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Seasonal Composition of Benthic Diatom Associations in the Cedar River Basin (Iowa)

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This is the first detailed report on the taxonomy and ecology of diatoms in the portion of the upper reaches of the Cedar River basin in Iowa. This paper describes the diatom taxa from shallow benthic substrata collected quarterly between 11 October 1975 and 19 February 1977 at 14 sampling stations. Just over 500 frustules were counted from each of the 216 samples obtained. Analysis of water samples collected at the same time as the diatoms indicates these streams have alkaline hard waters rich in nutrients with extreme turbidity level fluctuation at irregular intervals.

The 281 diatom taxa identified represented 34 genera, the most diverse being *Navicula, Nitzschia, Gomphonema,* and *Fragilaria* (including *Synedra*). Over 10% of all diatoms counted were *Cyclotella meneghiniana*. Other diatoms most often reported as "plankton" but found in this study at greater than 4% total abundance in the haptobenthos included *Stephanodiscus parvus, S. hantzschii* var. *tenuis, Nitzschia acicularis,* and *Cyclotella atomus*. *Diatoma vulgare* was the only nonmotile pennate so abundant. Thirty-four taxa not previously reported from Iowa were found.

The Cedar River and its tributaries have regular seasonal changes in water conditions plus irregular fluctuations reflecting flood effects from storm events or from spring melting. The benthic diatoms respond to these changes in ways similar to diatoms in streams with more predictable disturbance regimes. However regular patterns in distribution and abundance of attached and motile diatoms are unlikely. The data presented strongly suggests that irregular erosion of diatom films and subsequent deposition of upstream benthic and planktonic diatoms along with silt determines the composition of the diatom portion of benthic communities as much as does seasonal succession or substrate affinity.

INDEX DESCRIPTORS: benthic diatoms, epiphyton, epipelon, epilithon, plankton, streams, Iowa

Diatoms colonize most submerged surfaces in aquatic ecosystems. In all but the slowest flowing stretches of streams and rivers benthic diatoms generally form more varied and abundant populations than do planktonic diatoms (Round 1973). Diatoms are often the most important algae in the microorganism community forming the biological film on benthic substrata (Pryfogle and Lowe 1979). The benthic diatom flora of a stream varies with temperature, current, light, turbidity, nutrients, dissolved oxygen, pH, alkalinity, substratum, grazing, and the available species pool (Patrick 1977; Douglas 1958).

The taxonomic composition and relative abundance of diatoms in benthic habitats provide a useful and widely employed means of monitoring the quality of water in the passing stream and also indicate the condition of the base of the food chain. However no widely accepted principle permits applying such information about diatoms or any other group of aquatic organisms to definitive statements about water quality (Wetzel 1983).

The diatom flora of several Iowa streams have been investigated by Dodd and his associates (Dodd 1971, Lowe 1972, Drum 1981) and by other researchers (Edwards and Christensen 1972, Edwards 1974, Van Steenburg et al 1984). However the diatom flora of the Cedar River Basin remains incompletely described (Main 1977). This study was initiated to survey the diatom flora of the Cedar River and its tributaries in northern Iowa. A sampling program was developed to provide relative abundances of collections from all available substrata during each season of the year for several years.

This paper reports the seasonal changes in benthic diatom taxa in the upper Cedar River basin between autumn 1975 and winter 1977.

METHODS AND MATERIALS

The portion of the Cedar River basin included in this study drains 13,280 square kilometers in NE Iowa (Fig. 1). The headwaters of the Cedar River and of its tributaries, the Little Cedar River, the Shell Rock River, and the Winnebago River lie in southern Minnesota, while the West Fork lies entirely within Iowa. The geologic terrain consists of limestone and dolomite bedrock (Devonian) overlain by increasingly thicker glacial till to the west and by increasing thicknesses of alluvial sand and gravel to the south with some loess deposits. The streams to the northwest flow through interlayered limestone and shale.

Cities along these rivers began using modern sewage treatment facilities about 10-20 years ago, and so most pollution during the

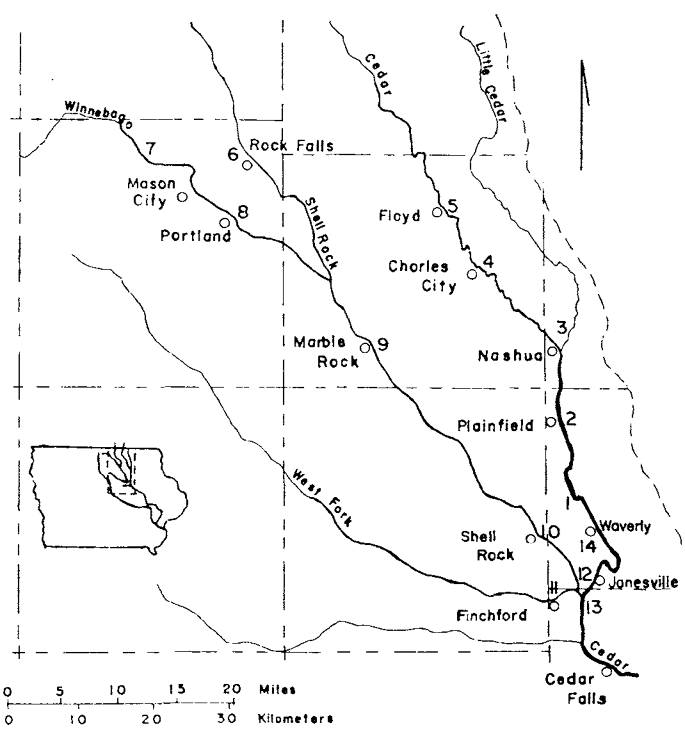

Fig. 1. Location of sampling stations within the Cedar River basin in northern Iowa.

period of study came from non-point sources, probably agricultural. Toxic waste dumps at Charles City have been leaching some arsenic into the Cedar River (ca. 5-20 ppb/day) along with a variety of hydrocarbons in smaller quantities.

Samples were collected at 14 stations during a one day collecting trip conducted four times a year in October, February, May, and August. These stations were located on the upper Cedar River and its tributaries in north central Iowa (see Table 1 for locations). At each station as many different substrata were sampled as were available. Occasionally duplicate samples of similar substrata were collected for comparison. Samples from bottom sediments, submerged rocks, woody material or ice were collected by suction using a large pipette with a rubber bulb. Epiphytic samples were collected by hand. All samples were stored in small vials, kept under refrigeration in the lab until live observations were completed and then either cleaned or preserved in 5% formalin. Since the first collections took one month before live observations were completed, subsequent collections were preserved in 5% formalin if not cleaned within one week after collection. Microscopic examination of the collections was made to obtain a rough estimate of the proportion of living cells and to note the presence of other microorganisms. The diatoms were then cleaned by boiling in nitric acid. Rinsed diatom suspensions were mounted in Hyrax; unmounted portions of the samples were preserved in formalin and stored in sealed vials. The slides used for counting and the unmounted samples are retained in the author's personal herbarium. Duplicate sets of slides are being placed in the Diatom Herbarium at the Iowa Lakeside Laboratory, Milford, Iowa.

Table 1. Locations of Cedar River Basin Stations Sampled for Benthic Diatoms Between October 1975 and February 1977

Station Number	Location	Site Description
1.	T92N R14W S21SE.	On the S bank of the Cedar River after a 90 degree bend to the E in Cedar Bend Park, Bremer County.
2.	T93N R14W S20S.	On the W bank of the Cedar River downstream from the State Hwy. 188 bridge E of Plainfield, Bremer County.
3.	T94N/95N R14W S4N/33S.	On the W bank of the Little Cedar River immediately above and below the county road bridge 3km N of Nashua, Chickasaw County.
4.	T95N R15W S20E.	On the E bank of the Cedar River where the county road leading S from State Hwy. 393 turns E; about 5 river km S of Charles City, Floyd County.
5.	T96N R16W S16E.	On the N bank of the Cedar River below the U.S. Hwy. 218 bridge N of Floyd, Floyd County. (This bridge has since been rebuilt a few meters W.)
6.	T97N R19W S21E.	On the S bank of the Shell Rock River about 100 meters downstream from the highway bridge in Rock Falls, Cerro Gordo County.
7.	T97N R21W S24W.	On the N bank of the Winnebago River between the county road bridge and a field drainage ditch 1 km N of the intersection of county roads B20 and S34 NW of Mason City, Cerro Gordo County.
8.	T96N R19W S20W.	On the NE bank of the Winnebago River immediately downstream from the county road S36 bridge near Portland, Cerro Gordo County.
9.	T94N R17W S17NE.	On the W bank of the Shell Rock River downstream from the dam and bridge in Marble Rock, Floyd County.
10.	T91N R15W S11N.	On the S bank of the Shell Rock River below the bridge in downtown Shell Rock, Butler County.
11.	T90N R14W S6SE.	On the N bank of the West Fork of the Cedar River along the bend in Thunderwoman County Park, Finchford, Black Hawk County.
12.	T91N R14W S35S.	On the E bank of the Cedar River immediately downstream from the U.S. Hwy. 218 bridge near the S end of Janesville, Bremer County.
13.	T90N R14W S16NE.	Below the confluence with the Shell Rock and West Fork Rivers on the W bank of the Cedar River immediately below the county highway bridge at Washington-Union Access of Black Hawk County. (The Oct 75 samples were collected from the E bank.)
14.	T91N R14W S2.	On the S bank of the Cedar River below and immediately downstream from the 3rd St SE bridge in Waverly, Bremer County.

Diatom counts of 500+ frustules per slide were made by scanning slides across the middle from near one edge toward the other along as many non-overlapping transects as needed using an 1000X oil immersion lens (Olympus BH). In counting, isolated valves were recorded but after the first valve the rest were recorded in pairs. Broken valves were counted only when most of the valve was intact.

Water samples for chemical analysis were collected along with diatom samples. These subsurface samples were transported back to the lab, refrigerated and analyzed the next day for color, turbidity, alkalinity, hardness, nitrate, total phosphate, orthophosphate and silica. Temperature, pH, dissolved carbon dioxide and dissolved oxygen were determined at the time of collection. All tests were made using a Hach DR-EL water test set (Hach Chemical Co., Ames, Iowa).

OBSERVATIONS AND RESULTS

Counts of diatoms from 216 samples collected from the 14 stations on the six dates reported include 281 different taxa (Table 2). These 216 samples were classified according to substratum using the characteristics discussed by Round (1981). Because many of the samples contained diatoms from more than one type of substratum, twelve categories were defined for this study (Table 3). The major difficulty with categorizing these substrata is that the Cedar River deposits a layer of silt which can include microalgae (considered seston for the purposes of this analysis) over all benthic surfaces. Changing flow and current patterns may wash most of such deposits off a benthic surface but at any time the areas observed in this study had a high proportion of silted substrata. About 60% of samples had noticeable silt when collected (Table 3). The presence of silt was confirmed by observation of fresh or preserved samples. Microscope observation showed that almost all samples contain many silt particles.

The greatest number of taxa occurred in October samples (Table 2). The reduced richness of winter diatoms relates to restricted sub-

Table 2. Comparison of Diatom Samples Analyzed

Date	Number of Samples	Total Diatom Count	Ave. No. Diatoms/ Sample	Ave. No. Taxa/ Sample	Total Taxa Observed
11-O-75	37	19105	516	41	174
20-F-76	34	17518	515	45	148
24-M-76	38	19477	513	44	169
23-A-76	41	20922	510	42	167
23-O-76	40	20285	507	41	175
19-F-77	26	13146	506	48	151
Entire Period	216	110,453	511	43	281

Table 3. Number of Samples of Each Substratum Type Collected from the Cedar River Basin Between October 1975 and February 1977.

Type	Substratum	No. of Samples each Date						Total
		Oct75	Feb76	May76	Aug76	Oct76	Feb77	
1	Silt or Mud	7	13	13	17	17	10	77
2	Sand	-	2	-	2	-	-	4
3	Rock	8	1	6	1	5	1	22
4	Wood	2	3	9	1	-	2	17
5	Algae or Aquatic Plants	7	4	3	11	10	4	39
6	Silt on Sand	-	3	4	-	-	-	7
7	Silt on Rock	9	8	1	4	6	4	32
8	Silt on Wood	-	-	-	2	-	2	4
9	Algae and Rock	3	-	1	-	-	2	6
10	Sand and Rock	-	-	-	1	-	-	1
11	Silted Algae	-	-	1	2	2	1	6
12	Silted Algae and Rock	1	-	-	-	-	-	1

stratum availability. Rock surfaces in frozen shallow water support neither epilithic growths of diatoms nor filamentous green algae which act as substrata for epiphytic diatoms. Moreover, as the ice melts from the bottom upward in submerged locations sheltered from direct current influence, silt accumulates along with epipelic and planktonic diatoms associated with seston. In May filamentous green algae remain depressed, partially in response to flood effects during the spring. Since epiphytic and epilithic substrata provide about one-fourth of the available benthic surfaces for diatoms in the Cedar River (Table 3), the reduced availability of such substrata in winter can be expected to reduce diatom diversity. In consequence, fewer samples were collected at each station during February 1976. In February 1977 four stations could not be sampled due to rapid rise in water level before break up of the ice cover (3: Little Cedar R.; 5: Floyd, Cedar R.; 6: Rock Falls, Shell Rock R.; 7: Above Mason City, Winnebago R.) Fresh collections from May and August showed greater numbers of dead or senescing cells than did October or February samples. This observation reflects more unfavorable growing conditions during the spring and summer. Most rocks were covered with silt in August as well.

It was impractical to combine distribution data on all 281 taxa in one list and so rare taxa are reported separately (Table 4). Diatom taxa were classified as rare if found in three or fewer samples with total cumulative abundance less than 27. In combination these 111 rare taxa amount to 319 of the total individual diatoms counted (0.29%). The remaining 170 taxa are listed in Table 5, which indicates their relative abundance in each part of the river basin. The values reported in Table 5 for each taxon are abundance classes based on their cumulative abundances at each station sampled. The taxonomy and distributional ecology of the diatoms listed in Table 5 are further discussed in the Systematic Discussion below. There have been numerous revisions of the taxonomy of these diatoms over the past ten years. Published iconographs used for identification are cited in Table 4 for the rare taxa and in the Systematic Discussion for the taxa in Table 5. The distributions of the rare taxa (Table 4) are not discussed in detail since these represent cases with insufficient data to generalize beyond the fact of their relatively restricted occurrence.

New distributional records for Iowa are noted in the Systematic Discussion. Besides the 13 new records from the major taxa, another 21 of the rare taxa are also new records for Iowa.

The seasonal patterns of distribution of the 20 most abundant diatom taxa (68% of the total count) are compared in Fig. 2. The data indicate that, with few exceptions, relative abundances in October 1975 and February 1976 were not repeated one year later. The best repetition occurs in the most abundant taxa: *Cyclotella meneghiniana* and *Stephanodiscus parvus*. *Nitzschia acicularis*, *Navicula salinarum* var. *intermedia*, *Nitzschia gandersheimiensis* var. *tenuirostris*, and *Navicula cryptocephala* var. *veneta* also maintained stable abundances from one year to the next. The most abundant taxa of February 1976, *Nitzschia lauenburgiana*, *Gomphonema olivaceum* and *Nitzschia dissipata*, were reduced more than expected due to the collection of fewer samples in 1977. Other taxa showing a reduction one year later include *Diatoma vulgare* and *Cyclotella pseudostelligera* in October, *Skeletonema potamos* in both October and February and *Synedra ulna* in February. The increased abundance in the second year of *Stephanodiscus hantzschii* var. *tenuis*, *Cyclotella atomus*, *Nitzschia inconspicua*, *Achnanthes minutissima*, *Amphora perpusilla* and *Navicula lanceolata* contributed to the frequent absence of seasonal pattern seen in Fig. 2.

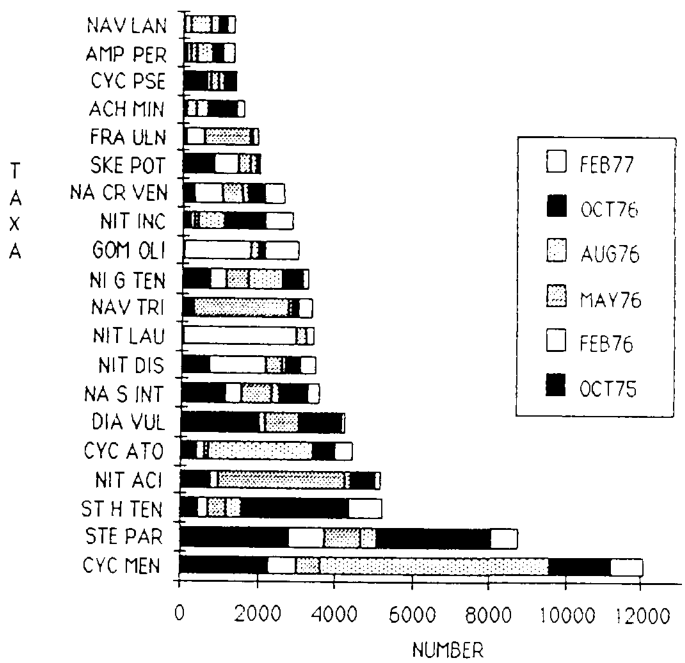

Fig. 2. Seasonal and total abundance of the 20 most abundant diatom taxa found in the Cedar River basin between Oct 1975 and Feb 1977. (Full names can be found in Table 5; CYC = Cyclotella, STE and ST = Stephanodiscus, NIT and NI = Nitzschia, DIA = Diatoma, NAV and NA = Navicula, GOM = Gomphonema, SKE = Skeletonema, FRA = Fragilaria, ACH = Achnanthes, AMP = Amphora.)

Table 4. Rare diatom taxa recorded from Cedar River Basin haptobenthos sampled between October 1975 and February 1977. Records are of station number, season, substratum type with the number counted in parentheses (). Identical records for a taxon are indicated by a dash/-/. Synonyms and iconographs for identification comparison are indicated in brackets [].

Taxon	Station/Date/Substratum (Count)
Achnanthes hungarica (Grun.) Grun.	6/O75/3(1), 7/M76/7(1)
[Patrick and Reimer (1966) p. 259, Pl. 16, Figs. 27-28]	
Amphora ovalis (Kütz.) Kütz.	7/O75/7(2)
[Patrick and Reimer (1975) p. 68, Pl. 13, Figs. 1-2]	
Biddulphia laevis Ehr.	8/O75/3(2), -/-/9(2)
[Edmondson (1959) p. 187, Fig. 7.53]	
Caloneis cleveii (Lagerst.) Cl.	6/A76/3(2), -/-/1(1)
[Hustedt (1930) p. 236, Fig. 359]	
C. limosa (Kütz.) Patr.	6/A76/3(1)
[Patrick and Reimer (1966) p. 587, Pl. 54, Fig. 10]	
C. ventricosa (Ehr.) Meist.	7/O75/7(3), 8/-/3(1), -/-/5(1)
[Patrick and Reimer (1966) p. 583, Pl. 54, Fig. 3]	
C. ventricosa v. *minuta* (Grun.) Patr.	3/O75/1(2), -/-/5(1), 6/F76/1(1)
[Patrick and Reimer (1966) p. 584, Pl. 54, Fig. 2]	
C. ventricosa v. *truncatula* (Grun.) Meist.	6/M76/1(1), 8/-/11(1), 11/O76/7(2)
[Patrick and Reimer (1966) p. 585, Pl. 54, Fig. 5]	
C. species #1	7/O75/7(2)
Cocconeis fluviatilis Wallace	3/O75/2(1), 4/A76/5(1), -/-/1(3)
[Patrick and Reimer (1966) p. 243, Pl. 15, Figs. 11-12]	
Coscinodiscus lacustris Grun.	10/O75/12(1)
[Hustedt (1930) p. 113, Fig. 90]	
Cyclotella astrea (Ehr.) Kütz. *emend* Hakans. & Locker	6/M76/3(3)
[often misnamed *Stephanodiscus astraea* (Ehr.) Grun.]	
[Hustedt (1930) p. 110, Fig. 85]	
Cymatopleura elliptica (Bréb.) W. Smith	11/A76/3(1)
[Hustedt (1930) p. 426, Fig. 825]	
Cymbella minuta v. *pseudogracilis* (Choln.) Reim.	1/O75/1(1)
[Patrick and Reimer (1975) p. 50, Pl. 9, Figs. 1a-2b]	
C. species #2	9/O75/5(2)
Entomoneis ornata (J.W. Bailey) Reim.	6/O75/1(1), 9/-/7(1)
[Patrick and Reimer (1975) p. 4, Pl. 1, Figs. 3-4]	
Epithemia turgida (Ehr.) Kütz.	4/O75/1(2), 7/-/7(2)
[Hustedt (1930) p. 387, Fig. 733]	
Eunotia curvata (Kütz.) Lagerst.	7/F76/5(1)
[Patrick and Reimer (1966) p. 189, Pl. 10, Fig. 4]	
E. species #1	3/O75/1(1)
Fragilaria brevistriata v. *inflata* (Pant.) Hust.	8/F76/7(1), -/M76/11(1), 4/A76/4(1)
[Patrick and Reimer (1966) p. 129, Pl. 4, Fig. 16]	
F. capucina v. *mesolepta* Rabh.	7/M76/4(3), 8/-/3(2)
[Patrick and Reimer (1966) p. 119, Pl. 3, Fig. 6]	
F. construens v. *subsalina* Hust.	6/A76/3(5)
[Hustedt (1930) p. 141, Fig. 139]	
F. crotonensis Kitton	1/M76/6(2), 14/A76/5(6)
[Patrick and Reimer (1966) p. 121, Pl. 3, Figs. 11-12]	
F. crotonensis v. #1	13/O76/7(2), 10/A76/1(3), 12/-/-(1)
F. leptostauron (Ehr.) Hust.	13/F76/6(1), 4/A76/5(1)
[Patrick and Reimer (1966) p. 124, Pl. 4, Fig. 2]	
F. parasitica (W. Sm.) Grun. *in* V.H.	12/A76/5(1)
[=*Synedra parasitica* W. Sm.]	
[Patrick and Reimer (1966) p. 140, Pl. 5, Fig. 12]	
F. rumpens v. *fragilarioides* (Grun. *in* V.H.) Cl.-Euler	9/O76/3(1)
[= *Synedra rumpens* v. *fragilarioides* Grun.]	
[Patrick and Reimer (1966) p. 144, Pl. 6, Fig. 1]	
F. socia (Wallace) Lange-Bert.	1/O75/7(1), -/-/1(2), 9/O76/3(1)
[=*Synedra socia* Wallace]	
[Patrick and Reimer (1966) p. 145, Pl. 6, Figs. 4-6]	
F. ulna v. *oxyrhynchus* fo. *mediocontracta* (Forti) Hust. *nov. comb.*	10/F76/5(1)
[=*Synedra ulna* v. *oxyrhynchus* fo. *mediocontracta* (Forti) Hust.]	
[Patrick and Reimer (1966) p. 152, Pl. 7, Fig. 4]	
Gomphonema acuminatum Ehr.	7/F76/5(2), -/M76/-(1), 9/A76/-(1)
[Patrick and Reimer (1975) p. 112, Pl. 15, Figs. 2, 4, 7]	
G. angustatum v. *intermedia* Grun.	7/O76/1(1)
[Patrick and Reimer (1975) p. 126, Pl. 17, Fig. 20]	
G. angustatum v. *productum* Grun.	7/A76/5(2)
[Patrick and Reimer (1975) p. 127, Pl. 17, Fig. 22]	
G. angustatum v. *sarcophagus* (Greg.) Grun.	7/A76/7(1)
[Patrick and Reimer (1975) p. 128, Pl. 17, Fig. 23]	
G. brasiliense v. #1	8/A76/5(1)
consector Hohn & Hellerm.	8/O75/9(1), -/-/7(1), -/-/5(1)
[Patrick and Reimer (1975) p. 128, Pl. 17, Fig. 13]	
G. grunowii Patr.	6/O75/1(2), 11/-/5(1)
[Patrick and Reimer (1975) p. 131, Pl. 17, Fig. 6]	
G. instablis Hohn & Hellerm.	7/O76/1(1)
[Patrick and Reimer (1975) p. 145, Pl. 18, Fig. 20]	
G. intricatum Kütz.	2/O76/5(5), 3/-/7(2), 5/-/1(1)
[Patrick and Reimer (1975) p. 134, Pl. 18, Fig. 1]	
G. subclavatum v. *mexicanum* (Grun.) Patr.	9/F77/5(23)
[Patrick and Reimer (1975) p. 130, Pl. 16, Figs. 12-13]	
G. subclavatum v. *montanum* (Schumann) Cl.	11/O75/5(4), -/-/3(2), 7/A76/5(1)
[Schmidt (1902) Pl. 238, Fig. 4]	
G. tenellum Kütz.	9/O75/3(6), 8/A76/1(1)
[Patrick and Reimer (1975) p. 124, Pl. 17, Figs. 16a-b]	
G. species #10	2/O75/3(4)
G. species #16	9/O75/7(1)
G. species #23	11/F77/7(1)
G. species?	12/O75/7(1), 2/A76/1(2), -/F77/4(1)
Gyrosigma exilis (Grun.) Reim.	12/O75/7(1), -/-/-(1)
[Patrick and Reimer (1966) p. 322, Pl. 24, Fig. 4]	
G. spencerii v. *curvula* (Grun.) Reim.	1/A76/1(1)
[Patrick and Reimer (1966) p. 316, Pl. 23, Fig. 8]	
G. species?	12/M76/3(1)
Hantzschia amphioxys (Ehr.) Grun.	3/M76/1(1)
[Hustedt (1930) p. 394, Fig. 747]	
H. amphioxys var. *capitata* (O. Müll.) Hust.	2/F76/6(1), 6/M76/1(1)
[Hustedt (1930) p. 394, Fig. 748]	
H. amphioxys v. #1	10/M76/4(1), 4/A76/-(2), 14/F77/1(1)
Melosira distans (Ehr.) Kütz.	2/F76/4(2), 6/M76/1(2)
[Hustedt (1930) p. 92, Fig. 53]	
M. distans v. *lirata* (Ehr.) Bethge	2/O75/1(1), 14/F77/5(2)
[Hustedt (1930) p. 93, Fig. 55]	
M. distans v. *lirata* fo. *lacustris* (Grun.) Bethge	1/M76/6(2)
[Hustedt (1930) p. 93, Fig. 57]	
M. granulata v. *muzzanensis* (Meister) Bethge	6/O76/7(2)
[Hustedt (1930) p. 88, Fig. 47]	
M. italica subsp. *subarctica* O. Müll.	10/F77/1(2), 13/-/-(1), -/-/4(1)
[Hustedt (1930) p. 92, Fig. 52]	
Navicula barbarica Hust.	14/F77/1(1)
[Hustedt (1949) p. 97, Figs. 14-17]	
N. biconica Patr.	5/A76/5(1)
[Patrick and Reimer (1966) p. 469, Pl. 44, Fig. 8]	
N. cocconeiformis Greg. *ex* Grev.	2/F76/4(1)
[Patrick and Reimer (1966) p. 451, Pl. 41, Fig. 5]	
N. difficillima Hust.	5/A76/8(1), 7/-/7(1)
[Hustedt (1950) p. 436, Pl. 38, Fig. 86-88]	
N. exigua v. *signata* Hust.	1/O76/1(1)

[Hustedt (1950) Pl. 37, Figs. 54-55]
N. hambergii Hust. 5/M76/4(1), 4/A76/1(1)
[Patrick and Reimer (1966) p. 519, Pl. 49, Fig. 16]
N. integra (W. Sm.) Ralfs 2/F76/1(1), 4/-/-(1)
[Patrick and Reimer (1966) p. 473, Pl. 45, Fig. 6]
N. laevissima Kütz. 4/A76/1(1), 7/O76/-(1)
[Patrick and Reimer (1966) p. 497, Pl. 47, Fig. 13]
N. mutica f. *intermedia* (Hust.) Hust. 5/M76/1(1)
[Hustedt (1962) pp. 585-6, Fig. 1593]
N. mutica v. *cohnii* (Hilse) Grun. 2/A76/1(1)
[Patrick and Reimer (1966) p. 454, Pl. 42, Fig. 3]
N. mutica v. *stigma* Patr. 8/O75/5(1), -/-/-(1)
[Patrick and Reimer (1966) p. 455, Pl. 42, Fig. 5]
N. mutica v. *tropica* Hust. 10/O75/1(1)
[Patrick and Reimer (1966) p. 455, Pl. 42, Fig. 4]
N. mutica v. #2 4/O76/1(1)
N. pupula v. *capitata* Skv. & Meyer 11/O75/7(2)
[Patrick and Reimer (1966) p. 496, Pl. 47, Fig. 8]
N. pupula v. *mutata* (Krasske) Hust. 8/F77/9(1)
[Patrick and Reimer (1966) p. 496, Pl. 47, Figs. 9-10]
N. pupula v. *rectangularis* (Greg.) Grun. 3/O76/11(1), 6/-/1(1)
[Patrick and Reimer (1966) p. 497, Pl. 47, Fig. 12]
N. seminulum Grun. 9/O76/7(1)
[Patrick and Reimer (1966) p. 489, Pl. 46, Fig. 19]
N. seminulum v. *hustedtii* Patr. 4/A76/7(10), 6/-/3(1)
[Patrick and Reimer (1966) p. 489, Pl. 46, Fig. 20]
N. tantula Hust. 3/O75/1(1)
[Hustedt (1962) p. 250, Fig. 1375]
N. zanoni Hust. 9/O75/5(1)
[Hustedt (1949) p. 92, Pl. 5, Fig. 1-5]
N. species #6 5/M76/4(1), -/-/1(1)
N. species #13 1/A76/8(1)
N. species #14 1/A76/8(1)
N. species #20 1/O76/1(2)
N. species #23 9/F77/11(3)
N. species #25 2/F77/8(2), 9/-/1(1)
N. species #26 8/F77/1(1), 9/-/-(5)
Neidium affine v. *amphirhynchus* (Ehr.) Cl. 4/A76/5(2), 4/-/1(1), 5/-/1(2)
[Patrick and Reimer (1966) p. 391, Pl. 35, Fig. 3]
N. affine v. *undulatum* (Grun.) Cl. 11/F77/1(2)
[Patrick and Reimer (1966) p. 393, Pl. 35, Figs. 7-8]
Nitzschia acuta Hantzsch 4/O76/1(1), -/-/7(1)
[Hustedt (1930) p. 412, Fig. 790]
N. amphibia v. #1 7/M76/7(1)
N. amphioxoides Hust. 1/O75/3(1), 6/O76/7(2)
[Hustedt (1949) p. 140, Pl. 13, Figs. 65-72]
N. bryophila Hust. 4/O76/7(1), 5/-/1(2), 6/-/7(1)
[Hustedt (1943) p. 232, Figs. 66-71]
N. dissipata v. *media* (Hantzsch) Grun. 4/A76/5(2), 8/-/1(1), 7/O76/1(1)
[Hohn and Hellerman (1963) p. 316, Pl. 5, Fig. 2]
N. hantzschiana Rabh. 7/O76/3(27)
[Hustedt (1930) p. 415, Fig. 797]
N. luzonensis Hust. 6/O76/7(1)
[Hustedt (1942) p. 137, Figs. 331-336]
N. palea v. *tropica* Hust. 5/O76/1(2)
[Hustedt (1949) p. 147, Figs. 26-29]
N. radicula Hust. 6/O76/1(1)
[Lange-Bertalot and Simonsen (1978) p. 46, Pl. 8, Figs. 131-136]
N. sublinearis Hust. 9/O75/7(1), 6/M76/3(3), -/-/1(1)
[Hustedt (1930) p. 411, Fig. 786]
N. tryblionella v. *debilis* (Arnott) A. Mayer 5/O7.6/3(1)
[Hustedt (1930) p. 400, Fig. 759]
N. tryblionella v. *subsalina* Grun. 8/O75/9(1), 10/O76/1(1)
[Hustedt (1930) p. 399]
N. valdestriata Al. & Hust. 2/O76/1(1)
[Aleem and Hustedt (1951) p. 19, Fig. 5]
N. zululandica Choln. 1/M76/6(1), 2/-/1(2), 6/-/-(1)
[Cholnoky (1968) p. 82, Fig. 154]
N. species #26 4/A76/5(2), 10/O76/1(1)
N. species? 1/M76/6(1)
Opephora martyi Herib. 2/O76/4(1)
[Patrick and Reimer (1966) p. 115, Pl. 3, Fig. 3]
Pinnularia biceps f. *petersenii* Ross 12/F76/1(1)
[Patrick and Reimer (1966) p. 600, Pl. 55, Fig. 16]
P. brebissonii (Kütz.) Rabh. 6/M76/9(1), 2/F77/7(1)
[Patrick and Reimer (1966) pp. 614-615, Pl. 58, Fig. 6]
P. fasciata (Lagerstadt) Hust. 6/O76/7(2)
[Hustedt (1930) p. 316, Fig. 569]
P. species #1 6/M76/3(2)
Rhopalodia gibba v. *ventricosa* (Kütz.) V.H. 6/O76/7(1), 7/-/1(1)
[Hustedt (1930) p. 391, Fig. 741]
R. musculus (Kütz.) O. Müll. 11/F76/1(1), 12/F77/-(1)
[Hustedt (1930) p. 392, Fig. 745]
Stauroneis anceps Ehr. 1/O75/1(1)
[Patrick and Reimer (1966) p. 361, Pl. 30, Fig. 1]
Surirella species #1 7/M76/4(1)

The few diatoms with similar seasonal patterns of abundance include *C. meneghiniana* and *C. atomus* which were dominant in August samples. The May dominants, *N. acicularis, N. tripunctata* and *F. ulna,* also have somewhat similar seasonal abundance patterns. Whether these similarities persist during a second season of the period of greatest abundance for these taxa will be seen when the May and August 1977 samples are analyzed. With the possible exception of *N. tripunctata* these taxa often occur in plankton, settle onto benthic surfaces with the seston, and according to microscropic observations in this study, form healthy populations on benthic surfaces. In fact it is noteworthy that the five most abundant taxa found in the benthos (Fig. 2) are widely reported in the literature as plankton.

The water characteristics are summarized in Table 6 with the mean values for all stations on each date and the range from minimum value to maximum value for each factor presented. These are alkaline, hard waters. Hardness was determined for August 1976 and subsequent samples. The mean value for total hardness was above 200 mg/l and the minimum-maximum range was similar to that for alkalinity. For all samples analyzed hardness and alkalinity have a strong positive correlation (p: 0.001). Similarly color had a strong positive correlation with turbidity. The turbidity values recorded during this period have been subsequently found to represent the low end of possible levels for this factor in the Cedar River. These samples were collected during periods of low run-off and relatively low water flow in order to facilitate the sampling of benthic diatoms. In the summer of 1984 a series of samples was taken to evaluate the effects of flooding on the water characteristics. One such sample removed from the Cedar River in Waverly at the peak of a high flow resulting from heavy rains upstream recorded a turbidity of 975 JTU. One day later the turbidity was 450 JTU. Turbidity appears to be the factor with greatest variations among stations and within seasons.

The minimum-maximum values for each factor in Table 6 overlapped between dates with the exception of temperature which showed the expected seasonal variation for this region. The year-to-year variation in temperature shown by the October samples was no doubt increased by the fact that the 1976 samples were collected almost two weeks later by the calendar. There is annual variation in the timing of major changes in river water temperature, and a drop of 10 degrees C within 24 hours has been documented (unpublished

Table 5. Distribution and Abundance of Diatoms Commonly Found in the Cedar River, October 1975 - February 1977. Values are classes based on relative abundance of all diatoms counted at that site (1 = <1%; 2 = 1-5%; 3 = 5-20%; 4 = >20%).

River	Cedar River							Little Cedar	West Fork	Shell Rock			Winnebago		
Sample Site	13	12	14	1	2	4	5	3	11	10	9	6	8	7	
Number of Samples	12	12	15	19	18	17	14	18	12	16	17	11	21	14	
Diatom Taxa															Total
Achnanthes:															
clevei Grun.	-	1	-	-	1	1	1	1	-	-	-	-	-	-	41
exigua Grun.	-	1	-	-	1	-	-	-	-	-	-	1	-	1	4
hauckiana v. *rostrata* Schulz	-	-	-	-	-	1	1	-	-	-	-	-	-	-	17
lanceolata (Bréb.) Grun.	1	1	1	1	1	1	1	2	1	1	1	1	1	2	590
lanceolata v. *dubia* Grun.	1	1	1	1	2	1	1	2	1	1	-	1	1	1	500
minutissima Kütz.	2	1	1	1	1	1	2	2	2	2	2	1	1	3	1588
Amphora:															
ovalis v. *affinis* (Kütz.) V.H. *ex.* DeT.	1	-	-	1	1	1	-	-	-	1	1	1	-	1	28
perpusilla (Grun.) Grun.	1	1	1	2	1	2	2	1	1	2	2	2	1	2	1371
submontana Hust.	1	2	1	1	1	1	1	-	1	1	-	1	1	1	193
veneta Kütz.	-	-	-	-	-	-	-	-	-	1	-	1	1	-	8
Asterionella:															
formosa Hass.	-	-	-	-	-	-	-	-	1	-	-	-	-	1	23
Caloneis:															
amphisbaena (Bory) Cl.	-	-	-	-	1	-	-	-	1	1	1	-	-	-	13
bacillum (Grun.) Cl.	1	-	-	1	-	1	-	1	1	-	1	-	-	1	17
lewisii v. *inflata* (Schultze) Patr.	-	-	-	-	-	-	-	1	1	-	-	1	-	1	8
Cocconeis:															
pediculus Ehr.	-	1	1	1	1	2	1	2	3	2	2	2	1	2	1245
placentula Ehr.	1	-	-	-	1	-	-	1	-	1	-	-	-	-	21
placentula v. *euglypta* (Ehr.) Cleve	-	1	-	1	1	1	1	1	1	1	-	-	1	1	75
placentula v. *lineata* (Ehr.) V.H.	1	1	1	1	1	2	1	1	1	1	1	1	3	2	1168
Cyclotella:															
atomus Hust.	2	3	2	2	3	1	1	3	3	3	2	1	2	3	4466
glomerata Bachm.	1	2	1	2	1	1	2	1	1	1	1	1	1	1	684
kutzingiana v. *planetophora* Fricke	-	-	-	-	1	-	-	1	-	-	-	-	-	-	4
meneghiniana Kütz.	3	3	4	4	3	3	3	2	3	2	2	2	2	2	12061
nana Hust.	1	1	1	1	1	1	1	1	1	1	1	1	1	-	274
pseudostelligera Hust.	2	2	2	2	2	2	2	1	1	1	1	1	2	1	1401
Cylindrotheca:															
gracilis (Bréb.) Grun.	1	-	-	1	1	1	1	1	1	-	-	1	-	-	14
Cymatopleura:															
solea (Bréb.) W. Smith	1	1	1	1	1	1	1	1	1	1	1	-	1	1	179
Cymbella:															
affinis Kütz.	1	-	1	-	1	-	-	-	-	1	-	-	1	-	10
microcephala Grun.	1	-	-	1	-	-	-	-	-	-	-	1	1	-	39
minuta Hilse *ex* Rabh.	2	1	1	1	1	1	1	1	1	1	1	1	1	1	315
minuta fo. *latens* (Krasske) Reimer	1	-	-	-	-	-	1	-	-	1	1	-	1	-	9
prostata (Berk.) Cl.	-	-	-	1	-	-	-	-	-	1	-	-	1	-	8
sinuata Gregory	-	-	1	1	1	1	1	1	1	-	1	1	1	1	73
tumida (Bréb. *ex.* Kütz.) V.H.	1	1	-	1	1	-	1	1	1	1	1	1	1	1	100
Diatoma:															
vulgare Bory	2	1	2	2	1	2	3	3	2	2	3	2	2	2	4264
Epithemia:															
adnata (Kütz.) Bréb.	-	1	-	-	-	1	-	-	-	-	-	1	-	-	5

Fragilaria:															
brevistriata Grun.	1	1	-	1	-	1	-	-	-	-	1	1	1	1	48
capucina Desm.	-	-	-	-	1	-	-	-	-	1	-	-	1	1	5
capucina v. *austriaca* (Grun.) Lange-Bert.	-	-	1	1	1	-	-	-	-	-	-	1	-	-	11
construens (Ehr.) Grun.	1	2	1	1	1	1	-	-	-	1	1	1	1	1	161
construens v. *venter* (Ehr.) Grun.	1	2	1	1	1	1	1	1	-	1	1	1	1	1	201
delicatissima (W. Sm.) Lange-Bert.	-	-	-	-	-	-	-	-	-	1	1	-	1	-	4
parasitica v. *subconstricta* Grun. *in* V.H.	1	-	1	1	1	1	1	1	1	-	1	-	1	1	45
pinnata Ehr.	-	-	-	-	-	-	-	-	1	-	-	-	1	1	7
pinnata v. *lancettula* (Schum.) Hust.	-	-	-	1	-	1	-	-	-	1	1	1	-	1	39
ulna (Nitzsh) Lange-Bert.	2	2	2	2	2	2	2	1	1	2	2	1	2	2	1942
ulna var. *acus* (Kütz.) Lange-Bert.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	251
ulna v. *contracta* (Østr.) *nov. comb.*	1	1	2	1	1	2	2	1	-	1	1	1	1	-	312
ulna v. *spathulifera* (Grun. *in* V.H.) *nov. comb.*	-	-	1	-	-	-	-	-	1	-	1	1	1	1	27
vaucheriae (Kütz.) Petersen	1	1	1	1	2	1	1	1	1	1	1	1	2	1	764
vaucheriae v. *capitellata* (Grun.) Patr.	-	-	-	-	-	-	-	-	-	1	1	1	-	-	36
Frustulia:															
vulgaris (Thwaites) De Toni	1	-	-	1	1	1	-	-	1	-	-	-	-	1	24
Gomphonema:															
angustatum (Kütz.) Rabh.	1	-	1	1	-	1	1	1	1	1	1	1	1	3	592
angustatum v. *citera* (Hohn & Hellerm.) Patr.	-	-	-	-	-	-	-	-	1	1	-	-	1	-	7
cleveii Fricke	1	1	1	1	1	1	1	1	1	1	1	1	1	2	291
curtum Hust.	-	-	2	-	-	-	-	-	-	-	1	-	-	-	80
dichotomum Kütz.	1	-	1	1	-	1	-	1	1	1	1	1	-	1	73
olivaceum (Lyngbye) Kütz.	2	2	2	2	2	2	1	3	1	2	2	2	3	2	3022
parvulum (Kütz.) Kütz.	1	1	1	1	1	1	1	1	1	2	2	1	1	2	877
subclavatum (Grun.) Grun.	-	-	-	-	-	1	-	-	1	1	1	1	1	1	10
subclavatum v. 22	-	-	1	1	-	-	-	-	-	-	2	-	-	-	116
tergestinum (Grun.) Fricke	1	-	1	1	1	1	1	1	1	2	2	2	1	1	836
Gyrosigma:															
acuminatum (Kütz.) Rabh.	-	-	-	-	1	1	1	-	-	-	-	-	-	1	5
obtusatum (Sulliv. & Wormley) Boyer	-	-	-	1	-	1	-	1	-	1	-	-	-	-	9
scalproides (Rabh.) Cl.	1	1	1	-	1	1	-	1	-	-	-	-	-	-	18
spencerii (Quek.) Griff. & Henfr.	1	1	1	1	1	1	-	1	-	-	-	-	1	1	54
Melosira:															
granulata (Ehr.) Ralfs	1	1	1	1	-	1	-	-	1	1	1	1	1	1	173
granulata v. *angustissima* O. Müll.	1	1	1	1	1	-	-	1	1	1	1	2	2	2	565
italica (Ehr.) Kütz.	1	1	-	1	1	1	1	-	-	1	1	1	2	1	179
varians Ag.	1	1	1	1	1	1	2	1	2	1	1	2	2	2	845

Meridion:															
circulare (Grev.) Agardh	1	-	-	-	-	1	-	-	1	-	-	1	1	1	78
Navicula:															
accomoda Hust.	1	1	1	-	1	1	1	1	1	-	1	-	1	1	49
arvensis Hust.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	182
atomus (Kütz.) Grun.	-	1	1	1	1	1	1	1	-	-	-	1	-	-	57
capitata Ehr.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	208
cincta (Ehr.) Ralfs	-	1	-	-	-	-	1	-	-	-	1	-	1	1	9
citrus Krasske	1	1	1	1	1	1	-	1	-	1	1	1	1	1	62
cryptocephala Kütz.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	146
cryptocephala f. *minuta* Peters.	1	1	1	1	1	1	-	1	1	1	1	1	1	-	223
cryptocephala v. *veneta* (Kütz.) Rabh.	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2627
cuspidata (Kütz.) Kütz.	1	-	1	1	1	1	1	1	1	1	1	1	1	1	72
decussis Østr.	1	1	1	1	1	1	1	1	1	-	1	1	1	1	273
elginensis (Greg.) Ralfs	-	-	-	1	-	1	-	-	1	-	-	-	1	1	7
gregaria Donkin	1	1	1	2	2	2	2	2	1	1	1	-	1	1	945
heufleri Grun.	1	-	-	-	1	-	-	-	-	-	-	1	-	1	6
heufleri v. *leptocephala* (Bréb. *ex* Grun.) Patr.	1	1	1	1	1	2	2	1	1	1	1	1	1	1	390
ingenua Hust.	-	-	-	1	1	1	1	-	-	-	-	-	-	-	8
lanceolata (Ag.) Kütz.	1	1	1	2	2	1	1	1	2	2	2	2	2	2	1362
luzonensis Hust.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	470
menisculus v. *upsaliensis* (Grun.) Grun.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	134
minima Grun.	1	1	1	1	1	1	2	2	1	1	1	2	1	1	719
minima v. *atomoides* (Grun.) Cl.	1	1	1	1	1	-	-	-	1	-	1	1	1	1	105
monoculata Hust.	-	1	-	-	-	-	-	-	-	-	-	-	1	1	5
mutica Kütz.	1	-	1	1	1	1	-	1	-	-	1	-	-	1	11
nigrii De Notaris	1	1	1	1	1	1	1	2	-	1	-	1	-	1	240
notha Wallace	1	1	1	1	1	1	1	1	-	1	1	1	1	1	196
pelliculosa (Bréb. *ex* Kütz.) Hilse	2	1	2	1	1	1	1	1	-	2	1	1	1	1	827
protracta f. *subcapitata* (Wislouch & Poretzky in Poretzky) Hust.	-	1	1	1	1	-	1	-	-	1	-	-	-	1	75
pupula Kütz.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	245
pygmaea Kütz.	-	-	-	1	1	1	1	1	-	-	-	-	1	-	18
radiosa v. *parva* Wallace	1	1	1	-	-	1	1	1	1	1	1	1	1	-	40
radiosa v. *tenella* (Bréb. *ex* Kütz.) Grun.	1	-	1	-	-	-	-	-	-	-	-	-	1	-	29
rhynchocephala Kütz.	1	-	-	1	1	-	1	-	1	-	-	-	-	-	26
rhynchocephala v. *germainii* (Wallace) Patr.	1	1	1	1	1	2	2	1	2	1	1	1	1	1	622
salinarum v. *intermedia* (Grun.) Cl.	2	2	2	2	2	2	3	2	1	2	2	3	3	2	3589
seminulum v. *intermedia* Hust.	1	1	1	1	1	1	1	2	1	1	1	1	1	1	336
symmetrica Patr.	1	1	1	1	1	1	2	1	1	1	1	1	1	1	517
tenelloides Hust.	1	2	1	1	1	1	1	1	1	1	1	1	1	1	183
tripunctata (O.F. Müll.) Bory	2	2	1	2	1	3	3	1	1	2	2	2	2	2	3377
tripunctata v. *schizonemoides* (V.H.) Patr.	2	1	1	-	1	2	1	1	-	1	2	1	1	1	705
viridula (Kütz.) Ehr.	1	1	1	1	1	1	1	1	-	1	-	-	-	-	31
viridula v. *argunensis* Skv.	1	1	1	1	-	-	-	-	1	-	1	-	1	1	50
viridula v. *rostellata* (Kütz.) Cl.	2	1	1	1	2	1	2	2	2	1	1	1	1	1	935

Neidium:															
dubium (Ehr.) Cl.	1	-	-	1	1	-	-	1	1	1	-	-	-	1	14
Nitzschia:															
accedens Hust.	-	-	1	-	-	-	-	-	1	-	1	-	1	1	10
acicularioides Hust.	2	1	1	1	1	1	1	1	1	2	1	2	1	1	1128
acicularis (Kütz.) W. Smith	2	2	2	2	3	3	3	3	3	2	1	2	2	3	5172
alpina Hust. *emend* Lange-Bert.	1	2	1	-	-	-	-	-	-	-	-	-	1	1	109
amphibia Grun.	1	1	1	1	1	1	1	1	1	1	2	2	1	1	602
angustata (W. Sm.) Grun.	-	-	-	-	-	1	-	-	-	-	-	-	1	1	8
apiculata (Greg.) Grun.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	130
biacrula Hohn & Hellerm.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	73
calida Grun.	1	-	1	1	1	1	1	1	-	-	1	1	1	1	39
capitellata Hust.	-	1	-	-	1	1	1	1	-	-	-	1	1	1	35
closterium V.H.	1	1	-	1	1	1	-	-	1	1	1	1	2	1	272
dissipata (Kütz.) Grun.	2	2	3	2	2	2	2	2	2	2	2	2	3	1	3472
elegans Hust.	1	1	1	1	1	-	-	-	-	1	-	1	-	1	39
elegantula Grun.	1	1	-	1	1	1	1	1	1	1	1	1	2	1	226
fonticola Grun. in V.H.	1	1	1	1	1	1	1	1	1	1	2	1	1	1	878
frequens Hust.	1	1	1	1	1	1	1	1	1	1	-	1	1	1	123
frustulum (Kütz.) Rabh.	1	-	-	-	1	1	-	1	-	-	1	1	-	1	42
ganderscheimiensis fo. *tenuirostris* Grun. in V.H. *emend* L.-B.	2	2	2	2	2	2	2	2	3	2	2	2	2	3	3286
graciliformis Lange-Bert. & Sim.	1	2	1	2	2	1	1	1	1	1	1	1	1	2	818
gracilis Hantzsch	1	-	1	1	-	-	-	-	-	-	-	-	-	-	21
hungarica Grun.	1	1	1	1	1	1	1	1	1	1	-	1	1	1	103
incomptus Hohn & Hellerm.	-	1	-	1	1	1	1	1	-	-	-	-	-	-	30
inconspicua Grun.	2	1	1	1	2	1	2	2	2	2	3	2	3	1	2868
lauenburgiana Hust.	2	2	1	2	2	2	1	2	1	3	3	1	2	1	3411
linearis (Agardh) W. Sm.	1	1	1	2	2	1	1	2	3	1	1	1	1	1	1008
linkei Hust.	-	-	-	1	1	-	-	1	1	-	1	-	-	-	12
palea (Kütz.) W. Sm.	1	1	1	2	2	2	2	2	1	1	2	2	1	1	1212
perminuta Grun.	1	-	1	-	1	-	1	1	-	-	-	1	-	-	26
pertica Hohn & Hellerm.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	132
pumila Hust.	1	-	-	1	-	1	-	-	1	-	1	-	-	-	10
pusilla Kutz. *emend* L.-B.	1	1	1	1	1	1	1	1	1	1	1	1	1	2	527
recta Hantzsch	-	-	1	1	1	-	-	-	-	-	-	-	1	1	7
sigma (Kütz.) W. Sm.	-	-	-	1	-	-	1	-	-	-	-	-	1	1	6
sigmoidea (Nitz.) W. Sm.	1	1	-	1	-	1	1	1	1	1	1	-	1	1	76
substrostratoides Choln.	1	1	1	1	1	1	-	1	1	1	1	1	1	1	69
supralitorea L.-B.	1	1	1	-	-	-	-	-	1	1	-	-	-	-	18
tenuis W. Sm. *emend* L.-B.	1	1	1	1	1	1	1	1	2	1	1	1	1	1	544
tryblionella v. *levidensis* (W. Sm.) Grun.	1	1	-	1	1	-	1	-	-	1	-	1	-	-	17
tryblionella v. *victoriae* Grun.	-	-	-	1	1	1	-	-	-	-	-	-	-	-	14
tryblionella v. 1	-	1	1	-	-	1	-	-	1	1	-	-	-	-	6
umbonata (Ehr.) L.-B.	1	1	-	1	1	1	1	-	1	1	1	1	1	1	52
vermicularis (Kütz.) Hantz.	1	1	1	1	1	1	-	1	1	1	1	1	1	1	187

Rhoicosphenia:															
curvata (Kütz.) Grun. *ex* Rabh.	1	1	2	1	1	2	1	1	1	2	2	2	2	1	1321
Skeletonema:															
potamos (Weber) Hasle	1	3	2	3	2	2	1	2	1	1	1	1	1	1	2023
Stauroneis:															
smithii Grun.	1	-	-	-	-	-	-	-	-	-	-	-	-	1	5
Stephanodiscus:															
dubius (Fricke) Hust.	1	2	1	1	1	1	-	1	1	2	2	1	2	1	703
hantzschii Grun.	1	1	2	1	1	1	1	1	1	1	1	2	1	1	599
hantzschii fo. *tenuis* (Hust.) Hak. & Stoerm.	3	3	3	3	2	2	1	2	1	3	2	2	2	2	5247
niagarae Ehr.	1	-	-	-	-	-	-	-	-	1	-	1	-	-	8
parvus Stoerm. & Hak.	3	3	3	3	3	2	2	3	2	3	3	3	3	2	8759
Surirella:															
angusta Kütz.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	236
iowensis Lowe	-	1	-	-	-	-	-	-	1	-	-	-	-	1	13
ovata Kütz.	1	1	1	1	1	1	1	2	2	1	1	1	1	2	545
ovata v. *pinnata* (W. Sm.) Hust.	1	1	1	1	2	2	-	1	2	1	1	-	1	1	392
ovata v. *salina* W. Sm.	-	1	-	-	-	-	1	1	-	-	-	-	-	-	6
robusta v. *splendida* (Ehr.) Cl.	-	-	-	-	1	1	-	1	1	-	1	-	-	-	8
Thalassiosira:															
weissflogii (Grun.) G. Fryx. & Hasle	1	1	2	2	2	1	1	2	1	1	1	1	1	1	783

data) in the autumn. Dissolved oxygen (Hach PAO titration and Winkler titration) did not relate so much to temperature as to turbulence (values were almost always above 6.0 mg/l) and to biotic factors (slight diurnal variation was observed).

Nutrient levels were invariably high and probably related as much to ground water inputs as to run-off as shown by the February samples which were collected before water levels increased during the period of late winter thaw. This thaw results from warming of the river ice from beneath by ground water and often coincides with a period of warmer air temperatures which temporarily stops surface freezing. The higher nitrate values in May probably did relate to run-off from fertilized fields. The high total phosphate levels in August may have been related to detritus processes associated with high water temperatures, but the nature of these processes is speculative. Filamentous blue-green algae were most abundant in benthic layers in the August untreated diatom samples compared to samples from other dates examined microscopically. This peak in blue-greens correlated with the phosphate levels. Silicon was also abundant in all seasons with levels usually in the range of 8-12 mg/l; stations on the Cedar River had the lowest silica values recorded in this study during August and October 1976 when values ranged from 0.35-4.0 mg/l.

SYSTEMATIC DISCUSSION

Here the occurrence of the more abundant diatom taxa is discussed and their systematic affinities presented. The source of reference specimens or iconographs used for identification is given in brackets. Any variations from published taxonomic and ecologic descriptions have been noted. I have indicated the growth form [*sensu* Round (1981)] with respect to substratum on the basis of observations made in this study. The distributional and abundance information summarized in Table 5 is related to the sample substratum classification (Table 3) where it seems significant. Space did not permit listing each sample separately in Table 5; here that information is brought forth when a pattern is apparent. The rare taxa are briefly described in Table 4.

MELOSIRALES

Melosira granulata (Ehr.) Ralfs.
[Hustedt (1930) pp. 87-88, Fig. 44]
Epipelon?; found most frequently in samples from the lower reaches of the larger rivers; never more than 2% of any sample.

M. granulata var. *angustissima* O. Mull.
[Hustedt (1930) pp. 87-88, Fig. 45. Kilham and Kilham (1975) showed that this is a growth form of the previous taxon. The name is retained here to reflect the ecological difference found in this study.]
Epipelon?; found in most situations where the nominate occurred, but also very abundant at the upper stations of the Shell Rock and Winnebago Rivers, where it was about 10% of some August samples from a variety of substrata that showed evidence of seston deposition.

M. italica (Ehr.) Kutz.
[Hustedt (1930) p. 91, Fig. 50]
Settled from plankton?; widespread in the larger reaches of the river system and reaching 2-5% of October 1975 samples from below Mason City where it was not recorded one year later.

M. varians Agardh
[Hustedt (1930) pp. 85-86, Fig. 41]
Epilithon, epiphyton; most abundant in samples collected in the cooler months at upriver locations, especially on rock or wood substrata. Filamentous colonies of this taxon comprised 25% of one sample from a rock at Finchford in October 1976.

THALASSIOSIRALES

Cyclotella atomus Hust.
[Huber-Pestalozzi and Hustedt (1942) p. 398, Fig. 486; this is reprinted in Weber (1966) p. 24, Fig. 13; Lowe (1975) notes the occurrence of marginal strutted processes on every 3rd/4th costa visible as thickenings using light microscopy]
Epipelon; widespread; formed over 20% of individuals in 12 samples either from August 1976 or from silted substrata with most from

both. A pattern of high abundance in tributaries with some decrease downstream in larger rivers was noted.

C. glomerata Bachm.
[Hustedt (1930) pp. 105-6, Fig. 81; Lowe (1975) notes marginal strutted processes radial to every 4th to 7th stria]
Epipelon?; most common in October samples; 5-10% of 5 samples from a variety of substrata. The only other Iowa report of this taxon is from the Mississippi River (Vansteenburg et al, 1984).

C. kutzingiana var. *planetophora* Fricke
[Hustedt (1930) p. 99, Fig. 63]
Settled from plankton?; only found in 4 samples.

C. meneghiniana Kütz.
[Hustedt (1930) p. 100, Fig. 67]
Epipelon; most abundant; found in 210 of 216 samples; greater than 50% of 11 samples all from August 1976 and also from silted substrata except two *Cladophora* samples; least abundant in samples from the Winnebago River.

C. nana Hust. [= *T. pseudonana* (Hust.) Hasle & Heimdal]
[Hustedt (1957) pp. 212-213, Fig. 1, 2; Lowe and Busch (1975) illustrate light and SEM photomicrographs of specimens without the central fultoportula; this is the case for the Cedar River taxon.]
Epipelon; no apparent pattern to distribution, never more than 6% of a sample; Drum (1981) reported this taxon from the Des Moines River in the early 1960s.

C. pseudostelligera Hust.
[Huber-Pestalozzi and Hustedt (1942) p. 397, Fig. 485; this is reprinted in Weber (1966) p. 27, Fig. 22; Lowe (1975) located marginal strutted processes at 2-4 micrometer intervals and notes the variable presence of the central ornamentation.]
Epipelon; 4-10% of 20 samples most from October 1975 in the larger streams; least abundant in epiphyton but present.

Skeletonema potamos (Weber) Hasle
[Hasle and Evensen (1976); this is a small (ca. 3 micrometers diameter), lightly silicified, filamentous diatom that often is found with two valves of adjacent frustules attached or as one frustule with the adjacent valves attached; prolonged boiling in acid might destroy it]
Epipelon?; although found in only half the samples it was widespread with greatest abundance in the middle stations of the Cedar River in silt samples (20% of three) in October 1975.

Stephanodiscus dubius (Fricke) Hust.
[= *Cyclostephanos dubius* (Fricke) Round]
[Hustedt (1930) p. 109, Fig. 84; however the size range is 7-10 micrometers in diameter in the Cedar River rather than the 10-25 described by Hustedt. Specimens previously reported as *S. astraea* v. *minutula* (Kutz.) Grun. (Main 1977) have been transferred to this taxon.]
Epipelon; 15% of two silted samples in August 1976 at Marble Rock and Janesville; present at most stations except in upper Cedar River.

S. hantzschii Grun. *in* Cl. & Grun.
[Hustedt (1930) p. 110, Fig. 87; Hakansson and Stoermer (1984) have interpreted the features visible under light microscopy using SEM and clarified its relation to the following taxon.]
Epipelon; found in about one-half of the samples; only twice barely in excess of 5% relative abundance.

S. hantzschii fo. *tenuis* (Hust.) Hak. & Stoerm.
[Weber (1966) p. 30, fig. 30, reproduces Hustedt's original publication; see Hakansson and Stoermer (1984) for SEM interpretation of light microscopy. Their descriptions match the Cedar River specimens very closely.]
Epipelon; found at all stations in most seasons, least abundant at the upstream stations except in October 1976, when it was between 10-20% of 10 samples with silt from a variety of locations.

S. niagarae Ehr.
[Weber (1966) p. 30, Fig. 29; Theriot and Stoermer (1981) present some of the variation in this taxon.]
Settled from plankton?; eight individuals found in six samples, all but one in May 1976.

S. parvus Stoerm. & Hak.
[Stoermer and Hakansson (1984); diatoms reported in Main (1977) as *S. subtilis* (van Goor) A. Cl. have been transferred to this taxon. It seems probable that diatoms published as *S. invisitatus* Hohn & Hellerman are also this taxon, e.g., Weber (1966) p. 29, Fig. 28. Otherwise this taxon has not been reported from Iowa except from the Cedar River (Main 1977).]
Epipelon; 2nd most abundant; found in 202 samples (93.5%) with its greatest abundance in the larger rivers reaching 40% of samples from two stations on the Shell Rock in October of each year.

Thalassiosira weissflogii (Grun.) Fryxell & Hasle [= *T. fluviatilis* Hust.]
[Fryxell and Hasle (1977); Hustedt (1930), pp. 95-96, Fig. 61]

Table 6. Water Characteristics of the Cedar River Basin, October 1975 - February 1977. Values Reported Are Means or Minimum - Maximum Ranges for 14 Stations on the Date Sampled.

FACTOR	OCT 75	FEB 76	MAY 76	AUG 76	OCT 76	FEB 77
Mean Temp. (°C)	13.0	1.5	17.8	25.9	5.4	0.2
Min-Max Temp.	11-16	1-4	17-20.5	23-29	4-6	0-2
Mean Turbidity (JTU)	13.5	30.8	40.6	34.6	33.6	10.8
Min-Max Turb.	0-40	10-90	18-65	5-85	0-70	3-22
Mean Alkalinity (mg/1 HCO_3)	201	186	196	172	195	203
Min-Max Alk.	150-250	130-230	120-250	130-240	140-255	160-230
Mean Nitrate (mg/1)	1.6	2.1	5.3	1.0	1.3	1.9
Min-Max N	0.5-3.1	1.3-3.8	3.9-9.0	0.5-2.1	0.4-2.7	1.3-2.6
Mean Total Phosphate (mg/1)	1.6	3.0	2.6	5.5	1.1	4.0
Min-Max P	0.9-2.8	1.6-4.2	1.3-4.0	2.9-9.5	0.1-4.3	2.3-6.0

Epipelon; often present in small numbers becoming most abundant in August in all samples from the Cedar River below the Little Cedar River except Janesville (2-12%). This diatom has formed blooms appearing as surface foams in the Cedar River following rains in August (unpublished observation).

FRAGILARIALES

Diatoma vulgare Bory
[Patrick and Reimer (1966) p. 109-110, Pl. 2, Fig. 9]
Epiphyton, epilithon; greater than 20% of 14 samples of epilithic or epiphytic substrata except for one epipelic sample in which the sediment had developed a crusted surface; 87% of an epilithic sample at Marble Rock in October 1975; found at all stations although very infrequent in August. Since it is commonly reported to be a cold water diatom, its reduced abundance in February samples may be due to some interference, possibly ice formation in the shallow water habitat sampled. When found in samples suspected to be of largely sestonic origin, this diatom is in low abundance and often appears to be senescent or dead.

Fragilaria brevistriata Grun.
[Patrick and Reimer (1966) pp. 128-129, Pl. 4, Fig. 14]
Epipelon; counted 48 individuals in 15 samples, most from rock or silt as in one sample with 17 from Janesville in February 1977.

F. capucina Desm. [=*S. rumpens* Kutz.]
[Patrick and Reimer (1966) p. 143, Pl. 5, Fig. 19]
Epiphyton; five individuals found on five separate samples, two of which were senescing *Cladophora* spp.

F. capucina var. *austriaca* (Grun.) Lange-Bert. [=*S. amphicephala* var. *austriaca* (Grun.) Hust.]
[Patrick and Reimer (1966) pp. 138-139, Pl. 5, Fig. 8]
Settled from plankton?; eleven individuals found in six samples. The only previous published report of this taxon from Iowa is from the upper Des Moines River (Gudmundson, 1972).

F. construens (Ehr.) Grun.
[Patrick and Reimer (1966) p. 125, Pl. 4, Fig. 4]
Epipelon; widely distributed; most abundant on mud surface at Janesville in February 1977 (13%).

F. construens var. *venter* (Ehr.) Grun.
[Patrick and Reimer (1966) p. 126, Pl. 4, Figs. 8-9]
Epipelon?; similar distribution to previous taxon but not identical.

F. delicatissima (W. Sm.) Lange-Bert. [=*S. delicatissima* W. Sm.]
[Patrick and Reimer (1966) p. 136, Pl. 5, Fig. 2]
Settled from plankton?; four individuals in four samples from the Shell Rock and Winnebago in August 1976.

F. parasitica var. *subconstricta* Grun. *in* V.H. [=*S. parasitica* var. *subconstricta* (Grun.) Hust.; although this taxon was synonymized with *F. parasitica* (W. Sm.) Grun. *in* V.H. by Lange-Bertalot (1980), the nominate variety has been found only once so far in the Cedar River; these taxa may have ecological validity and so are retained.]
[Patrick and Reimer (1966) p. 140, Pl. 5, Fig. 13]
Epiphytic on large motile epipelic and epilithic diatoms (observed on *Nitzschia* spp. in this study); occurred as less than 1% of 28 samples from different parts of the river system in different seasons.

F. pinnata Ehr.
[Patrick and Reimer (1966) p. 127, Pl. 4, Fig. 10]
Settled from plankton?; seven individuals found in four samples.

F. pinnata var. *lancettula* (Schum.) Hust.
[Patrick and Reimer (1966) p. 128, Pl. 4, Fig. 12]
Epipelon; 39 individuals in 16 samples primarily silt or rock over half of which were located at Rock Falls at all seasons.

F. ulna (Nitzsch) Lange-Bert. [=*S. ulna* (Nitzsch) Ehr.]
[Patrick and Reimer (1966) p. 148-149, Pl. 7, Figs. 1-2]
Epilithon, epiphyton; 16th most abundant; found in less than half the samples, most abundant at contiguous stations on the Shell Rock and Winnebago Rivers in May 1976 where of 9 samples it was 56% of one and 21-22% of four others. The substrata were rock (2), mud, wood, *Cladophora* sp. Found at all stations in more than one season; somewhat less abundant at the uppermost stations on each branch of the river.

F. ulna var. *acus* (Kutz.) Lange-Bert. [=*Synedra acus* Kutz.]
[Patrick and Reimer (1966) pp. 135-136, Pl. 5, Fig. 1]
Epilithon, epiphyton; found at all stations but Finchford in May 1976 but reached its greatest abundance below Mason City on rock (8%) and nearby *Potamogeton* sp. (3%) in October 1975.

F. ulna var. *contracta* (Ostr.) nov. comb.
Basionym: *Synedra ulna* var. *contracta* Ostr. *in* Bot. Faeroes, pt. 1, p. 281, Fig. 47. 1901.
This new combination is needed to bring the name into conformity with other changes.
[Patrick and Reimer (1966) pp. 150-151, Pl. 7, Fig. 3]
Epilithon, epiphyton; found in only 28 samples most in the Cedar River during May 1976, reaching 20% of a *Cladophora* sample and 5-12% of samples from wood, rock, or silt substrata.

F. ulna var. *spathulifera* (Grun. *in* V.H.) nov. comb.
Basionym: *Synedra spathulifera* Grun. *in* V.H., Syn. Diat. Belgique, Pl. 38, Fig. 4. 1881.
Synonym: *Synedra ulna* var. *spathulifera* (Grun.) V.H., Syn. Diat. Belgique, p. 151. 1885.
This new combination is needed to bring the name into conformity with other changes.
[Patrick and Reimer (1966) pp. 153-154, Pl. 7, Fig. 8]
Epilithon, epiphyton; 27 individuals were found in 10 samples all but one in October with most epiphytic or epilithic.

F. vaucheriae (Kutz.) Petersen
[Patrick and Reimer (1966) p. 120, Pl. 3, Figs. 14-15]
Epiphyton, epilithon?; occurring most frequently in February and May with maximum abundance (24 and 28%) on algae/rock and wood samples from February 1977.

F. vaucheriae var. *capitellata* (Grun.) Patr.
[Patrick and Reimer (1966) p. 121, Pl. 3, Fig. 16]
Seston, epiphyton; 36 individuals found in three samples with 33 from one sample on submerged grass at Rock Falls in February 1976.

Meridion circulare (Grev.) Agardh
[Patrick and Reimer (1966) pp. 113, Pl. 2, Fig. 15]
Epiphyton; most frequent occurrence in smaller streams in cooler seasons, notably two epiphytic samples in February 1976 from above Mason City (7%) and Rock Falls (2%).

ACHNANTHALES

Achnanthes clevei Grun.
[Patrick and Reimer (1966) p. 267, Pl. 17, Figs. 21-22]
Epipelon; 41 individuals found in 17 samples most of which were of silt from the upper stations on the Cedar River.

A. exigua Grun.
[Patrick and Reimer (1966) pp. 257-258, Pl. 16, Figs. 21-22]
Epipelon; four specimens found in four samples in no pattern.

A. hauckiana var. *rostrata* Schulz
[Patrick and Reimer (1966) p. 269, Pl. 17, Figs. 33-34]
Epipelon; 17 specimens found in four samples including silt from the upper Cedar River.

A. lanceolata (Breb.) Grun.
[Patrick and Reimer (1966) pp. 269-270, Pl. 18, Figs. 1-10]
Epilithon, epipelon; found in almost half of all samples usually in low abundance; greatest abundance in epiphyton (24% of sample 52) and silted epilithon especially above Mason City.

A. lanceolata var. *dubia* Grun.
{Patrick and Reimer (1966) p. 271, Pl. 18, Figs. 11-15}
Epilithon, epipelon, epiphyton; mostly occurring on a variety of substrata in the upper Cedar River and Little Cedar River.

A. minutissima Kütz.
{Patrick and Reimer (1966) pp. 253-254, Pl. 16, Figs. 9-10}
Epiphyton, epilithon; widespread in most seasons with its greatest abundance as an epiphyte (55% of sample 172, 38% of sample 94, 30% of sample 183, 20% of sample 125).

Cocconeis pediculus Ehr.
{Patrick and Reimer (1966) p. 240, Pl. 15, Figs. 3-4}
Epiphyton; greatest relative abundance in three October epiphytic samples: 58% (no. 27), 23% (no. 9), 20% (no. 164); widespread except at the lowest stations on the Cedar River.

Cocconeis placentula Ehr.
{Patrick and Reimer (1966) p. 240, Pl. 15, Fig. 7}
Epilithon, epiphyton; 21 individuals found in 4 samples, including 18 (3.5%) in sample 9 (see above); the other samples were epilithic or epiphytic also.

Cocconeis placentula var. *euglypta* (Ehr.) Cleve
{Patrick and Reimer (1966) pp. 241-242, Pl. 15, Fig. 8}
Epilithon, epiphyton; 75 individuals in 25 samples from varied conditions except May and August.

Cocconeis placentula var. *lineata* (Ehr.) V.H.
{Patrick and Reimer (1966) p. 242, Pl. 15, Figs. 5-6}
Epilithon, epiphyton; widespread, over 5% of 8 samples of epilithon and epiphyton with a notable occurrence of 79% on *Potamogeton* in August at station 8 where it was also abundant in October 1975.

NAVICULALES

Caloneis amphisbaena (Bory) Cl.
{Patrick and Reimer (1966) p. 579, Pl. 53, Fig. 2}
Epipelon; 13 individuals found in 7 samples, seven found in a silted rock sample from Finchford in February 1977.

C. bacillum (Grun.) Cl.
{Hustedt (1930) p. 236, Fig. 360; Patrick and Reimer (1966) pp. 586-587, Pl. 54, Fig. 8; these specimens have a broader transverse fascia than illustrated in Patrick and Reimer; they are at the short end of the size range reported}
Epipelon; 17 individuals found in 10 samples on all types of substrata in cooler seasons, over half in February 1977.

C. lewisii v. *inflata* (Schultze) Patr.
{Patrick and Reimer (1966) p. 589, Pl. 54, Fig. 12}
Epipelon, epipelon; eight individuals found in five samples of silt or rock from stations on smaller streams.

Frustulia vulgaris (Thwaites) De Toni
{Patrick and Reimer (1966) pp. 309-310, Pl. 22, Fig. 6}
Epilithon, epiphyton, epipsammon; 24 individuals found in nine samples almost exclusively from the lower Cedar River; 2.5% of sample 74 (wood) in May.

Gyrosigma acuminatum (Kütz.) Rabh.
{Patrick and Reimer (1966) pp. 314-315, Pl. 23, Figs. 1-3}
Epipelon, epilithon; five individuals found in five samples; no pattern.

G. obtusatum (Sulliv. & Wormley) Boyer
{Patrick and Reimer (1966) p. 317, Pl. 23, Fig. 5}
Epipelon, epilithon; nine individuals found in 7 samples most including obvious silt; May and October samples from several locations.

G. scalproides (Rabh.) Cl.
{Patrick and Reimer (1966) p. 318, Pl. 23, Fig. 7}
Epipelon, epilithon; 18 individuals found in 12 samples from a variety of substrata; appeared mostly in February at stations on the Cedar River.

G. spencerii (Quek.) Griff. & Henfr.
{Patrick and Reimer (1966) pp. 315-316, Pl. 23, Fig. 4}
Epipelon, epilithon; 2% of sample 10 (silt); most often observed in Oct. and Feb. in the Cedar River, but found at other seasons and in the Winnebago River.

Navicula accomoda Hust.
{Patrick and Reimer (1966) p. 468, Pl. 44, Fig. 7}
Epipelon; 49 individuals found in 33 samples which were widespread in all seasons from a wide variety of substrata.

N. arvensis Hust.
{Patrick and Reimer (1966) p. 483, Pl. 46, Figs. 1-2}
Epipelon; two of the four samples in which it was most abundant (2-4%) had algal substrata; found at all stations in one season or another.

N. atomus (Kütz.) Grun.
{Patrick and Reimer (1966) p. 488, Pl. 46, Fig. 16}
Epipelon; 57 individuals found in 17 scattered samples; less than 1% except 5% of sample 70 (silt on rock).

N. capitata Ehr.
{Patrick and Reimer (1966) pp. 536-537, Pl. 52, Figs. 1-2}
Epipelon; greater than 1% of eight samples all involving silted substrata; rarely found in the Shell Rock and its tributaries.

N. cincta (Ehr.) Ralfs
{Patrick and Reimer (1966) p. 516, Pl. 49, Fig. 8}
Epipelon; nine individuals found in six samples.

N. citrus Krasske
{Hustedt (1930) p. 303, Fig. 529}
Epipelon; 62 individuals found in 33 samples from all types of substrata; most abundant in August samples from all but the Little Cedar and West Fork.

N. cryptocephala Kütz.
{Patrick and Reimer (1966) p. 503, Pl. 48, Fig. 3}
Epilithon, epipelon, epiphyton; most abundant (2-3%) on five samples from silt, rock, and wood in October 1976 in the Cedar River.

N. cryptocephala fo. *minuta* Peters.
{Hohn and Hellerman (1963) p. 297, Pl. III, Fig. 18; these specimens are sometimes a little shorter than described ranging down to 18 micrometers}
Epiphyton, epipelon; greatest abundance on *Cladophora* (8% of sample 188 and 5% of sample 203) and on silt (7% of sample 206) in October 1976 at Washington-Union Access and in February 1977 above there in the Shell Rock River.

N. cryptocephala var. *veneta* (Kutz.) Rabh.
{Patrick and Reimer (1966) pp. 504-505, Pl. 48, Fig. 5}
Epiphyton, epilithon, epipelon; found in 207 (96%) of the samples; usually most abundant in February with October next; equally abundant on all substrata and never over 20%.

N. cuspidata (Kütz) Kütz.
{Patrick and Reimer (1966) p. 464, Pl. 43, Figs. 9-10}
Epipelon, epilithon; about 1% at most of any sample and then on silt and/or rock; not restricted by season; least abundant in the Winnebago River.

N. decussis Ostr.
{Patrick and Reimer (1966) pp. 518-519, Pl. 49, Fig. 15}
Epipelon; 2-3% of three samples with silt; almost absent from the Shell Rock and Winnebago Rivers.

N. elginensis (Greg.) Ralfs
{Patrick and Reimer (1966) pp. 524-525, Pl. 50, Fig. 3}

Epipelon; seven individuals found in five samples.

N. *gregaria* Donkin

{Patrick and Reimer (1966) pp. 467-468, Pl. 44, Fig. 6; Schoeman and Archibald (1978) extend Patrick's description by noting that sometimes the striae are slightly radiate in the center and become slightly convergent at the poles, while the central area is often asymmetric being square on the side with an expanded central nodule and semi-elliptical on the other; this latter description matches the Cedar Basin specimens, in which the asymmetric central nodule is prominent. This taxon is quite similar to N. *secreta* v. *apiculata* Patr. in which the central area seems less well defined as one focuses up and down.}

Epipelon, epipsammon; 13% of a silt sample (no. 167) and 7% of two sand samples (45 and 46); only one specimen counted in October 1976; seldom found in the upper Shell Rock and Winnebago Rivers. This does not seem to have appeared in any published reports from Iowa.

N. *heufleri* Grun.

{Patrick and Reimer (1966) p. 515, Pl. 49, Fig. 6}

Epipelon?; six individuals found in six samples.

N. *heufleri* var. *leptocephala* (Breb. *ex.* Grun.) Patr.

{Patrick and Reimer (1966) p. 515, Pl. 49, Fig. 7}

Epiphyton, epipelon; 4-6% of seven samples from silt or algal substrata, including *Spirogyra* which suggests its growth is more epipelic than truely epiphytic; least common at Marble Rock.

N. *ingenua* Hust.

{Hustedt (1962) pp. 279-280, Fig. 1410; Hustedt's description: lanceolate with slightly produced ends, the central area extends to both margins expanding along the radiate striae on one side but rectangular on the other as a result of an additional short stria outside the one leading from the central nodule, 7.5-9 micrometers long, 3-4 micrometers wide, about 24 striae in 10 micrometers, the striae very radiate and punctate; the only difference observed in these specimens is a striae count as low as 20 in 10 micrometers}

Epipelon; eight individuals found in seven samples all involving silt; only from the Cedar River and most found in May. This appears to be a new Iowa record.

N. *lanceolata* (Agardh) Kütz.

{Patrick and Reimer (1966) p. 511, Pl. 48, Fig. 19, not 20 which does not resemble these specimens as much as 19 does}

Epipelon; greatest abundance in silt samples (28% of sample 92, 21% of sample 202, 16% of sample 103, 13% of sample 112); found at every station in almost every season, but most abundant and widespread in May.

N. *luzonensis* Hust.

{Patrick and Reimer (1966) p. 492, Pl. 46, Fig. 24}

Epipelon; only 52nd in abundance yet found in 135 samples (62%); 6% of sample 70 (silt on rock), but usually less than 1%.

N. *menisculus* var. *upsaliensis* (Grun.) Grun.

{Patrick and Reimer (1966) pp. 519-520, Pl. 49, Figs. 17-18}

Epipelon; less than 1% of samples from a variety of substrata.

N. *minima* Grun.

{Patrick and Reimer (1966) pp. 488-489, Pl. 46, Figs. 17-18}

Epilithon, epiphyton, epipelon?; 22% of sample 118 (*Spirogyra*), 17% of sample 125 (exposed *Cladophora*), 9% of sample 110 (silt on wood) all in August in the upper Cedar River and Little Cedar River; present at all stations in August and usually less abundant or absent in the other seasons.

N. *minima* var. *atomoides* (Grun.) Cl.

{Hustedt (1930) p. 272, Fig. 442; this is a shorter and more finely striated version of the nominate variety with which Patrick (Patrick and Reimer 1966) has synonymized it, however in the Cedar River the specimens of each seem distinct}

Epilithon, epiphyton; 5.5% of sample 110 (silt on wood); 2% of sample 215 (*Hormidium* on rock); almost as numerous in February 1977 as in August 1976, but with a scattered distribution.

N. *monoculata* Hust.

{Schoeman and Archibald (1979)}

Epipelon; one-two individuals counted in two silt samples from the Winnebago River in October 1976 and in two silt samples from the Cedar River in February 1977. This taxon has not been previously reported from Iowa.

N. *mutica* Kütz.

{Patrick and Reimer (1966) p. 452, Pl. 42, Fig. 2}

Epilithon?; eleven individuals found in ten samples from a variety of substrata in no particular seasonal or spatial pattern.

N. *nigrii* De Notaris

{Granetti (1968) p. 428, Figs. 1-2; this has finer striae (30 in 10 micrometers) than does N. *minima* var. *atomoides* and so is also kept distinct}

Epipelon; over half the individuals found on silt and silted *Spirogyra* at the Little Cedar River station in October 1976; otherwise widespread in low abundance.

N. *notha* Wallace

{Patrick and Reimer (1966) p. 528, Pl. 50, Figs. 10-11}

Epipelon, epilithon?; widespread in low abundance; 2% of two silt samples (165 and 175) and of one rock sample (171) in October 1976.

N. *pelliculosa* (Breb. *ex.* Kütz.) Hilse

{Patrick and Reimer (1966) p. 484, Pl. 46, Fig. 5}

Epipelon, epiphyton; 32% of sample 213 (wood) and 22% of sample 212 (silt) at Washington-Union Access, 21% of sample 207 (*Cladophora*) and 10% of sample 206 (silt) at Shell Rock, 11% of sample 215 (*Klebsormidium*) at Waverly in February 1977; found at all stations in the colder seasons.

N. *protracta* fo. *subcapitata* (Wislouch & Poretzky in Por.) Hust.

{Hustedt (1962) p. 316, Fig. 1434; differs from the nominate variety shown in Patrick and Reimer (1966) p. 471, Pl. 45, Fig. 3, by having broad capitate ends}

Epipelon; greatest abundance on silted surfaces (3% of samples 191 and 193) in February, in the middle stations on the Cedar River, otherwise rare or absent.

N. *pupula* Kütz.

{Patrick and Reimer (1966) p. 495, Pl. 47, Fig. 7}

Epilithon, epipelon, ephiphyton; 5.5% of sample 33 (silt) and 4.5% of sample 119 (sand and rock); found at all stations in a variety of seasons.

N. *pygmaea* Kütz.

{Patrick and Reimer (1966) p. 442, Pl. 39, Fig. 4}

Epipelon; 18 individuals found in 15 samples; never over 1%; no pattern.

N. *radiosa* var. *parva* Wallace

{Patrick and Reimer (1966) p. 510, Pl. 48, Figs. 16}

Epilithon; 40 found in 21 samples; never repeated the second year.

N. *radiosa* var. *tenella* (Breb. *ex* Kütz.) Grun.

{Patrick and Reimer (1966) p. 510, Pl. 48, Fig. 17}

Epilithon, epiphyton; 29 found in 3 samples with 27 in sample 188 (*Cladophora*).

N. *rhynchocephala* Kütz.

{Patrick and Reimer (1966) p. 505, Pl. 48, Fig. 6}

Epilithon, epiphyton; 26 individuals found in 11 samples with 14 found in sample 1 (silted rock); found only in the first three samplings at scattered locations in the lower part of the basin.

N. *rhynchocephala* var. *germainii* (Wallace) Patr.

{Patrick and Reimer (1966) p. 506, Pl. 48, Fig. 8}

Epipelon; of 10 samples where this was between 4-6% in abundance, seven were obviously silted (samples 10, 14, 29, 33, 124, 126, 128), two were from rock surfaces (13 and 28) and one was of algae on wood (11); this taxon peaked in abundance at the Cedar River stations above Cedar Bend in October 1975 and in the following August, was less abundant in October 1976 and lesser still at other seasons; a similar pattern held for the other stations with abundances reduced so much that this taxon was not often found in counts of 500 during unfavorable seasons.

N. salinarum var. *intermedia* (Grun.) Cl.
[Patrick and Reimer (1966) p. 503, Pl. 48, Fig. 2; the alternating pattern of length of the central striae important to recognizing this taxon varies considerably on valves of the same frustule and even from side-to-side of the same valve; the capitate ends have a more pronounced protraction than occurs in *N. cryptocephala* with which it seems most easily confused in this flora]
Epipelon; found in 193 samples (90%); most abundant on samples involving noticeable silt (25% of sample 17, 22% of sample 20, 20% of sample 16), or rock surfaces (26% of sample 152, 16% of sample 15) or plants (23% of sample 21); seasonal peak abundances occurred in October and May with occasional high values in February at all stations except Finchford where it was seldom counted.

N. seminulum var. *intermedia* Hust.
[Hustedt (1962) pp. 242-243, Fig. 1368; Lowe (1972) also illustrates this taxon]
Epipelon, epiphyton?; greatest abundance on *Cladophora* (6% of sample 9) with lesser numbers on a variety of algae and silted algae or silt samples; widespread in small numbers.

N. symmetrica Patr.
[Patrick and Reimer (1966) p. 513, Pl. 49, Fig. 2]
Epiphyton; between 5-10% of 5 epiphytic samples; greatest abundance in August at most stations.

N. tenelloides Hust.
[Patrick and Reimer (1966) p. 534, Pl. 51, Fig. 7]
Epipelon; greatest abundance on silt samples (14% of sample 211, 4% of sample 194); found at all stations at some time but developing greatest abundance in the more recent samples.

N. tripunctata (O.F. Mull.) Bory
[Patrick and Reimer (1966) p. 513, Pl. 49, Fig.3]
Epilithon, epiphyton; formed massive growths on woody and rock surfaces in the upper Cedar River in May (82% of sample 85, 66% of sample 88, 65% of sample 86, 57% of sample 84, 41% of sample 82); seldom found in August samples; it seemed to be replaced in February 1976 by variety *schizonemoides*.

N. tripunctata var. *schizonemoides* (V.H.) Patr.
[Patrick and Reimer (1966) p. 514, Pl. 49, Fig. 4]
Epipelon, epilithon; most numerous in February 1976 on silted samples and wood (19% of 47, 13% of 69, 12% of 49, 10% of 56); rarely observed otherwise.

N. viridula (Kütz.) Ehr.
[Patrick and Reimer (1966) p. 506, Pl. 48, Fig. 9]
Epipelon; epilithon?; 31 individuals found in 25 samples, mostly of silt in the Cedar and Little Cedar Rivers.

N. viridula var. *argunensis* Skv.
[Skvortzow (1938) p. 408, Pl. 1, Figs. 9 & 33; larger (28-33 micrometers in the Cedar River, but smaller than the 32-35 in the original description) and more linear than *N. heufleri* var. *leptocephala* which it resembles somewhat, also its striae (12-15 in 10 micrometers) are more distinct as is typical of the *viridula* taxon]
Epipelon (the original description says "Habit. inter Potamogeton"); 1-3% of 3 samples of silt (numbers 198, 208, 211); most occurrences were in February 1977.

N. viridula var. *rostellata* (Kütz.) Cl.
[Patrick and Reimer (1966) pp. 507-508, Pl. 48, Fig. 12]
Epipelon, epilithon; 6-11% of 8 samples with noticeable silt and one from a rock surface; found at all stations in all seasons with the exception of the upper Shell Rock and Winnebago Rivers where this taxon was usually absent.

Neidium dubium (Ehr.) Cl.
[Patrick and Reimer (1966) pp. 404-405, Pl. 37, Fig. 5]
Epipelon; epilithon; found in the Cedar River only in August 1976, but occurred during other seasons in tributaries.

Stauroneis smithii Grun.
[Patrick and Reimer (1966) p. 365, Pl. 30, Fig. 12]
Epilithon, epipelon; five individuals found in four samples all but one from the uppermost station on the Winnebago River.

Amphora ovalis var. *affinis* (Kütz.) V.H. *ex* De T.
[Patrick and Reimer (1975) p. 69, Pl. 13, Figs. 3-4]
Epilithon, epipsammon; 28 individuals found in 17 samples from all substrata especially those with silt, most from the Shell Rock River.

A. perpusilla (Grun.) Grun.
[Patrick and Reimer (1975) p. 70, Pl. 13, Figs. 8a-11b]
Epilithon; greatest abundance on rock and wood (22% of sample 192, 11% of 129 and 168, 10% of 132) but widespread in all seasons and probably spread widely in the seston.

A. submontana Hust.
[Patrick and Reimer (1975) pp. 76-77, Pl. 14, Figs. 7a-b, however the striae are difficult to resolve]
Epilithon, epipelon; greatest abundance in two silt samples from the lowest stations on the Cedar River in February 1977 (14% of sample 211, 3% of sample 212; otherwise its distribution is scattered.

A. veneta Kütz.
[Patrick and Reimer (1975) pp. 72-73, Pl. 14, Figs. 2-3]
Epilithon, epiphyton?; eight individuals found in six samples from the upper Shell Rock and Winnebago all involving algae or silt.

Cymbella affinis Kütz.
[Patrick and Reimer (1975) p. 57, Pl. 10, Fig. 7; the teratological form "excised" on the mid-ventral margin has been observed in addition to a form with two isolated stigmata at the end of the central striae on the ventral side]
Epiphyton, epilithon; ten individuals found in six samples on algae, wood, or silt in October 1976 and February 1977.

C. microcephala Grun.
[Patrick and Reimer (1975) pp. 33-34, Pl. 4, Figs. 12a-13b]
Epiphyton; greatest abundance on *Cladophora* (5.5% of sample 188), otherwise epiphytic or in silt, usually in October samples.

C. minuta Hilse *ex* Rabh.
[Patrick and Reimer (1975) pp. 47-48, Pl. 8, Figs. 1a-4b]
Epiphyton, epilithon; 16% of sample 188 (*Cladophora*), otherwise less than 3% of any sample from any station at any season.

C. minuta fo. *latens* (Krasske) Reimer
[Patrick and Reimer (1975) p. 49, Pl. 8, Figs. 5a-6b]
Epiphyton?; nine individuals observed in six samples.

C. prostrata (Berk.) Cl.
[Patrick and Reimer (1975) p. 40, Pl. 6, Fig. 4]
Epilithon; eight individuals found in five samples.

C. sinuata Gregory
[Patrick and Reimer (1975) p. 51, Pl. 9, Figs. 3a-4b]
Epilithon; 73 found in 38 samples, most from the upper Cedar River and Little Cedar River.

C. tumida (Breb. *ex* Kütz.) V.H.
[Patrick and Reimer (1975) p. 58, Pl. 10, Fig. 8]
Epilithon; 4% of a rock sample from Finchford in October 1976,

otherwise found in small numbers at most locations and in most seasons.

Gomphonema angustatum (Kütz.) Rabh.
[Patrick and Reimer (1975) p. 125, Pl. 17, Figs. 17-19]
Epilithon, epiphyton; 60% of sample 171 (rock), 28% of sample 52 (grass in the mouth of an agricultural ditch), 9% of sample 94 (*Cladophora*), all above Mason City on the Winnebago River; found in small numbers downstream from there and elsewhere at all seasons.

G. angustatum var. *citera* (Hohn & Hellerm.) Patr.
[Patrick and Reimer (1975) pp. 125-126, Pl. 17, Fig. 14]
Epilithon, epiphyton; seven individuals found in 4 samples from a variety of substrata in February 1977 at stations on the Shell Rock and its tributaries.
This is a new Iowa record.

G. clevei Fricke
[Patrick and Reimer (1975) p. 138, Pl. 18, Fig. 6]
Epilithon, epipelon; 28% of sample 132 (silt on rock) in August at the station where *G. angustatum* is abundant at other seasons, otherwise less than 3% of a variety of substrata many with silt; found at any station in one season or another.

G. curtum Hust. [=*Gomphoneis curta* (Hust.) Lange-Bert.]
[Hustedt (1945) pp. 939-940, Pl. 42, Figs. 37-43; Lange-Bertalot (1987b) p. 405, Pl. 10, Figs. 4-10, Pl. 11, Figs. 1-4; Hustedt described the values as elliptical-club shaped with convex sides and with ends blunt, rounded, and at times a little produced; length: 10-22 micrometers, breadth: 5-6 micrometers, striae: 18-20 in 10 micrometers; the Cedar River specimens fit this with two exceptions which are being studied further: (1) a few frustules are found which are 30-35 micrometers long, and (2) both small and large frustules have been found which have one valve as described and one valve with a coarser striae count; such smaller valves match the description of *G. tergestinum* (see below) while the larger valves resemble *G. subclavatum* (see below)]
Epiphyton; 80 individuals found in 6 samples; 7% and less on *Cladophora* at Waverly in October; also found in February 1977 at Waverly (*Cladophora*) and Shell Rock (silt).

G. dichotomum Kütz.
[Patrick and Reimer (1975) pp. 135-136, Pl. 18, Figs. 2-3]
Epiphyton, epipelon; 2-3% of samples 71 (silted rock) and 182 (*Cladophora*); found in February and October on the Cedar and Shell Rock Rivers and in May 1976 on the Shell Rock in all three samples from Rock Falls.

G. olivaceum (Lyngbye) Kütz. [=*Gomphoneis olivacea* (Lyngbye) Dawson]
[Patrick and Reimer (1975) pp. 139-140, Pl. 18, Figs. 13-14]
Epiphyton, epilithon, epipelon; greater than 20% of 9 February samples found on rock (85% of sample 44, 29% of sample 47), on wood (25% of sample 43, 21% of sample 195, 20% of sample 213), as a flocculent layer on silt (70% of sample 55, 20% of sample 210), and epiphytic on grass (23% of sample 50) and on *Cladophora* (26% of sample 207) from several different stations each year; found at all stations in different seasons but with much reduced abundance in May, August, and October.

G. parvulum (Kütz.) Kütz.
[Patrick and Reimer (1975) pp. 122-123, Pl. 17, Figs. 7-12]
Epilithon, epiphyton; 27% of sample 139 (*Cladophora*) at Marble Rock where this taxon was most abundant in all seasons; found at all stations in most seasons.

G. subclavatum (Grun.) Grun.
[Patrick and Reimer (1975) p. 129, Pl. 16, Fig. 10]
Epilithon, epiphyton; ten individuals found in nine samples from rock or algal substrata.

G. subclavatum var. 22
[closely resembles Patrick and Reimer (1975) Pl. 16, Fig. 13, but not Fig. 12 which is also called var. *mexicanum* and which seems to be a separate taxon; the Cedar River specimens have more variable dimensions — length: 24-62 micrometers, breadth: 9.5-13 micrometers, striae: 10-12 in 10 micrometers near the center of the valve becoming 14-16 at the ends; the greater breadth and striae count suggest that this is a new variety]
Epiphyton, epilithon; 83rd in total abundance but found in only 6 samples in August and October 1976; most abundant on *Cladophora* at Marble Rock (18% of sample 139 and 3% of sample 177).

G. tergestinum (Grun.) Fricke
[Patrick and Reimer (1975) p. 136, Pl. 18, Fig. 5]
Epiphyton; of the 12 samples in which this taxon was more than 2% in abundance, all were from *Cladophora;* greatest abundance was 41% of samples 91 and 177; except for sample 91, most occurrences were in October and February samples. This taxon has so far only been reported in Iowa from the Cedar River (Main 1977).

Rhoicosphenia curvata (Kütz.) Grun. *ex.* Rabh.
[Patrick and Reimer (1966) pp. 282-283, Pl. 20, Figs. 1-5]
Epiphyton, epilithon; usually found in the middle stations on the Shell Rock and Cedar Rivers with greatest abundance on *Cladophora* at Charles City in October 1976 (47%); above 5% in epiphyton only (14 of 127 samples).

EPITHEMIALES

Epithemia adnata (Kütz.) Breb.
[Patrick and Reimer (1975) pp. 179-180, Pl. 24, Figs. 3-4]
Epiphyton?; five individuals found in four samples, all but one silt, suggesting that these were washed in from upstream.

NITZSCHIALES

Cylindrotheca gracilis (Breb.) Grun.
[Hustedt (1930) p. 393, Fig. 746]
Settled from plankton?; 14 individuals found in 12 samples from all substrata in the Cedar River.

Nitzschia accedens Hust.
[Hohn and Hellerman (1963) p. 314, Pl. V, Fig. 13; a few specimens were longer than their description reaching 45 micrometers]
Epipelon; ten individuals found in seven samples, mostly of silt. No previous published report from Iowa.

N. acicularioides Hust.
[Hustedt (1959) pp. 415-416, Figs. 22-24]
Epipelon, epilithon; 26-23% of three silt samples (numbers 90, 100, 106) and 10-14% of four samples from wood or rock (89, 101, 102, 107) in May 1976 from stations from Rock Falls downstream on the Shell Rock and Cedar Rivers; widespread in smaller numbers.

N. acicularis (Kütz.) W. Sm.
[Hustedt (1930) p. 423, Fig. 821]
Epipelon; all 14 samples with relative abundance ranging for 20-78% were from silted substrata; most abundant in May with October next; found at all stations.

N. alpina Hust. *emend* Lange-Bert.
[Lange-Bertalot (1980) pp. 42-43, Fig. 54-62, except Fig. 58 which has concave sides and is very similar to diatoms reported in this study as *N. elegantula*]
Epipelon; 17% of sample 211 (silt); counted only in February 1977 in the Cedar and Winnebago Rivers. This appears to be the first report of this taxon from Iowa waters.

N. amphibia Grun.
[Hustedt (1930) p. 414, Fig. 793]
Epiphyton, epipelon; greatest abundance in two *Cladophora* samples (13% of sample 139, 8% of 177); 1-3% on variety of other substrata; somewhat more abundant in August samples at most stations.

N. angustata (W. Sm.) Grun.
[Hustedt (1930) p. 402, Fig. 767]
Epipelon; eight individuals found in seven samples in August and October 1976, mostly from silt.

N. apiculata (Greg.) Grun.
[Hustedt (1930) p. 401, Fig. 765]
Epipelon; never over 2% of a sample; found at all stations in at least two seasons.

N. biacrula Hohn & Hellerm.
[Hohn and Hellerman (1963) p. 315, Pl. 4, Figs. 40-41]
Epipelon, epilithon?; almost 1% of six samples from rock and/or silt samples; most commonly observed in May samples except at Shell Rock River stations where it was seldom counted. This has not been previously published from Iowa waters.

N. calida Grun.
[Schoeman and Archibald (1976)]
Epipelon; 39 individuals found in 27 samples from a wide variety of substrata; never more than 1% of any sample; widespread except for West Fork and Shell Rock Rivers.

N. capitellata Hust.
[Hustedt (1930) p. 414, Fig. 792]
Epipelon; 35 individuals found in nine samples; most observations were in October 1975; over 1% of two samples involving silt (samples 20 and 17).

N. closterium V.H.
[Hustedt (1930) p. 424, Fig. 822]
Epipelon; 22% of sample 134 (silt) and 2-7% of four other samples from a variety of substrata in August from the Winnebago River and stations downstream on the Shell Rock River.

N. dissipata (Kütz.) Grun.
[Hustedt (1930) p. 412, Fig. 789]
Epipelon, epiphyton; found in 195 samples (90%); greatest abundance in silted samples (56% of sample 56, 49% of sample 71, 23% of sample 70); 10-20% of seven samples, all but one (sample 9 on *Cladophora*) noticeably silted; most often absent or lowest in abundance at a station in August.

N. elegans Hust.
[Hohn and Hellerman (1963) p. 318, Pl. V, Fig. 9]
Epipelon; 39 individuals found in 21 samples; always less than 1% of a sample; most frequent in August.

N. elegantula Grun.
[Schoeman and Archibald (1976)]
Epipelon; 2-11% of five samples from silt or silted substrata; most abundant in August samples from the upper Shell Rock River, Winnebago River and middle Cedar River stations; over 50% of the total count was from Portland in August and October 1976 and February 1977. This appears to be the first published report of this taxon from Iowa waters.

N. fonticola Grun. in V.H.
[Hustedt (1930) p. 415, Fig. 800]
Epipelon; over 20% of two samples from silted algae at Marble Rock (49% of sample 202 in February 1977, 21% of sample 138 in August 1976); from 2-7% of 17 samples, 14 of which were from obviously silted substrata; least abundant in February and May 1976, otherwise found at most stations.

N. frequens Hust.
[Hohn and Hellerman (1963) p. 318, Pl. V, Fig. 7]
Epipelon; epilithon; the six samples with 1-2% of this taxon included silt, rock, and silted rock samples; found each season from at least one station with widest distribution and greatest abundance in May and August.

N. frustulum (Kütz.) Rabh.
[Hustedt (1930) pp. 414-415, Fig. 795]
Epiphyton, epipelon; 1-2% of six samples from silt or algal substrata from scattered dates and locations.

N. gandersheimiensis fo. *tenuirostris* Grun. in V.H. *emend* Lange-Bert.
[Lange-Bertalot (1980) pp. 47-48, Figs. 3-6; previously reported from the Cedar River (Main 1977) and from other Iowa waters as *N. subcapitellata* Hust.]
Epipelon; counted in 199 samples (92%); 47% of sample 140, 22% of both samples 29 and 170, all from silted substrata; 5-10% of eight samples all but 2 from obviously silted substrata; found at all stations in all seasons.

N. gracilis Hantzsch
[Hustedt (1930) pp. 416-417, Fig. 794]
Epipelon?, epilithon?; almost 2% of two samples from wood and silted rock at Washington-Union Access in May; only two other observations of single individuals.

N. graciliformis Lange-Bert. & Sim.
[Lange-Bertalot and Simonsen (1978) pp. 33-34, Fig. 215]
Epipelon; 27% of sample 54 (silt) and 10-20% of three other silt samples (samples 53, 66, 67); 90% of the individuals counted were from February samples when it was found at all but two stations.

N. hungarica Grun.
[Hustedt (1930) pp. 401-402, Fig. 766]
Epipelon; exceeded 1% of only three samples (samples 10, 103, 170) all of which were silt; widespread for a low abundance diatom; found in most seasons at stations other than the lower Cedar and Shell Rock Rivers.

N. incomptus Hohn & Hellerm.
[Hohn and Hellerman (1963) p. 318, Pl. IV, Fig 43]
Epipelon; about 1% of four samples from silt or *Spirogyra* samples; found only in August in the Cedar and Little Cedar Rivers. This appears to be the first published report of this taxon from Iowa waters.

N. inconspicua Grun.
[Lange-Bertalot (1977) pp. 265-266, Taf. 2, Fig. 22-25, 27a; previously identified from the Cedar River and probably from many other Iowa waters as *N. frustulum* var. *perpusilla* (Main 1977)]
Epilithon, epiphyton?; 20-40% of six samples, four from silt (37% of sample 204, 30% of sample 175, 29% of sample 165, 20% of sample 157) and two from *Cladophora* (29% of sample 156, 26% of 176) from the same stations as two of the silt samples; widespread at all stations in most seasons.

N. lauenburgiana Hust.
[Hohn and Hellerman (1963) p. 318, Pl. V, Fig. 12; Lange-Bertalot (1977) included this in *N. gandersheimiensis*, but the specimens in the Cedar River do not overlap with any other taxa similarly treated by Lange-Bertalot]
Epipelon, epilithon; 20-46% of 14 samples from silted substrata and wood in February 1976; 2-8% of six samples (four silted, one wood, one rock) in May 1976; 2-6% of eight samples from similar substrata in February 1977; the only station where it was not abundant in February 1976 was the uppermost on the Winnebago River; the cause of the severe reduction in maximum abundance in February 1977 appears to be the more rapid ice breakup and subsequent flooding.

N. linearis (Agardh) W. Sm.
[Hustedt (1930) p. 409, Fig. 784]
Epipelon, epilithon?; 21% of sample 64 (silt on rock) and 20% of sample 65 (silt) from the West Fork; most abundant at each station in February or May 1976.

N. linkei Hust.
[Hustedt (1939) p. 661, Fig. 114]
Epipelon; twelve individuals found in six samples from the fall and winter. This appears to be the first published Iowa report of this taxon.

N. palea (Kütz.) W. Sm.
{Hustedt (1930) p. 416, Fig. 801}
Epiphyton, epipelon; 5-10% of five samples from *Spirogyra* (2), *Cladophora,* wood, and silt; found at all stations in most seasons.

N. perminuta Grun.
{Lange-Bertalot (1977) p. 263, Pl. 2, Fig. 9-10; Hustedt (1930) p. 415 as *N. frustulum* var. *perminuta}*
Epipelon; 4% of one silt sample in August; one individual counted in each of six scattered samples.

N. pertica Hohn & Hellerm.
{Hohn and Hellerman (1963) p. 320, Pl. V, Fig. 10}
Epipelon; 4% of sample 140 (August, silt); 1-2% of 3 silt samples and of one rock sample; found at all stations in at least two seasons but most abundant in all seasons in the Shell Rock and Winnebago Rivers.

N. pumilla Hust.
{Lange-Bertalot and Simonsen (1978) p. 45, Pl. 9, Figs. 149-150, not 151-154 which represent emendations to Hustedt's taxon which do not appear to occur in the Cedar River}
Epipelon; ten individuals from five samples from a variety of silted substrata in August 1976 and February 1977 at scattered stations.

N. pusilla (Kütz.) Grun. *emend* Lange-Bert.
{Lange-Bertalot (1977) pp. 273-275, Pl. 7, Figs. 1-10; whether Grunow's name can be applied to this taxon is in doubt because it apparently cannot be shown conclusively that the taxon Grunow described is the same that Kutzing described; in either case the taxon depicted by Lange-Bertalot (1977) seems identical to the Cedar River specimens observed with light microscopy; this taxon has also been called *N. latens* Hust.}
Epipelon; 24% and 14% of two silt samples from above Mason City in February 1976; 2-3% of six samples involving silt from several other stations; widespread in most seasons. First published report from Iowa waters.

N. recta Hantzsch
{Hustedt (1930) p. 411, Fig. 785}
Epilithon?, epipelon?; seven individuals found in six samples most of which were from silted rocks at stations on the Cedar and Winnebago Rivers.

N. sigma (Kütz.) W. Sm.
{Hustedt (1930) p. 420, Fig. 813}
Epipelon; six individuals found in five samples from silted substrata on the Cedar and Winnebago Rivers.

N. sigmoidea (Nitz.) W. Sm.
{Hustedt (1930) p. 419, Fig. 810}
Epipelon; 1-3% of three silted samples in February 1976; not counted in August; widely distributed in small numbers.

N. subrostratoides Choln.
{Cholnoky (1966) p. 59, Taf. 6, Figs. 171-173}
Epipelon?; 1-3% of six samples from a variety of substrata, half with obvious silt; found at most stations in August, rarely in October 1976 and February 1977.

N. supralitorea Lange-Bert.
{Lange-Bertalot (1979) p. 215, Figs. 25-26}
Epipelon?; found in most samples from the lower Cedar River and West Fork Rivers in February 1977. Firsr published report from Iowa waters.

N. tenuis W. Sm. *emend* Lange-Bert. & Sim.
{Lange-Bertalot and Simonsen (1978) p. 56, Figs. 222-230}
Epilithon, epipelon; 2-6% of 12 samples from rock and/or silt substrata; widespread in most seasons, least so in August.

N. tryblionella var. *levidensis* (W. Sm.) Grun.
{Hustedt (1930) p. 399, Fig. 760}
Epipelon; less than 1% of eight samples, most from silted substrata in August.

N. tryblionella var. *victoriae* Grun.
{Hustedt (1930) p. 399, Fig. 758}
Epipelon, epilithon?; less than 1% of eight samples from wood, rock, and/or silt from the Cedar River in August 1976 and February 1977.

N. tryblionella var. 1
{Resembles var. *levidensis* but with only 7-9 fibulae/10 micrometers instead of 12}
Epipelon, epiphyton?; six individuals found in separate samples most from silted substrata with two including algae; scattered locations and seasons.

N. umbonata (Ehr.) Lange-Bert.
{Lange-Bertalot (1978a)}
Epipelon; never more than 2% of a sample; all samples with more than one counted are from silted substrata; most occurrences were in May at widespread stations; occurred in most other seasons.

N. vermicularis (Kütz.) Hantz.
{Hustedt (1930) p. 419, Fig. 811}
Epipelon; 2-5% of five silt samples; found at all stations except Floyd in February and/or May 1976; found on all sample dates only at Charles City.

SURIRELLALES

Cymatopleura solea (Breb.) W. Smith
{Hustedt (1930) pp. 425-426, Fig. 823a}
Epipelon; widespread (75 samples) where silt occurred but never over 3% of a sample.

Surirella angusta Kütz.
{Hustedt (1930) p. 435, Figs. 844-845}
Epilithon, epipelon; greatest abundance was 2-8% of five samples from silt and/or wood in February 1976 and 1977 at different locations; widespread in small numbers.

S. iowensis Lowe
{Lowe (1972) p. 69, Pl. V, Figs. 2-3}
Epipelon, epilithon?; 13 individuals found in eight samples from silt or rock; most were found at two stations (Finchford and above Mason City) in the first year of sampling.

S. ovata Kütz.
{Hustedt (1930) p. 442, Fig. 863-864}
Epipelon, epilithon; 4-12% of seven samples from wood and/or silt; most abundant in February or May at all stations.

S. ovata var. *pinnata* (W. Sm.) Hust.
{Hustedt (1930) p. 442, Fig. 865}
Epipelon, epilithon; 4-14% of six samples of silt or silt on rock or wood; most abundant in February samples.

S. ovata var. *salina* W. Sm.
{Hustedt (1930) p. 442, Fig. 866}
Epipelon; six individuals found in six samples, mostly of silt; only counted in the Cedar and Little Cedar Rivers.

S. robusta var. *splendida* (Ehr.) Cl.
{Hustedt (1930) p. 437, Figs. 851-852}
Epipelon; eight individuals found in seven samples, mostly of silt.

DISCUSSION

The significant environmental factors influencing the occurrence of benthic diatoms in the Cedar River basin include natural seasonal factors as well as water quality factors which can be influenced by human activities. The presence of silt modifies habitat conditions on most substrata available. All stations in all seasons were characterized by alkaline hard waters, aerobic conditions, and sufficient quantities of major nutrients for growth.

The earliest known report of diatoms from Iowa is that by Ehrenberg (1856: 84-86) who listed about 75 diatoms from the Des Moines River at Ft. Dodge (Reimer, personal communication). Dodd (1971) has reported over 900 diatom taxa from the state of Iowa. Reimer (personal communication) has curated over 400 taxa in the Iowa Lakeside Laboratory Diatom Herbarium. The Cedar River diatoms reported here add thirty-four to the published list of Iowa diatoms. The more abundant new records include the following fourteen taxa: *Navicula gregaria*, *N. ingenua*, *N. monoculata*, *Gomphonema angustatum* var. *citera*, *G. curtum*, *G. tergestinum*, *Nitzschia accedens*, *N. alpina*, *N. biacrula*, *N. elegantula*, *N. incomptus*, *N. linkei*, *N. pusilla*, and *N. supralitorea*. Of these *N. gregaria*, *G. tergestinum*, and *N. pusilla* were most abundant and widespread. Additions to the published flora of Iowa also include twenty rarer taxa: *Cocconeis fluviatilis*, *Coscinodiscus lacustris*, *Fragilaria construens* var. *subsalina*, *F. ulna* var. *oxyrhynchus* fo. *mediocontracta*, *Gomphonema consector*, *G. instablis*, *G. subclavatum* var. *montanum*, *Gyrosigma exilis*, *Navicula barbarica*, *N. difficillima*, *N. exigua* var. *signata*, *N. seminulum* var. *hustedtii*, *N. zanoni*, *Nitzschia amphioxoides*, *N. bryophila*, *N. radicula*, *N. tryblionella* var. *subsalina*, *N. zululandica*, *Pinnularia fasciata*, and *Rhopalodia musculus*. Some of these taxa are no doubt chance occurrences due to dispersal and may never be found here again.

The benthic diatom flora throughout the portions of the Cedar River basin included in this study appears homogeneous. The dominant taxa (Fig. 2) occurred at stations on all parts of the river basin. Many of these taxa, such as *Cyclotella meneghiniana* and *Diatoma vulgare*, are known to be abundant when nutrient levels are fairly high (Williams and Scott 1962; Lowe 1974). These two taxa occur numerous times in excess of 50% of a diatom sample. Another group of taxa contributes to homogeneity among the samples. These are widespread (Table 5) but seldom more than 20% of a sample. Diatoms having this pattern of distribution and abundance include *Nitzschia dissipata*, *N. gandersheimiensis* fo. *tenuirostris*, *N. amphibia*, *N. palea*, *N. linearis*, *N. tenuis*, *Navicula salinarum* var. *intermedia*, *N. cryptocephala* var. *veneta*, *N. viridula* var. *rostellata*, *N. luzonensis*, *Amphora perpusilla*. These diatoms characterize the Cedar River flora as much as do the dominants in the sense that this group of widespread intermediate abundance diatoms may represent the more stable component of benthic diatom associations in the Cedar River.

The rare taxa (Table 4) represent an interesting set of diatoms in the context of community history. Some of these may represent a sort of background of taxa able to become abundant should conditions change in an appropriate direction. Others may be slowly disappearing because present conditions represent a change from a more favorable past environment. In the case of the Cedar River, some may even represent frustules that have been eroded from upstream bedrock. It seems virtually impossible microscopically to recognize in a heavily silted fresh collection the presence of rare empty frustules of any but the largest of such potential fossil diatoms. After acid treatment such a judgement is obviously much harder. In an acid treated sample, however, one wonders when looking at a valve that appears heavily eroded, whether it may have been sitting empty in the sediments, and if so, for how long. This aspect of diatom ecology needs further investigation.

There are some differences in diatom distribution and abundance between the smaller tributaries and the lower parts of the main channels of the Shell Rock and Cedar Rivers (Table 5). Some epipelic/planktonic diatoms such as *S. potamos* and *M. italica* are more abundant in seston in larger streams while others like *M. granulata* var. *angustissima* are more abundant in smaller tributaries. The pattern insofar as abundant taxa are involved is not of restriction from one stream or another so much as it is a difference in relative abundance.

Seasonal changes in the diatom flora occurred, but from one year to the next there were usually variations in the relative abundance of the most abundant taxa (Fig. 2) and in the occurrence of some of the diatoms with smaller population sizes (Table 4). Since the actual date of sampling varied by up to two weeks and there were differences in seasonal weather patterns, the absence of a strong pattern in composition of the diatom flora from one year to the next may be an artifact of the sampling date selection.

Substratum affinities occur but the expected distribution patterns often disappear from the effects of heavy deposition of silt laden with diatom taxa from the plankton or eroded from upstream habitats. Many of the taxa identified in this study as epipelon have been described by others as plankton. The occurrence of planktonic centrics as the most abundant diatoms in the benthic attached flora may be an indication of the prominence of deposition in the ecology of the Cedar River. However examination of fresh samples indicates that these centrics when abundant are healthy growing members of the association. It also appears that silt deposits include a large proportion of sestonic diatoms which may be of benthic or planktonic origin and may grow in sestonic associations. Plankton and seston samples are now being collected along with haptobenthos in an attempt to better define these interactions in the Cedar River.

Microscopical examination of fresh samples indicated that most diatoms present appeared healthy; relatively few empty frustules were observed. In a few cases where samples were held for up to four weeks in a refrigerator (10 degrees C) little apparent change in species abundance or composition was detected on reexamination, although senescence became apparent. In one case there was evidence of cell division associated with morphological variation (manuscript in preparation). The most samples (6) with more than 10% empty frustules of any taxon occurred during May when the water levels remained considerably elevated after the spring flooding.

Empty or senescent frustules may have resulted from other conditions as well. Inhibiting factors may have been present in the form of agricultural chemicals. Of the potentially hazardous chemicals known to be present, arsenic is probably present in too low a concentration to affect diatom growth, since phosphate levels are high (Sanders 1979). Grazing produces empty or senescent frustules perhaps selectively. Several samples were collected from surfaces where snails had plowed furrows in the material sampled. In the absence of proper controls it cannot be stated that such grazing influenced community structure, but there appeared to be size selection. Under the microscope, numerous examples of ciliates and sarcodinians ingesting diatoms or withdrawing the cell contents could be seen.

This study indicates the need to distinguish, as Pielou (1975) does, between community stability and environmental stability. Flooding also destabilizes the environment in which benthic surficial microorganisms grow. As described in this study, flooding imposes an irregular pattern of instability on the sequential pattern of population abundance resulting from seasonal effects. Erosion of benthic substrata and subsequent siltation presumably make colonization by new taxa more possible than would be likely if the substratum were already colonized. Evaluation of samples from succeeding years will help decide whether the diatom portion of the community is fundamentally stable but temporarily responding to short term disturbance or making a long term response to a continuing environmental change.

Lotspeich (1980) discussed the need to classify watersheds as ecosystems based on the integrative response of the stream to the geology, climate, soil, vegetation and human land use of the watershed. It remains to be seen how well the benthic diatoms of the Cedar River integrate the ecosystems formed by the surrounding watershed units. These surface growing producers do seem to be responding to factors beyond the substratum and seasonal cycles of the river itself. Floods and associated turbidity need to be evaluated more fully in terms of historical patterns and the influence of human disturbance in the watershed.

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