was also occasionally opened to assure adequate aeration.

2.2.2 Extraction Procedures

The fauna were extracted from the soil samples by means of the Berlese funnel technique. Two plywood cabinets were used, one with 24 funnel units and the other with four. The funnels were steep-sided cones constructed of smooth, rigid paper. Each was about 25 cm in length, about 15 cm in diameter at the upper open end, and about 0.6 cm in diameter at the lower end. When in place in a cabinet, the lower end opened over a small collecting jar containing 70 percent ethyl alcohol. The soil sample was placed in the upper part of the cone on screening that held the soil but permitted passage of small soil organisms downward.

When an apparatus was loaded with samples, electric light bulbs in the cabinet above each funnel served to warm and dry the soil. This forced the soil invertebrates downward until they eventually dropped into the alcohol in the collecting jars. The lights were adjusted to keep the air temperature in the cabinets between 38°C and 46°C. Forty-eight hours were required to completely extract all organisms from the soil samples.

Soil from each sampling site was saved for weighing and volume measurements after removal from the Berlese funnels. These figures are included in Table 3 and will permit comparisons of total weight and volume with samples taken at the same sites in subsequent years.

The soil invertebrates extracted from the sample corings are being stored in vials of 70 to 75 percent alcohol in a refrigerator. They can be kept indefinitely in this state and will be available for more detailed identification and analysis in the future.

Table 2.3

THE CORING DEPTH AND TOTAL VOLUME AND WEIGHT OF SOIL SAMPLES TAKEN IN THE VICINITY
OF THE BACA GEOTHERMAL DEMONSTRATION POWER PLANT FOR STUDIES OF THE SOIL INVERTEBRATE FAUNA.
(August 25-26, 1980)

SAMPLE PLOT	CORING DEPTH (cm)									TOTAL SAMPLE VOLUME (cm ³)	TOTAL SAMPLE WEIGHT (kg)
	1	2	3	4	5	6	7	8	Mean		
A 150(Forest) 150(Meadow) 300 600 1000	15	15	14	8	15	14	13	14	13.500	4048	3.2
	15	15	12	15	15	15	15	12	14.250	7294	5.5
	15	15	15	15	15	15	15	15	15.000	5556	5.5
	15	15	15	15	15	15	15	15	15.000	5556	4.8
	15	15	15	15	15	15	14	15	14.875	5671	4.3
D 50 150 300 600	12	8	10	13	12	14	14	15	12.250	4048	3.6
	10	14	13	15	10	15	15	14	13.250	3245	3.0
	13	14	15	12	13	15	15	15	14.000	3934	4.1
	15	15	11	13	15	15	15	14	14.125	4638	3.9
E 150 300	14	8	7	12	12	14	14	14	11.875	3704	3.6
	15	12	10	12	10	14	13	12	12.250	3934	3.2

2.2.3 Identification and Analysis

Identification and analysis of the soil invertebrates fauna has concentrated on the arthropods, especially the insects, myriapods, and arachnids. These are the taxa that are preferentially extracted from soil samples with the Berlese funnel technique. Since most of the species are small, usually less than a few millimeters in length, they are sometimes referred to as "micro-arthropods."

Identification of the organisms extracted from these soil samples is being carried out with a dissecting microscope because of their small size. Twelve replicates out of 88 had been analyzed by the end of November 1980. In these analyses, the total micro-anthropod fauna was broken down into 28 taxa. The number of individuals of each taxon present in a replicate sample was determined and total counts were made for insects, myriapods, and arachnids, with a special category under the latter heading for the very numerous soil mites (Acarina).

SECTION 3.0

SURVEY RESULTS

3.1 CHEMICAL ANALYSIS OF VEGETATION AND SOILS

3.1.1 Vegetation

The results of the chemical analysis of foliage samples are presented in Table 3.1 for June-July 1980 and in Table 3.2 for September, 1980. The concentrations of boron, arsenic, mercury, and fluorine seem well within the normal range for natural vegetation and crops. Mercury concentrations were consistently low, at or below the limit of detection (0.1 ppm) in almost every sample. Arsenic levels were also quite low, with most values below 1.0 ppm. In the June-July sampling period, fluorine concentrations were recorded within a narrow range, from below the limit of detection (3 ppm) to 11 ppm. The September samples included some higher values, ranging up to 42 ppm. Boron concentrations were more variable, with most levels between 10 and 30 ppm in the June-July period, while September levels were generally higher including many over 30 ppm and one as high as 180 ppm.

3.1.2 Soils

The results of the chemical analysis of soil samples are presented in Table 3.3. Concentrations of arsenic and mercury in soils were quite comparable to those recorded for vegetation samples. Boron, however, was present in soils at much lower levels than in foliage, while fluorine concentrations in soils greatly exceeded those in vegetation. The shallow (0 to 7.5 cm) and deep (7.5 to 15 cm) samples at each plot tended to show very similar chemical analyses.

3.2 VISUAL DAMAGE ASSESSMENT OF VEGETATION

The most striking observation was heavy insect infestation during the June sampling period. Quaking aspen foliage was particularly affected. This insect activity had declined significantly by September. No foliar pathogens were noted in either survey.

Alder were seen to display some early senescence, although the condition was noted consistently outside as well as within the study area.

3.3 SOIL INVERTEBRATE FAUNA

The results of preliminary counting and analysis of soil invertebrate samples extracted from 12 of the 88 corings are presented in Table 3.4. The total number of arthropods per replicate coring ranged from 148 in A 300a to 655 in D 300b, with a mean of 363.75. Because each sample represented a surface area of 35 cm², this mean value extrapolated to an overall density of 104,000 arthropods/m² of surface area. This figure falls within the normal range encountered in previous studies of forest and meadow soil arthropod populations. A full analysis of all soil invertebrate samples will be provided as an addendum to this report.

Table 3.1

CONCENTRATIONS OF BORON, ARSENIC, MERCURY, AND FLUORINE IN FOLIAGE
 SAMPLES TAKEN IN THE VICINITY OF
 THE BACA GEOTHERMAL DEMONSTRATION POWER PLANT
 (June 24-27 and July 9-11, 1980)

SAMPLE PLOT		BORON ppm	ARSENIC ppm	MERCURY ppm	FLUORINE ppm
A 150	Gambel Oak	10	0.4	< 0.1	< 3
	Quaking Aspen	26	0.4	< 0.1	8
	Alder	66	0.3	< 0.1	6
	Douglas Fir	27	1.1	< 0.1	5
A 300	Quaking Aspen	34	0.3	< 0.1	6
	Alder	25	0.4	< 0.1	9
A 600	Quaking Aspen	37	0.1	< 0.1	10
	Alder	28	0.1	< 0.1	11
	Douglas Fir	19	0.5	< 0.1	4
A 1000	Quaking Aspen	20	0.1	< 0.1	5
	Alder	19	0.3	< 0.1	7
	Douglas Fir	14	1.4	< 0.1	8
B 150	Quaking Aspen	36	0.2	< 0.1	8
	Douglas Fir	19	0.6	< 0.1	9
	White Fir	14	0.1	< 0.1	7
B 300	Quaking Aspen	28	< 0.1	< 0.1	3
	Douglas Fir	22	0.8	< 0.1	5
	White Fir	17	0.1	< 0.1	8
B 600	Quaking Aspen	22	< 0.1	< 0.1	4
	Douglas Fir	20	0.4	< 0.1	4
	White Fir	10	0.1	< 0.1	7

Table 3.1 (continued)

SAMPLE PLOT		BORON ppm	ARSENIC ppm	MERCURY ppm	FLUORINE ppm
C 150	Grass	14	0.1	<0.1	3
	Alder	38	0.4	<0.1	11
	White Fir	17	0.1	<0.1	5
	Ponderosa Pine	18	0.3	<0.1	3
C 300	Grass	43	0.2	< 0.1	6
	Alder	30	0.2	< 0.1	7
	White Fir	31	0.2	< 0.1	5
C 600	Alder	23	0.3	< 0.1	8
	Douglas Fir	22	0.1	< 0.1	7
	Ponderosa Pine	17	0.1	< 0.1	6
C 1000	Grass	16	0.5	< 0.1	5
	Alder	22	0.4	< 0.1	10
	Douglas Fir	17	0.9	< 0.1	8
	Ponderosa Pine	15	0.1	< 0.1	10
D 50	Gambel Oak	23	0.1	< 0.1	5
		23	0.1	< 0.1	5
		24	0.1	< 0.1	8
		19	0.1	< 0.1	4
		21	0.1	< 0.1	3
		22	0.1	< 0.1	8
	White Fir	26	0.2	< 0.1	8
		25	0.1	< 0.1	9
		23	0.1	0.1	8
		15	0.1	< 0.1	5
		17	0.1	< 0.1	5

Table 3.1 (continued)

SAMPLE PLOT		BORON ppm	ARSENIC ppm	MERCURY ppm	FLUORINE ppm
D 50	Ponderosa Pine	20	0.1	< 0.1	3
		17	0.2	0.1	5
		14	0.1	< 0.1	3
		17	0.1	0.2	8
		15	0.1	< 0.1	3
D 150	Gambel Oak	24	0.1	< 0.1	4
	White Fir	20	0.1	< 0.1	7
D 300	Gambel Oak	24	0.1	< 0.1	5
	Douglas Fir	33	1.0	< 0.1	4
	White Fir	28	0.2	< 0.1	9
D 600	Gambel Oak	20	< 0.1	< 0.1	6
	Douglas Fir	27	0.9	0.1	5
	White Fir	18	0.2	< 0.1	8
E 150	Gambel Oak	21	0.3	< 0.1	3
	White Fir	18	0.6	< 0.1	4
E 300	Gambel Oak	20	< 0.1	< 0.1	7
		20	0.2	< 0.1	6
		18	0.1	< 0.1	4

Table 3.2

CONCENTRATIONS OF BORON, ARSENIC, MERCURY, AND FLUORINE IN FOLIAGE
 SAMPLES TAKEN IN THE VICINITY OF
 THE BACA GEOTHERMAL DEMONSTRATION POWER PLANT
 (September 16-19, 1980)

SAMPLE PLOT		BORON ppm	ARSENIC ppm	MERCURY ppm	FLUORINE ppm
A 150	Grass	7	0.4	< 0.1	4
	Gambel Oak	33	0.2	< 0.1	8
		32	0.2	< 0.1	< 3
		23	0.3	< 0.1	4
		33	0.3	0.1	< 3
		26	0.3	< 0.1	15
		64	0.4	< 0.1	4
	Quaking Aspen	28	0.6	< 0.1	7
	Alder	75	0.8	< 0.1	14
		88	0.8	< 0.1	20
		86	1.0	< 0.1	42
		180	1.8	< 0.1	29
		93	1.0	< 0.1	32
	Douglas Fir	26	2.4	< 0.1	6
A 300	Grass	5	0.3	< 0.1	< 3
	Quaking Aspen	33	0.4	< 0.1	10
		90	0.8	< 0.1	12
		14	0.3	< 0.1	12
		46	0.3	< 0.1	11
		49	0.3	< 0.1	8
	Alder	31	0.7	< 0.1	21
	Douglas Fir	20	1.4	< 0.1	5
A 600	Grass	8	0.4	< 0.1	5
	Quaking Aspen	47	0.4	< 0.1	11
	Alder	46	0.3	< 0.1	8
	Douglas Fir	18	0.7	< 0.1	3

Table 3.2 (continued)

SAMPLE PLOT		BORON ppm	ARSENIC ppm	MERCURY ppm	FLUORINE ppm
A 1000	Grass	6	0.2	< 0.1	16
	Quaking Aspen	20	0.2	< 0.1	4
	Alder	32	0.3	0.1	< 3
	Douglas Fir	14	1.4	< 0.1	4
B 150	Quaking Aspen	45	0.6	< 0.1	19
	Douglas Fir	17	0.4	< 0.1	13
	White Fir	19	0.2	< 0.1	8
B 300	Quaking Aspen	33	0.1	< 0.1	6
	Douglas Fir	31	0.3	0.1	6
	White Fir	19	0.2	< 0.1	7
B 600	Quaking Aspen	35	0.1	< 0.1	5
	Douglas Fir	24	1.0	0.2	8
	White Fir	14	0.2	< 0.1	6
C 150	Grass	4	0.4	< 0.1	< 3
		6	0.6	0.1	< 3
		5	0.4	< 0.1	< 3
		4	0.3	< 0.1	< 3
		4	0.4	< 0.1	7
	Alder	56	0.5	< 0.1	3
	White Fir	24	0.4	< 0.1	6
	Ponderosa Pine	22	0.3	0.1	6
C 300	Grass	18	0.8	< 0.1	< 3
	Alder	81	0.6	< 0.1	4
	White Fir	50	0.8	0.1	6

Table 3.2 (continued)

SAMPLE PLOT		BORON ppm	ARSENIC ppm	MERCURY ppm	FLUORINE ppm
C 600	Grass	6	0.5	< 0.1	4
	Alder	32	0.5	0.1	9
	Douglas Fir	45	0.5	< 0.1	14
	Ponderosa Pine	16	0.4	< 0.1	10
C 1000	Grass	6	0.5	< 0.1	5
	Alder	49	0.6	0.1	4
	Douglas Fir	22	0.7	< 0.1	7
		23	0.4	0.2	10
		25	0.4	< 0.1	11
		9	0.6	0.1	7
		19	1.0	0.1	12
	Ponderosa Pine	16	0.1	< 0.1	3
		17	0.3	< 0.1	< 3
		18	0.1	0.1	6
		17	0.3	< 0.1	7
		24	0.5	0.1	6
D 50	Gambel Oak	27	0.2	< 0.1	4
		30	0.1	< 0.1	5
		36	0.1	< 0.1	5
		36	0.1	< 0.1	6
		32	0.2	< 0.1	5
	White Fir	30	0.3	< 0.1	5
		24	0.3	< 0.1	6
		22	0.2	< 0.1	9
		14	0.3	< 0.1	3
		21	0.3	< 0.1	7

Table 3.2 (continued)

SAMPLE PLOT			BORON ppm	ARSENIC ppm	MERCURY ppm	FLUORINE ppm
D 50	Ponderosa Pine		17	0.2	0.2	< 3
			14	0.1	< 0.1	5
			10	0.2	< 0.1	3
			14	0.1	< 0.1	3
			17	0.4	< 0.1	< 3
D 150	Gambel Oak		29	0.1	< 0.1	6
	White Fir		20	0.2	0.2	6
D 300	Gambel Oak		38	0.2	0.1	6
	Douglas Fir		25	1.9	< 0.1	6
	White Fir		15	0.2	< 0.1	5
D 600	Gambel Oak		23	0.1	< 0.1	5
	Douglas Fir		20	1.7	< 0.1	4
	White Fir		21	0.2	< 0.1	6
E 150	Gambel Oak		34	0.3	< 0.1	29
	White Fir		23	0.5	< 0.1	14
E 300	Gambel Oak		30	0.5	< 0.1	6
	White Fir		22	0.2	< 0.1	18

Table 3.3

CONCENTRATIONS OF BORON, ARSENIC, MERCURY, AND FLUORINE IN SOIL
 SAMPLES TAKEN IN THE VICINITY OF THE
 BACA GEOTHERMAL DEMONSTRATION POWER PLANT
 (September 16-19 1980)

SAMPLE PLOT	BORON		ARSENIC		MERCURY		FLUORINE	
	ppm Sat'd Extract		ppm Soil		ppm Soil		ppm Soil	
	0-7.5cm	7.5-15cm	0-7.5cm	7.5-15cm	0-7.5cm	7.5-15cm	0-7.5cm	7.5-15cm
A 150	0.61	0.38	2.6	5.7	< 0.1	< 0.1	345	390
300	0.25	0.27	3.0	4.9	0.1	0.1	250	275
600	0.33	0.24	1.9	0.4	< 0.1	< 0.1	255	260
1000	0.16	0.13	2.1	2.0	< 0.1	< 0.1	340	345
B 150	0.27	0.20	1.3	1.1	< 0.1	< 0.1	345	325
300	0.32	0.22	1.6	1.6	< 0.1	< 0.1	250	255
600	0.25	0.32	5.3	1.8	< 0.1	< 0.1	170	165
C 150	0.21	0.17	4.2	2.2	< 0.1	< 0.1	340	390
300	0.57	1.6	5.0	3.6	< 0.1	< 0.1	365	395
600	0.16	0.17	3.3	3.8	< 0.1	< 0.1	390	425
1000	0.23	0.18	3.5	4.2	< 0.1	< 0.1	275	305
D 50	0.18	0.15	4.0	7.1	< 0.1	< 0.1	470	375
150	0.29	0.24	3.8	3.7	< 0.1	< 0.1	255	210
300	0.19	0.19	5.8	8.5	< 0.1	< 0.1	325	315
600	0.23	0.29	4.7	5.5	< 0.1	< 0.1	390	290
E 150	0.20	0.14	10.3	11.1	< 0.1	< 0.1	470	530
300	0.22	0.28	3.3	2.8	< 0.1	< 0.1	160	200

Table 3.4(continued)

TAXON	SAMPLE PLOT AND REPLICATE												Total
	A 150a	A 150b	A 300a	A 1000a	D 150a	D 150b	D 300a	D 300b	D 600a	E 150a	E 150b	E 300a	
<u>ARACHNICA</u> (continued)													
Prostigmata													
Tydeidae	4	5	12	8	23	16	19	49	26	8	13	23	206
Rhagidiidae	14	1		2		3		7			6	3	36
Eupodidae	23	3	6	12	18	13	6	1	8	41	50	19	200
Bdelloidea	4				2	2	2		1	3	4	2	20
Raphignathoidea	2			1						2	8	20	33
Other Prostigmata	11	1	1	4		3	3	19		2	2	5	51
Endostigmata	14	8		6		22	2	15		210	3	4	284
Heterostigmata	14	2	60	55	60	21	70			31	3	16	332
Astigmata	1		29			1			10	1	2		44
Total Acarina	360	159	133	138	219	252	244	247	211	372	133	171	2639
Total Arachnida	361	159	133	138	219	252	244	250	211	374	133	171	2645
Total Arthropoda	422	470	148	578	278	338	323	655	301	474	165	204	4365

Table 3.4

PRELIMINARY COUNTS OF SOIL INVERTEBRATE POPULATIONS FROM 12 SOIL CORINGS TAKEN
IN THE VICINITY OF THE BACA GEOTHERMAL DEMONSTRATION POWER PLANT
(August 25-26, 1980)

TAXON	SAMPLE PLOT AND REPLICATE												Total
	A 150a	A 150b	A 300a	A 1000a	D 150a	D 150b	D 300a	D 300b	D 600a	E 150a	E 150b	E 300a	
<u>INSECTA</u>													
Diptera larvae	2	8	2		2	1	1		2	6	3		27
Coleoptera larvae	6	3		2				4		1	1		17
Coleoptera adults		2								1	1		4
Lepidoptera larvae		1		1	1					1			4
Pseudococcidae		159	1		1	1		376					538
Aphididae	3	9											12
Psocoptera	2							1			1	1	5
Thysanoptera				1				1					2
Protura		1	1	1	1	2		5		7		3	21
Collembola	31	137	11	435	54	67	76	16	88	83	21	29	1058
Other Insecta	3						1						4
Total Insecta	57	320	15	440	59	71	78	403	90	99	27	33	1692
<u>MYRIAPODA</u>													
Pauropoda	2					11		1			3		17
Symphyla	1										1		2
Chilopoda	1					4	1	1		1			9
Diplopoda							1	1		1	1		9
Total Myriapoda	4					15	1	2		1	5		28
<u>ARACHNICA</u>													
Araneae	1							3					4
Pseudoscorpionida										2			2
<u>Acarina</u>													
Cryptostigmata	243	112	13	7	75	139	131	128	141	48	37	61	1135
Megostigmata													
Gamasina	30	27	12	43	41	32	11	28	25	26	5	18	298

SECTION 4.0

DISCUSSION

4.1 CHEMICAL ANALYSIS OF VEGETATION AND SOILS

4.1.1 Sampling Procedures

Since the potential impact of cooling tower drift is of prime concern in this study, it is critical to obtain foliage samples from a point within the crown of each tree that would be directly exposed to air flow from the cooling tower. On a number of sample trees, the portion of the crown that is likely to intercept drift is 10 to 20 meters above the ground. This is true of several trees on the A transect, most of the trees on the C transect, and a few on the D transect.

The sampling procedures used in 1980 were not effective in harvesting foliage from the upper crown area of these tall trees. Samples could not be obtained from the ground by means of hand or pole pruners. The use of extension handles for the pole pruner and a rope saw were not effective. An extension ladder was tried, but proved to be unsafe due to irregular topography and lack of solid support on the smooth, round tree trunk; the ladder did not provide sufficient height in most cases anyway.

Efficient sampling of the upper crown areas of taller trees thus remains an unsolved problem. Other investigators who have had to sample foliage in upper tree crowns report that the safest, most efficient, and cost-effective technique is the use of a shotgun to sever branches for collection. If permission can be obtained for use of a shotgun, this method would provide the most efficient technique.

4.1.2 Analytical Procedures

It is not known for certain what elements may carry over from geothermal brine to the steam phase during the flash process. Because materials other than boron, arsenic, mercury, or fluorine may enter the cooling water, it may be useful to consider establishing soil and vegetation baseline values for some additional elements. This could be accomplished in 1981, following close consultation between WESTEC and the Participant to determine the most appropriate elements for study.

4.2 VISUAL DAMAGE ASSESSMENT OF VEGETATION

No particular problems were encountered in sampling or assessing the current status of the vegetation with respect to insect damage, pathogens, or air pollutants. The most noteworthy observation was the heavy insect damage to quaking aspen early in the summer, a feature of high-altitude forests throughout the region.

4.3 SOIL INVERTEBRATE FAUNA

Preliminary analysis of the number of various taxa represented in replicate soil samples reveals certain patterns. For example, Table 3.4 lists certain taxa that are present in such low numbers that statistical treatment of these populations would be difficult. These include Coleoptera larvae and adults, Psocoptera, Protura, and Araneae. Groups such as the Pseudococcidae (mealybugs) present another type of problem. They usually occur in great abundance when found but are often completely absent from a sample. These insects are associated with plant roots upon which they feed and are therefore highly aggregated in the soil. If a colony is included in a coring, large numbers appear. Attempts to detect population changes by statistical tests would be seriously hampered by the high variance/mean ratio.

It would seem reasonable to place primary emphasis on those taxa that are found in reasonable numbers in most samples. These could include the Collembola, Cryptostigmata, Gamasina, and certain groups of Prostigmata. These are likely to yield results susceptible to standard statistical tests.

Certain adjustments in sampling procedures are proposed at this time. First, the coring depth should be reduced to 10 cm, instead of 15 cm. This would make it much easier to obtain samples of uniform volume from both rocky and non-rocky plots. The great majority of the soil invertebrate fauna is undoubtedly concentrated near the surface, so total counts would not be significantly reduced. Furthermore, the effects, if any, of cooling tower drift would be seen in analysis of the surface fauna.

Second, instead of using a two-piece rectangular coring tool, a similar rectangular core sample could be obtained by making four flat cuts independently with a chisel-like tool. This would give greater flexibility in avoiding rocks, while the soil sample could be kept to a constant volume by filling a rigid container to a predetermined depth.

Third, the number of replicates taken at each sample plot should be increased to 10. This would not significantly increase the time devoted to sample collection and analysis, but it would give a better chance of detecting spatial and temporal differences within and between plots through statistical tests.

SECTION 5.0
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