Great Basin Naturalist

Volume 44 | Number 3 Article 3

7-31-1984

Diatoms of the Middle Fork of the Salmon River drainage, with notes on their relative abundance and distribution

C. E. Cushing
Battelle-Pacific Northwest Laboratories, Richland, Washington

S. R. Rushforth
Brigham Young University

DIATOMS OF THE MIDDLE FORK OF THE SALMON RIVER DRAINAGE, WITH NOTES ON THEIR RELATIVE ABUNDANCE AND DISTRIBUTION

C. E. Cushing[1] and S. R. Rushforth[2]

ABSTRACT.— A total of 145 species of diatoms was collected from 13 sites in the Middle Fork of the Salmon River drainage, Idaho, USA. *Achnanthes minutissima* was the prevalent species with an importance index of 19.25. Cluster analysis revealed 2 main site groupings, sites above the entrance of Loon Creek and sites below. The entrance of Loon Creek (6th order) increases the Middle Fork of the Salmon River to a 7th order stream. Shannon-Weiner diversity values were generally high.

We have been characterizing the algal flora of Intermountain western North America for the past several years. At present, we are characterizing the diatom floras of several important stream systems in this area to add information to a general diatom flora of the region (Squires et al. 1973, Lawson and Rushforth 1975, Benson and Rushforth 1975, Clark and Rushforth 1977, Ross and Rushforth 1980, Rushforth et al. 1981a, Johansen and Rushforth 1981, and Cushing et al. 1983). Our studies have also extended to standing waters and other unique environments (e.g., Evenson et al. 1981, Felix and Rushforth 1979, Rushforth et al. 1981b, St. Clair and Rushforth 1976, and others).

The purpose of this paper is to document the species of diatoms in the Middle Fork of the Salmon River in Idaho and several of its important tributaries (Marsh Creek, Indian Creek, East Fork of Indian Creek, Loon Creek, and Big Creek). We also determined distributional patterns within this system and performed several statistical analyses of abundance. Data also are given for one site on the main Salmon River, just below the confluence with the Middle Fork (see Fig. 1 for collection sites).

METHODS

Field

Samples were collected between 23 July and 1 August 1978. Diatom collections were made by brushing rocks with a stiff-bristle brush and collecting the algae in plastic bags. All samples were sent to the Philadelphia Academy of Natural Sciences for identification and enumeration. At the academy permanent slides were prepared and 1000 valves were randomly identified and enumerated from each site.

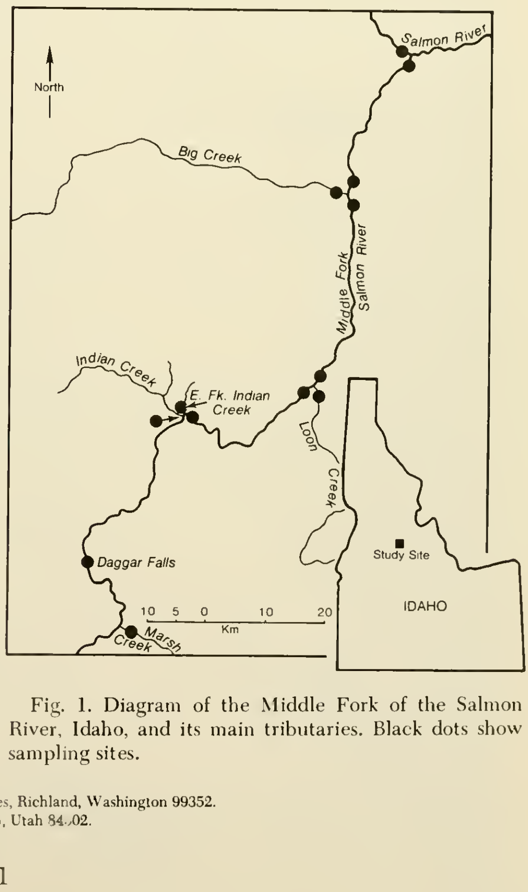

Fig. 1. Diagram of the Middle Fork of the Salmon River, Idaho, and its main tributaries. Black dots show sampling sites.

[1]Environmental Sciences Department, Battelle-Pacific Northwest Laboratories, Richland, Washington 99352.
[2]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

These data were collected as part of a more extensive sampling regime intended to evaluate the influence of tributaries on certain ecological variables and predictions of the River Continuum Concept (Vannote et al. 1980). For a more complete description of the sampling sites and other data from these studies, see Bruns et al. (1982), Cushing et al. (1983), and Bruns et al. (1984).

Statistical Analyses

An "important species" index for diatom species encountered was calculated by multiplying the percent of a taxon in all samples (frequency of occurrence) by its average percent relative density in all samples (Ross and Rushforth 1980). This method is often used in studies of terrestrial vegetation (Warner and Harper 1972) and is advantageous since it considers both the frequency of occurrence of a species together with its percent relative density in each sample.

Similarity indices between the 13 samples collected were calculated following the methods of Ruzicka (1958). Calculated similarity indices were then clustered following Sneath and Sokal (1973) to examine if patterns of diatom distribution were evident. Diatom community diversity was measured for each sample using the Shannon-Wiener diversity index (Shannon and Weaver 1949, Patten 1962).

Results and Discussion

There were 145 species of diatoms identified from these samples (Table 1). Cushing et

TABLE 1. Diatom distribution and percent relative abundance in the Middle Fork of the Salmon River, Idaho, drainage.

Species	Location[a]												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Achnanthes austriaca v. *helvetica* Hust.	–[b]	0.2	–	–	–	–	–	–	–	–	–	0.1	0.4
A. biporoma Hohn & Hellerm.	–	0.1	–	–	–	0.2	–	0.2	0.1	0.1	–	0.2	0.7
A. detha Hohn & Hellerm.	0.1	1.1	–	0.1	–	0.3	–	–	0.5	0.3	–	1.0	–
A. didyma Hust.	–	–	–	–	–	–	–	0.1	–	–	–	–	–
A. exigua v. *heterovalva* Krasske	–	0.2	–	0.1	–	–	–	0.1	0.2	0.2	–	0.1	–
A. lanceolata (Bréb.) Grun.	5.6	3.3	18.1	5.5	3.1	5.1	0.7	1.3	14.7	3.1	0.4	3.8	0.5
A. lanceolata v. *dubia* Grun.	0.1	0.2	–	0.3	0.2	0.4	–	–	–	0.3	–	0.6	–
A. laterostrata Hust.	–	0.7	–	–	–	0.2	–	–	–	0.1	–	0.3	–
A. lewisiana Patr.	–	0.6	–	–	0.5	1.6	–	0.1	0.3	0.8	–	1.7	0.1
A. linearis (W. Sm.) Grun.	–	–	–	–	–	–	–	–	–	–	–	–	0.2
A. linearis v. *pusilla* Grun.	–	0.1	–	–	–	–	–	–	–	1.7	0.2	0.1	0.3
A. marginulata Grun.	0.1	0.1	–	–	–	–	–	–	0.4	–	–	–	0.1
A. minutissima Kütz.	31.5	11.5	5.2	41.2	9.6	29.2	0.5	20.4	27.1	62.6	14.9	16.2	16.3
A. peragalli Brun & Herib.	–	0.3	–	–	–	–	–	0.1	–	0.1	–	–	–
A. peragalli v. *parvula* (Patr.) Reim.	–	0.2	–	–	–	–	–	–	–	–	–	–	–
A. pinnata Hust.	–	–	–	–	–	–	–	0.1	–	–	0.1	–	0.1
Amphora ovalis v. *pediculus* (Kütz.) V.H. ex DeT.	0.5	0.6	–	0.2	0.1	–	–	0.2	–	0.2	0.4	–	–
A. perpusilla (Grun.) Grun.	0.3	0.2	–	0.3	0.2	0.7	0.1	0.4	0.1	–	1.0	0.1	0.1
Caloneis bacillum (Grun.) Cl.	–	–	–	–	–	–	–	–	–	–	–	–	0.1
Cocconeis diminuta Pant.	0.1	–	–	–	–	–	–	–	–	–	–	–	–
C. pediculus Ehr.	0.1	–	–	–	–	–	–	0.1	–	–	0.5	–	–
C. placentula Ehr.	–	–	0.2	0.2	0.1	0.1	–	–	–	–	–	–	–
C. placentula v. *euglypta* (Ehr.) Cl.	4.5	4.7	6.5	1.6	5.0	12.2	2.2	8.3	2.8	3.2	2.8	2.1	0.1
C. placentula v. *lineata* (Ehr.) V.H.	2.3	7.6	16.0	0.7	9.5	3.0	1.4	2.2	1.7	1.4	0.2	1.8	0.7
C. thumensis A. Mayer	–	–	–	–	–	0.1	–	–	–	–	–	–	–
Cyclotella meneghiniana Kütz.	–	–	–	–	–	–	–	–	–	–	–	0.1	–
Cymbella affinis Kütz.	–	0.1	–	–	0.1	–	–	–	0.2	0.1	5.9	–	0.2
C. brehmii Hust.	–	–	–	–	–	–	–	7.6	0.1	0.1	0.2	–	–

[a]1–Indian Creek
2–Middle Fork below Indian Creek
3–East Fork, Indian Creek
4–Loon Creek
5–Middle Fork above Loon Creek
6–Middle Fork below Loon Creek
7–Big Creek
8–Middle Fork above Big Creek
9–Middle Fork below Big Creek
10–Middle Fork above Salmon River
11–Salmon River below Middle Fork, Salmon River
12–Middle Fork at Daggar Falls
13–Marsh Creek

[b]Blank denotes absence

Table 1 continued.

Species	Location[a]												
	1	2	3	4	5	6	7	8	9	10	11	12	13
C. cymbiformis (Ag.) Ag.	2.3	–	0.1	0.7	–	–	–	0.5	0.5	0.3	–	0.1	0.1
C. microcephala Grun.	–	–	–	–	–	0.2	–	0.4	0.2	0.1	–	–	0.1
C. minuta Hilse ex Rabh.	2.8	2.2	2.8	3.1	0.6	3.0	0.2	1.2	1.5	2.3	0.7	1.1	5.1
C. minuta v. *latens* (Krasske) Reim.	–	0.2	–	–	–	–	–	–	–	0.1	–	0.2	0.8
C. minuta v. *silesiaca* (Bleisch ex Rabh.) Reim.	0.5	0.7	1.2	0.4	0.4	0.2	0.1	0.3	0.2	0.7	–	0.4	2.0
C. minuta muelleri Hust.	1.3	0.9	0.1	0.1	0.5	0.3	–	0.3	0.1	0.1	–	0.2	0.1
C. naviculiformis Auersw. ex Heib.	–	–	–	–	–	–	–	–	–	–	–	–	0.1
C. prostrata (Berk.) Cl.	–	–	–	–	–	–	–	–	–	0.1	–	–	–
C. sinuata Greg	2.0	1.5	0.2	3.0	0.3	1.6	0.1	0.8	1.6	2.2	0.8	1.2	0.5
Denticula elegans Kütz.	0.1	–	–	0.1	–	–	–	–	–	–	–	–	0.2
Diatoma tenue Ag.	–	–	–	0.3	–	–	–	–	–	–	–	–	0.1
D. vulgare Bory	–	–	–	1.2	–	–	–	0.3	–	0.5	1.2	0.1	0.1
D. vulgare v. *breve* Grun.	0.6	1.2	0.4	0.4	0.4	0.1	–	0.2	0.6	0.5	–	0.7	0.8
Diatomella balfouriana Grev.	–	–	–	–	–	–	–	–	0.1	–	–	–	0.1
Didymosphenia geminata (Lyngb.) M. Schmidt	–	–	–	–	–	–	–	–	–	–	–	–	0.1
Epithemia adnata (Kütz.) Breb.	0.4	0.4	–	–	1.5	–	–	7.9	0.1	0.3	–	0.3	–
E. sorex (Kütz.)	–	0.2	–	0.1	1.1	0.3	–	5.7	1.3	2.6	2.9	–	–
E. turgida (Ehr.) Kütz.	–	1.7	–	–	2.9	1.7	0.4	6.8	0.6	0.6	0.1	2.3	–
Eunotia pectinalis v. *minor* (Kütz.) Rabh.	0.1	–	–	–	–	–	–	–	–	–	–	0.1	–
E. rabenhorstii v. *monodon* Grun.	–	–	–	–	–	–	–	–	–	0.1	–	–	–
E. tenella (Grun.) Cl.	–	0.1	–	–	–	–	–	–	–	–	–	0.2	–
E. tridentula Ehr.	–	–	–	–	–	–	–	–	–	–	–	–	0.1
Fragilaria brevistriata Grun.	–	–	–	–	–	0.1	–	0.1	0.1	–	–	0.2	–
F. construens v. *exigua* (W. Sm.) Schulz	–	–	–	–	–	–	–	–	–	–	–	–	0.2
F. construens v. *pumila* Grun.	0.4	8.7	–	0.7	4.0	1.1	0.1	1.3	2.9	2.8	0.6	2.9	3.4
F. construens v. *subsalina* Hust.	–	2.7	–	–	0.3	0.5	–	–	0.8	1.1	–	2.1	1.3
F. construens v. *venter* (Ehr.) Grun.	–	0.4	–	–	–	–	–	–	0.5	0.2	–	0.7	0.1
F. intermedia Grun.	–	–	–	–	–	–	–	–	–	–	–	–	0.2
F. leptostauron (Ehr.) Hust.	0.1	1.2	0.1	0.3	0.6	0.5	–	0.8	0.2	0.7	0.5	0.7	1.2
F. pinnata Ehr.	1.7	10.5	–	0.8	6.1	3.8	0.7	1.6	4.2	3.8	1.9	10.2	7.2
F. pinnata v. *lancettula* (Schum.) Hust.	0.2	0.5	–	0.1	–	0.4	–	–	–	–	–	0.2	0.3
F. vaucheriae (Kütz.) Peters.	5.5	6.8	31.8	8.0	5.5	3.3	1.0	1.2	5.3	4.8	15.6	5.3	7.2
Gomphoneis eriense (Grun.) Skv. & Meyer	0.2	–	0.4	1.7	0.1	–	0.1	–	1.4	3.3	0.2	0.1	–
G. herculeana (Ehr.) Cl.	0.4	0.2	–	1.9	–	–	0.4	–	0.5	0.8	–	–	0.1
G. herculeana v. *robusta* (Grun.) Cl.	0.2	–	–	0.5	–	–	–	–	–	0.1	0.2	–	–
Gomphonema angustatum (Kütz.) Rabh.	–	–	0.4	–	–	–	–	–	–	–	–	0.2	0.1
G. brasiliensis Grun	0.2	0.9	–	0.3	–	1.9	–	2.7	0.1	0.1	–	0.4	–
G. clevei Fricke	4.2	4.6	4.1	3.1	4.2	4.6	0.7	3.2	2.8	2.7	6.1	5.4	1.7
G. intricatum Kütz.	0.3	4.5	1.9	0.2	0.8	5.0	1.0	2.9	1.1	1.2	3.5	1.8	0.4
G. olivaceum (Lyngb.) Kütz.	–	0.1	–	4.4	0.1	0.1	0.2	–	0.2	0.1	–	–	–
G. olivaceoides Hust	0.6	0.7	0.4	6.2	–	1.2	–	0.3	0.6	1.4	0.8	0.4	0.4
G. parvulum (Kütz.) Kütz.	0.5	–	0.9	0.3	–	0.1	–	0.1	–	0.1	0.1	0.1	–
G. subclavatum (Grun.) Grun.	0.1	0.1	0.2	0.5	–	0.5	–	0.3	–	0.2	–	–	0.1
Hannaea arcus (Ehr.) Patr.	3.1	0.3	1.0	5.9	0.4	0.6	0.1	0.4	0.7	0.6	0.3	2.5	4.3
Hantzschia amphioxys (Ehr.) Grun.	–	–	–	–	–	–	–	0.1	0.6	–	–	–	–
Melosira distans v. *alpigena* Grun.	–	0.6	–	–	–	0.2	–	–	0.1	–	–	0.4	3.4
M. italica (Ehr.) Kütz.	–	0.3	–	–	0.2	–	–	0.6	0.1	–	–	0.2	0.6
M. italica v. *tenuissima* (Grun.) O. Müll.	0.4	2.6	–	–	0.8	–	–	–	0.3	0.3	–	1.9	1.2
M. varians C. A. Ag.	–	–	–	–	–	0.1	–	–	–	–	–	–	–
Meridion circulare (Greg.) Ag.	0.4	0.1	0.3	–	–	–	–	0.1	0.1	–	–	0.3	0.3
Navicula anglica Ralfs	–	–	–	–	–	–	–	–	–	–	–	0.1	–
N. arvensis Hust.	0.2	–	–	–	–	–	–	0.1	–	–	–	–	–
N. bryophila Peters.	–	–	0.1	–	–	–	–	2.2	–	0.3	–	–	–
N. cincta (Ehr.) Ralfs	0.1	–	0.3	0.3	0.1	0.2	–	0.4	0.2	0.2	–	0.1	–
N. cocconeiformis Greg. ex Grev.	–	–	–	–	–	–	–	–	–	–	–	0.1	–
N. convergens Patr.	–	–	–	–	–	–	–	–	–	–	–	0.1	–
N. contenta v. *biceps* (Arn.) V. H.	–	–	–	–	–	0.1	–	–	0.1	–	–	–	–
N. cryptocephala Kütz.	–	–	–	–	–	0.1	–	–	–	0.4	–	0.2	0.1

Table 1 continued.

Species	Location[a]												
	1	2	3	4	5	6	7	8	9	10	11	12	13
N. cryptocephala v. *veneta* (Kütz.) Rabh.	1.2	0.6	2.6	0.2	1.0	1.9	0.2	2.0	0.7	0.2	2.7	0.7	0.1
N. digna Hust.	0.1	–	–	–	–	–	–	–	–	–	–	0.1	–
N. indifferens Hust.	0.2	–	–	–	–	–	–	–	–	–	–	0.1	–
N. mediopunctata Hust.	–	–	–	–	–	–	–	–	–	0.1	–	–	–
N. menisculus Schum.	0.5	–	0.1	0.1	0.1	–	0.2	0.2	0.3	–	0.1	0.1	–
N. minima Grun.	0.8	2.5	0.3	–	0.4	0.7	–	0.1	0.5	0.7	–	1.8	0.6
N. minuscula Grun.	–	–	–	–	–	0.2	–	0.1	–	–	–	–	–
N. mutica Kütz.	–	–	–	–	–	–	–	–	–	0.1	–	–	–
N. mutica v. *cohnii* (Hilse) Grun.	–	–	–	–	–	–	–	1.1	1.6	0.3	–	–	–
N. mutica v. *undulata* (Hilse) Grun.	–	–	–	–	–	–	–	0.2	–	–	–	–	–
N. ochridana Hust.	–	–	–	–	–	–	–	0.1	0.1	0.4	–	0.4	–
N. pelliculosa (Breb. ex Kütz.) Hilse	0.2	–	–	–	–	–	–	–	–	–	–	–	–
N. pseudoscutiformis Hust.	–	0.1	–	–	–	–	–	–	–	0.1	–	–	0.1
N. pupula Kütz.	–	–	–	–	–	–	–	–	–	0.1	0.2	–	–
N. pupula v. *capitata* Skv. & Meyer	–	–	–	–	–	–	–	–	–	–	–	0.1	–
N. pupula v. *rectangularis* (Greg.) Grun.	–	0.5	–	–	–	–	–	–	–	–	–	–	–
N. radiosa Kütz.	–	0.1	–	–	–	0.1	–	–	–	–	–	0.1	–
N. radiosa v. *tenella* (Breb. ex Kütz.) Grun.	0.3	0.2	0.2	0.4	0.1	0.9	–	0.6	0.2	1.0	1.7	0.4	–
N. rhynchocephala Kütz.	–	–	–	–	–	–	–	–	–	–	–	0.1	–
N. salinarum v. *intermedia* (Grun.) Cl.	0.4	–	–	–	0.1	–	–	–	–	0.3	0.1	–	–
N. schoenfeldii Hust.	0.3	0.2	–	–	0.1	0.1	–	0.3	0.1	–	0.1	0.4	–
N. secreta v. *apiculata* Patr.	0.2	0.1	–	–	–	–	–	–	–	–	0.1	–	–
N. seminulum Grun.	11.7	0.6	0.2	0.1	29.5	0.3	87.0	0.1	2.5	3.9	1.0	0.4	–
N. tantula Hust.	0.1	–	–	0.1	–	–	–	0.2	–	–	–	0.3	0.1
N. tripunctata (O.F. Müll.) Bory	–	–	0.1	0.1	0.2	0.9	–	0.9	0.1	0.4	0.1	–	–
N. viridula (Kütz.) emend V.H.	–	–	–	–	–	0.1	–	–	–	–	0.1	–	–
Nitzschia angusta (W.Sm.) Grun.	–	–	–	–	0.1	–	–	–	–	–	–	–	0.2
N. amphibia Grun.	–	0.1	–	–	–	–	–	–	0.1	0.1	–	0.2	–
N. bicata Hust.	0.2	0.1	–	0.1	–	–	–	0.1	–	–	–	–	0.2
N. confinis Hust.	0.3	–	–	–	–	–	–	–	–	–	–	–	–
N. dissipata (Kütz.) Grun.	–	0.3	–	–	0.2	–	–	0.1	0.2	0.4	1.0	0.1	–
N. dissipata v. *media* Hantz.	1.4	–	0.3	0.9	0.7	1.0	–	–	0.2	0.3	1.3	–	0.3
N. fonticola Grun.	0.1	–	–	–	–	–	–	0.1	0.1	0.4	–	–	0.2
N. frustulum Kütz.) Rabh.	0.4	0.7	0.7	0.5	0.3	0.6	0.1	1.0	1.8	0.7	1.2	1.3	0.1
N. frustulum v. *perminuta* Grun.	1.0	2.2	0.4	1.3	1.5	1.9	0.1	3.5	2.9	5.3	1.6	5.0	1.1
N. frustulum v. *subsalina* Hust.	0.2	0.1	–	–	–	0.1	–	–	–	0.1	–	0.1	–
N. gracilis Hantz.	–	–	–	–	–	0.1	–	–	–	–	–	–	–
N. kuetzingiana Hilse	0.3	–	–	0.1	–	–	–	–	–	0.1	3.7	0.8	0.2
N. recta Hantz.	0.1	–	–	–	–	0.1	–	–	–	–	–	–	–
N. romana Grun.	1.9	0.2	–	0.2	–	0.5	0.2	0.5	0.5	0.4	0.2	0.5	0.4
N. tropica Hust.	–	–	0.2	–	–	–	–	–	–	0.1	–	0.1	–
Pinnularia biceps Greg.	–	–	–	–	0.1	–	–	–	–	–	–	–	–
P. borealis Ehr.	–	–	–	–	–	–	–	0.3	1.3	0.2	0.1	0.1	0.1
P. mesolepta (Ehr.) W. Sm.	–	–	–	–	–	–	–	–	–	0.1	–	–	–
P. obscura Krasske	–	–	–	–	–	–	–	0.1	–	–	–	–	–
P. subcapitata Greg.	0.1	–	–	–	–	–	–	–	–	–	–	–	–
Rhoicosphenia curvata (Kütz.) Grun. ex Tabh.	0.8	0.1	1.3	0.6	0.5	3.6	0.1	3.0	0.7	0.2	17.1	0.1	0.1
Rhopalodia gibba (Ehr.) O. Müll.	–	0.1	–	–	–	–	–	–	–	–	–	–	–
R. gibberula (Ehr.) O. Müll.	–	–	–	–	–	–	–	0.1	0.1	–	–	0.1	–
Stauroneis anceps Ehr.	–	0.1	–	–	–	–	–	–	–	–	–	–	–
S. kriegeri Patr.	0.1	–	–	–	–	–	–	–	–	–	–	–	–
Synedra mazamaensis Sov.	0.2	1.4	–	–	–	0.4	0.9	0.2	1.4	2.9	3.5	0.2	–
S. minuscula Grun.	–	0.9	0.2	–	0.1	0.2	–	0.2	0.5	0.3	0.2	2.6	17.6
S. rumpens Kütz.	1.0	0.5	–	0.1	0.4	0.6	0.1	–	0.6	0.5	0.1	2.1	1.7
S. rumpens v. *familiaris* (Kütz.) Hust.	–	0.3	–	–	–	–	–	–	–	0.1	–	–	0.2
S. rumpens v. *fragilarioides* Grun.	–	–	–	–	–	–	–	0.1	–	–	–	–	–
S. rumpens v. *meneghiniana* Grun.	0.4	–	0.7	–	0.1	–	–	–	0.2	0.3	–	–	0.5
S. ulna (Nitz.) Ehr.	1.4	1.3	–	0.4	5.2	0.5	1.1	0.8	5.4	4.1	1.6	10.1	12.1
Tabellaria flocculosa (Roth) Kütz.	–	–	–	–	–	0.1	–	–	–	–	–	–	0.1

al. (1983) reviewed the general distribution of the dominant species and stated that the Middle Fork system is characterized by an *Achnanthes minutissima* Kütz.–*Fragilaria pinnata* Ehr.–*Navicula seminulum* Grun.–*Cocconeis placentula* Ehr. species complex. Their analysis did not include the samples from the East Fork of Indian Creek, nor were statistical methods used. Both have been included in the present analysis and alter the dominant species complex somewhat. *Achnanthes minutissima* (importance value = 19.25) is the prevalent diatom throughout the system in terms of both occurrence and numbers. *Navicula seminulum* (9.75), *Fragilaria vaucheriae* (Kütz.) Peters (7.79), *Achnanthes lanceolata* (Bréb.) Grun. (5.02), *Cocconeis placentula* var. *euglypta* (Ehr.) Cl. (4.31), *Cocconeis placentula* var. *lineata* (Ehr.) V.H. (3.73), *Fragilaria pinnata* (3.73), *Gomphonema clevei* Fricke (3.65), and *Synedra ulna* (Nitz.) Ehr. (3.14) are the other dominant taxa in the Middle Fork system (Table 2). Although *Navicula seminulum* is found throughout the Middle Fork system, its relatively high importance value is related to its high abundance in Big Creek; this occurrence is also reflected in the Shannon-Weiner value of 1.1 at this site (Table 3). The above taxa are common components of stream systems both in Europe (Johansson 1980, Kaweka 1981) and North America (Lawson and Rushforth 1975, Ross and Rushforth 1980).

Table 2. Importance values (percent presence x average frequency) of the dominant diatom species collected from the Middle Fork of the Salmon River drainage, Idaho.

Achnanthes minutissima	19.25
Navicula seminulum	9.75
Fragilaria vaucheriae	7.79
Achnanthes lanceolata	5.02
Cocconeis placentula var. *euglypta*	4.31
Cocconeis placentula var. *lineata*	3.73
Fragilaria pinnata	3.73
Gomphonema clevei	3.65
Synedra ulna	3.14
Rhoicosphenia curvata	2.17
Nitzschia frustulum var. *perminuta*	2.14
Fragilaria construens var. *pumila*	2.05
Cymbella minuta	2.05
Gomphonema intricatum	1.89
Hannaea arcus	1.55
Synedra minuscula	1.35
Cymbella sinuata	1.22
Navicula cryptocephala var. *veneta*	1.08
Epithemia turgida	0.91
Gomphoneis herculeana var. *robusta*	0.85
Nitzschia frustulum	0.72
Epithemia sorex	0.67
Synedra mazamaensis	0.59
Cymbella minuta var. *silesiaca*	0.50
Synedra rumpens	0.50

Our cluster analysis produced two groups of sample locations (Fig. 2). Although the clustering was not tight, a general pattern was evident. The first group of sites (Middle Fork below Big Creek, Middle Fork above Salmon River, Middle Fork below Loon Creek, Indian Creek, Loon Creek, and Middle Fork above Big Creek), with the exception of Indian Creek, essentially make up the lower sections of the Middle Fork drainage below Loon Creek. The second group (Middle Fork below Indian Creek, Middle Fork at Daggar Falls, Marsh Creek, and Middle Fork above Loon Creek) constitutes the upper drainage basin section above Loon Creek. It is perhaps significant that the Middle Fork of the Salmon changes from 6th to 7th order where it receives 6th order Loon Creek. This results in a 33% increase in flow volume (J. T. Brock, pers. comm.) and a coincident increase in mean depth since the channel width does not change markedly at this location. Similarly, Bruns et al. (1982) reported that the largest portion of ecological change in the Middle Fork drainage system occurred upstream of the entrance of Loon Creek, and only slight changes occurred below. Bruns et al. (1982) were using link analysis, rather than stream order, and the site at Loon Creek was at link magnitude 1000. The final three sites were atypical of the rest and clustered with them at low values. These sites

Table 3. Shannon-Wiener diversity index values for 13 sites on the Middle Fork of the Salmon River drainage, Idaho.

Site	Diversity
Marsh Creek	4.2
Middle Fork at Daggar Falls	4.8
Indian Creek	4.2
Middle Fork below Indian Creek	4.8
East Fork, Indian Creek	3.3
Loon Creek	3.6
Middle Fork above Loon Creek	3.9
Middle Fork below Loon Creek	4.3
Big Creek	1.1
Middle Fork above Big Creek	4.6
Middle Fork below Big Creek	4.3
Middle Fork above Salmon River	4.7
Salmon River below Middle Fork, Salmon River	4.2

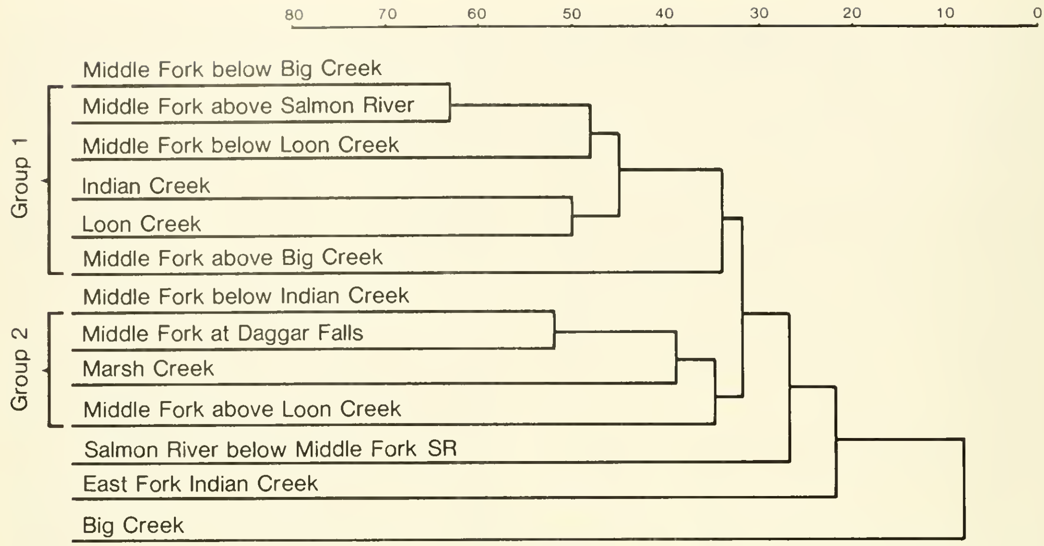

Fig. 2. Dendrogram showing results of cluster analysis of 13 sites on the Middle Fork of the Salmon River, Idaho, and its tributaries.

included the main Salmon River below the Middle Fork, the East Fork of Indian Creek, which is a small, heavily shaded 3rd order site, and Big Creek, which had high detritus standing crops (G. W. Minshall, pers. comm.) and low species diversity.

Calculated Shannon-Weiner diversity values are generaly quite high (Table 3). All values exceeded 3.3 with the exceptions of the East Fork of Indian Creek and Big Creek. Highest diversities were found in the Middle Fork below Indian Creek (4.8), in the Middle Fork at Daggar Falls (4.8), and at the mouth of the Middle Fork (4.7). No general pattern was evident in these data, with high and low values generally distributed throughout the system.

This study has presented data on the dominant diatoms in the Middle Fork of the Salmon River system. Future floristic and ecological studies in this region should enhance our initial species list and will further contribute knowledge of the diatoms of western North America.

Acknowledgments

We thank D. A. Andrews, J. T. Brock, D. A. Bruns, D. H. Funk, and T. F. Cuffney for their field assistance; C. W. Reimer and N. Roberts of the Academy of Natural Sciences, Philadelphia, for identifying and counting the diatoms; and K. W. Cummins, G. W. Minshall, R. L. Vannote, and J. B. Wallace for discussions and help in the field. This is contribution No. 25 from the River Continuum Studies, and was done under National Science Foundation Grant DEB-7811671 from the Ecosystems Analysis Program.

Literature Cited

Benson, C. E., and S. R. Rushforth. 1975. The algal flora of Huntington Canyon, Utah, USA. Bibliotheca Phycologica 18:1–177.

Bruns, D. A., G. W. Minshall, J. T. Brock, C. E. Cushing, K. W. Cummins, and R. L. Vannote. 1982. Ordination of functional groups and organic matter parameters from the Middle Fork of the Salmon River, Idaho. Freshw. Invertebr. Biol. 1(3):2–12.

Bruns, D. A., G. W. Minshall, C. E. Cushing, K. W. Cummins, J. T. Brock, and R. L. Vannote. 1984. Tributaries as modifiers of the river continuum concept: analysis by polar ordination and regression models. Arch. Hydrobiol. 99:208–220.

Clark, R. L., and S. R. Rushforth. 1977. Diatom phytoplankton and periphyton studies of the headwaters of Henry's Fork of the Snake River, Island Park, Idaho, USA. Bibliotheca Phycologica 33:1–204.

Cushing, C. E., K. W. Cummins, G. W. Minshall, and R. L. Vannote. 1983. Periphyton, chlorophyll *a*, and diatoms of the Middle Fork of the Salmon River. Holarc. Ecol. 6:221–227.

Evenson, W. E., S. R. Rushforth, J. D. Brotherson, and N. Fungladda. 1981. The effects of selected physical and chemical factors on attached diatom populations in the Uintah Basin of Utah, USA. Hydrobiologia 83:325–330.

Felix, E. A., and S. R. Rushforth. 1979. The algal flora of the Great Salt Lake, Utah, USA. Nova Hedwigia 31:163–195.

Johansen, J. R., and S. R. Rushforth. 1981. Algae of surface waters and soils of the federal oil shale lease areas of eastern Utah. Nova Hedwigia 34:333–390.

Johansson, C. 1980. Attached algal vegetation in two stony streams in NW Jamtland, Sweden. Ecology, volume and primary production. Medd. Vaxtbiol. inst., Uppsala 1, 15 pp. + append.

Kawecka, B. 1981. Sessile algae in European mountain streams. 2. Taxonomy and autecology. Acta. Hydrobiol. 23:17–46.

Lawson, L. L., and S. R. Rushforth. 1975. The diatoms of the Provo River, Utah. Bibliotheca Phycologica 17:1–149.

Patten, B. C. 1962. Species diversity in net phytoplankton of Raritan Bay. J. Marine Res. 20:57–75.

Ross, L. E., and S. R. Rushforth. 1980. The effects of a new reservoir on the attached diatom communities in Huntington Creek, Utah. Hydrobiologia 68:157–165.

Rushforth, S. R., J. D. Brotherson, N. Fungladda, and W. E. Evenson. 1981a. The effects of dissolved heavy metals on attached diatoms in the Uintah Basin of Utah, USA. Hydrobiologia 83:313–323.

Rushforth, S. R., L. L. St. Clair, J. Grimes, and M. C. Whiting. 1981b. The phytoplankton of Utah Lake. Great Basin Nat. Mem. 5:85–100.

Ruzicka, M. 1958. Anwendung mathematisch-statistischer Methoden in der Geobotanik (Synthetische Bearbeitung von Aufnahmen). Biologia, Batisl. 13:647–661.

Shannon, C. E., and W. Weaver. 1949. The mathematical theory of communication. Univ. of Illinois Press, Urbana. 117 pp.

Sneath, P H. A., and R. R. Sokal. 1973. Numerical taxonomy. W. H. Freeman and Co., San Francisco. 573 pp.

Squires, L. E., S. R. Rushforth, and C. J. Endsley. 1973. An ecological survey of the algae of Huntington Canyon, Utah. BYU Sci. Bull., Biol. Ser. 18(2):1–87.

St. Clair, L. L., and S. R. Rushforth. 1976. The diatom flora of Timpanogos Cave National Monument, Utah. Amer. J. Bot. 63:49–59.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. 1980. The River Continuum Concept. Can. J. Fish. Aquat. Sci. 37:130–137.

Warner, J. H., and K. T. Harper. 1972. Understory characteristics related to site quality for aspen in Utah. BYU Sci. Bull., Biol. Ser. 16(2):1–20.