U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

PALYNOLOGICAL DATA FROM A 989-FT (301-M) CORE OF PLIOCENE AND EARLY PLEISTOCENE SEDIMENTS FROM BRUNEAU, IDAHO

Robert S. Thompson[1]

Open-File Report 92-713

[1]Box 25046, MS 919, Denver Federal Center, Denver, CO 80225

TABLE OF CONTENTS

TABLES AND APPENDIX

ILLUSTRATIONS

Introduction

The U.S. Geological Survey's PRISM (Pliocene Research Investigations and Synoptic Mapping) Project is conducting multi-disciplinary research on paleoclimatic conditions during the middle Pliocene, the last period of sustained warmth in Earth history. Mapped paleoclimatic data from this period will be used to validate numerical-model simulations of past climates, and will thus aid in the improvement of these models' ability to predict climates substantially different from that of today. Additionally, these data may provide insights into the nature of regional climatic patterns in a warmer-than-modern global climate and help determine the nature, amplitude, and timing of paleoclimatic variations within this warm period.

In an effort to extend the geographic coverage of the PRISM data set and to increase knowledge of Pliocene paleoclimatic variations in the interior of North America, a 989-ft (301-m)-long sediment core was obtained from the Bruneau and Glenns Ferry Formations near the town of Bruneau, Idaho. This report presents basic coring data and palynological counts from this core, and some preliminary observations on their possible paleoclimatic significance.

Stratigraphic and Temporal Framework

Sedimentary deposits discussed in this report are assigned to the Glenns Ferry and Bruneau Formations of Malde and Powers (1962). These formations are part of the "Idaho Group" of lacustrine, fluvial, and flood plain sediments that were deposited from late Miocene through early Pleistocene time in a subsiding basin on the western Snake River Plain in southwestern Idaho. Through much of this time, small volcanoes episodically erupted on the western Snake River Plain and deposited thick sequences of basalt in many areas.

The Pliocene Glenns Ferry Formation deposits occur in sequences up to ~2000 ft (610 m) thick along the axis of the Snake River from near Twin Falls, Idaho, to easternmost Oregon (Malde and Powers, 1962; Malde, 1991; fig. 1). The lacustrine facies of this formation contains fish remains that suggest a deep, cold lake, similar to Lake Baikal and the Upper Great Lakes today (Smith et al., 1982, Smith, 1987). The ostracode fauna contains many "exotic" (strange, now-extinct) species that Forester (1991) interpreted as reflecting evolution in a large, long-lived lake.

For parts of its history, the Glenns Ferry lake had a lake margin elevation as high as 3576 ft (1090 m; Smith, 1987) to 3800 ft (1159 m; Jenks and Bonnichsen, 1989), and the margins have remained little altered by tectonic activity in the period since the lake desiccated (Jenks and Bonnichsen, 1989). The elevation of the Bruneau core site (discussed below) is ~2925 ft (892 m) and thus the shoreline of Glenns Ferry lake at its maximum was 651 to 875 ft (198 to 267m) above the core site. It is probable that subsidence lowered the elevation of the central basin while sediments were accumulating, but nevertheless it appears that the Bruneau site was under deep water for much of Glenns Ferry time.

Biogeographic and chemical data suggest that the Glenns Ferry lake had an outlet (Malde, 1991) and that the outlet river flowed across the northwest Great Basin to California and the Pacific Ocean. At the same time, the eastern Snake River Plain (which today drains westward into southwestern Idaho) was apparently not part of the Glenns Ferry drainage, but instead drained southward into Utah (Taylor and Bright, 1987). Paleomagnetic (Neville et al., 1979) and vertebrate-paleontological data (Repenning, 1987) indicate that the Glenns Ferry Formation deposition began prior to ~3.8 Ma and that sediment accumulation continued into the early Matuyama Chron (< 2.48 Ma) and perhaps to as young as ~2 Ma (Repenning, 1987; Malde, 1991). Deposition in the Glenns Ferry lake apparently ceased ~3 Ma in the eastern portion of this region (perhaps due to infilling on the margin), but continued for another million years farther west (Malde, 1991).

A large lake could not exist on the western Snake River Plain today because of the outflow of the Snake River northward through Hells Canyon. Malde (1991) interpreted the wide-spread Tuana and Tenmile gravels that overlie the Glenns Ferry Formation as indicative of high-energy flow through this region, and by extension, of the (earlier?) cutting of the Hells Canyon outlet. Although poorly dated, the downcutting of this canyon apparently occurred near 2 Ma (Malde, 1991). Smith et al. (1982) noted that earlier lake regressions (such as the one that occurred between

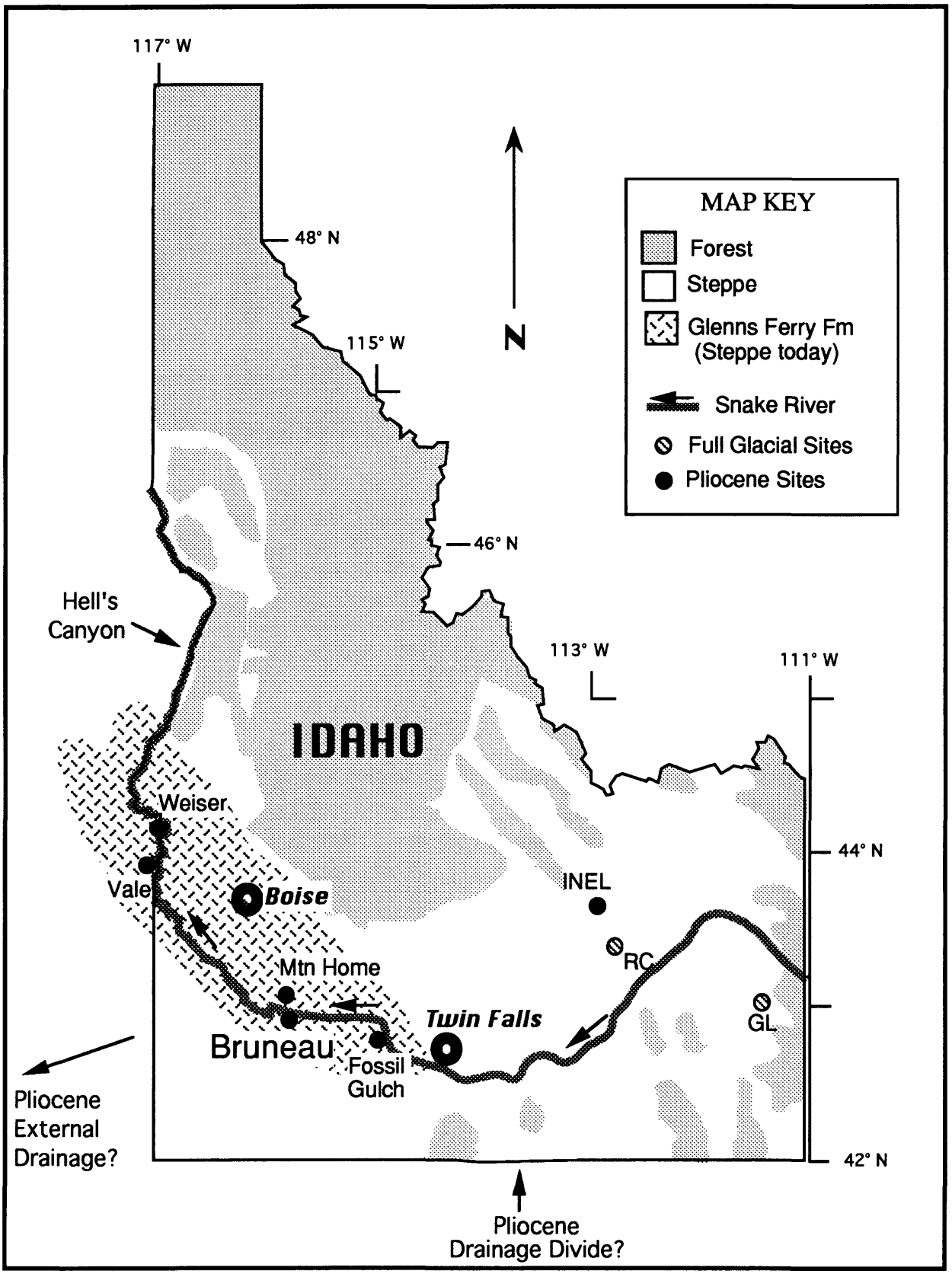

Figure 1. Map showing the generalized extent of the Glenns Ferry Formation and of modern Forest and Steppe coverage in Idaho. INEL = Idaho National Engineering Laboratory, RC = Rattlesnake Cave (Bright and Davis, 1982), GL = Grays Lake (Beiswenger, 1991).

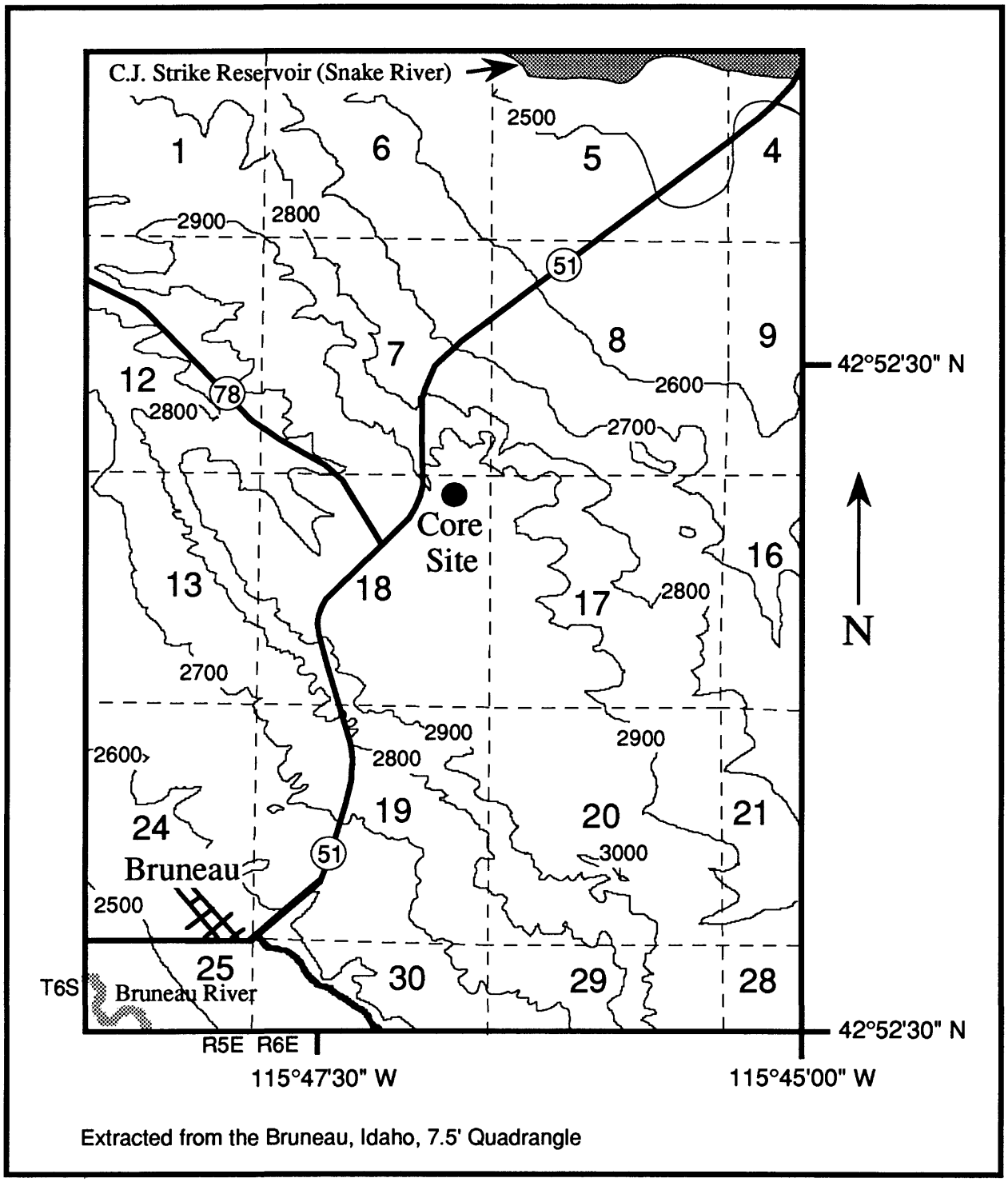

Figure 2. Map showing the location of the Bruneau coring site on the ridge between the Snake and Bruneau Rivers in southwestern Idaho.

the Pliocene Glenns Ferry Formation and the underlying Miocene Chalk Hills Formation) were limited enough in their drawdown that lacustrine fishes survived these events. In contrast, the regression at the end of the Glenns Ferry lake period led to the extinction of all the Neogene deep-water lacustrine fish species, and thus the lake habitat appears to have been completely absent in the time between the Glenns Ferry and Bruneau lakes.

The volcanic and sedimentary deposits of the early Pleistocene Bruneau Formation overlie the gravel units discussed above (Malde and Powers, 1962). In contrast to the widespread thick deposits of the large Glenns Ferry lake, the lacustrine deposits of the Bruneau Formation are scattered and discontinuous. Malde (1991) interpreted this pattern as indicating the presence of smaller lakes behind lava dams across the Snake River. He identified four statges where canyons were filled by both lava and lacustrine deposits that occurred between ~1.9 and ~1.0 Ma, based on paleomagnetic data and K-Ar dates (Amini et al., 1984).

Other workers (e.g. Jenks and Bonnichsen, 1989) do not accept portions of Malde's regional stratigraphy (as presented above), and argue that the series of lakes that occupied the same basin from late Miocene through early Pleistocene time should all be referred to as "Lake Idaho." The data in this report have little bearing on this argument, and for convenience Malde's stratigraphic terms are used throughout.

Site selection

For Pliocene paleoclimatic studies, I sought to identify a site in the Glenns Ferry Formation where fossil pollen would be preserved in a quasi-continuous sequence of fine-grained deposits. In addition, since the drilling rig had a 1000 ft (305 m) depth limit, it was desirable to avoid places with thick sequences of Pliocene and Quaternary basalts. To meet these criteria, it was necessary to limit the search for a drilling site to deep-water deposits of the central basin.

Previous coring of "Idaho Group" sediments revealed variable thicknesses of lacustrine sediments and basalt. West of the Bruneau core site, up to 2320 ft (707 m) of volcanic siltstones and mudstones were observed in well cuttings from west of Grand View (McIntyre, 1979), while north of the Bruneau site, well-cuttings from near Mountain Home (Arney et al., 1984) revealed up to 4000 ft (1220 m) of lacustrine sedimentary deposits with interspersed basalts. Cores north of the Snake River (e.g. Whitehead and Lindholm, 1985; Lewis and Stone, 1988) frequently include hundreds to thousands of feet of basalt with lenses of interspersed lacustrine sediments.

The Bruneau site was suggested by Margi Jenks of the Idaho Geological Survey, based on regional geologic mapping by the Idaho State Geological Survey. Stratigraphic logs from water wells drilled at ~2525 ft (770 m) elevation near the town of Bruneau (Littleton and Crosthwaite, 1957) indicated at least 1000 ft (305 m) thickness of lacustrine sediments without major basalt units. After consultation with the Bureau of Land Management, a site within a gravel pit on the ridge north of Bruneau (fig. 2) was selected as the drilling location with the least potential for environmental damage.

Site Background

Location and Geologic Setting. The Bruneau core site is located at ~2925 ft (892 m, figs. 1 and 2) in the NE $^1/_4$, NE $^1/_4$, Sec. 18, T.6S., R.6E. (42° 54' 31.5" N, 115° 46' 46.8" W). Malde (1989) mapped the deposits above 2850 to 2900 ft (869 to 884 m) on this ridge as "gravel-shore deposits" of the Bruneau Third Canyon Stage. He categorized the sediments between ~2625 - 2650 ft (800 - 808 m) and 2850 - 2900 ft (869 - 884 m) as lake beds of this same stage (except for a down-faulted block of gravel-shore deposit along a NW/SE trending fault near the town of Bruneau). Deposits below ~2625 - 2650 ft (800 - 808 m) were mapped as poorly consolidated lacustrine and fluvial sediments of the Glenns Ferry Formation.

Modern vegetation and climate . The vegetation surrounding the core site has been heavily disturbed by agricultural and gravel-pit activities. Introduced Eurasian species (primarily *Bromus tectorum* [cheatgrass] and *Salsola kali* [Russian thistle], are abundant at the site. Native species include *Artemisia tridentata* (big sagebrush), *Chrysothamnus* spp. (rabbitbrush), *Gutierrezia sarothrae* (snakeweed), and *Oryzopsis hymenoides* (Indian ricegrass). Overall, the vegetation can

be characterized as semiarid steppe, and the nearest native tree species (excluding riparian trees in some drainages) are tens of kilometers away in mountains to the north and south of the western Snake River Plain.

Thirty-year climate normals for Boise, Idaho, at a similar elevation to the coring site (2840 ft [866 m], Court, 1974) farther west on the Snake River Plain, indicate that the region experiences a wide range of seasonal temperatures (mean January temperature = -1.9° C [28.5° F], mean July temperature = 23.7° C [81.1° F]) under a semi-arid precipitation regime (mean annual precipitation = 290 mm [11.42"]) with pronounced summer drought.

Coring and Curation. The sediment core from Bruneau was drilled between August 7 and September 5, 1991, with a Portadrill 524-3A drilling rig that took a 3" (7.62 cm) diameter core in 10 to 15 ft (3.05 to 4.57 m) increments (Table 1). Core sediments were logged and described in the field and initial sets of paleomagnetic and paleontological samples were collected. Core segments were cut into 2 ft (0.61 m) lengths and placed in core boxes. These were shipped to the USGS Core Research Facility at the Denver Federal Center, where the core now resides. In Denver, the core sediments were described in greater detail, additional paleomagnetic and paleontological samples were collected, and magnetic susceptibility was logged. To maintain continuity with the drillers' records, all core depths are reported here in feet.

Due to variations in sedimentology and to drilling problems, sediment recovery was uneven over the length of the core (Table 2). The upper 28.3 ft of sediments were coarse gravels and cobbles that were not cored (see right-hand column on Table 1), and this accounts for the low core recovery in the upper 100-ft depth range. Deposits from 28.3 to 156.5 are silty claystones and clayey siltstones of Malde's (1989) lacustrine facies of the Bruneau Formation. These sediments are tan in color, are iron-stained and platey, and do not seem to represent deep-water environments. Sediments in the 156.5 to 198 ft range were primarily gravels and cobbles, and consequently little material was recovered here. A thick bed of sand (198.0 to 362.8 ft) underlies this zone of coarse material, and appears to grade into the Glenns Ferry lacustrine deposits below. These data seem to suggest that the sand layer may represent the end of the Glenns Ferry lake, and that the overlying gravel/cobble layer represents an unconformity between the sands and the Bruneau lake beds. However, Malde (1989) assigns these sand deposits to the Bruneau Formation.

Sediments from 364.3 ft to the base of the core are olive-green silty claystones of remarkably uniform composition (the "blue shale" of local drilling logs). There is some variation in induration in this sedimentary unit, which caused difficulties in drilling and accounts for much of the lack of recovery in the 401 - 500 ft and 801 - 800 ft intervals (Table 2). These claystones are apparently deep-water sediments deposited in a long-lived Glenns Ferry lake.

Chronology. Although tephras are common in outcrops along the southern margin of the Glenns Ferry Formation near Bruneau, no non-basaltic tephras were recovered in the Bruneau core. Smith (1987) attempted to trace some of the regional tephra marker-beds from lake margin to deep-water deposits near Bruneau, but unfortunately was unsuccessful. Although both diatom and ostracode assemblages differ markedly between the Bruneau and Glenns Ferry Formations, neither group yet provides definitive absolute age information in the Glenns Ferry portion of the record (one diatom taxon does provide information on the age of the Bruneau lake beds — see discussion below).

Preliminary paleomagnetic data from the Bruneau core (H.J. Rieck, oral communication, 1992) indicate that the sediments assigned to the Glenns Ferry Formation (i.e. those below ~360 ft) are normally magnetized and (based on their stratigraphic position) presumably fall within the late Gauss Chron (>2.48 Ma, Mankinen and Dalrymple, 1979). The Bruneau lake beds have reversed magnetism (as at other Bruneau localities; Malde, 1991) and thus are of Matuyama age (2.48 to 0.73 Ma). These beds contain a diatom species that is not known in deposits older than ~1.7 Ma in western North America (J.P. Bradbury, oral communication, 1992), and thus the Bruneau lake beds appear to be younger than the Olduvai Normal Event (1.87 to 1.67 Ma) within the Matuyama Chron. This interpretation is in good agreement with K-Ar dates of 1.37 to 1.67 Ma that have been associated with the "Third Canyon Stage" of the Bruneau Formation (Amini et al., 1984; Malde, 1985).

Table 1. Core recovery and sediment description for the Bruneau, Idaho, core. "Missing (ft)" refers to the length of core missing between the top of the current drive and the bottom of the preceding drive.

Drive	Range (ft)	Missing (ft)	Dominant Sediment Type
0	0.0 — 28.3	n/a	gravel, cobbles
1	28.3 — 32.9	28.3	"
2	32.9 — 42.9	0.0	"
3	45.8 — 57.9	2.9	"
4	64.7 — 70.9	6.8	"
5	72.4 — 82.0	1.5	"
6	85.0 — 97.0	3.0	"
7	100.3 — 105.6	3.3	"
8	108.4 — 115.6	2.8	"
9	119.1 — 129.8	3.5	clayey siltstone
10	129.8 — 141.0	0.0	"
11	141.0 — 156.0	0.0	"
12	156.0 — 156.5	0.0	"
13	188.0 — 198.0	31.5	gravel, cobbles
14	198.3 — 212.0	0.3	fine sand
15	212.0 — 227.0	0.0	"
16	227.0 — 242.0	0.0	"
17	242.3 — 254.0	0.3	"
18	254.0 — 269.0	0.0	"
19	269.0 — 284.0	0.0	"
20	284.0 — 299.0	0.0	"
21	299.0 — 312.3	0.0	"
22	312.3 — 327.3	0.0	"
23	327.3 — 334.9	0.0	"
24	334.9 — 340.9	0.0	"
25	342.0 — 351.8	1.1	"
26	351.8 — 362.8	0.0	"
27	364.3 — 378.4	1.5	silty claystone
28	378.4 — 384.4	0.0	"
29	392.7 — 403.9	8.3	"
30	403.9 — 410.3	0.0	"
31	413.9 — 428.1	3.7	"
32	438.8 — 443.8	10.7	"
33	443.8 — 456.5	0.0	"
34	458.8 — 468.5	2.3	"
35	473.8 — 486.8	5.3	"
36	486.8 — 499.8	0.0	"
37	499.8 — 510.8	0.0	"

Table 1 (con't)

Drive	Range (ft)	Missing (ft)	Dominant Sediment Type
38	514.3 — 521.4	3.5	silty claystone
39	521.4 — 539.3	0.0	"
40	539.3 — 548.6	0.0	
41	548.6 — 559.3	0.0	"
42	559.3 — 573.3	0.0	"
43	583.6 — 594.8	10.3	"
44	606.3 — 606.7	11.5	"
45	606.7 — 611.5	0.0	"
46	612.3 — 625.7	0.8	"
47	625.8 — 637.0	0.2	"
48A	643.3 — 644.4	6.3	"
48B	644.8 — 655.0	0.4	"
49	657.5 — 665.7	2.5	"
50	667.9 — 679.3	2.3	"
51	682.0 — 693.4	2.7	"
52	695.2 — 708.2	1.8	"
53	708.3 — 721.8	0.1	"
54	722.0 — 735.8	0.3	"
55	735.8 — 749.8	0.0	"
56	751.1 — 764.5	1.3	"
57	766.7 — 778.5	2.2	"
58	778.7 — 792.6	0.2	"
59	792.7 — 806.7	0.1	"
60	822.6 — 824.1	15.9	"
61A	824.1 — 824.3	0.0	"
61B	824.3 — 834.0	0.0	"
61C	834.0 — 838.3	0.0	"
62A	839.7 — 840.0	1.3	"
62B	840.0 — 843.8	0.0	"
63A	850.6 — 854.3	6.8	"
63B	854.3 — 857.8	0.0	"
64	860.4 — 872.8	2.6	"
65	879.8 — 886.8	7.1	"
66A	886.8 — 888.3	0.0	"
66B	889.4 — 897.9	1.2	"
67	897.9 — 912.4	0.0	"
68	913.6 — 927.1	1.2	"
69	928.1 — 941.6	1.0	"
70	943.1 — 956.3	1.5	"
71	968.4 — 974.1	12.2	"
72	974.8 — 988.8	0.8	"

No paleomagnetic data are available for the sand and gravel/cobble sediments between 362.8 and 156.6 ft, but following the logic presented above, these deposits should fall between 2.48 and 1.67 Ma (or slightly earlier or later, depending on how much of late Gauss and post-Olduvai Matuyama time is missing from the Glenns Ferry and Bruneau lake beds).

Palynology

Sediment samples were treated with chemical reagents to remove unwanted mineral and organic materials, and the residues analyzed under 400 to 1000X magnification. A minimum of 300 terrestrial pollen grains was counted in each sample (Appendix 1). Eighty-nine palynological samples were counted from the Bruneau core (10 Bruneau and 79 Glenns Ferry samples), as well as two surface samples from the area immediately surrounding the core site. In addition, there were seven samples that were barren of pollen (at 46.8, 69.2, 80.3, 303.0, 331.3, 340.4, and 753.8 ft). No attempts were made to recover pollen from the sand, gravel, and cobble zones.

The palynoflora expressed in the Bruneau core assemblages is essentially modern. A small number grains of "Tertiary relicts" (taxa common in the earlier Tertiary in the western United States, but extirpated today) were recovered from several samples (Table 3), but none appear to have any definitive biostratigraphic significance. Indeed, the representations of these taxa are so low (only 84 total grains out of 30685 specimens counted [0.27%]) that it is not possible to dismiss the idea that they are reworked from earlier deposits. If these grains are not reworked, then these plants must have been quite rare (and perhaps restricted to riparian habitats [see Leopold and Wright, 1985]), and, with the exception of *Ulmus* (elm), none appear to have survived into the early Pleistocene.

Large-scale environmental fluctuations are evident in the changing proportions of steppe and coniferous forest taxa through the Bruneau core record (figs. 3, 4, and 5). Steppe vegetation is represented by *Artemisia* (sagebrush), *Ambrosia*-type (ragweed and relatives), Tubuliflorae (other Asteraceae), Chenopodiineae (Chenopodiaceae and related taxa in the Amaranthaceae), *Sarcobatus* (greasewood), and Poaceae (grasses). Coniferous forest is represented by *Pinus* (pine, usually the dominant forest element), *Abies* (fir), TCT (Taxaceae-Cupressaceae-Taxodiaceae: junipers, cedars, and relatives), as well as lesser amounts of *Picea* (spruce), *Pseudotsuga/Larix* (Douglas fir and/or larch), *Tsuga* (hemlock), and (very rarely) *Sequoia*. As illustrated in Table 4, *Pinus*, *Abies* and other conifers are positively correlated in the Glenns Ferry portion of the record, and are generally negatively correlated with the steppe taxa listed above. There are statistical constraints within this percentage data matrix, but nevertheless it appears that a simple forest vs. steppe model for vegetational change through the Bruneau record (fig. 3) explains most of the observed variability.

It should be recognized that this palynological record from a large lake system represents the integration of pollen from a large source area. If Taylor and Bright (1987) are correct, the Glenns Ferry source area did not include those areas of eastern Idaho, Montana, and Wyoming that today drain into the Snake River, but nevertheless the Bruneau core record may include inputs from as far away as the mountains of central Idaho and northern Nevada.

The stratigraphic record of palynological changes in the Bruneau core is reviewed in the discussion that follows. For convenience, an informal series of zones is placed along the depth axes in figures 3 and 4, and the discussion is organized along these lines (from core bottom to core top).

Zone XI. (989 to 910 ft, figs. 3 and 4). Conifers (mainly *Pinus*) dominant over steppe. These samples resemble Glenns Ferry assemblages of undetermined age from Vale, Oregon, and (to a lesser degree) ~4 Ma samples from Oregon near Weiser, Idaho (fig. 1; Thompson, unpublished data).

Zone X. (910 to 810 ft, figs. 3 and 4). Variable, but steppe taxa generally greater than conifers. *Artemisia* and Chenopodiineae higher than below, *Pinus* and other conifers lower.

Zone IX. (810 to 720 ft, figs. 3 and 4). Conifers dominant over steppe. High *Pinus*, *Abies*, other conifers; moderate *Artemisia*; low Chenopodiineae and essentially no *Quercus* (oak).

Zone VIII. (720 to 640 ft, figs. 3 and 4). Steppe dominant over conifers. High *Artemisia* and Chenopodiineae, coupled with relatively high *Quercus*.

Table 2. Percent sediment recovery ((length recovered)/(length cored)) in 100-foot (30.5-m) increments for the Bruneau, Idaho, core.

Depth Range (ft)	001-100	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-989
Percent Recovery	54%	62%	100%	89%	78%	86%	72%	96%	65%	81%

Table 3. The stratigraphic record of "Tertiary relicts" in the Bruneau, Idaho, pollen profile (which includes 89 fossil samples).

	Lowest Occurence	Highest Occurence	Maximum abundance	Number of Samples
cf. *Cedrus*	988.8 ft	397.0 ft	2%	34
Podocarpus?	988.8 ft	461.8 ft	<1%	5
Sequoia	871.8 ft	699.6 ft	<1%	3
Carya	449.6 ft	449.6 ft	<1%	1
Fagus	773.0 ft	773.0 ft	<1%	1
Ilex	988.8 ft	988.8 ft	<1%	1
Juglans/Pterocarya	986.9 ft	485.6 ft	<1%	3
Ulmus	955.3 ft	86.9 ft	<1%	11

Table 4. Correlation matrix for major palynological taxa from the Bruneau, Idaho, core. The original percentage data were transformed by the log-ratio method (Kovach, 1990) prior to analysis. Key to taxa: PIN = *Pinus*, ABI = *Abies*, CON = other conifers, TCT = Taxaceae-Cupressaceae-Taxodiaceae, QUE = *Quercus*, TRE = other trees and shrubs, ART = *Artemisia*, TUB = Tubuliflorae, CHE = Chenopodiineae, SAR = *Sarcobatus*, POA = Poaceae, HER = herbs and forbs, IND = Indeterminate. Critical values for correlation coefficients for 70 degrees of freedom (df here = 76) are .232 for $\alpha = .05$ and .302 for $\alpha = .01$ (Rohlf and Sokal, 1969). Correlation coefficients in bold are significant at the .01 level and those in italics are significant at the .05 level.

	IND	**HER**	**POA**	**SAR**	**CHE**	**TUB**	**AMB**	**ART**	**TRE**	**QUE**	**TCT**	**CON**	**ABI**
PIN	-0.17	-0.03	0.15	**-0.33**	**-0.54**	-0.20	**-0.42**	-0.01	**-0.34**	**-0.53**	0.17	**0.72**	**0.51**
ABI	**-0.44**	-0.03	-0.12	*-0.30*	*-0.24*	*-0.27*	-0.03	**-0.35**	**-0.50**	**-0.34**	0.16	**0.47**	
CON	-0.23	-0.10	0.04	**-0.31**	**-0.50**	**-0.37**	*-0.24*	-0.19	**-0.38**	**-0.38**	0.12		
TCT	0.20	0.01	-0.03	*-0.30*	**-0.32**	*0.25*	**-0.31**	0.20	-0.15	**-0.36**			
QUE	*-0.26*	-0.18	-0.05	-0.05	0.05	**0.51**	-0.20	**0.43**	0.01				
TRE	*0.24*	0.16	0.00	0.17	-0.01	0.21	*-0.26*	**0.33**					
ART	**0.48**	0.16	-0.03	0.18	**-0.31**	**0.47**	**-0.38**						
AMB	-0.22	**-0.35**	**-0.33**	0.17	**0.64**	-0.22							
TUB	**0.47**	0.20	-0.11	0.04	0.05								
CHE	-0.11	**-0.31**	**-0.39**	0.22									
SAR	-0.06	-0.16	*-0.25*										
POA	0.03	0.04											
HER	0.08												

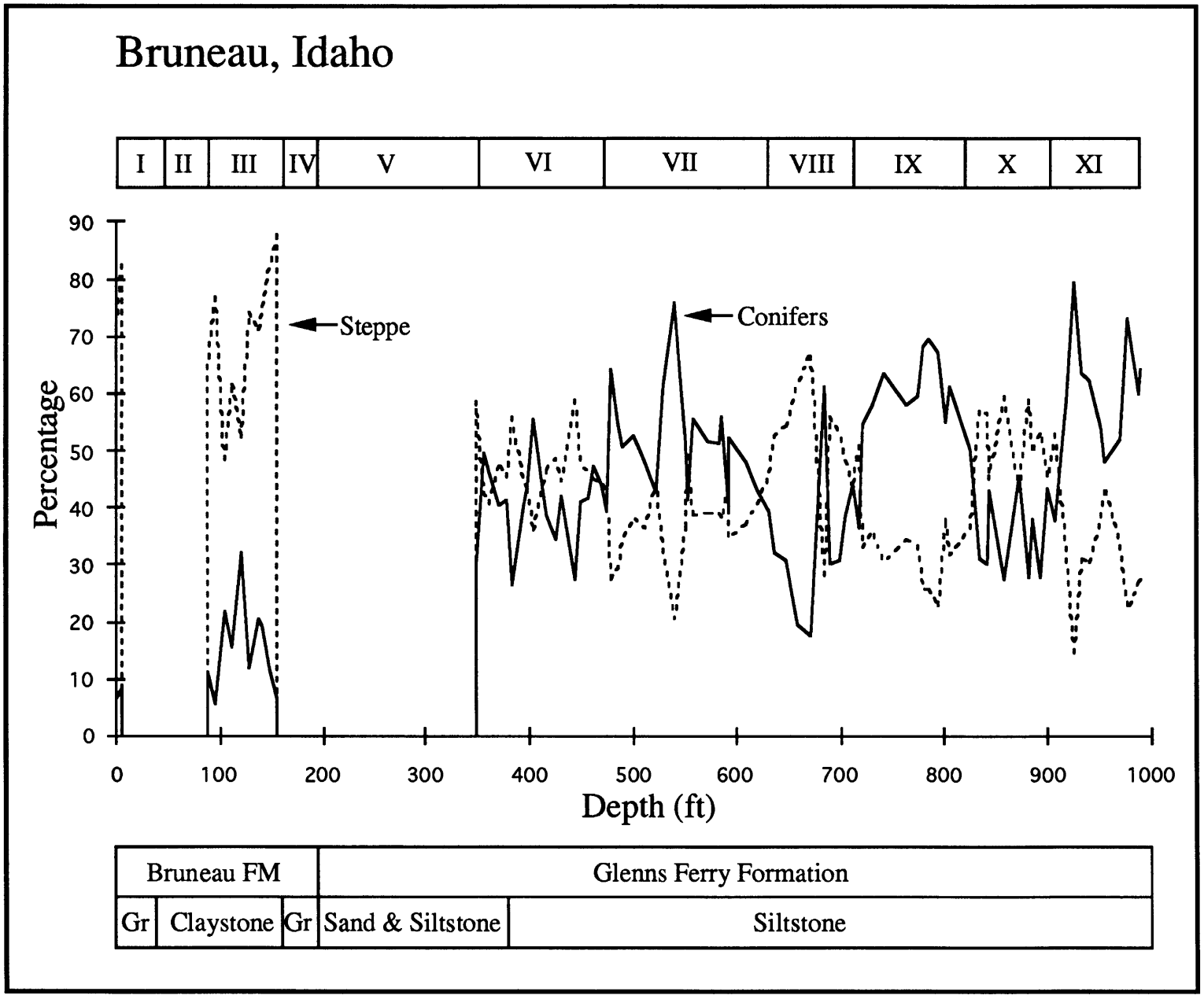

Figure 3. Variations in conifer and steppe vegetation plotted against depth for the Bruneau core. See text for an explanation of categories.

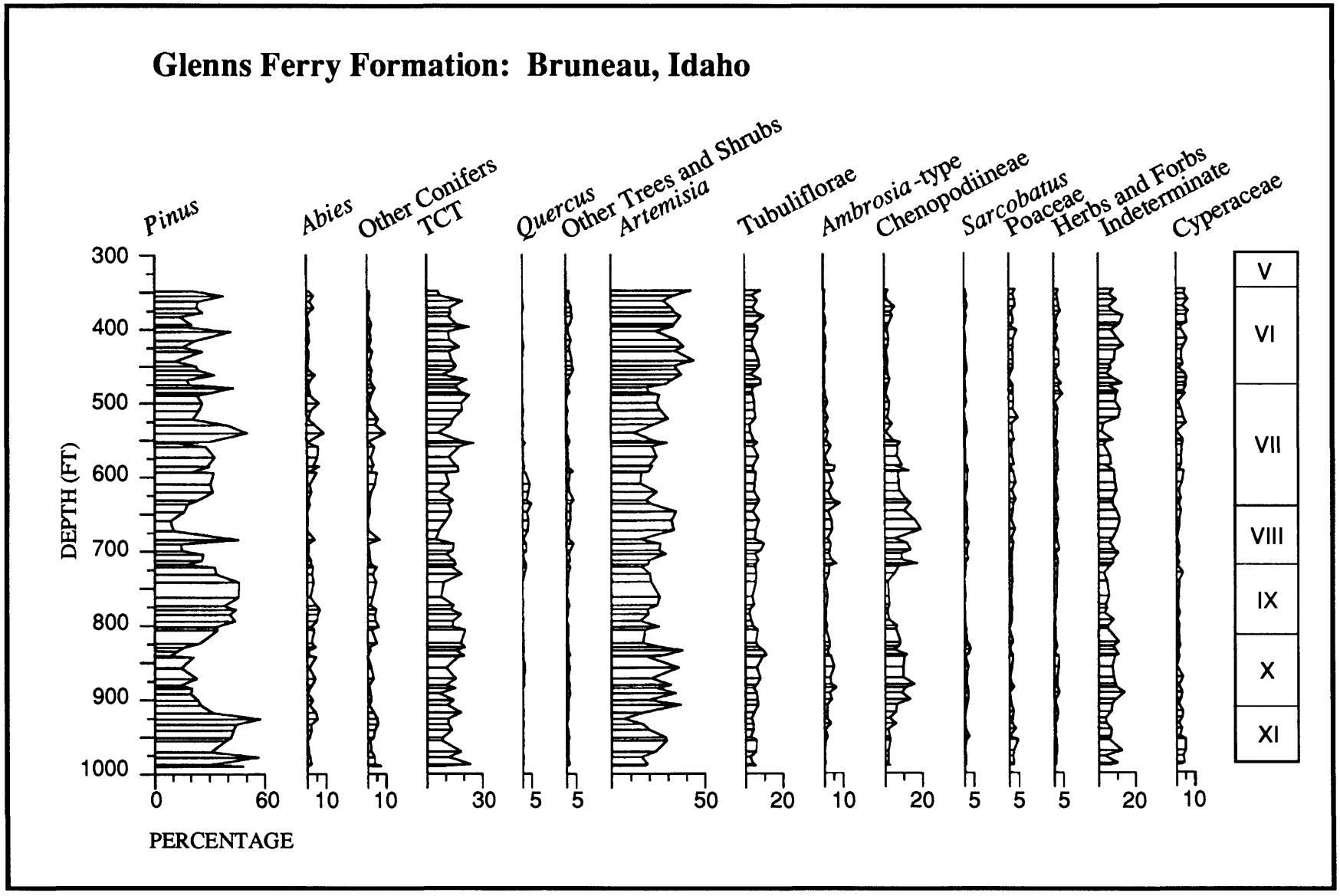

Figure 4. Pollen profile of the Glenns Ferry Formation portion of the Bruneau core.

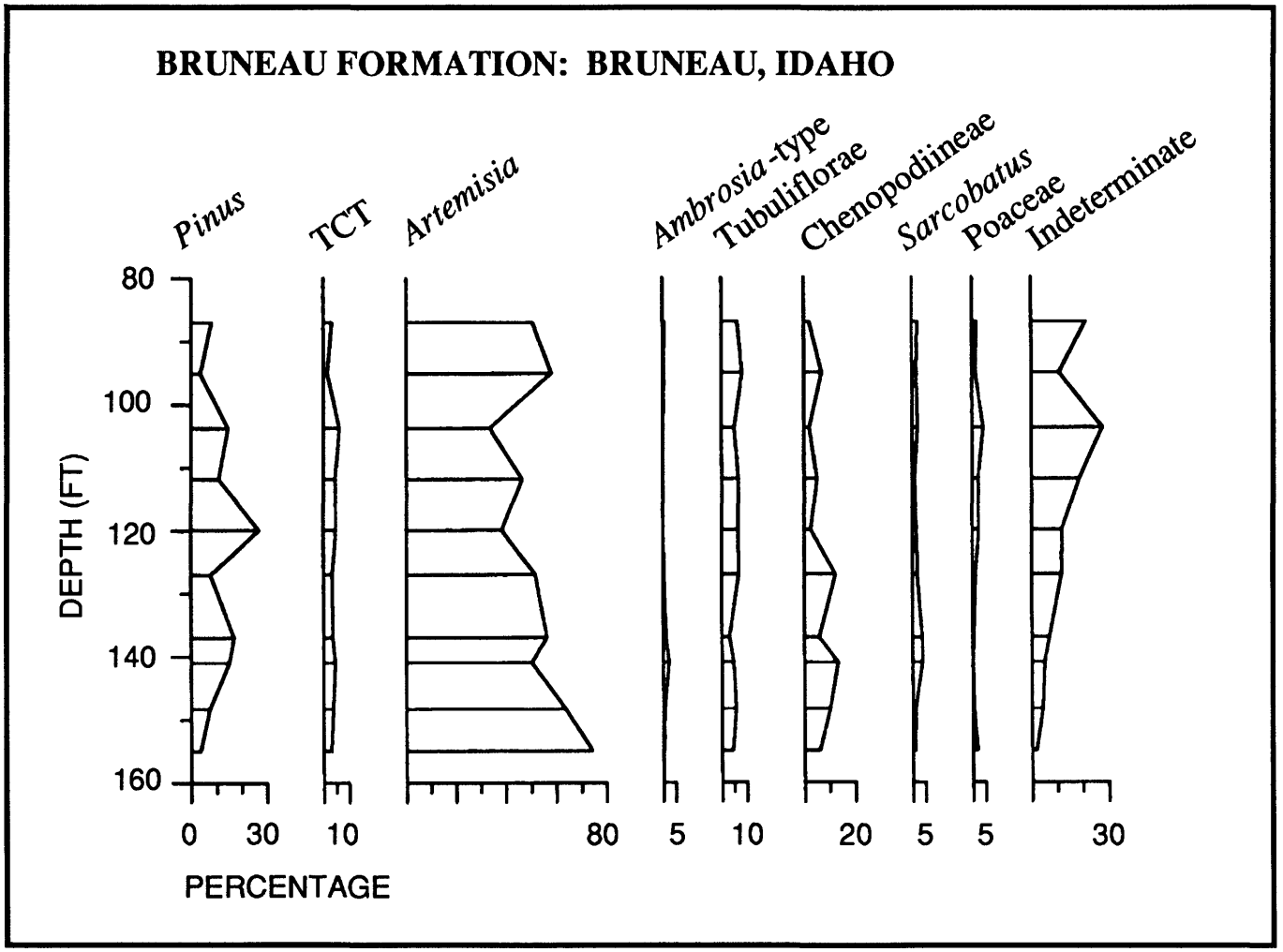

Figure 5. Pollen profile from the Bruneau lake beds portion of the Bruneau core.

Zone VII. (640 to 475 ft, figs. 3 and 4). Conifers dominant over steppe. *Pinus* dominant or co-dominant with TCT, *Abies* sporadically high through this interval. *Artemisia* dominant in steppe vegetation with common Tubuliflorae and generally low Chenopodiineae and *Sarcobatus*. *Quercus* relatively high toward bottom.

Zone VI. (475 to 348 ft, figs. 3 and 4) Variable, but steppe generally slightly greater than forest. Floristic composition similar to above.

Zone V. (348 to 198 ft) fine sand, becoming siltier with depth. No pollen preservation or paleomagnetic results.

Zone IV. (198 to 157 ft) Zone of cobbles, gravel, and sand (equivalent of Ten Mile and Tuana Gravels of Malde [1991]?). Bounded by an unconformity at the top?

Zone III. (157 to 87 ft, figs. 3 and 5) Bruneau lake beds: steppe vegetation (~50 to 90%), dominated by *Artemisia* (34 to 74%).

Zone II. (87 to 28 ft) Zone of no pollen recovery in the upper Bruneau lake beds.

Zone I. (28 to 0 ft) No recovery through the uppermost interval of gravel, cobbles, and convoluted sands. Surface sediment pinch samples (Appendix 1) are dominated by steppe taxa (especially Chenopodiineae at 40 to 51%) with very low representations of conifers (Pinus to 6 to 8%).

The overall pattern of the Glenns Ferry portion of the palynological record is a quasi-sine wave oscillation of coniferous forest advancing and receding (fig. 3), but with forest percentages lessening through time (even during the forest periods). A similar-forest-to-steppe-to-forest pattern is evident in palynological data from older Glenns Ferry sediments farther east (Leopold and Wright, 1985); in a core of unknown age within the Glenns Ferry Formation near Mountain Home, Idaho (Thompson, unpublished data); and in a core from the Idaho National Engineering Laboratory that apparently spans most of the Pliocene (Thompson, 1991). I interpret this pattern as indicative of actual changes in the position of the forest boundary (approaching and receding from the lake), although transgressions and regressions within the lake system itself could have greatly influenced the pollen record, particularly as increased habitat space for Chenopodiineae became exposed during lower lake phases. This may have been an amplification of the signal more than anything, for a climatic change that caused a lake regression could also lessen the forest representation in the watershed. Leopold and Denton (1987, p. 844) have drawn a convincing relationship between the modern forest/steppe boundary in the interior Pacific Northwest and the 15 to 20" (380 to 500 mm) isohyet for mean annual precipitation, and thus fluctuations in precipitation seem to be the most likely cause of forest/steppe oscillations during the Pliocene.

Palynological data from northern South America (Hoogmeistra, 1989) exhibit what appear to be orbitally-induced (40 Kyr?) oscillations prior to ~2.5 Ma, while contemporaneous data from the Netherlands (Zagwijn, 1992) and northern California (Adam et al., 1989) show vegetation varying on much longer time-scales (hundreds of thousands of years). As the Glenns Ferry portion of the Bruneau core does not yet have a precise age-model, I cannot assess whether the timing of the forest-steppe oscillations matches either of these records.

The palynological assemblages of the Bruneau Formation resemble late Wisconsinan Full Glacial samples from southeastern Idaho (e.g. Bright and Davis, 1982; Beiswenger, 1991), implying cold-dry (glacial?) conditions during portions of the early Pleistocene.

Acknowledgments
Margi Jenks of the Idaho Geological Survey helped determine the core location and provided regional background information. The Bureau of Land Management permitted the USGS to drill on land in their jurisdiction. The Buckaroo Ditch Board kindly allowed us to draw water for the drilling operation. Todd Hunter, Steve Grant, Brian Bretz, and Art Clark conducted the drilling operation, and Hugh Rieck, Farley Fleming, Jenny Buchner, Brett Givens, and Eric Fisher provided field and/or laboratory assistance. Russ Dubiel and Tom Fouch provided useful comments on the core sediments, and Platt Bradbury, Claire Carter, Rick Forester, and Chuck Repenning provided paleontological information. Tom Michalski and the crew at the USGS Core Research Facility curated the core. Farley Fleming and Doug Nichols edited the manuscipt. This effort was funded by the USGS Geologic Division Global Change and Climate History Program.

References

Adam, D.P., Bradbury, J.P., Rieck, H.J., and Sarna-Wojcicki, A.M. ,1990, Environmental changes in the Tule Lake Basin, Siskiyou and Modoc Counties, California, from 3 to 2 Million Years before present: U.S. Geological Survey Bulletin 1933. 13 p.

Amini, H., Mehnert, H.H., and Obradovich, J.D., 1984, K-Ar ages of late Cenozoic basalts from the western Snake River Plain, Idaho: Isochron/West v. 41, 7-11.

Arney, B.H., Gardner, J.N., and Belluomini, S.G., 1984, Petrographic analysis and correlation of volcanic rocks in Bostic 1-A well near Mountain Home, Idaho: Los Alamos National Laboratory report LA-9966-HDR (Hot Dry Rock). [UC-66a], 29 p.

Beiswenger, J.M., 1991, Late Quaternary vegetational history of Grays Lake, Idaho: Ecological Monographs v. 61, 165-182.

Bright , R.C. and Davis, O.K., 1982, Quaternary paleoecology of Idaho Nat. Eng. Lab., Snake River Plain, Idaho: American Midland Naturalist v. 108, 21-33.

Court, A., 1974, The climate of the conterminous United States, *in* Bryson, R.A. and Hare, F.K. , eds., Climates of North America. World Survey of Climatology Volume 11. Elsevier Scientific Publishing Company. Amsterdam-London-New York. Pp. 193-343

Forester, R.M., 1991, Pliocene-Climate history of the western United States derived from lacustrine ostracodes: Quaternary Science Reviews v. 10, 133-146.

Hooghiemstra, H., 1989, Quaternary and upper-Pliocene glaciations and forest development in the tropical Andes: evidence from a long high-resolution pollen record from the sedimentary basin of Bogotá, Colombia: Palaeogeography, Palaeoclimatology, Palaeoecology v. 72, 11-26.

Jenks, M.D., and Bonnichsen, B., 1989, Subaqueous basalt eruptions into Pliocene Lake Idaho, Snake River Plain, Idaho, *in* Chamberlain, V.E., Breckenridge, R.M., and Bonnichsen, B., eds., Guidebook of Northern and Western Idaho and Surrounding Area: Idaho Geological Survey Bulletin v. 28, 17-34.

Kovach, W.L., 1990, Multi-Variate Statistical Package Plus - Version 2.0. User's Manual: University College of Wales, Aberystwyth, Wales, U.K.

Leopold, E.B. and Denton, M.F., 1987, Comparative age of grassland and steppe east and west of the Northern Rocky Mountains: Annals of the Missouri Botanical Garden 74, 841-867.

Leopold, E.B. and Wright, V.C., 1985, Pollen profiles of the Plio-Pleistocene transition in the Snake River Plain, Idaho, *in* Smiley, C.J. ed., Late Cenozoic History of the Pacific Northwest: A.A.A.S. Pacific Division, San Francisco. Pp. 323-348.

Lewis, R.E. and Stone, M.A.J., 1988, Geohydrologic data from a 4,403-foot geothermal test hole, Mountain Home Air Force Base, Elmore County, Idaho: U.S. Geological Survey Open-File Report 88-166. 30 p.

Littleton, R.T. and Crosthwaite, E.G., 1957, Ground-water geology of the Bruneau-Grand View area Owyhee County, Idaho: U.S. Geological Survey Water-Supply Paper 1460-D, 145-198.

Malde, H.E., 1985, Guidebook. Raft trip through the Snake River Birds of Prey Area to View Canyon-filling Volcanics and Lake Beds of the Pleistocene Snake River: Rocky Mountain Section, Geological Society of America, 38th Annual Meeting, April 20-26, 1985, Boise, Idaho. 48 p.

Malde, H.E., 1989, Geologic map of the Bruneau Formation in the C.J. Strike Dam and Bruneau Quadrangles, Southwestern Idaho. U.S. Geological Survey Miscellaneous Field Studies Map MF-2063-E.

Malde, H.E., 1991, Quaternary geology and structural history of the Snake River Plain, Idaho and Oregon, *in* Morrison, R.B., ed., Quaternary nonglacial geology; Conterminous U.S.: The Geology of North America v. K-2, 251-281.

Malde, H.A. and Powers, H.A., 1962, Upper Cenozoic stratigraphy of Western Snake River Plain, Idaho: Geological Society of America Bulletin v. 73, 1197-1220.

Mankinen, E.A. and Dalrymple, G.B., 1979, Revised geomagnetic polarity time scale for the interval 0—5 m.y. B.P.: Journal of Geophysical Research v. 84, 615-626.

McIntyre, D.H., 1979, Preliminary description of Anshutz Federal No. 1 Drill Hole, Owyhee County, Idaho: U.S. Geological Survey Open-File Report 79-651. 15p.

Neville, C., Opdyke, N.D., Lindsay, E.H., and Johnson, N.M., 1979, Magnetic stratigraphy of Pliocene deposits of the Glenns Ferry Formation, Idaho, and its implications for North American mammalian biostratigraphy: American Journal of Science v. 279, 503-526.

Repenning, C.A., 1987, Biochronology of the microtine rodents of the United States. *in* Woodburne, M.O., ed., Cenozoic Mammals of North America: University of California Press, Berkeley. Pp. 236-268.

Rohlf, F.J. and Sokal, R.R., 1969, Statistical Tables: W.H. Freeman and Co., San Francisco. 253 p.

Smith, G.R., 1987, Fish speciation in a Western North American Pliocene Rift Lake: Palaios v. 2, 436-445.

Smith, G.R., Swirydczuk, K., Kimmel, P.G., and Wilkinson, B.H., 1982, Fish biostratigraphy of late Miocene to Pleistocene sediments of the western Snake River Plain, Idaho, *in* Bonnichsen, B. and Breckenridge, R.M., eds., Cenozoic Geology of Idaho: Idaho Bureau of Mines and Geology Bulletin v. 26, 519-541.

Taylor, D.W. and Bright, R.C., 1987, Drainage history of the Bonneville Basin: Utah Geological Association Publication v. 16, 239-256.

Thompson, R.S., 1991, Pliocene environments and climates in the western United States: Quaternary Science Reviews v. 10, 115-132.

Whitehead, R.L. and Lindholm, G.F., 1985, Results of geohydrologic test drilling in the eastern Snake River Plain, Gooding County, Idaho. U.S. Geological Survey Water-Resources Investigations Report 84-4294. 31 p.

Zagwijn, W.H., 1992, The beginning of the Ice Age in Europe and its major subdivisions: Quaternary Science Reviews v. 11, 583-591.

Appendix A

Depth (ft)	SurfE	SurfW	86.9	95.0	103.7	111.8	119.9	127.1	137.1	141.0	148.3	154.9	348.4	354.9	362.1	371.1	377.6	382.6	393.8	397.0
CONIFERS																				
Abies	0	0	0	0	1	1	1	1	0	0	0	0	4	11	5	12	3	1	5	1
Cedrus?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Picea	0	0	0	1	1	0	0	0	0	0	1	0	2	0	1	1	0	0	2	0
Pinus	20	26	24	12	47	34	84	24	56	58	24	12	75	116	75	74	83	47	62	57
Podocarpus?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudotsuga/Larix	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Sequoia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCT	2	0	10	5	20	14	15	10	12	17	12	9	21	22	61	40	42	40	50	72
Tsuga heterophylla	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Tsuga mertensiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vesiculate undiff.	0	0	0	0	2	0	0	2	0	0	0	0	1	3	2	1	2	2	5	3
OTHER TREES AND SHRUBS																				
Acer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alnus	0	1	4	1	0	2	2	0	0	0	0	3	1	0	0	1	1	1	0	1
Betula	0	0	1	0	0	1	1	0	1	0	0	1	1	1	1	2	0	0	1	1
Carya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Castenopsis?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cercocarpus-type	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephedra trifurca-type	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Ephedra viridis-type	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0
Fagus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraxinus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ilex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juglans/Pterocarya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quercus	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	3	0	0	0	1
Rhamnaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ribes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Salix	0	0	1	5	2	1	4	1	1	1	2	3	1	1	1	0	2	1	2	1
Shepherdia	1	0	2	4	0	3	2	0	0	0	1	0	3	2	1	5	4	8	1	0
Symphoricarpos/Lonicera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulmus	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
ASTERACEAE																				
Ambrosia-type	2	2	2	2	0	0	0	1	4	10	3	1	2	1	1	2	0	2	4	2
Artemisia	36	84	153	186	110	148	121	161	187	196	206	234	150	104	87	103	106	126	103	102
Liguliflorae	0	0	0	1	0	0	0	0	0	0	0	0	2	2	2	2	5	2	0	2
Tubuliflorae	8	2	19	26	17	21	21	21	10	18	18	14	30	11	21	14	18	36	14	21
CHENOPODIINEAE																				
Chenopodiineae undiff.	169	126	7	22	7	16	8	38	19	51	33	19	6	2	4	17	9	14	7	5
Sarcobatus	1	2	7	5	7	3	5	6	13	15	4	3	2	4	3	6	2	4	2	1
HERBS AND FORBS																				
Apiaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Arceuthobium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix A

Depth (ft)	SurfE	SurfW	86.9	95.0	103.7	111.8	119.9	127.1	137.1	141.0	148.3	154.9	348.4	354.9	362.1	371.1	377.6	382.6	393.8	397.0
Brassicaceae	16	2	0	1	2	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1
Caryophyllaceae	0	0	0	0	1	0	0	0	0	0	0	0	3	0	1	2	2	2	1	1
Eriogonum	1	0	1	0	0	1	2	2	4	2	1	0	0	0	1	1	0	0	0	0
Fabaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Gilia-type	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Labiatae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Liliaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onagraceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phlox	0	0	0	5	2	2	0	1	0	1	0	3	1	0	0	0	0	1	1	2
Poaceae	23	46	5	5	14	8	8	4	2	1	3	6	11	6	9	10	3	6	7	1
Polemonium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Polygonum californica-type	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rosaceae	0	0	0	1	0	0	1	1	0	1	0	0	0	0	1	1	1	0	1	0
Rumex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thalictrum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Valeriana	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OTHER																				
Unknown	0	0	0	0	0	1	0	0	0	0	0	0	0	1	2	1	0	0	0	0
Indeterminate	53	27	64	35	90	59	37	36	23	19	14	6	28	18	31	19	26	45	36	32
Terrestrial Pollen Sum	332	318	301	319	324	316	313	311	332	390	323	315	347	307	312	320	314	339	306	309
Tracers	n/a	n/a	112	18	23	33	82	44	23	18	8	5	72	18	35	53	20	11	15	12
FERNS, FERN-ALLIES, ETC.																				
Equisetum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isoetes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Lycopodium	0	0	1	0	0	0	0	0	0	0	0	0	3	1	0	2	0	2	1	2
Monolete Spores	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Osmunda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trilete Spores	0	0	2	2	1	0	0	1	0	0	0	0	1	2	0	3	1	0	1	0
AQUATIC PLANTS																				
Cyperaceae	1	0	2	11	15	4	0	3	0	1	0	1	17	13	21	11	22	18	18	8
Menyanthes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myriophyllum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuphar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonum amphibium-type	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Potamogeton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sagitarria	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0
Typha latifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Typha/Sparganium	0	0	0	0	0	1	0	0	0	0	0	0	1	0	2	0	1	0	0	2
ALGAE																				
Botryococcus	0	0	2	1	1	0	0	0	0	2	4	0	1	15	0	0	0	1	1	1
Pediastrum	0	0	3	1	1	0	0	0	0	0	0	0	5	1	0	0	1	0	0	2

Appendix A

Depth (ft)	403.3	415.3	424.4	430.2	442.9	449.6	455.4	461.8	468.3	474.8	479.0	485.6	488.7	499.9	510.1	521.2	529.1	540.2	551.8	553.8
CONIFERS																				
Abies	3	5	0	4	3	2	3	15	7	3	4	6	6	22	7	4	14	29	3	4
Cedrus?	1	0	0	1	0	0	0	0	0	1	4	2	1	0	1	2	1	0	1	1
Picea	0	1	0	0	0	0	2	1	1	1	0	1	0	0	0	1	1	2	0	0
Pinus	139	71	48	85	36	72	73	104	55	61	133	97	75	86	76	74	122	160	94	42
Podocarpus?	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Pseudotsuga/Larix	0	0	0	0	1	0	1	0	1	0	2	1	0	0	3	0	1	0	0	1
Sequoia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TCT	39	39	55	39	45	51	44	26	67	53	50	61	74	63	60	51	41	20	59	81
Tsuga heterophylla	0	0	0	2	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Tsuga mertensiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vesiculate undiff.	4	5	3	6	3	4	5	3	3	6	7	5	6	2	3	18	10	29	2	3
OTHER TREES AND SHRUBS																				
Acer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alnus	0	2	0	1	1	2	4	2	0	4	1	1	1	0	0	0	2	0	0	1
Betula	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Carya	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Castenopsis?	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	1
Cercocarpus-type	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Ephedra trifurca-type	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ephedra viridis-type	0	0	0	1	0	2	0	0	0	0	0	1	0	0	0	0	0	0	1	0
Fagus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraxinus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ilex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juglans/Pterocarya	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Quercus	0	1	3	1	0	0	0	0	0	0	0	1	0	0	2	0	2	0	2	5
Rhamnaceae	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ribes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salix	1	2	1	0	0	2	2	0	1	0	1	1	0	0	1	0	0	0	1	3
Shepherdia	2	4	3	4	8	2	6	3	1	1	0	2	1	0	2	1	0	1	2	0
Symphoricarpos/Lonicera	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulmus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ASTERACEAE																				
Ambrosia-type	0	4	4	2	3	0	1	1	1	1	0	3	2	7	2	8	2	7	3	7
Artemisia	79	110	119	111	144	107	107	120	100	93	59	64	82	81	82	107	72	37	72	95
Liguliflorae	1	3	0	3	4	3	0	2	0	2	1	2	2	2	1	0	0	0	0	1
Tubuliflorae	22	12	13	18	24	25	19	9	26	27	13	12	14	17	16	19	8	9	15	21
CHENOPODIINEAE																				
Chenopodiineae undiff.	4	7	5	3	5	4	4	5	8	6	4	3	2	8	7	5	12	2	14	26
Sarcobatus	1	3	2	2	3	4	5	3	1	2	2	3	2	4	0	1	3	5	1	2
HERBS AND FORBS																				
Apiaceae	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2	1	0	0	1	0
Arceuthobium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix A

Depth (ft)	403.3	415.3	424.4	430.2	442.9	449.6	455.4	461.8	468.3	474.8	479.0	485.6	488.7	499.9	510.1	521.2	529.1	540.2	551.8	553.8
Brassicaceae	1	0	0	1	0	2	0	0	0	1	0	0	0	0	0	2	0	0	0	0
Caryophyllaceae	1	1	1	3	0	2	1	0	2	5	1	4	4	0	1	0	2	3	1	2
Eriogonum	0	0	0	1	0	1	0	2	0	0	1	1	0	0	0	0	0	0	0	1
Fabaceae	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Gilia-type	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Labiatae	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Liliaceae	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onagraceae	0		0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0
Phlox	0	0	0	0	0	0	0	0	1	3	0	1	4	0	3	2	0	0	1	0
Poaceae	13	7	7	6	7	7	6	3	0	5	7	6	7	8	6	16	5	5	8	5
Polemonium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonaceae	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Polygonum californica-type	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	0	0	0
Rosaceae	0	0	0	0	1	0	0	0	1	1	1	0	1	0	0	0	0	0	0	1
Rumex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thalictrum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valeriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OTHER																				
Unknown	0	2	0	0	1	1	1	0	0	0	3	0	1	0	0	0	0	1	0	1
Indeterminate	23	33	42	30	29	19	21	14	25	41	17	34	31	30	37	38	9	6	25	13
Terrestrial Pollen Sum	334	313	307	325	322	315	306	318	304	318	311	317	319	331	312	351	310	316	308	318
Tracers	32	50	21	14	41	17	10	61	20	5	50	28	21	35	19	9	10	17	17	22
FERNS, FERN-ALLIES, ETC.																				
Equisetum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isoetes	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Lycopodium	2	4	2	3	2	6	2	6	3	0	4	6	4	3	7	2	5	7	6	2
Monolete Spores	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Osmunda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trilete Spores	0	0	2	0	0	1	0	1	1	1	1	2	0	0	1	3	1	2	0	0
AQUATIC PLANTS																				
Cyperaceae	9	19	13	9	9	12	4	15	18	16	17	12	16	3	8	14	17	0	12	12
Menyanthes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myriophyllum	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Nuphar	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Polygonum amphibium-type	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	2	0	0
Potamogeton	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0
Sagitarria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Typha latifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Typha/Sparganium	0	2	0	0	0	0	0	0	0	1	0	0	1	1	0	0	4	4	1	0
ALGAE																				
Botryococcus	1	0	1	0	0	0	1	0	2	1	0	1	0	0	1	0	1	1	0	0
Pediastrum	2	0	0	1	0	1	0	0	1	4	0	0	1	0	0	0	0	0	2	1

Appendix A

Depth (ft)	558.8	572.9	584.8	585.8	592.8	593.9	609.1	620.5	631.3	636.3	647.3	659.1	671.7	683.7	689.7	699.6	704.2	712.4	717.9	721.3
CONIFERS																				
Abies	19	18	11	20	3	17	5	7	3	5	0	1	0	13	2	3	1	7	7	11
Cedrus?	0	1	1	1	1	0	1	0	0	0	1	0	0	1	0	2	0	0	0	0
Picea	1	1	3	1	0	1	1	1	0	0	1	0	1	5	0	0	0	1	0	2
Pinus	87	105	95	91	64	106	99	100	74	56	54	28	38	142	46	47	91	81	52	105
Podocarpus?	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudotsuga/Larix	1	0	0	0	2	3	0	0	0	1	0	0	1	2	0	0	1	0	0	0
Sequoia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
TCT	55	38	52	51	54	33	40	22	45	35	45	33	24	15	47	44	36	46	49	43
Tsuga heterophylla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Tsuga mertensiana	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vesiculate undiff.	10	3	6	6	3	11	10	5	3	2	2	0	0	13	1	0	2	3	6	11
OTHER TREES AND SHRUBS																				
Acer	0	0	0	0	0	0	1	0	3	1	1	0	0	1	3	0	1	0	0	0
Alnus	0	0	0	0	2	0	1	0	1	0	1	0	0	0	1	0	0	0	0	1
Betula	1	0	2	0	2	2	2	0	0	1	3	3	1	1	0	1	1	1	2	1
Carya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Castenopsis?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cercocarpus-type	0	0	0	0	1	0	0	1	2	0	0	0	0	0	2	0	1	3	1	0
Ephedra trifurca-type	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ephedra viridis-type	0	0	0	0	1	1	0	1	0	1	0	3	2	1	0	2	0	0	0	2
Fagus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraxinus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Ilex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juglans/Pterocarya	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
Quercus	1	1	2	3	1	5	13	10	7	15	8	10	11	1	6	7	1	3	6	6
Rhamnaceae	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ribes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salix	0	0	0	0	2	3	0	1	3	2	1	1	1	0	4	2	2	1	0	3
Shepherdia	1	2	1	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0
Symphoricarpos/Lonicera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulmus	0	0	0	0	2	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0
ASTERACEAE																				
Ambrosia-type	12	1	8	17	17	7	15	7	14	26	7	13	16	6	11	10	10	12	21	8
Artemisia	67	77	66	66	63	52	50	76	58	64	115	102	121	47	83	79	100	63	61	51
Liguliflorae	1	0	1	0	0	1	0	0	2	0	1	1	1	0	0	0	0	1	2	0
Tubuliflorae	13	22	14	13	12	18	16	14	23	20	13	23	20	15	32	25	17	22	17	17
CHENOPODIINEAE																				
Chenopodiineae undiff.	21	20	30	14	40	23	24	24	36	42	34	50	70	15	37	43	30	28	54	23
Sarcobatus	2	2	2	4	6	6	6	3	1	3	6	4	7	2	8	4	5	6	1	3
HERBS AND FORBS																				
Apiaceae	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	3	0	0
Arceuthobium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix A

Depth (ft)	558.8	572.9	584.8	585.8	592.8	593.9	609.1	620.5	631.3	636.3	647.3	659.1	671.7	683.7	689.7	699.6	704.2	712.4	717.9	721.3
Brassicaceae	2	0	0	0	0	1	0	0	1	2	0	0	0	0	0	1	1	1	1	1
Caryophyllaceae	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eriogonum	0	1	1	1	1	0	0	0	0	0	1	3	0	0	1	3	0	0	2	0
Fabaceae	0	0	0	2	0	0	1	0	0	0	1	2	0	0	0	0	0	0	0	0
Gilia-type	0	0	0	1	0	0	0	0	2	0	0	0	0	1	0	1	0	0	0	0
Labiatae	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Liliaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onagraceae	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Phlox	0	0	0	0	3	0	1	2	0	0	0	0	2	0	1	0	0	0	0	0
Poaceae	4	4	8	1	5	7	10	4	10	7	6	3	11	3	7	5	4	4	3	4
Polemonium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Polygonaceae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Polygonum californica-type	0	1	3	0	0	2	0	2	0	0	0	1	1	0	3	0	0	0	1	0
Rosaceae	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	1	1	0	3
Rumex	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thalictrum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valeriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OTHER																				
Unknown	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	2	0	0	1	0
Indeterminate	11	20	22	10	27	28	29	30	24	22	32	37	37	24	19	27	37	25	25	21
Terrestrial Pollen Sum	310	321	330	303	316	329	327	313	316	307	335	318	365	312	317	312	342	313	312	320
Tracers	22	20	14	24	17	12	37	42	38	2	17	21	7	62	14	18	27	19	34	6
FERNS, FERN-ALLIES, ETC.																				
Equisetum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isoetes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Lycopodium	4	5	1	5	1	2	1	0	1	1	1	2	1	2	0	3	1	1	2	0
Monolete Spores	0	1	0	1	0	2	0	1	0	1	0	1	0	0	1	0	0	0	1	0
Osmunda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Trilete Spores	0	2	1	0	0	1	1	1	0	1	1	0	0	5	1	0	0	0	1	0
AQUATIC PLANTS																				
Cyperaceae	10	8	9	7	3	13	9	4	8	4	8	5	4	1	3	5	6	1	5	1
Menyanthes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myriophyllum	1	0	0	1	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Nuphar	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonum amphibium-type	0	0	1	0	0	0	0	0	0	0	0	0	0	4	1	0	0	0	0	2
Potamogeton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sagitarria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Typha latifolia	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Typha/Sparganium	3	3	4	4	1	3	1	1	0	0	2	0	3	2	2	2	3	0	1	0
ALGAE																				
Botryococcus	0	2	0	1	1	0	0	0	0	0	0	0	0	4	0	9	0	2	27	1
Pediastrum	1	1	4	1	0	0	0	3	0	0	0	0	1	0	9	5	2	0	2	0

Appendix A

Depth (ft)	730.8	741.8	762.0	773.0	778.8	785.1	794.4	802.0	805.8	824.3	829.3	834.4	840.6	842.4	857.2	871.8	880.7	884.8	891.7	900.5
CONIFERS																				
Abies	8	12	6	16	22	19	17	7	13	8	15	3	4	15	3	14	10	4	1	10
Cedrus?	0	3	0	1	2	2	0	6	0	4	1	0	0	0	2	0	0	0	0	0
Picea	0	2	1	1	3	2	2	1	2	1	0	0	0	0	0	1	1	0	0	0
Pinus	105	153	152	119	141	133	139	107	112	80	52	42	28	66	45	74	51	66	63	76
Podocarpus?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudotsuga/Larix	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0
Sequoia	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
TCT	59	31	26	46	40	61	45	44	68	59	66	51	66	53	31	50	38	48	21	46
Tsuga heterophylla	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tsuga mertensiana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vesiculate undiff.	5	10	7	2	10	9	11	9	5	11	2	5	1	0	4	7	2	3	4	6
OTHER TREES AND SHRUBS																				
Acer	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alnus	1	0	0	2	1	0	0	1	3	1	1	0	0	0	0	0	1	0	0	0
Betula	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2	0	2	2	1
Carya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Castenopsis?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0
Cercocarpus-type	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
Ephedra trifurca-type	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephedra viridis-type	0	0	1	0	0	0	0	1	0	0	0	0	2	0	3	0	0	0	1	0
Fagus	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraxinus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ilex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juglans/Pterocarya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Quercus	3	0	0	1	0	0	1	0	0	2	2	3	1	1	4	2	3	0	0	0
Rhamnaceae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ribes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salix	1	1	0	0	0	1	0	0	0	0	0	1	4	2	1	1	1	1	0	2
Shepherdia	0	1	0	1	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0
Symphoricarpos/Lonicera	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Ulmus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
ASTERACEAE																				
Ambrosia-type	8	2	6	4	3	4	3	5	3	10	10	6	8	11	16	10	14	20	9	13
Artemisia	64	70	86	76	60	64	47	81	58	53	82	124	92	58	110	67	117	77	109	62
Liguliflorae	1	2	0	0	1	0	0	1	0	0	2	0	0	2	0	1	0	0	0	0
Tubuliflorae	18	18	12	14	8	7	10	13	21	18	21	30	37	29	18	25	21	13	19	20
CHENOPODIINEAE																				
Chenopodiineae undiff.	16	5	6	7	5	4	7	20	19	27	23	16	38	32	30	31	57	35	28	42
Sarcobatus	1	0	2	0	0	1	1	2	3	4	9	10	7	2	6	3	4	5	6	6
HERBS AND FORBS																				
Apiaceae	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	1	0	2	0	1
Arceuthobium	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix A

Depth (ft)	730.8	741.8	762.0	773.0	778.8	785.1	794.4	802.0	805.8	824.3	829.3	834.4	840.6	842.4	857.2	871.8	880.7	884.8	891.7	900.5
Brassicaceae	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
Caryophyllaceae	0	0	3	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0
Eriogonum	0	0	1	0	0	0	0	0	1	0	1	0	0	2	3	1	4	0	5	1
Fabaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0
Gilia-type	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labiatae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Liliaceae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Linum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Onagraceae	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Phlox	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	1	1	0
Poaceae	4	5	3	3	5	4	4	2	0	6	2	1	4	6	4	1	4	8	0	2
Polemonium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polygonaceae	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Polygonum californica-type	0	1	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	2	0
Rosaceae	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	1	0	0	0
Rumex	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thalictrum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valeriana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OTHER																				
Unknown	0	2	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0
Indeterminate	9	15	19	13	15	11	27	17	16	36	26	29	36	28	23	26	34	30	45	31
Terrestrial Pollen Sum	311	334	333	312	319	324	318	322	326	324	319	326	329	311	308	321	368	318	320	319
Tracers	18	21	23	26	12	17	30	24	23	18	14	29	35	2	30	34	22	15	22	6
FERNS, FERN-ALLIES, ETC.																				
Equisetum	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isoetes	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Lycopodium	2	4	2	6	5	4	1	5	1	1	1	1	0	0	0	1	0	4	0	0
Monolete Spores	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0
Osmunda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trilete Spores	0	2	0	1	1	0	0	0	0	0	0	0	1	3	0	0	0	1	0	0
AQUATIC PLANTS																				
Cyperaceae	11	5	4	3	3	6	2	5	4	5	7	3	3	5	0	12	6	5	10	8
Menyanthes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myriophyllum	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nuphar	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Polygonum amphibium-type	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Potamogeton	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sagitarria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Typha latifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Typha/Sparganium	1	0	1	0	0	0	4	0	0	0	0	0	0	2	2	3	1	1	2	1
ALGAE																				
Botryococcus	27	9	5	2	23	1	0	1	0	3	1	1	0	0	0	0	3	11	0	3
Pediastrum	19	0	0	0	0	1	1	0	0	1	1	0	0	3	1	0	0	0	2	3

Appendix A

Depth (ft)	907.5	917.6	925.8	933.0	940.7	950.6	955.3	970.0	977.2	986.9	988.8
CONIFERS											
Abies	4	15	18	7	7	4	0	3	5	7	3
Cedrus?	0	1	1	0	1	4	1	0	0	1	3
Picea	0	1	0	2	2	0	0	2	4	2	5
Pinus	84	103	184	137	136	132	126	99	184	97	155
Podocarpus?	1	0	0	0	0	0	0	0	0	0	1
Pseudotsuga/Larix	0	0	0	0	0	0	0	0	0	0	1
Sequoia	0	0	0	0	0	0	0	0	0	0	0
TCT	36	60	36	36	43	27	26	60	38	75	27
Tsuga heterophylla	0	0	0	0	0	1	0	0	0	0	1
Tsuga mertensiana	0	0	0	0	0	0	0	0	0	0	0
Vesiculate undiff.	1	9	16	15	9	5	3	4	8	9	12
OTHER TREES AND SHRUBS											
Acer	0	0	0	0	0	0	0	1	0	0	0
Alnus	0	0	0	0	0	0	0	0	0	0	0
Betula	0	0	0	0	0	1	0	0	0	0	0
Carya	0	0	0	0	0	0	0	0	0	0	0
Castenopsis?	0	0	0	0	0	0	2	0	0	1	0
Cercocarpus-type	0	0	0	0	0	0	0	0	0	0	0
Ephedra trifurca-type	0	0	0	0	0	0	0	0	1	0	0
Ephedra viridis-type	1	0	0	0	1	1	0	0	0	1	0
Fagus	0	0	0	0	0	0	0	0	0	0	0
Fraxinus	0	0	0	0	0	0	0	0	0	0	0
Ilex	0	0	0	0	0	0	0	0	0	0	1
Juglans/Pterocarya	0	0	0	0	0	0	0	0	0	1	0
Quercus	0	1	0	1	0	0	1	0	1	1	0
Rhamnaceae	0	0	0	0	0	0	0	0	0	0	0
Ribes	0	0	0	0	0	0	0	0	0	0	0
Salix	0	1	1	0	1	0	0	1	0	1	0
Shepherdia	3	0	1	0	0	2	1	1	1	1	1
Symphoricarpos/Lonicera	0	1	0	0	0	0	0	0	0	0	0
Ulmus	0	0	0	0	0	0	1	0	0	0	0
ASTERACEAE											
Ambrosia-type	5	5	4	11	1	5	2	0	0	1	0
Artemisia	123	55	21	51	63	92	96	76	51	60	57
Liguliflorae	0	1	1	0	3	2	0	2	1	1	0
Tubuliflorae	22	14	10	13	13	8	19	18	7	12	16
CHENOPODIINEAE											
Chenopodiineae undiff.	20	19	6	17	4	7	8	5	5	4	7
Sarcobatus	4	2	0	1	2	8	3	0	2	2	2
HERBS AND FORBS											
Apiaceae	0	0	1	0	0	0	1	0	0	0	0
Arceuthobium	0	1	0	0	0	0	0	0	0	0	0

Appendix A

Depth (ft)	907.5	917.6	925.8	933.0	940.7	950.6	955.3	970.0	977.2	986.9	988.8
Brassicaceae	0	0	0	0	0	0	1	0	0	0	0
Caryophyllaceae	0	0	3	1	0	0	0	0	0	0	2
Eriogonum	1	1	0	0	0	0	0	2	0	1	0
Fabaceae	0	0	0	0	0	0	0	0	0	0	0
Gilia-type	0	0	0	0	0	0	0	0	1	0	0
Labiatae	0	0	0	0	0	0	0	0	0	0	0
Liliaceae	0	0	0	0	0	0	0	0	0	0	0
Linum	0	0	0	0	0	0	1	0	0	0	0
Onagraceae	0	0	0	0	0	0	0	0	0	0	0
Phlox	0	1	0	0	0	0	0	0	1	0	0
Poaceae	3	7	5	4	10	0	14	7	7	7	7
Polemonium	0	0	0	0	0	0	0	0	0	0	0
Polygonaceae	0	0	0	0	0	0	0	1	0	0	0
Polygonum californica-type	2	0	0	0	0	0	0	0	0	1	0
Rosaceae	0	2	0	0	0	0	0	0	0	0	0
Rumex	0	0	0	0	0	0	0	0	0	0	0
Thalictrum	0	0	0	0	0	0	0	0	0	0	0
Valeriana	0	0	0	0	0	0	0	0	0	0	0
OTHER											
Unknown	0	0	0	1	0	0	1	0	0	0	0
Indeterminate	24	23	12	13	22	21	18	41	10	33	22
Terrestrial Pollen Sum	334	323	320	310	318	320	325	323	327	319	323
Tracers	37	10	20	31	17	43	5	24	15	6	40
FERNS, FERN-ALLIES, ETC.											
Equisetum	0	0	0	0	0	0	0	0	0	0	0
Isoetes	0	0	0	0	0	0	0	0	0	0	0
Lycopodium	0	1	5	2	7	4	0	0	7	0	2
Monolete Spores	0	0	0	2	0	1	0	0	0	0	0
Osmunda	0	0	0	0	0	0	0	0	0	0	0
Trilete Spores	1	0	1	1	0	0	0	1	0	0	0
AQUATIC PLANTS											
Cyperaceae	3	11	10	4	9	5	16	16	12	14	8
Menyanthes	0	0	0	0	0	0	1	0	0	0	0
Myriophyllum	0	0	0	0	0	0	0	0	0	0	1
Nuphar	0	0	0	0	0	0	0	0	0	0	0
Polygonum amphibium-type	0	0	0	1	0	0	0	0	0	0	0
Potamogeton	1	0	0	0	0	0	0	0	0	0	0
Sagitarria	0	0	0	0	0	0	0	0	0	0	0
Typha latifolia	0	0	0	0	0	0	0	0	0	0	0
Typha/Sparganium	0	1	0	1	0	0	0	2	0	0	0
ALGAE											
Botryococcus	0	3	10	3	1	0	0	0	0	0	0
Pediastrum	0	38	10	2	2	0	0	3	1	1	0