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A Review of Research Studies at Mountain Lake, Virginia

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INTRODUCTION

Mountain Lake, Giles County, Virginia (37° 27' 56" N, 80° 31' 39" W) is the only natural lake of significance in the unglaciated highlands of the southern Appalachians (Fig. 1). This oligotrophic montane lake located at 1181m (3875 ft) elevation near the summit of Salt Pond Mountain occupies a relatively small, undisturbed watershed which is about five times the surface area of the full lake. All surface outflow of water occurs at the northwest end into Pond Drain, then Little Stony Creek and the New River. Although Mountain Lake (or Salt Pond) has been known since its discovery by the British surveyor Christopher Gist in 1751 (Johnston, 1898), it remained free of published scientific studies until 1884. This first and many subsequent scientific studies of Mountain Lake are scattered widely among various journals, books, documents, and theses (often unpublished or obscure), making acquisition and compilation difficult. Yet this literature is relevant and often essential for future investigations, especially in the physical, chemical, and biological limnology, the geology, and the origin and paleohistory of Mountain Lake. Accordingly, a brief chronological review of the pertinent scientific literature on Mountain Lake with some previously unpublished new information from the author's laboratory and field records are here included.

LITERATURE REVIEW

Rogers' (1884) geological studies of the Virginias comprises the first scientific work on Mountain Lake, published posthumously. Rogers investigated the geology around the lake during his appointment as Director of the Geological Survey of Virginia (today's Virginia and West Virginia) in 1835-1841. The following excerpts beginning on page 109 are especially informative:

> *One of the most curious objects in the particular district which we have just been treating, is the lake near the summit of Salt Pond Mountain ... This beautiful sheet of water is situated at the intersection of the Salt Pond Mountain and several of its spurs, and not as is commonly supposed, on the top of the mountain. Its height above the base of the mountain, is probably from 900 to 1000 feet, but it is surrounded by steep and lofty hills on every side, excepting that by which it is approached, and that through which its water finds a small outlet, falling in a picturesque cascade of great height, and then flowing rapidly into the creek below. The outlet appears formerly to have been deeper than at present, and the extent of the lake was therefore much less than it now is. Rocks and earth gradually accumulating at the passage, have dammed the waters up, and hence the trees and shrubs which grew upon its margin, may now be seen sometimes standing erect at a considerable depth beneath its surface. Its length is about three quarters of a mile–its greatest width about half a mile. By careful soundings from side to side, in many parts of it, the greatest depth that could be found was from 56 to 60 feet; but such was the transparency of the water, that the bottom could be seen nearly in its deepest parts. No animal is found in it but a small species of salamander or water lizard*. [W. B. Rogers, Director, Geological Survey of Virginia, 1835-41; President, National Academy of Sciences]

Rogers (1884) made several points noteworthy when compared to Mountain Lake today. The "cascade of great height" entering Pond Drain no longer exists; it may have been eliminated when the county road was built along the west side of the lake. Second, the "trees and shrubs" seen "at considerable depth" attest to the dramatic fluctuations in lake levels. These have been documented in Table 1. The lake must have been full in 1835-41 to have a cascade and submerged trees at considerable depth. Rogers' maximum depth measurement of 60 feet shows that he failed to detect the deepest point shown in Fig. 1.

The second scientific study of Mountain Lake was nearly a century later. Williams (1930) conducted the first limnological investigation during the first summer of classes at the University of Virginia's Mountain Lake Biological Station. The lake measured 0.75 mi (1.2 km) long, 0.25 mi (0.40 km) wide, and 110 ft (33.5 m) maximum depth. This was the first report of the great maximum depth, which was only positively verified 69

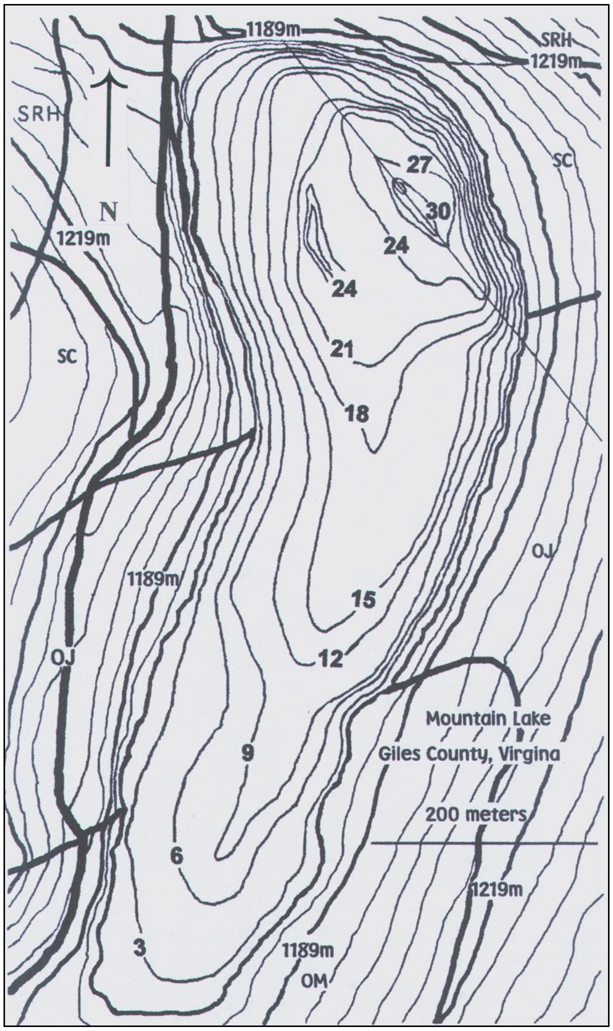

Fig. 1. Sonar bathymetric map of Mountain Lake in 1997 showing the SE to NW fracture trace. Lake depth contours and surrounding USGS topographic contours in meters. OM = Ordovician Martinsburg shale, OJ = Ordovician Juniata sandstone, SC = Silurian Clinch sandstone, SRH = Silurian Rose Hill sandstone.

years later when the first sonar mapping of the lake bathymetry was reported (Cawley, 1999; Cawley et al., 2001b). Surface water temperatures in July-August 1930 were 23.5-24.5 ^{o}C. Williams noted that the lake was fed mostly by springs rather than surface input. Chemically the lake water was characterized by pH 6.4, 30 mg/l bicarbonate, 1.4 mg/l dissolved silica, and no detectable nitrate. Several other variables measured at VPI's Chemistry Department laboratories and reported by Williams may not have been reliable by the analytical methods available in 1930, which moreover were not cited in the thesis. Plankton tows collected 15 green algae and two diatoms (Table 2). Williams also identified one protozoan, one rotifer, and three crustaceans as part of the zooplankton (Table 3).

Hutchinson & Pickford (1932) made two brief visits to Mountain Lake in the summer of 1931, primarily to explore the limnology and origin of the lake. Physical and chemical variables cited were Secchi disk transparency depth (7.0 m), dissolved oxygen (8.0 mg/l at 22 m), soluble phosphate phosphorus (0-3 µg/l at 10 m), nitrate nitrogen (0-20 µg/l at 10 m), and dissolved silica (1.0-2.8 mg/l at 10m). Magnesium, calcium, sulfate, chloride, iron, and several other chemicals also were measured. The net plankton consisted of one blue-green alga, 11 green algae, one diatom, two rotifers, and three cladocerans (Tables 2, 3). Hutchinson & Pickford (1932) also addressed the origin of Mountain Lake primarily by quoting a Mr. G.A. Stone:

> *...a stream flowed north and cut a rocky gap in the Clinch sandstone, which overlies the Martinsburg shale.* [Note that the Juniata sandstone which lies between the Clinch and Martinsburg was either overlooked or assumed to be part of the Clinch Formation.] *The lake was formed by the caving in of overhanging ledges of this hard rock undermined by the stream, large fallen masses clogging the narrow outlet and damming up the stream.*

Sharp (1933) published the first detailed geological study at Mountain Lake and discussed the lake's origin, building upon the earlier work of Rogers (1884) and Hutchinson & Pickford (1932). Sharp states:

> *The valley of a stream flowing through one of these ridges was apparently dammed by blocks creeping downward from the ridge, thus impounding the lake…*

and

> *...great blocks of the* [Clinch] *formation crept downward over the shale slopes, gradually filling the valley bottom just above the notch. The Clinch may also have fallen as talus, or as a rockslide, although there is no evidence of the latter.*

and later

> *Stumps rooted one or two feet below the surface of the lake indicate a fairly recent increase in depth. ...maybe attributed to a more thorough sealing of the interstices of the block dam.*

Once again, the Juniata sandstone lying between the Clinch and Martinsburg was not mentioned.

Ferguson et al. (1939) surveyed the turbellarian fauna in the Mountain Lake region during summer 1938. From the lake they reported 19 species (Table 3). This paper also reports chemical analytical data, such as iron, aluminum oxides, bicarbonates, dissolved silica, calcium, magnesium, nitrates, and dissolved oxygen–all very similar to the data of Hutchinson & Pickford (1932). In addressing the lake's origin, the geological formation description again did not mention the Juniata sandstone. Moreover, Ferguson et al. attributed the lake's origin to "a natural solution collapse basin", proposed earlier by Holden (1938), and claimed that the Martinsburg shale underlying the basin was high in lime content, a point never confirmed by any other investigators (Parker et al., 1975).

Coker & Hayes (1940) during the 1937 summer led their hydrobiology class at the biological station in a study of the biota of Mountain Lake. Using plankton net tows, they found one blue-green, one diatom, one chrysophyte, one coccoid dinoflagellate, six green algae, one protozoan, one copepod, two cladocerans, and two rotifers (Tables 2, 3). Macrophytes collected from the lake included *Elodea*, *Isoetes*, *Alisma plantago-aquatica*, *Eleocharis obtusa*, and an unidentified grass. Secchi disk transparency was 5.5 m. Grover & Coker (1940) added a few other algal taxa (Table 2), as well as counts at different depths for select plankton, based on the same 1937 summer collections while at the biological station. Forest's (1954) checklist of algae in the vicinity of Mountain Lake Biological Station also included a number of species from the lake (Table 2).

McCalla (1942) examined the year-round numbers and distribution of Crustacea in Mountain Lake, 1941-42. His thesis addressed especially the copepod *Diaptomus leptopus* Forbes and the cladocerans *Daphnia pulex* deGeer, *Diaphanosoma brachyurum* Lievin, and *Bosmina obtusirostris* Sars. McCalla also listed a few net phytoplankton and zooplankton, and the deep water midge *Chaoborus* Lichtenstein (Tables 2, 3).

Table 1. Approximate percent of a full Mountain Lake based on 24 historical accounts (see below). Updated since Parker et al. (1975).

YEAR(S)	% of FULL LAKE	SOURCE	YEAR(S)	% of FULL LAKE	SOURCE
1751	80	A	1898-1904	60, 100	L
1768-1804	20	B	1904-05	100	M
1794	50	C	1913	95	J
1820	50	D	1930	95	J
1835	100	E	1935	85	N
1855	100	F	1952-53	85	O
1861	100	G	1959 spring	60	P
1864	100	H	1959 summer	100	P
1865-1869	20	I	1969-97	100	Q
1871	100	G	1997-2000	95	Q
1879	100	J	2001-02	75	R
1885-88	95	K	2003 summer	100	R

Sources: A = Gist 1751, according to Pownall (1776), Darlington (1893), Johnston (1898), Summers (1903), Mulkearn (1954). B = Johnston (1906), Roberts, cited by Lewis (1957). C = Deed to property with sketch (Marland, 1967). D = Lewis (1957). E = Rogers (1884). F = Robert Beyer painting (Wright, 1973). G = Pollard (1870), Pendleton (1920). H = Major Barnett cited by Lewis (1957). I = Mrs. Ingles cited by Lewis (1957). J = Chapman (1949). K = Mrs. Ingles cited by Chapman (1949), Lewis (1957). L = Chapman (1949), Campbell (1898). M = Dietrich (1957). N = Lewis (1957). O = USDA, Soil Conservation Service aerial photograph. P = Mrs. Dolinger, pers. comm. (Parker et al., 1975). Q = Parker and students. R = Parker.

Table 2. Algal taxa reported from Mountain Lake. Classification follows Lee (1999) and Cawley et al. (1999) with taxa listed alphabetically under their classes. Numbers following taxa indicate sources: 1 = Williams (1930), 2 = Hutchinson & Pickford (1932), 3 = Coker & Hayes (1940), 4 = Grover & Coker (1940), 5 = McCalla (1942), 6 = Forest (1954), 7 = Whitford (1964), 8 = Obeng-Asamoa & Parker (1972), 9 = Dubay & Simmons (1979), 10 = Van Brunt (1984), 11 = Jervis (1988), 12 = Parson & Parker (1989b), 13 = Beaty & Parker (1994), 14 = Beaty & Parker (1996a), 15 = Cawley et al. (1999), 16 = Cawley et al. (2001a), 17 = Cawley et al. (2002). Taxa designated ^{b} are primarily benthic, other taxa are primarily planktonic.

CYANOPROKARYOTA	
CYANOPHYCEAE	
Unknown colonial sp.	2
Anabaena sp.	3, 4, 7, 8, 15
Anacystis sp.	7
Aphanocapsa delicatissima West & West	8
Aphanocapsa elachista West & West	8, 12, 14
Aphanocapsa elachista var. conferta West & West	12
Aphanocapsa endophytica G.M. Smith	8
Aphanocapsa rivularia (Carm.) Rabenhorst	12
Aphanothece sp.	1
Aphanothece gelatinosa (Henn.) Lemmermann	8
Aphanothece microscopica Nageli	7, 8, 12, 15
Aphanothece saxicola Naegeli	12
Aphanothece stagnina (Spreng.) A. Braun	6
Chroococcus dispersus (V. Keiss) Lemmermann	8, 12
Chroococcus dispersus var. *minor* G.M. Smith	7, 15
Chroococcus minimum (Keisal.) Lemmermann	12
Chroococcus minor (Kütz.) Naegeli	8
Chroococcus minutus (Kütz.) Naegeli	12, 14
Chroococcus varius A. Braun in Rabenhorst	12
Coccochloris stagnina Spreng. from *Coelosphaerium* sp.	6
Cylindrospermum catenatum Ralfs	6
Dactylococcopsis musicola Hustedt	12
Eucapsis sp.	12
Gloeocapsa halmatodes Kützing	12, 15
Gloeocapsa punctata Naegeli	8
Gloeocapsa sp.	12
Gomphosphaeria wichurae (Hilse) Drouet & Daily	8
Gomphosphaeria sp.	6
Hapalosiphon arboreus West & West	6
Hapalosiphon pumilus (Kütz.) Kirchner	8
Merismopedia glauca (Ehren.) Naegeli	8
Merismopedia punctata Meyen	8
Merismopedia tenuissima Lemmermann	8
Merismopedia sp.	2, 8
Microcystis aeruginosa Kützing	8, 12
Microcystis firma (Bréb. et Lenom.) Schmidle	12
Microcystis incerta Lemmermann	8
Nostoc spongiaeforme C.A. Agardh	12
Oscillatoria sp.	7, 8, 12, 14
Oscillatoria agardhii Gomont	6
Oscillatoria angustissima West & West	12
Phormidium uncinatum (Agardh) Gomont	6, 12
Phormidium sp.	12
Radiocystis geminata Skuja	12
Rivulalia beccariana (De Not.) Born & Flahault	6
Rivularia compactum (Ag.) Born & Flahault	6
Scytonema mirabile (Dillw.) Born	6, 12
Sacconema sp.	6
CHLOROPHYTA	
CHLOROPHYCEAE	
Ankistrodesmus falcatus (Corda) Ralfs	7, 8, 12
Ankistrodesmus falcatus var. *mirabilis* West & West	12
Aphanochaete vermiculoides Wolle (discussed as *Herposteiron vermicularis*)	1
Botryococcus braunii Kützing	8, 12
Botryococcus protuberans var. *minor* G.M. Smith	8
Botryococcus sudeticus Lemmermann	12
Bulbochaete sp.	6, 8, 12, 14
Carteria sp.	10
Chaltosphaeridium sp.	6
Chlamydomonas cienkowskii Schmidle	8
Chlamydomonas globose Snow	8
Chlamydomonas reinhardi Dangeard	10
Chlamydomonas sp.	1, 7, 10, 12, 15
^{b}*Characium cylindricum* Lambert	1
Chlorella vulgaris Beijerinck	8, 12, 15
Chlorococcum sp.	13, 15
Chodatella sp.	13, 15
Coelastrum microsporum Naegeli	12
Crucigenia irregularis Wille	8, 12
Crucigenia quadrata Morren	3, 4, 8, 12, 15
Crucigenia rectangularis (Naeg.) Gay	3, 8, 12
Cylindrocapsa sp.	12
Dictyosphaerium ehrenbergianum Naegeli	8
Dictyosphaerium pulchellum Wood	6, 7, 8, 12
Dictyosphaerium reniforme Bulnhein	6, 7
Dictyosphaeriopsis sp.	3, 4
Dimorphococcus lunatus A. Braun,	3, 4
Elakatothrix gelatinosa Wille	12
Eremosphaera viridis DeBary	4, 6
Eudorina elegans Ehrenberg	7, 15
Gloeoactinum limneticum G.M. Smith	6
Gloeocystis gigas (Kütz.) Lagerheim	8, 12
Gloeocystis maior Gerneck ex Lemmermann	12
Gloeocystis paraliniana (Menegh.) Naegeli	12
Gloeocystis planctonica (West & West) Lemmerman	12,15
Gloeocystis vesiculosa Naegeli	8, 12
Gloeocystis sp.	7
Kirchneriella lunaris (Kirch.) Moebius	8
Kirchneriella obesa (W. West) Schmidle	12
Kirchneriella sp.	2, 6
Lobocystis dichotoma Thompson	12
Microspora stagnorum (Kütz.) Lagerheim	6
Microspora sp.	7
Nephyrocytium agardhianum Naegeli	12
Oedogonium sp.	1, 8, 12, 14
Onychonema filiforme (Ehren.) Roy & Bisset	6
Oocystis borgei Snow	8, 12, 14
Oocystis crassa Wittrock	8
Oocystis elliptica West & West	8
Oocystis eremosphaeria G.M. Smith	12
Oocystis pusilla Hansgirg	12, 15
Oocystis sp.	12
Ourococcus sp.	6
Palmella sp.	6
Pandorina morum (Muell.) Bory	7, 13, 15
Pediastrum araneosum (Racib.) G.M. Smith	8
Pediastrum biradiatum Meyen	12
Pediastrum boryanum (Turp.) Meneghini	8, 15
Pediastrum duplex var. *rugulosum* Raciborski	12
Pediastrum integrum Naegeli	7, 8, 12

Table 2 (continued)

CHLOROPHYCEAE (continued)	
Pediastrum sculptatum G.M. Smith	12
Pediastrum tetras forma *evoluta* West	12
Planktosphaeria gelatinosa G.M. Smith	4, 6, 8
Protoderma viride Kützing	8
Protoderma sp.	6
Quadrigula chodatii (Tan.-Ful.) G.M. Smith	2, 8, 12, 13, 14, 15
Quadrigula closteroides (Bohlin) Printz	12
Quadrigula lacustris (Chod.) G.M. Smith	7, 8
Quadrigula pfitzeyi (Schroder) G.M. Smith	12
Quadrigula sp.	2, 6
Radiofilum conjuctivum Schmidle	8
Rhizoclonium sp.	12
Scenedesmus arcuatus Lemmermann	12
Scenedesmus bijuga (Turp.) Lagerheim	6, 12, 15
Scenedesmus obliquus (Turp.) Kützing	8
Scenedesmus quadricauda (Chod.) G.M. Smith	12
Scenedesmus quadricauda (Turp.) Brébisson var. *quadrispina*	8, 12
Scenedesmus sp.	8
Schoederia setigera (Schroed.) Lemmermann	12
Scourfieldia complanata West	12, 15
Selenastrum sp.	13, 15
Sphaerellopsis gloeocystiformis Dill	12
Sphaerocystis schroeteri Chodat	7, 8, 13, 14
Sphaerocystis sp.	6
Sphaerozoma granulatum Roy & Bissett	7
Stichococcus bacillaris Naegeli	12
[b]*Stigeoclonium flagelliferum* Kützing	12
[b]*Stigeoclonium* sp.	12
Stylosphaeridium stipitatum (Bachm.) Geitler & Gimesi	12
Tetraedron sp.	13, 15
Tetraspora lubrica (Roth) Agardh	1
Tetraspora sp.	12
Trochiscia sp.	13, 15
Volvox aureus Ehrenberg	2, 4, 5, 6, 8, 13, 14
Volvox tertius Meyer	4, 5, 8
Volvox sp.	1
Unknown flagellate sp.	8, 12
ULVOPHYCEAE	
[b]*Ulothrix subconstricta* G.S. West	12
CHAROPHYCEAE	
Arthrodesmus incus (Bréb.) Hassall	6
Arthrodesmus octocornis Ehrenberg	6
Arthrodesmus phimus Turner	12
Arthrodesmus quadratus (Schm.) Teiling	12, 15
Arthrodesmus subulatus Kützing	12
Arthrodesmus sp.	7
Bambusina brebissonii Kützing	8, 12
Bambusina confervacea West & West	12
Chaetosphaeridium spp.	6
[b]*Chara braunii* Gemlin	9
[b]*Chara schweinitzii* A. Braun	7
[b]*Chara* sp.	3, 11
Closterium baillyanum Brébisson	12
Closterium costatum Corda	12
Closterium lunula forma *gracilis* Messik	8
Closterium nematodes Josh	12
Closterium moniliferum (Bréb.) Ehrenberg	8, 12
Closterium sigmoideum (Lagerh.) Norstedt	8
Closterium sp.	1, 2, 7, 8
Cosmarium botrytis Meneghini	7, 8
Cosmarium commensurale Nordst	8
Cosmarium contractum var. *papillatum* West & West	2
Cosmarium dentatum Wolle	4, 8, 12
Cosmarium denticulatum Borge	7, 12
Cosmarium denticulatum forma *borgei* Irene-Marie	8
Cosmarium furcatospermum West & West	6
Cosmarium margaritatum (Lund.) Roy & Bisset	8
Cosmarium monomazum Lundell	8
Cosmarium phaseolus Brébisson	12, 15
Cosmarium portianum Archer	6
Cosmarium pseudoconnatum Norstedt	6
Cosmarium pseudopymidatum Lundell	6
Cosmarium quadratulum (Gay) DeToni	6
Cosmarium sexangularis Lundell	6
Cosmarium sp.	7, 8
Cosmocladium saxonicum DeBary	1
Cosmocladium sp.	2, 6
Desmidium aptogonum Brébisson	12
Desmidium baileyi (Ralfs) Nordstedt	12
Desmidium cylindricum Gréville	8
Desmidium sp.	6
Desmidium grevillii (Kütz.) Debary	12
Euastrum elegans Kützing	8
Euastrum sinuosum Lenor	8
Euastrum verrucosum Ehrenberg	6
Genicularia spirotaenia DeBary	12
Gonatozygon kinahani (Arch.) Rabenhorst	7, 12
Gonatozygon monotaenium DeBary	12
Gonatozygon pilosum Wolle	8, 12
Gonatozygon sp.	6
Hyalotheca dissiliens (Smith) Brébisson	1, 12
Mesotaenium sp.	12, 15
Micrasterias americana (Ehren.) Ralfs	4
Micrasterias fimbriata var. *spinosa* Bisset	8
Micrasterias furcata Ralfs	12
Micrasterias mahabuleshwarensis Hobs	8, 12
Micrasterias papilifera Brébisson	6
Micrasterias radiata Hassall	1, 2, 7, 8, 12
Micrasterias radiata var. *alata* Prescott & Scott	12
Micrasterias radiata var. *dichotoma* (Wolle) Cushman	12
Micrasterias radiata var. *gracillima* G.M. Smith	6, 12
Micrasterias radiosa Ralfs	7, 8, 12
Micrasterias radiosa var. *ornata* f. *elegantior* West & West	7
Micrasterias rotata (Grév.) Ralfs	1, 2, 4, 6, 8, 12
[b]*Mougeotia* sp.	1, 8, 12, 15
Netrium digitus (Ehren.) Tzigsoha & Rothe	8
[b]*Nitella flexilis* (L.) Agardh.	6, 9
[b]*Nitella megacarpa* T.F. Allen	11
Penium margaritaceum (Ehren.) Brébisson	6
Penium sp. Brébisson	7, 8
Pleurotaenium trabecula (Ehren.) Naegeli	12
Pleurotaenium sp.	1
[b]*Spirogyra* sp.	12
Spirotaenia condensata Brébisson	6
Spirotaenium sp.	7
Spondylosium granulatum Roy from *S. papilliosum* West & West	6
Spondylosium planum (Wolle) West & West	12
Spondylosium pygmaeum (Cooke) W. West	6
Spondylosium vertebratum var. *punctulatum* West & West	12
Staurastrum ankyroides Wolle	12
Staurastrum arctiscon (Ehren.) Lundell	1, 2, 6, 8, 12
Staurastrum curvatum W. West	3, 4
Staurastrum dakoti Taft	12
Staurastrum leptacanthum Nordst	12
Staurastrum limneticum Schmidle	4, 12, 15

Table 2 (continued)

CHAROPHYCEAE (continued)	
Staurastrum ophiura Lundell	1, 2, 7, 12, 13
Staurastrum ophiura var. *cambricum* (Lund.) West & West	8
Staurastrum orbiculare Ralfs	6
Staurastrum polymorphum Brébisson	6, 12
Xanthidium antilopaeum (Bréb.) Kützing	8
Xanthidium armatum (Bréb .) Rabenhorst	7
Xanthidium subhastiferum West & West	7
Xanthidium sp.	2, 6
[b]*Zygnema* sp.	8
HETEROKONTOPHYTA	
TRIBOPHYCEAE	
Characiopsis cylindrica (F.D. Lamb) Lemmermann (described as *Characium cylindricum*, a green alga)	1
Chlorosaccus sp.	6
Ophiocytium capitatum Wolle	8
[b]*Vaucheria* sp.	6
CHRYSOPHYCEAE	
Chlorochromonas minuta Lewis	12, 15
Chromulina ovalis Klebs	12, 15
Chromulina sp.	7, 10
Dinobryon cylindricum Imhof	10
Dinobryon divergens Imhof	10, 12
Dinobryon elegantissimum Bourrelly	12, 15
Dinobryon sertularia Ehrenberg	7, 10
Dinobryon sociale Ehrenberg	12
Dinobryon sp.	3, 4
Mallomonas acaroides Perty	10, 12, 15
Mallomonas caudata Irvanoff	10, 15
Mallomonas sp.	10, 12
Uroglena volvox Ehrenberg	10
Uroglenopsis americana Lemmermann	10
Unknown flagellate sp.	1, 12
Unknown flagellate sp.	2, 12
SYNUROPHYCEAE	
Synura adamsi G.M. Smith	10
Synura sphagnicola Korshikov	10
Synura uvella Ehrenberg	10
Synura sp.	10, 12, 15
BACILLARIOPHYCEAE	
[b]*Achnanthes lanceolata* (Breb.) Grün var. *lanceolata*	16
[b]*Achnanthes linearis* (Wm. Sm.) Grün var. *linearis*	16
[b]*Achnanthes minutissima* Kützing var. *minutissima*	16
[b]*Achnanthes* sp.	13, 15
[b]*Amphora ovalis* var. *affinis* (Kütz.) Van Heurck ex DeToni	16
[b]*Anomoeoneis serians* var. *brachysira* (Bréb. ex Kütz.) Hustedt	17
[b]*Anomoeoneis serians* (Breb ex Kütz) Cleve var *serians*	16, 17
[b]*Anomoeoneis vitrea* (Grün) Ross var. *vitrea*	16
Asterionella formosa Hassall	12
[b]*Caloneis bacillum* (Grün) Cleve var. *bacillum*	16
[b]*Caloneis limosa* (Kütz.) Patr. var. *limosa*	16
[b]*Caloneis ventricosa* var. *truncatula* (Grün) F. Meister	16
[b]*Caloneis ventricosa* (Ehren.) F. Meister var. *ventricosa*	16, 17
[b]*Cocconeis placentula* var. *lineata* (Ehren.) Van Heurck	16
[b]*Cocconeis placentula* Ehrenberg var. *placentula*	16
Cyclotella bodanica Eulenstein	16, 17
Cyclotella comensis Grün	17
Cyclotella compta (Ehren) Kützing	8, 15
Cyclotella meneghiniana Kützing	7, 8, 12, 16
Cyclotella operculata (Agardh) Kützing	6
Cyclotella stelligera (Cleve & Grün) Van Heurck	17
[b]*Cymatopleura solea* (Bréb.) W. Sm.	17
[b]*Cymbella affinis* Kützing var. *affinis*	16
[b]*Cymbella affinis* Kützing var. *affinis* (teratological form)	16
[b]*Cymbella amphicephala* Naegeli ex Kützing var. *amphicephala*	16
[b]*Cymbella cuspidata* Kützing var. *cuspidata*	16
[b]*Cymbella delicatula* Kützing var. *delicatula*	16
[b]*Cymbella inaequalis* (Ehren.) Rabenhorst var. *inaequalis*	16
[b]*Cymbella lunata* W.Smith var. *lunata*	16, 17
[b]*Cymbella minuta* Hilse ex Rabenhorst var *minuta*	16
[b]*Cymbella naviculiformis* Auerswald ex Heiberg var. *naviculiformis*	16
[b]*Cymbella* sp.	12, 15
Diatoma sp.	6
[b]*Epithemia argus* (Ehren.) Kützing var. *argus*	17
[b]*Eunotia incisa* W. Smith ex W. Gregory var. *incisa*	16
[b]*Eunotia pectinalis* (O. Mull.) Rabenhorst var. *pectinalis*	16
[b]*Eunotia pectinalis* var. *undulata* (Ralfs) Rabenhorst	16
[b]*Eunotia sera* var. *diadema* (Ehren.) Patrick	16
[b]*Eunotia valida* Hustedt var. *valida*	17
[b]*Eunotia* sp.	12
Fragilaria bicapitata A. Mayer var. *bicapitata*	16
Fragilaria brevistriata var. *inflata* (Pant.) Hustedt	16, 17
Fragilaria constrictica Ehrenberg var. *constricta*	17
Fragilaria contruens (Ehren.) Grün var. *construens*	16, 17
Fragilaria contruens var. *venter* (Ehren.) Grün	17
Fragilaria pinnata Ehrenberg var. *pinnata*	16, 17
Fragilaria virescens. var. *capitata* Østrup	17
Fragilaria sp.	8, 12, 15
[b]*Frustulia rhomboides* (Ehren.) DeToni var. *rhomboides*	16
[b]*Frustulia vulgaris* (Thwaites) DeToni var. *vulgaris*	17
[b]*Gomphonema acuminatum* Ehrenberg var. *acuminatum* ("coronata")	16
[b]*Gomphonema acuminatum* var. *elongatum* (W. Sm.) Carr	16
[b]*Gomphonema affine* Kützing var. *affine*	16, 17
[b]*Gomphonema angustatum* (Kütz.) Rabenhorst	13, 15
[b]*Gomphonema angustatum* (Kütz.) Rabenhorst var. *angustatum*	17
[b]*Gomphonema gracile* Ehrenberg emend Van Heurck var. *gracile*	17
[b]*Gomphonema intricatum* var. Kützing var. *intricatum*	16
[b]*Gomphonema intricatum* var. *vibrio* (Ehren.) Cleve	16
[b]*Gomphonema parvulum* Kützing var. *parvulum*	17
[b]*Gomphonema subclavatum* var. *commutatum* (Grün) A. Mayer	16
[b]*Gomphonema truncatum* var. *capitatum* (Ehren.) Patrick	16, 17
[b]*Gomphonema truncatum* var. *turgidum* (Ehren.) Patrick	16, 17
[b]*Gomphonema turris* Ehrenberg var. *turris*	16
[b]*Gomphonema* sp.	7, 8, 12
Melosira arenaria Moore	17
Melosira distans (Ehren.) Kützing	17
Melosira italica (Ehren.) Kützing	16
Melosira varians Agardh	12
Melosira sp.	12
[b]*Meridion* sp.	12
[b]*Navicula cryptocephala* Kützing var. *cryptocephala*	16
[b]*Navicula exigua* W. Gregory ex Grün var. *exigua*	17
[b]*Navicula gracilis* Ehrenberg	12, 15
[b]*Navicula integra* (W. Sm.) Ralfs. var. *integra*	17
[b]*Navicula minima* Grün	16
[b]*Navicula mutica* Kützing var. *mutica*	17
[b]*Navicula pupula* var. *capitata* Skrine & Meyer	17
[b]*Navicula pupula* var. *rectangularis* (Greg.) Grün	16
[b]*Navicula radiosa* Kützing var. *radiosa*	16
[b]*Navicula scutelloides* W. Smith ex W. Gregory var. *scutelloides*	16
[b]*Navicula scutiformis* Grün ex A.S. var. *scutiformis*	17
[b]*Navicula* sp.	12, 16
Neidium sp.	12

Table 2 (continued)

BACILLARIOPHYCEAE (continued)	
[b]*Nitzschia capitellata* Hustedt	16
[b]*Nitzschia linearis* (Ag.) W. Smith	17
[b]*Nitzschia palea* (Kütz.) W. Smith	16
[b]*Nitzschia sigma* (Kütz.) W.Smith	16
[b]*Nitzschia sinuata* (W. Smith) Grün var. *tabellaria*	16
[b]*Nitzschia tryblionella* var. *victoriae* Grün	17
[b]*Odontidium* sp.	6
[b]*Pinnularia abaujensis* (Pant.) Ross var. *abaujensis*	17
[b]*Pinnularia acrosphaeria* W.Smith var *acrosphaeria*	16
[b]*Pinnularia acuminata* var. *instabilis* (A.S.) Patrick	17
[b]*Pinnularia appendiculata* (Ag.) Cleve var. *appendiculata*	17
[b]*Pinnularia bogotensis* (Grün) Cleve var. *bogotensis*	17
[b]*Pinnularia formica* (Ehren.) Patrick var. *formica*	17
[b]*Pinnularia intermedia* (Lagerst.) Cleve var. *intermedia*	17
[b]*Pinnularia legumen* (Ehren.) Ehrenberg var. *lugumen*	17
[b]*Pinnularia maior* (Kütz.) Rabenhorst var. *maior*	17
[b]*Pinnularia maior* var. *transversa* (A.S.) Cleve	17
[b]*Pinnularia mesogongyla* Ehrenberg var. *mesogongyla*	17
[b]*Pinnularia nodosa* (Ehren.) W. Smith var. *nodosa*	17
[b]*Pinnularia parvula* (Ralfs) Cleve-Euler var. *parvula*	17
[b]*Pinnularia substomatophora* Hustedt var. *substomatophora*	17
[b]*Pinnularia viridis* var. *commutata* (Grün) Cleve	16
[b]*Pinnularia viridis* (Nitz.) Ehrenberg var. *viridis*	17
[b]*Pinnularia* sp.	7
[b]*Pinnularia* sp. (resembles *P. subcapitata* var. *hilsenna* of O. Muller [1898])	16
[b]*Stauroneis acuta* W. Smith var. *acuta*	16
[b]*Stauroneis phoenicenteron* f. *gracilis* (Ehren.) Hustedt	16
[b]*Stauroneis phoenicenteron* (Nitz.) Ehrenberg var. *phoenicenteron*	17
Stephanodiscus alpinus Hustedt	16
[b]*Surirella* sp.	12
[b]*Surirella tenera* W. Gregory	16
Synedra rumpens Kützing var. *rumpens*	17
Synedra tenera Agardh	12
Synedra ulna (Nitz.) Ehrenberg	12, 15, 16
Synedra ulna var. *longissima* (W.Smith) Brun	16
Synedra sp.	7, 8, 12
Tabellaria fenestrata (Lyngb.) Kützing	1, 3, 8, 12
Tabellaria fenestrata (Lyngb.) Kützing var. *fenestrata*	16, 17
Tabellaria fenestrata (Lyngb.) Kützing var. *fenestrata*. (ribbed form)	15, 16
Tabellaria flocculosa (Roth) Kützing	7, 8, 15
Tabellaria flocculosa (Roth) Kützing var. *flocculosa*	16, 17
Tabellaria quadriseptata Knudsen var. *quadriseptata*	17
Tabellaria sp.	2, 3, 12
Vanheurckia sp.	1
CRYPTOPHYTA	
CRYPTOPHYCEAE	
Chilomonas paramecium Ehrenberg	10, 12
Chilomonas sp.	10
Chroomonas norstedii Hansgirg	10, 15
Chroomonas sp.	10
Cryptochrysis commutata Pascher	10
Cryptomonas erosa Stein	10
Cryptomonas erosa var. *reflexa* Marsson	12
Cryptomonas obovoidea Pascher	10
Cryptomonas ovata Ehrenberg	10, 12, 15
Cryptomonas pusilla Bachman	12
Cryptomonas pyrenoidifera Geitler	12
Cryptomonas sp.	10, 12
Cyathomonas truncata Fromental	10

DINOPHYTA	
DINOPHYCEAE	
Ceratium hirundinella (O. Mull.) Dujardin	7
Glenodinium borgei (Lemm.) Schiller	8
Glenodinium cinctum Mueller	12
Glenodinium minimum (Langtzsch) Bachman	12
Glenodinium oculatum Stein	12
Glenodinium palustre (Lemm.) Schiller	12
Glenodinium pulvisculus (Ehren.) Stein	7, 12
Glenodinium sp.	10
Gymnodinium fuscum (Ehren.) Stein	10, 12
Gymnodinium rotundatum Klebs	10
Gymnodinium tatricum Woloszynska	12
Gymnodinium triceratium Skuja	10
Gymnodinium sp.	10, 12, 13, 14, 15
Gyrodinium sp.	10
Hemidinium nasutum Stein	6, 10
Hemidinium sp.	10
Peridinium cinctum (Muell.) Ehrenberg	8, 12, 14
Peridinium cunningtonni Lemmermann	12
Peridinium inconspicuum Lemmermann	7, 8, 10, 12, 15
Peridinium willei Huitfeld-Kaas	7, 8
Peridinium wisconsinense Eddy	12
Peridinium volzii Lemmermann	12
Peridinium sp.	10, 14
Urococcus sp.	3
EUGLENOPHYTA	
EUGLENOPHYCEAE	
Anisonema acinus Dujardin	10
Astasia sp.	10
Entosiphon obliquum Klebs	10
Entosiphon sulcatum Dujardin	10
Euglena oxyuris Schmarha	10
Euglena spirogyra Ehrenberg	10
Euglena sp.	10, 12
Notosolenus sp.	10
Peranema trichophorum (Ehren.) Stein	6, 7, 10
Peranema sp.	10
Phacus caudatus Huebner	6
Phacus longicaudus Huebner	6
Phacus pleuronectes Müller	6, 10
Phacus pyrum Ehrenberg	6, 10
Phacus triqueter (Ehren.) Dujardin	6
Phacus sp.	12, 15
Trachelomonas hispida Perty	10
Trachelomonas horrida Palmer	10
Trachelomonas sp.	13, 15
Tropidoscyphus sp.	10
CHLOROMONADOPHYTA	
CHLOROMONADOPHYCEAE	
Gonyostomum semen Drising	10

Table 3. Invertebrate fauna reported from Mountain Lake. Classification follows Ward & Whipple (1965) with taxa listed alphabetically under higher taxonomic categories. Numbers following taxa indicate sources: 1 = Williams (1930), 2 = Hutchinson & Pickford (1932), 3 = Ferguson et al. (1939), 4 = Coker & Hayes (1940), 5 = McCalla (1942), 6 = Roth & Neff (1964), 7 = Marland (1967). Taxa designated ^{b} are primarily benthic, other taxa are primarily planktonic. * = Genus valid but species not found in Biological Abstracts.

RHIZOPODA	
Difflugia sp. Leclerc	1,4
TURBELLARIA	
^{b} *Bothrioplana semperi* M. Braun	3
^{b} *Castrada* sp. O. Schmidt	3
^{b} *Daliella* sp. [=*Dalyellia* sp. Fleming]	3
^{b} *Euplanaria trigrina**	3
^{b} *Fonticola gracilis**	3
^{b} *F. morgani**	3
^{b} *Fuhrmannia* sp.*	3
^{b} *Microstomum lineare* Muller	3
^{b} *Planaria dactyligera* Kenk	3
^{b} *Prorhynchus stagnalis* M. Schultze	3
^{b} *Rhynchomesostoma rostratum* [=*rostrata*] Muller	3
^{b} *Rhynchoscolex simplex* Leidy	3
^{b} *Stenostomum grande*	3
^{b} *S. kepneri**	3
^{b} *S. saliens**	3
^{b} *S. tenuicaudatum**	3
^{b} *S. tuberculosum**	3
^{b} *S. virginianum**	3
^{b} *Typhloplana* sp. Ehrenberg	3
ROTIFERA	
Chydorids	7
Conochilus sp. Hlava	1
Conochilus unicornis Rousselet	2,4,5
Notholca longispina*	2,4
OLIGOCHAETA	
^{b} *Limnodrilus hoffmeisteri* Claparede	6
^{b} Lumbriculidae	6
^{b} *Tubifex templetoni* Southern	6
CLADOCERA	
Bosmina sp. Baird	7
Bosmina obtusirostris Sars.	5
Daphnia sp. O. F. Muller	7
Daphnia longispina O.F.Muller	1
Daphnia pulex Leydig em. Richard	2,4,5
Diaphanosoma brachyurum Lieven	1,2,4,5
OSTRACODA	
^{b} *Candona* sp. Baird	6
COPEPODA	
Cyclops vernales*	5
Diaptomus eregonensis*	1
D. leptopus S. A. Forbes*	2,4,5
DIPTERA	
^{b} *Chaoborus* sp. Lichtenstein	5
^{b} *Chaoborus punctipennis* Say	6
^{b} *Microtendipes* sp. Kieffer	6
^{b} *Procladius culiciformis* L.	6
^{b} *Tendipes attenuatus* Walk*	6
^{b} *T. modestus* Say*	6

Eckroade's (1962) thesis on the geology of the Mountain Lake area largely duplicated Sharp's (1933) findings:

> *Lateral erosion of the stream valley in the Tuscarora* [=Clinch] *produced large blocks which crept down slope and down the dip into the valley and reached the outcrop of the Tuscarora where further movement downstream was arrested. Frost heaving of Tuscarora along its outcrop and movement of large blocks, probably by solifluction* [gradual slipping downslope], *produced more blocks which crept downstream and dammed against the already persistent blocks. Complete damming of the north end of the lake was accomplished by a filling of interstices in the bouldery deposit by smaller blocks and fragments and organic matter.*

Apparently Eckroade was the first to note the upper Ordovician Juniata sandstone Formation located between the lower Ordovician Martinsburg shale and lower Silurian Tuscarora (Clinch) sandstone. He also noted the Martinsburg was divided into three units, the two lower calcareous with limestone and the upper (at Mountain Lake) of "...brown-weathering thin- to medium-bedded sandstones and siltstones" (i.e., not calcareous, nor of limestone).

Whitford (1964) added a number of new phytoplankton taxa to the list for Mountain Lake (Table 2). He was one of the first to note in the shallows at the south end of the lake the scattered beds of the macrophyte *Ceratophyllum demersum* L. and the alga *Chara schweinitzii* A.Br. Two emergent vascular plants also were fairly common, namely *Isoetes engelmanii* A.Br. and *Alisma plantago-aquatica* L., first noted by Coker & Hayes (1940). Limnological data reported were pH 6.4-7.4, little buffering, Secchi disk transparency 2.5-7.0 m, orthophosphate-P <3 µg/l, nitrate-N <20 µg/l, silica 2.8 mg/l, much of this taken from Hutchinson & Pickford (1932).

Roth & Neff (1964) conducted the most thorough physical and chemical limnological study of the time on Mountain Lake. They included a study of the profundal fauna at 22 m depth: two species of tubificids, 1-2 species of ostracods, 4+ species of tendipedids, and *Chaoborus* sp. (Table 3). Attached macrophytes in the lake included the alga *Nitella flexilis* (first listed by Forest, 1954), the moss *Fontinalis antipyretica,* and the vascular plants *Isoetes engelmanii*, *Potamogeton natans*, *P. pectinalis*, *Elodea nuttallii*, and *Ceratophyllum demersum*.

Marland (1967) conducted the first paleolimnological study of Mountain Lake. He collected seven sediment cores–three for ^{14}C dating and four for microfossil analysis. The frequency of occurrence with core depth of >20 microfossil species was recorded. Especially noteworthy was the variation in percent composition of littoral and planktonic (*Daphnia* and *Bosmina*) cladocerans, suggesting occurrence of at least three prolonged periods in the past when Mountain Lake had low water levels (i.e., mostly littoral cladocerans). Marland (1967) suggested that the most recent low water level probably occurred about 1786, and this was supported by a 1794 survey filed in the Montgomery County Court House which showed "...changes in the outlet position of Pond Drain and the shape of the lake…[suggesting]…the lake to be 600-700 feet shorter and about 100 feet narrower." Thus, the lake would have been 25 feet (8 m) below full capacity. Marland (1967) was aware of 14 sawed tree trunks which must have once grown along the shore of a much smaller lake and that leakage through the Clinch boulders coupled with drought occurring in the small watershed with a relatively low 5:1 ratio of watershed area to lake area could easily explain the past fluctuations in lake levels. Most water entering Mountain Lake was from springs. Based on a maximum core bottom ^{14}C-dated age of 9180 ± 330 YBP (years before present) and Sharp's (1933) geological studies with proposed lake origin, Marland (1967) concluded that a periglacial climate with frost action and solifluction created the colluvium at the north end of the lake basin about 10,000 YBP, but a permanent lake may not have formed until 2,000 YBP. Addressing the trophic state of the lake, Marland (1967) noted that a compound quotient of 0.43 calculated for phytoplankton in the1960s was 0.91 in the early 1930s. He further noted that the planktonic diatom *Cosmocladium saxonicum* which characterized oligotrophic waters, was abundant in 1930, 1931, and 1935, but absent in 1964-1966. All this suggested eutrophication was beginning.

Obeng-Asamoa & Parker (1972) published the first year-round biological and chemical limnological study of Mountain Lake. Ranges in pH of 5.9-7.2, generally low concentrations of the ions NH_4^{+1}, NO_3^{-1}, PO_4^{-3}, SiO_2, SO_4^{-2}, Cl^{-1}, and Fe, as well as the summer orthograde oxygen curves with hypolimnetic oxygen never dropping below 8.0 mg/l, all suggested oligotrophy. Phytoplankton densities were low, but consisted of many species (Table 2). Desmids dominated in summer, *Cyclotella compta* dominated in winter and spring, and the green algae *Sphaerocystis schroeteri and Planktosphaeria gelatinosa* occurred year-round. Primary productivity using chlorophyll, oxygen, and ^{14}C methods all gave low values characteristic of oligotrophic waters. Highest productivity in summer occurred in the metalimnion which also showed oxygen supersaturation. *Cyclotella* cell counts and size ranges and microalgae beneath lake ice in winter suggested high winter productivity which may have been in part heterotrophic. Obeng-Asamoa (1971) and Obeng-Asamoa & Parker (1972) also listed the littoral macrophytes, namely *Alisma* sp., *Ceratophyllum demersum, Chara schweinitzii, Elodea nuttallii, Isoetes engelmannii, and Nitella flexilis.*

Simmons & Neff (1973) reported limnological data collected at Mountain Lake from 1965-68. ^{14}C primary productivity measurements in light and dark 300 ml BOD bottles at various depths on seven occasions showed values ranging over 0.9-482.2 $mgC/m^2/d$ (average 209.4). In summer, productivity ranged as high as 85 $mgC/m^3/d$. They concluded that these values generally indicated oligotrophy.

Parker et al. (1975) conducted a geological investigation at Mountain Lake which led to the conclusion that the lake formed by "damming of the headwaters of a stream with talus (sliderock)". Such talus largely consisted of Clinch sandstone boulders that formed during the Quarternary perhaps 10,000 YBP when a periglacial climate with abundant frost action and solifluction prevailed. This origin for the lake is similar to or in agreement with Rogers (1884), Hutchinson & Pickford (1932), Sharp (1933), Eckroade (1962), and Marland (1967) who effectively ruled out the "natural solution collapse basin" idea of Ferguson et al. (1939) and Holden (1938). Parker et al. (1975) also stressed that the Clinch boulder sliderock dam was not completely sealed, which accounted for the lake level fluctuations and submerged tree trunks representing trees that had invaded and grown in the meadow created by prolonged drought-induced drop in lake levels. A ^{14}C date in a southern yellow pine trunk with 22 annual growth rings collected at 10 m depth in the then full lake gave a value of 1655 ± 80 (ca. 350 YBP).

Parker (1976) measured photosynthetic production in the lake at various depths during the summer of 1973 and obtained values of 380-886 $mgC/m^2/d$. These values were about twice those reported by Simmons & Neff (1973). Rather than eutrophication as an explanation, two variations in the ^{14}C method likely caused much of the differences: (1) Parker (1976) used more transparent screw-capped bottles in place of the thick glass BOD bottles of Simmons & Neff - hence, more photosynthetically available radiation in Parker's measurements. (2) Parker measured not only cellular, but also extracellular, fixed carbon, the latter frequently amounting to $\geq$ 25% of the total. Significant extracellular products of photosynthesis are well-known features for oligotrophic lakes and oceans (see Parker & Parson, 1987).

Dubay (1976) and Dubay & Simmons (1979) addressed the phenomenon of the oxygen supersaturation in the summer metalimnion of Mountain Lake. The oxygen maximum in 1974 was at 7-10 m depth and very near to the 11 m depth of the maximum biomass of the attached *Nitella flexilis*. In contrast, they reported no correlation between the positive heterograde oxygen curve and the phytoplankton densities or their estimates of phytoplankton primary productivity. They concluded that *Nitella* rather than the phytoplankton was responsible mainly for the metalimnetic oxygen maximum.

Dubay (1976) and Dubay & Simmons (1981) compared the ash-free dry weight biomasses of macrophytes collected from five transects from 0-11 m in Mountain Lake using SCUBA. *Nitella flexilis* overwhelmingly dominated with $\geq$ 90% of the total macrophyte biomass at all except the shallowest depths. The biomasses of other macrophytes followed the sequence *Fontinalis novae-angliae*>*Ceratophyllum demersum*> *Anacharis canadensis* >*Chara braunii*.

Mikell et al. (1983) reported the first investigation of the effects of high dissolved oxygen on heterotrophic plankton communities, using Mountain Lake as a model. This lake often developed a metalimnetic oxygen maximum in summer, such that instead of saturated 0_2 levels of 10 mg/l at 8m, the dissolved 0_2 often reached supersaturation of 14 mg/l. Mikell et al. (1983) demonstrated that 42 mg 0_2/l inhibited heterotrophic bacterioplankton in Mountain Lake based on colony forming units (CFU) and D-[U-^{14}C]glucose incorporation into extractable lipid of the CFU, and respiration plus assimilation of the D-[U-^{14}C]glucose. Additions of superoxide dismutase or catalase did not produce a significant difference. Thus, exogenous oxygen byproducts apparently were not responsible and the inhibition from high 0_2 concentrations most likely was intracellular.

Seaburg et al. (1983) isolated 115 clonal, unialgal strains, 60 of which were from Mountain Lake, and tested their ability to grow between 2-40 ^{o}C. Of the total isolates, 63 came from $\leq$ 6 ^{o}C and 52 came from $\geq$ 20 ^{o}C habitats. Based on the temperature-growth responses alone, 24% of the plankton and 17% of the periphyton isolates could have been perennial or year-round in natural habitats. At 5 ^{o}C, 56% of the warm-water plankton isolates and 48% of the warm-water periphyton isolates were incapable of growth, suggesting likely summer algal strains. At 25 ^{o}C, 25% of the cold-water plankton and 13% of the cold-water periphyton isolates were incapable of growth, suggesting likely winter algal strains. This investigation demonstrated that temperature alone is an important factor regulating seasonal changes in algal community structure.

VanBrunt (1984) studied seasonal variations in protozoan colonization of polyurethane foam units suspended in Mountain Lake. Seasonal changes caused much instability in the colonization curves which spanned 21 days. VanBrunt's measurements of pH, hardness, alkalinity, dissolved 0_2, and temperature all resembled the data of most previous workers. The ciliates and flagellates (including some algae) were not consistently identified, but their structural differences allowed an estimate of the number of probable species in spring, summer, and fall.

Jervis (1988) and Jervis et al. (1988) showed that the dominant macrophyte in Mountain Lake first cited by Forest (1954) and perpetuated by later workers (i.e., Roth & Neff, 1964; Obeng-Asamoa & Parker, 1972; Dubay & Simmons, 1979) was not *Nitella flexilis*. Rather, the monospecific genus in the lake was *Nitella megacarpa* T.F.A.

Parson & Parker (1989a) reviewed the more recent stresses to the Mountain Lake ecosystem. These included seasonal leakage of septic tanks, leakage of phosphate-containing detergents from a laundromat, installation of a pipeline and pump system for bringing air conditioning coolant water from lake to hotel in hot weather, and construction of concrete piers and limestone paths. Changes to the lake included higher extractable chlorophyll a, higher phytoplankton productivity, changes in the species composition of the phytoplankton community, and a more persistent and enlarging hypolimnetic volume depleted in oxygen. These observations suggested eutrophication. Yet Parson & Parker (1989a) noted that the lake had several features resisting eutrophication: (1) The relatively well-preserved state of the natural vegetation within the lake basin; (2) the large volume of relatively clean precipitation, runoff, and spring water feeding the lake, which annually nearly matched the lake's volume; and (3) the limited recreational uses of the lake and watershed.

Parson & Parker (1989b) produced the first comprehensive list of algae observed in Mountain Lake. Their list comprised 331 taxa , of which only 92 had been reported by previous investigators. The 331 included 45 Cyanophyceae (blue-greens), 185 Chlorophyta (greens), 25 Bacillariophyceae (diatoms), 20 Chrysophyceae (golden), three Tribophyceae (yellow-greens), 23 Dinophyceae (dinoflagellates), 16 Euglenophyceae (euglenoids), 13 Cryptophyceae (cryptophytes), and one Chloromonadophyceae (chloromonad).

Parker et al. (1991) showed by *in situ* measurements and calculations that the metalimnetic oxygen maximum at 6-10 m during late summer thermal stratification previously attributed to the macrophyte *Nitella* (Dubay & Simmons, 1979) most likely was due to the phytoplankton. At the depth of the metalimnion the biomass of *Nitella* was about 11x that of the phytoplankton, but the photosynthetic productivity of the phytoplankton was 25x that of the *Nitella* when the entire lake and not merely the water overlying the *Nitella* beds was included in the calculations. Highest productivity values occurred in 1989, namely 13.34 mgC/m^3/h of the lake mean of 22.79 mgC/m^2/h; this was the year that the septic tanks first installed in the 1930s were removed, inducing temporary record high concentrations of PO_3^{-3} and NH_4^{+1} in the lake.

Parson (1988) and Parson & Parker (1993) measured NH_4^{+1} uptake by phytoplankton using ^{14}C-methylamine and estimated the K_m (concentration at which the rate of uptake equals one-half of the maximum) and V_{max} (maximum uptake velocity) at two-week intervals over 6 months (May 15-Nov. 18). V_{max} increased steadily May-July in parallel with major changes in the phytoplankton community. Cryptophytes dominated in May, green algae in June and July, blue-greens July-October, and greens October-November. With blue-green dominance, V_{max} declined. K_m values increased May-July, but no correlation occurred thereafter. The coincidence of V_{max} and K_m values for ^{14}C-methylamine uptake and changing phytoplankton community structure suggested that the succession of algal communities may be occurring in response to differences in NH_4^{+1} affinities and uptake rates.

Beaty & Parker (1994) and Beaty (1995) reviewed information suggesting that Mountain Lake may have been undergoing eutrophication from oligotrophic to a meso-oligotrophic state. They included seasonal data for 1970-71 and 1985-93 which suggested trends toward $>NO_3^{-1}$ (especially 1990), $> NH_4^{+1}$ (especially 1989 +1990), $>^{14}C$ primary productivity (especially 1989), > hypolimnetic oxygen deficits (especially 1989), and probable anoxic sediments below 25m depth.

Beaty (1995) and Beaty & Parker (1996a) examined the relative importance of four phytoplankton size classes (pico-, nano-, micro-, and macro-) during thermal stratification in Mountain Lake. Based on ^{14}C-fixation rates, the microplankton (20-200 µm), which were most important in cell number and cell volume, contributed 95% of the total primary productivity. The picoplankton (<2 µm) ranked second in importance producing about 5% of the total primary productivity. The relatively small numbers of nano- (2-20 µm) and macro-plankton (>200 µm) contributed little primary productivity. The herbivore (second) level of the food chain (*Bosmina, Daphnia, Cyclops, Diaptomus*) appeared closely tied to grazing on the abundant microplankton although not necessarily equally over the 20-200 µm size range.

Beaty (1995) and Beaty & Parker (1996b) studied the affect of nutrient additions on *in situ* ^{14}C-primary productivity on the four phytoplankton size classes in Mountain Lake. Adding $P0_4^{-3}$, NH_4^{+1}, and sometimes NO_3^{-1} stimulated photosynthesis over 48 h, especially for the most dominant microplankton (20-200 µm), before any increase in cell numbers occurred. These findings suggested that any future increases in PO_3^{-3} and/or NH_4^{+1} could lead to eutrophication.

Cawley et al. (1999) reevaluated the trophic state of Mountain Lake. Orthophosphate [PO_3^{-3}] had been higher during 1980-90 than in years before 1980 but had returned to oligotrophic levels by 1997 [1.5 ug P/l] and 1998 [2.2 ug P/l]. Ratios of inorganic N:P of 143:1 and 235:1 indicated that phosphorus was the primary limiting nutrient regulating the oligotrophic state. Levels of dissolved SiO_2, about the same in previous studies, probably were limiting to many planktonic diatoms. Major phytoplankton algal taxa also were examined (Table 2).

Cawley et al. (2001b) reexamined the geology, hydrology, and morphometry of the lake and vicinity. A fracture trace analysis using resistivity measurements in the area confirmed that a lineation feature running SE to NW within and on both sides of the lake basin, including along Pond Drain, was actually a crevice or fault through which water probably could leave or enter during very dry (leaving) or excessively wet (entering) seasons. However, they added "…some water loss may also occur as leakage through Clinch sandstone colluvium at the northwest end of Mountain Lake, as proposed by earlier workers (Parker et al., 1975)."

The Clinch colluvium and natural dam were created by a periglacial climate with frost action and solifluction along with either a collapse of a cliff or the gradual creeping of boulders down slope, agreeing with several earlier workers cited in this review. Thus, Cawley et al. (2001b) modified these earlier assertions of the origin of Mountain Lake as follows: In addition to probable water losses through the Clinch colluvium, water losses or gains through the sediment-free deep crevice or fault at 33 m accompanies conduit erosion and periodic downsettling of overlying Clinch sandstone boulders. These processes also have been involved in the mechanisms for Mountain Lake's origin and periodic water-level fluctuations.

Cawley & Parker (2001) designed and built a new percussion coring device which enabled collection of seven sediment cores from Mountain Lake for analysis of the lake's paleohistory going back 6100 years (Cawley et al., 2001a). Their analysis of littoral: planktonic diatom ratios and forest: field pollen ratios in the sediment core layers enabled recognition of six prolonged periods when the lake probably was nearly dry or very small in size. Based on ^{14}C dating, these six low-water periods occurred at about 100, 400, 900, 1200, 1800, and 4100 YBP. The low-water intervals of 900 and 1200 YBP perfectly match the low-water periods suggested from littoral: planktonic cladoceran ratios by Marland (1967). Other low-water periods may well have occurred, but of too short duration for accurate detection within the sediment cores. The core contents at 6100 YBP suggested the existence of a full lake, contradicting Marland's (1957) suggestion that a full lake may not have begun until 2000 YBP. New diatom taxa also were noted by Cawley et al. (2001a) (Table 2).

Cawley et al. (2002) reported an analysis of diatoms in mini-cores taken from Ekman dredge samples dating back an estimated 100 years. They noted at least 66 diatom taxa belonging to 25 genera (Table 2); 12 of the 66 taxa were new records for Virginia inland waters. Planktonic diatoms were sparse, but attached epipelic and epiphytic diatoms were abundant. Cluster analysis of diatom counts from the recent lake sediments suggested seven delineated regions or assemblages within this relatively small lake. The assemblages were divided between shallow (primarily pennate) and deep-water (primarily centric) taxa.

DISCUSSION

Table 1 provides an update of the figure in Parker et al. (1975) showing the periods in the historic record when Mountain Lake was full (100%) or significantly lower (<100%). Cawley et al. (2001a) and data from Marland's (1967) dissertation showed that the lake prior to Gist's 1751 discovery (Johnston, 1898) also had periodic prolonged low-water levels. Even earlier, Parker et al. (1975) reported that a ^{14}C date from an in-place southern yellow pine stump collected from 10 m depth grew at the edge of a lower lake about 1655 ± 80. The pine may have been *P. pungens* Lamb. which occurs in the area, but positive distinction from 6-7 other species is not possible using wood anatomy alone. In April 2002, a drop of 7 m in lake level exposed another in-place tree trunk. This eastern white pine [*Pinus strobus* L.] was collected and ^{14}C-dated at 110 ± 50 YBP. The most likely interval when this tree grew for about 20 years along the shoreline of the lake was perhaps 1885-1904 based on Table 1 information.

The best explanation for the prolonged low-water phenomenon in Mountain Lake relates directly to the origin of the lake proposed by most previous investigators, namely by incomplete damming of a stream with Clinch sandstone colluvium (Hutchinson & Pickford, 1932; Sharp, 1933; Eckroade, 1962; Marland, 1967; Parker et al., 1975). [For additional details of the geology and colluvium, see Schultz et al., 1986; Mills, 1988; Schultz & Southworth, 1989] Cawley et al. (2001b) also proposed that major water loss may occur through a southeast-to-northwest fracture trace or fault located at the lake's maximum depth. This fracture trace or fault was easily detected using sonar bathymetric mapping. In fall 2001, three divers (Jacob Waller, Scott Elliot, Brian McCormick from Virginia Tech) located the fracture trace and identified a 1.5 x 2.5 ft (0.5 m x 0.8 m), sediment-free hole at 33 m depth of a full lake (Waller et al., pers. comm.). Such a hole might well serve as a conduit for water and sediment escape or entry, as proposed by Cawley et al. (2001b). No detectable currents near the hole were noted, however, during their brief visit. Subsequently, the divers confirmed the presence of numerous probable cracks or holes between Clinch boulders at shallower depths in the northwest corner of Mountain Lake. Thus, a combination of drought (prolonged below-normal precipitation) and excessive water losses through colluvial Clinch boulders and the deep fault has resulted in the periodic low-water levels. The impact of drought is all the more pronounced because of the very small ratio (5:1) of watershed to lake area.

Parker et al. (1975) calculated that about half of the water entering Mountain Lake must be leaving through subsurface cracks and holes in Clinch boulders. During 1997-2002, a prolonged drought with significantly below-normal annual precipitation accompanied a fairly steady drop in lake level to a point where the lake was only about 72% of full capacity, thus 9.2 m (30 ft) below full lake level in early November 2002. In November 2002 and subsequent months through August 2003, the lake level began rising as above-average precipitation returned to the region. By the end of August 2003, Mountain Lake reached full capacity again (Table 1). Figures 2a and 2b show Mountain Lake in August 1985 and August 2002, respectively. The below-normal precipitation in 1997-2002 has been documented through examination of the precipitation records of the University of Virginia's Mountain Lake Biological Station and Miles C. Horton Research Center. At these two nearest sites to Mountain Lake the annual precipitation in 1997-2001 was about 70% of annual means for 1982-1996, the latter being when the lake was consistently 100% full.

As the drought continued through 2001, no surface outflow from the lake to Pond Drain occurred. In fact, Pond Drain showed no surface water for a distance of up to nearly 1.0 km northwest of the lake. However, at just over 1.0 km northwest of the lake, suddenly large volumes of water came to the surface. A United States Geological Survey topographical map (Interior quadrangle) showed that this distance from the lake along Pond Drain has an elevation of about 40-45 m lower than the lake surface or about 8-13 m below the crevice and

Fig. 2A. Aerial photograph of a full Mountain Lake in August 1985 looking northward (photograph by Bruce Parker).

Fig. 2B. Aerial photograph of an 80% full Mountain Lake in August 2002 looking southward and showing non-forested meadow, especially at the south end (photograph by Jim Walker).

hole at the bottom of the lake. From several locations in this part of Pond Drain, Cawley & Parker (unpubl. data) collected fine sediments which they processed for diatom identification using standard procedures (Cawley et al., 2001a). The diatoms identified were mostly centric taxa identical to those occurring in Mountain Lake and uncharacteristic of diatom taxa living in mountain streams (Cawley & Parker, unpubl. data). They concluded that the sediments and diatoms from Pond Drain 1.0 km from the lake most likely were coming from the lake through the colluvial cracks and deep hole.

Table 2 lists 448 algal taxa representing 10 classes that have been reported in 17 investigations. While some of the algal taxa have been renamed recently, the earlier names have been retained here to avoid confusion. This is a 26% increase over the 331 taxa previously tallied by Parson & Parker (1989b). The new additions are largely of benthic diatom taxa described by Cawley et al. (2001a, 2002) which were not investigated by earlier workers. Of course, some of the algae in Table 2 have been reported only once or only during certain short seasons, while others have been more frequent and persistent. For example, Beaty & Parker (1994) compared the 10 most abundant phytoplankton for July 1970 (from Obeng-Asamoa, 1971) and July 1985 (from Parson & Parker,1989a). Table 4 repeats this list, and it will be seen that the 10 most abundant taxa in 1970 and 1985 were completely different. Table 4 also includes the 10 most abundant taxa for July 1997 and 1998 (from Cawley et al., 1999), and it will be noted that 8 taxa are different from 1970 and 1985. However, *Quadrigula chodatii* was in the top 10 in 1970 and *Scenedesmus bijuga* was in the top 10 in 1985. Parson & Parker (1989a) noted that *S. bijuga* became abundant following the addition of limestone paths near the south end of the lake and suggested that this species was stimulated by increased bicarbonate from the limestone. In 1998, tons of additional limestone were added to expand the parking area and create more paths at the south end of the lake. Thus, bicarbonate increase once again may explain the resurgence of *S. bijuga* back into the top 10.

Table 3 is the counterpart of Table 2 for the microfauna reported in seven investigations at Mountain Lake. The list includes 43 taxa belonging to eight orders. Although the list seems short compared to Table 2, many of the algae in Table 2 also can be classified as protozoa but have not been repeated in Table 3. In addition, fewer studies of the microfauna have been conducted in Mountain Lake.

During 1997 and 1998, Cawley et al. (1999) examined the levels of several nutrients in the lake, the five input streams, and year-round precipitation. These data have been repeated in Table 5, which shows that N, especially as NO_3^{-1}, was very high relative to P as PO_4^{-3}. Thus, the N:P ratios were 143:1 and 235:1, implicating P as the very severe limiting nutrient which primarily sustains the oligotrophic state of Mountain Lake. As Cawley et al. (1999) noted, in both freshwaters and oceans a balanced

Table 4. Phytoplankton ranks for July 1970 (Obeng-Asamoa, 1971), July 1985 (Parson & Parker, 1989a), and July 1997-1998 (Cawley et al., 1999) for Mountain Lake.

Rank	1970	1985	1997-98
1	*Bambusina brebissonii*	*Scenedesmus bijuga*	*Chlorella vulgaris*
2	*Staurastrum ophiura*	*Asterionella formosa*	*Gloeocystis planktonica*
3	*Radiofilum confunctivum*	*Gymnodinium* sp.	*Chlamydomonas* sp.
4	*Quadrigula chodatii*	*Cyclotella meneghiniana*	*Chroomonas norstedii*
5	*Sphaerocystis schroeteri*	*Chilomonas paramecium*	*Chlorochromonas minuta*
6	*Mougeotia* sp.	*Peridinium wisconsinense*	*Scenedesmus bijuga*
7	*Micrasterias radiosa*	*Chroococcus minutus*	*Crucigenia quadrata*
8	*Quadrigula lacustris*	*Spondylosium planum*	*Quadrigula chodatii*
9	*Micrasterias radiata*	*Chromulina ovalis*	*Cyclotella compta*
10	*Staurastrum arctiscon*	*Tabellaria fenestrata*	*Synedra ulna*

Table 5. Concentrations of PO_4 -P, NH_4-N, NO_3-N (as µg/L), SiO_2 (as mg/L), and the N:P ratio in Mountain Lake, input streams, and rainwater in 1997, 1998 (Cawley et al., 1999) and 2001 (new data).

Year	Variable	Lake	Input Streams	Rainwater	Lake N:P Ratio
1997	PO_4-P	1.5	4.8	20.7	
	NH_4-N	14.0	25.0	269.7	
	NO_3-N	200.0	1320.0	994.0	143:1
1998	PO_4-P	2.2	8.2	110.0	
	NH_4-N	16.0	25.0	503.0	
	NO_3-N	500.0	1359.0	2550.0	235:1
	SiO_2	0.39	0.44	0.38	
		Lake North	Lake South	Wetland	
2001	PO_4-P	0.50	0.25	5.75	
	NH_4-N	62.0	70.0	90.0	
	NO_3-N	27.0	18.0	28.0	236:1

N:P ratio will be 16:1 to 17:1. In December 2001, water collections were made from both ends of the lake and analyzed by the same procedures used by (Cawley et al., 1999). Table 5 shows that both NO_3^{-1} and PO_4^{-3} had dropped since 1997-98. However, the N:P ratio of 236:1 confirms that P remains the primary limiting nutrient.

The wetland and pond just south of the lake was constructed in 1997, then enlarged in 1998. A spring was opened at the surface just north of the hotel parking lot, creating a tiny cascade down the slope into the wetland and pond. Native algae, submergent and emergent vegetation quickly colonized this new habitat, forming a biological filter for water entering the lake. Table 6 lists the 13 most abundant taxa during the summers of these first two years of the wetland's existence. The list includes two algae and 11 non-algal taxa, a number of which were reported in earlier investigations of the lake and lake shore.

By contrast, Table 5 shows that PO_4^{-3} was high in the wetland, producing a nearly balanced N:P ratio of 21:1 Such a near-balanced ratio of these two nutrients will stimulate growth of algae and other vegetation, thereby removing most of the N and P before water is released into the lake. This most likely contributed to the lower concentrations of NO_3^{-1} and PO_4^{-3} in the lake during 2001.

A number of other invertebrate and vertebrate fauna common to Mountain Lake but little-studied there include

Table 6. Most abundant vascular plants and algae colonizing the new wetland at the south end of Mountain Lake during 1997 and 1998 (Identifications by B. Parker and Billie Jean Kirk using Godfrey & Wooten [1979, 1981] and confirmed by Tom Wieboldt). Voucher specimens deposited at the Massey Herbarium, Biology Department, Virginia Tech.

Species (& Family)	July 1997	Aug. 1998
Alisma subcordatum Raf. (Alismataceae)	x	x
Bidens frondosa L. (Asteraceae)		x
Callitriche heterophylla Pursh (Callitrichaceae)	x	
Eleocharis obtusa (Willd.) Schultes (Cyperaceae)	x	
Epilobium coloratum Biehler (Onagraceae)		x
Impatiens capensis Meerb. (Balsaminaceae)		x
Juncus subcaudatus (Engelm.) Cov. & S.F. Blake (Juncaceae)		x
Nitella megacarpa T.F.A. (Characeae)	x	
Onoclea sensibilis L. (Onocleaceae)		x
Polygonum hydropiper L. (Polygonaceae)	x	x
Polygonum sagittatum L. (Polygonaceae)	x	x
Spirogyra spp. (Charophyceae)	x	x
Veronica angallis-aquatica L. (Scrophulariaceae)	x	x

the crayfish *Orconectes juvenilis* (Hagen), red-spotted newt *Notophthalmus viridescens viridescens* (Rafinesque), bullfrog *Rana catesbeiana* (Shaw), bluntnose minnow *Pimephales notatus* (Rafinesque), redbreast sunfish *Lepomis auritus* (Linnaeus), bluegill *Lepomis macrochirus* (Rafinesque), largemouth bass *Micropterus salmoides* (Lacepede), and rainbow trout *Onchorhynchus mykiss* (Walbaum). These are probably all native species except for the rainbow trout which is stocked every few years to enhance the sport fishing. No attempt will be made here to list the numerous aquatic insects that abound in the lake and amongst other ecological roles provide valuable food sources for other fauna.

In 2000, the hemlock woolly adelgid (*Adelges tsugae*) arrived at Mountain Lake and began to spread throughout the forest parasitizing the hemlocks (*Tsuga canadensis* (L) Carr.). Over several years, this parasite can inflict severe damage to hemlock trees, ultimately causing death (Mayer et al., 2002). The hemlock-rhododendron forest surrounding much of the lake provides significant scenic beauty. Consequently, in 2001, Scott Salom and Tom McAvoy of the Virginia Tech Department of Entomology, initiated a program to control the woolly adelgid. Hundreds of hemlock trees received the recommended doses of Merit in the soil around their roots. Merit is a systemic pesticide for the woolly adelgid; the pesticide is taken up by the roots and transported to the branches and leaves throughout the tree reaching sites occupied by the woolly adelgid and killing the insect. Then, in winter 2002, Salom and McAvoy began releasing two beetle predators known to feed quite exclusively on the woolly adelgid: *Pseudoscymnus tsugae* and *Laricobiua nigrinus*. This program of chemical treatment and attempted biological control of the woolly adelgid will continue until its effectiveness can be assessed.

CONCLUDING REMARKS

This review included nearly 50 scientific studies conducted over the last 150 years on Mountain Lake, Giles County, Virginia. This lake is unique through its geology, hydrology, possession of a fault and colluvium, and unusually high aquatic species diversity. No other lake in the world apparently possesses this combination of features. No doubt, researchers will continue to find interest in this lake in future years.

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LITERATURE CITED

Beaty, M. H. 1995. Eutrophication of Mountain Lake, Giles County, Virginia. Ph.D. Dissertation. Virginia Polytechnic Institute & State University, Blacksburg, VA. 210 pp.

Beaty, M. H., & B. C. Parker. 1994. Investigations of eutrophication in Mountain Lake, Giles County, Virginia. Virginia Water Resources Research Center Bulletin 184: 1-66.

Beaty, M. H., & B. C. Parker. 1996a. Relative importance of pico-, nano-, and microplankton to the productivity of Mountain Lake, Virginia. Hydrobiologia 331: 121-129.

Beaty, M. H., & B. C. Parker. 1996b. Response of phytoplankton productivity to nutrient enrichment at Mountain Lake,Virginia. Journal of Freshwater Ecology 11: 421-431.

Campbell, M. R. 1898. Earthquake shocks in Giles County, Virginia. Science 7: 233-235.

Cawley, J. C. 1999. A re-evaluation of Mountain Lake, Giles County, Virginia: Lake origins, history, and environmental systems. Ph.D. Dissertation. Virginia Polytechnic Institute & State University, Blacksburg, VA. 118 pp.

Cawley, J. C., & B. C. Parker. 2001. An inexpensive diver-assisted percussion coring device. Journal of Sedimentary Research 71: 863-866.

Cawley, J. C., B. C. Parker, & M. H. Beaty. 1999. Re-evaluation of the trophic state of Mountain Lake, Virginia, U.S.A. Journal of Freshwater Ecology 14: 535-544.

Cawley, J. C., B. C. Parker, & T. L. Hufford. 2001a. An examination of the first sediment cores from Mountain Lake, Giles County, Virginia. Virginia Journal of Science 52: 241-258.

Cawley, J. C., B. C. Parker, & T. L. Hufford. 2002. Sediment diatom assemblages of Mountain Lake, a subalpine ecosystem, Giles County, Virginia. Castanea 67: 120-133.

Cawley, J. C., B. C. Parker, & L. J. Perren. 2001b. New observations on the geomorphology and origins of Mountain Lake. Earth Surface Processes and Land Forms 26: 429-440.

Chapman, H. H. 1949. Yale professor discusses Mountain Lake enigma. Virginia & Virginia County 3: 27.

Coker, R. E., & W. J. Hayes, Jr. 1940. Biological observations in Mountain Lake, Virginia. Ecology 21: 192-198.

Darlington, W. M. 1893. Christopher Gist's Journals, with Historical, Geographical, and Ethnological Notes and Biographies of his Contemporaries. J. R. Weldin & Co., Pittsburgh, PA. 296 pp.

Dietrich, R. V. 1957. Mountain Lake. Mineral Industries Journal 4: 7-8.

Dubay, C. I. 1976. The standing crop and distribution of macrophytes in Mountain Lake, Virginia, with particular emphasis on the contribution of *Nitella flexilis* (L) to the metalimnetic oxygen maximum. M.S. Thesis. Virginia Polytechnic Institute & State University, Blacksburg, VA. 97 pp.

Dubay, C. I., & G. M. Simmons, Jr. 1979. The contribution of macrophytes to the metalimnetic oxygen maximum in a montane, oligotrophic lake. American Midland Naturalist 101: 108-117.

Dubay, C. I., & G. M. Simmons, Jr. 1981. Distribution and composition of the macrophyte community in Mountain Lake, Virginia. Virginia Journal of Science 32: 17-22.

Eckroade, W. M. 1962. Geology of the Butt Mountain area, Giles County, Virginia. M.S. Thesis. Virginia Polytechnic Institute, Blacksburg, VA. 64 pp.

Ferguson, F., M. A. Stirewalt, T. D. Brown, & W. J. Hayes, Jr. 1939. Studies on the turbellarian fauna of the Mountain Lake Biological Station. I. Ecology and distribution. Journal of the Elisha Mitchell Scientific Society 55: 274-288.

Forest, H. S. 1954. Checklist of algae in the vicinity of Mountain Lake Biological Station. Castanea 19: 88-104.

Godfrey, R. K., & J. W. Wooten. 1979. Aquatic and Wetland Plants of Southeastern United States. Monocotyledons. University of Georgia Press, Athens. 715 pp.

Godfrey, R. K., & J. W. Wooten. 1981. Aquatic and Wetland Plants of Southeastern United States Dicotyledons. University of Georgia Press, Athens. 933 pp.

Grover, W. W., & R. E. Coker. 1940. A study of the depth distribution on certain net plankters in Mountain Lake, Virginia. Ecology 21: 199-205.

Holden, R. J. 1938. Geology of Mountain Lake, Virginia. Virginia Academy of Sciences Proceedings 1937-38: 73.

Hutchinson, G. E., & G. E. Pickford. 1932. Limnological observations of Mountain Lake, Virginia. Internationale Revue Gesamten Hydrobiologie und Hydrographie 27: 252-264.

Jervis, C. 1988. Investigation of some characteristics of the *Nitella* populations in Mountain Lake, Giles County, Virginia. M.S. Thesis. Virginia Polytechnic Institute & State University, Blacksburg, VA. 68 pp.

Jervis, C., B. C. Parker, & F. K. Daily. 1988. *Nitella megacarpa* T.F.A., the dominant macrophyte in Mountain Lake, Virginia. Castanea 53: 290-294.

Johnston, D. E. 1906. A History of Middle New River Settlements and Contiguous Territory. Privately printed, Huntington, WV. 500 pp.

Johnston, J. S. 1898. First Explorations of Kentucky: Dr. Thomas Walter's Journal of an Exploration of Kentucky in 1750, Being the First Record of a White Man to the Interior of that Territory Now First Published Entire, With Notes of a Biographical Sketch: Also Colonel Christopher Gist's Journal of a Tour Through Ohio and Kentucky in 1751, With Notes and Sketch. J. P. Morton & Co., Louisville, KY [Filson Historical Society Publication 13] 222 pp.

Lee, R. E. 1999. Phycology. 3rd Edition. Cambridge University Press, Cambridge, England. 614 pp.

Lewis, I. F. 1957. A history of Mountain Lake. Unpublished manuscript, Newman Library, Virginia Polytechnic Institute & State University, Blacksburg, VA. 26 pp.

Marland, F. C. 1967. The history of Mountain Lake, Giles County, Virginia: An interpretation based on paleolimnology. Ph.D. Dissertation. Virginia Polytechnic Institute, Blacksburg, VA. 129 pp.

Mayer, M., R. Chianese, T. Scudder, J. White, K. Vongpaseuth, & R. Ward. 2002. Thirteen years of monitoring the hemlock woolly adelgid in New Jersey forests. Pp. 50-60 *In* B. Onken, R. Reardon, & J. Lashomb (eds.), Proceedings: Hemlock Woolly Adelgid in the Eastern United States Symposium 5-7 February 2002. East Brunswick, NJ. New Jersey Agricultural Experiment Station, Rutgers – The State University of New Jersey, New Brunswick, NJ. 403 pp.

McCalla, F. L. 1942. Seasonal distribution of the plankton Crustacea of Mountain Lake, Virginia, 1941-1942. M.S. Thesis, University of Virginia, Charlottesville, VA. 37 pp.

Mikell, A. T., B. C. Parker, & G. M. Simmons, Jr. 1983. Sensitivity of an oligotrophic lake planktonic bacterial community to oxygen stress. Applied Environmental Microbiology 46: 545-548.

Mills, H. H. 1988. Surficial geology and geomorphology of the Mountain Lake area, Giles County, Virginia, including sedimentological studies of colluvium and boulder streams. United States Geological Survey Professional Paper 1469: 1-57.

Mulkearn, L. 1954. George Mercer Papers relating to the Ohio Company of Virginia, compiled and edited by Lois Mulkearn: Darlington Memorial Library, University of Pittsburgh Press, Pittsburgh, PA. 731 pp.

Obeng-Asamoa, E. K. 1971. Limnological investigation of Mountain Lake, Giles County, Virginia. Ph.D. Dissertation, Virginia Polytechnic Institute & State University, Blacksburg, VA. 113 pp.

Obeng-Asamoa, E. K. & B. C. Parker. 1972. Seasonal changes in phytoplankton and water chemistry of Mountain Lake, Virginia. Transactions of the American Microscopical Society 91: 363-380.

Parker, B.C. 1976. An estimate of the trophic state of Mountain Lake, Giles County, Virginia. Pp. 102-109 *In* B.C. Parker & M.K. Roane (eds.), The Distributional History of the Biota of the Southern Appalachians: Part IV. Algae and Fungi. The University Press of Virginia, Charlottesville.

Parker, B. C., & M. J. Parson. 1987. A modified ^{14}C primary productivity method. Virginia Journal of Science 38: 214-219.

Parker, B.C., L. J. Wenkert, & M. J. Parson. 1991. Cause of the metalimnetic oxygen maximum in Mountain Lake, Virginia Journal of Freshwater Ecology 6: 293-303.

Parker, B. C., H. E. Wolfe, & R. V. Howard. 1975. On the origin and history of Mountain Lake, Virginia. Southeastern Geology 16: 213-226.

Parson, M. J. 1988. Ammonia uptake by phytoplankton and limnological studies of Mountain Lake, Virginia. Ph.D. Dissertation, Virginia Polytechnic Institute & State University, Blacksburg, VA. 281 pp.

Parson, M. J., & B. C. Parker. 1989a. Mountain Lake, Virginia: An oligotrophic lake under increasing stress. Current Practices in Environmental Science & Engineering 4: 1-19.

Parson, M. J., & B. C. Parker. 1989b. Algal flora in Mountain Lake, Virginia: Past and present. Castanea 54: 79-86.

Parson, M. J., & B. C. Parker. 1993. Seasonal patterns of ammonium (methylamine) uptake by phytoplankton in an oligotrophic lake. Hydrobiologia 250: 105-107.

Pendleton, W. C. 1920. History of Tazewell County and southwest Virginia, 1748-1920. W. C. Hill Printing Company, Richmond, VA. 700 pp.

Pollard, E. A. 1870. A trip to New River, Salt Pond, Bald Knob and Little Stoney Creek. The Virginia Tourist, Lippincott, Philadelphia, PA. 277 pp.

Pownall, T. M. 1776. A topographical description of such parts of North America as are contained in (annexed) map of the middle British Colonies and in North America. Printed for J. Almon, opposite Burlington House, in Piccadilly, London. 16 pp.

Rogers, W. B. 1884. Report on geological reconnaissance of the state of Virginia, made under the appointment of the Board of Public Works, 1835. In: Geology of Virginias. D. Appleton Company, New York, NY. 832 pp.

Roth, J. C., & S. E. Neff. 1964. Studies of physical limnology and profundal bottom fauna, Mountain Lake, Virginia. Virginia Agricultural Experiment Station Bulletin 169: 1-44.

Schultz, A. P., E. K. Rader, & T. M. Guthright, II. 1986. Geological Maps of Giles County, Virginia. Virginia Division of Natural Resources, Publication 69, Charlottesville. Unpaginated.

Schultz, A. P., & C. S. Southworth. 1989. Large bedrock landslides of the Appalachian Valley and Ridge Province of eastern North America. Geological Society of America Special Paper 236: 57-74.

Seaburg, K. G., M. Kasper, & B. C. Parker. 1983. Seasonal differences in the temperature ranges of growth of Virginia algae. Journal of Phycology 19: 380-386.

Sharp, H. S. 1933. The origin of Mountain Lake, Virginia. Journal of Geology 41: 636-641.

Simmons, G. M., Jr., & S. E. Neff. 1973. Observations on limnetic carbon assimilation rates in Mountain Lake, Virginia, during its thermal stratification periods. Virginia Journal of Science 24: 206-211.

Summers, L, P. 1903. Annals of Southwest Virginia, 1769-1800. Privately printed, Abington, VA. 921 pp.

VanBrunt, M. R. 1984. Seasonal patterns of colonization by protozoa in an oligotrophic lake. M.S. Thesis, Virginia Polytechnic Institute & State University, Blacksburg, VA. 94 pp.

Ward, H. B., & G. C. Whipple. 1965. Fresh-Water Biology. 2nd Edition. W.T. Edmondson (ed.). John Wiley & Sons, New York, NY. 1,248 pp.

Whitford, L. A. 1964. The phytoplankton of an extremely oligotrophic lake. Advancing Frontiers of Plant Science 8: 157-160.

Williams, M. G. 1930. The net plankton of Mountain Lake. M.A. Thesis, University of Virginia, Charlottesville, VA. 25 pp.

Wright, L. 1973. Edward Beyer and the Album of Virginia. Virginia Cavalcade 22: 36-47.