Transactions of the Wisconsin Academy of Sciences, Arts and Letters. volume XXXIV 1942

Madison, Wis.: Wisconsin Academy of Sciences, Arts and Letters, 1942

https://digital.library.wisc.edu/1711.dl/B44YAM2CN6YXH8B

TRANSACTIONS

OF THE

WISCONSIN ACADEMY

OF

SCIENCES, ARTS AND LETTERS

VOL. XXXIV

NATURAE SPECIES RATIOQUE

MADISON, WISCONSIN
1942

OFFICERS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

President

A. W. Schorger, *Madison*

Vice-Presidents

In Science: W. N. Steil, *Marquette University*
In Arts: Ralph Buckstaff, *Oshkosh*
In Letters: Berenice Cooper, *Superior State Teachers College*

Secretary-Treasurer

Loyal Durand Jr., *University of Wisconsin*

Librarian

Gilbert H. Doane, *University of Wisconsin*

Curator

Charles E. Brown, *State Historical Museum*

Council

The President
The Vice-Presidents
The Secretary-Treasurer
The Librarian
E. A. Birge, *past president*
Charles S. Slichter, *past president*
Henry L. Ward, *past president*
L. J. Cole, *past president*
Charles E. Allen, *past president*
Rufus M. Bagg, *past president*
Chancey Juday, *past president*
Paul W. Boutwell, *past president*

Committee on Publication

The President
The Secretary-Treasurer
L. E. Noland, *University of Wisconsin*

Committee on Library

The Librarian
A. L. Barker, *Ripon College*
Ira A. Edwards, *Milwaukee Public Museum*
W. S. Marshall, *University of Wisconsin*
O. L. Kowalke, *University of Wisconsin*

Committee on Membership

The Secretary-Treasurer
E. F. Bean, *Wisconsin Geological Survey*
P. W. Boutwell, *Beloit College*
W. E. Rogers, *Lawrence College*
A. W. Schorger, *Madison*

TABLE OF CONTENTS

Correspondence relating to publication in the *Transactions* or to other Academy business should be directed to the Secretary, Loyal Durand Jr., 318 Science Hall, Madison, Wisconsin. Publications intended for the Library of the Academy should be sent directly to the Librarian, Gilbert H. Doane, University of Wisconsin Library, Madison, Wisconsin.

BIRDS OF THE UNIVERSITY OF WISCONSIN ARBORETUM

HARRY G. ANDERSON WILLIAM S. FEENEY
THEODORE M. SPERRY AND JOHN CATENHUSEN

This paper records for the information of the bird students, the birds seen on the University of Wisconsin Arboretum between 1933 and 1941. Most of the data were obtained by the authors incidental to other tasks on the area. Some data were contributed by other ornithologists or were obtained from the literature.

The Arboretum is situated on the shore of Lake Wingra in the outskirts of Madison, Wisconsin. Its boundaries and position are shown on the map. Its 1137 acres include diverse habitats for birds: open water, marshland, wet meadows, old fields, woody thickets, and woodland.

SEASONAL DISTRIBUTION

The observer of birds on the Arboretum may expect to find, during the various months of the year, about the following numbers of species:

January	25	July	80
February	35	August	100
March	85	September	140
April	130	October	95
May	180	November	60
June	100	December	35

Birds occurring on the Arboretum may be grouped according to the seasons during which they are present.

1. *Birds present yearlong:*

Mallard
Red-tailed Hawk
Bobwhite
Ring-necked Pheasant
Screech Owl
Great Horned Owl
Blue Jay
Barrel Owl (Occasional in the winter)
Long-eared Owl*
Short-eared Owl*
Red-headed Woodpecker (Uncommon in the Winter)
Hairy Woodpecker
Downy Woodpecker

* Present only in the winter.

[1] Journal Paper Number 5, University of Wisconsin Arboretum. Harry G. Anderson of the Department of Zoology studied birds on the Arboretum from 1933-1936; William S. Feeney of the National Park Service from 1936-1940; Theodore M. Sperry of the National Park Service from 1936-1941. John Catenhusen, Arboretum Biologist since July, 1941, edited this paper and contributed incidental observations.

Crow
Black-capped Chickadee
White-breasted Nuthatch
Carolina Wren (Casual visitor on Arboretum)
Starling
English Sparrow
Cardinal
Goldfinch

2. *Birds breeding further north, but wintering here:*

Old Squaw*
Goshawk
Rough-legged Hawk
Snowy Owl*
Saw-whet Owl*
Northern Horned Lark*
Northern Shrike*
Red-breasted Nuthatch*
Brown Creeper*
Evening Grosbeak*
Purple Finch
Pine Grosbeak*
Redpoll*
Pine Siskin*
Crossbill*
Slate-colored Junco
Tree Sparrow
Lapland Longspur
Snow Bunting*

3. *Birds breeding further north, wintering further south, here only in migration:*

Loon
Horned Grebe
Double-crested Cormorant
Whistling Swan
Canada Goose
Lesser Snow Goose
Blue Goose
Black Duck
Gadwall
Baldpate
Pintail
Green-winged Teal
Shoveler
Redhead
Ring-necked Duck
Canvas-back Duck
Greater Scaup Duck
Lesser Scaup Duck
American Golden-eye
Bufflehead
Ruddy Duck
Hooded Merganser
American Merganser
Red-breasted Merganser
Sharp-shinned Hawk
Osprey
Pigeon Hawk
Piping Plover
Connecticut Warbler
Solitary Sandpiper
Greater Yellow-legs
Lesser Yellow-legs
Pectoral Sandpiper
White-rumped Sandpiper
Baird's Sandpiper
Least Sandpiper
Red-backed Sandpiper
Long-billed Dowitcher
Semi-palmated Sandpiper
Sanderling
Herring Gull
Ring-billed Gull
Bonaparte's Gull
Common Tern
Caspian Tern
Yellow-bellied Sapsucker
Winter Wren
Hermit Thrush
Olive-backed Thrush
Gray-cheeked Thrush
Willow Thrush
Golden-crowned Kinglet
Ruby-crowned Kinglet
Black and White Warbler
Tennessee Warbler
Orange-crowned Warbler

* Irregular in occurrence, present only during some winters.

- Semi-palmated Plover
- Black-bellied Plover
- Ruddy Turnstone
- Wilson's Snipe*
- Black-throated Blue Warbler
- Myrtle Warbler
- Black-throated Green Warbler
- Cerulean Warbler
- Blackburnian Warbler
- Chestnut-sided Warbler
- Bay-breasted Warbler
- Black-poll Warbler
- Pine Warbler
- Palm Warbler
- Northern Water-Thrush
- Grinnell's Water-Thrush
- Louisiana Water-Thrush
- Nashville Warbler
- Northern Parula Warbler
- Magnolia Warbler
- Cape May Warbler
- Mourning Warbler
- Wilson's Warbler
- Canada Warbler
- Rusty Blackbird
- Leconte's Sparrow
- Clay-colored Sparrow
- Harris's Sparrow
- White-crowned Sparrow
- Gambel's Sparrow
- White-throated Sparrow
- Fox Sparrow
- Lincoln's Sparrow

4. *Birds breeding here or in the immediate vicinity but wintering further south:*

- Pied-billed Grebe
- Great Blue Heron
- Green Heron
- Black-crowned Night Heron
- American Bittern
- Least Bittern
- Blue-winged Teal
- Cooper's Hawk*
- Red-shouldered Hawk
- Broad-winged Hawk
- Marsh Hawk*
- Sparrow Hawk*
- Virginia Rail
- Sora Rail
- Yellow Rail
- Florida Gallinule
- American Coot
- Killdeer
- Woodcock
- Upland Plover
- Spotted Sandpiper
- Wilson's Phalarope
- Black Tern
- Mourning Dove*
- Yellow-billed Cuckoo
- Black-billed Cuckoo
- Whippoorwill
- Nighthawk
- Western House Wren
- Prairie Marsh Wren
- Short-billed Marsh Wren
- Catbird
- Brown Thrasher
- Robin*
- Wood Thrush
- Bluebird
- Blue-gray Gnatcatcher
- Cedar Waxwing*
- Migrant Shrike
- Bell's Vireo
- Yellow-throated Vireo
- Red-eyed Vireo
- Warbling Vireo
- Golden-winged Warbler
- Yellow Warbler
- Kentucky Warbler
- Ovenbird
- Northern Yellow-throat
- Redstart
- Bobolink
- Eastern Meadowlark*
- Western Meadowlark
- Red-winged Blackbird*
- Orchard Oriole
- Baltimore Oriole
- Brewer's Blackbird

* Occasional in winter.

Chimney Swift
Ruby-throated Hummingbird
Belted Kingfisher
Flicker
Eastern Kingbird
Arkansas Kingbird
Crested Flycatcher
Phoebe
Alder Flycatcher
Least Flycatcher
Wood Pewee
Prairie Horned Lark*
Tree Swallow
Bank Swallow
Rough-winged Swallow
Purple Martin
Bronzed Grackle
Cowbird
Scarlet Tanager
Rose-breasted Grosbeak
Indigo Bunting
Dickcissel
Towhee
Savannah Sparrow
Grasshopper Sparrow
Henslow's Sparrow
Vesper Sparrow
Chipping Sparrow
Field Sparrow
Swamp Sparrow
Song Sparrow*

Breeding Birds

Approximately 90 species of birds have been recorded as breeders on the Arboretum. They are listed under the months during which they have been observed to nest. The list includes the species observed to breed by the authors since 1933, plus a few species of exceptional interest observed by other ornithologists during the past decade. Birds that breed in the immediate vicinity, but have not been observed to breed on the Arboretum, are not included in this list, but are recorded under Lists 1 and 4.

February

Great Horned Owl

March

Mallard
Prairie Horned Lark
Crow

April

Blue-winged Teal
Red-tailed Hawk
Red-shouldered Hawk
Bobwhite
Ring-necked Pheasant
Killdeer
Woodcock
Mourning Dove
Screech Owl
Long-eared Owl
Northern Flicker

April (continued)

Phoebe
White-breasted Nuthatch

May

Green Heron
American Bittern
Cooper's Hawk
Marsh Hawk
Virginia Rail
Sora Rail
Florida Gallinule
American Coot
Spotted Sandpiper
Short-eared Owl
Belted Kingfisher
Ruby-throated Hummingbird
Red-headed Woodpecker
Hairy Woodpecker

* Occasional in winter.

May (continued)

Downy Woodpecker
Kingbird
Tree Swallow
Blue Jay
Black-capped Chickadee
House Wren
Long-billed Marsh Wren
Short-billed Marsh Wren
Catbird
Brown Thrasher
Starling
Yellow-throated Vireo
Red-eyed Vireo
Warbling Vireo
Yellow Warbler
Ovenbird
Northern Yellow-throat
Redstart
English Sparrow
Eastern Meadowlark
Western Meadowlark
Red-winged Blackbird
Baltimore Oriole
Cardinal
Rose-breasted Grosbeak
Indigo Bunting
Towhee

May (continued)

Savannah Sparrow
Chipping Sparrow
Field Sparrow
Swamp Sparrow
Song Sparrow

June

Least Bittern
Wilson's Phalarope (4)
Black Tern
Yellow-billed Cuckoo
Black-billed Cuckoo
Nighthawk
Whippoorwill
Crested Flycatcher
Alder Flycatcher
Least Flycatcher
Wood Pewee
Wood Thrush
Blue-gray Gnatcatcher (Schorger, unpublished journal, 1924)
Bell's Vireo (5)
Bobolink
Dickcissel
Eastern Goldfinch
Grasshopper Sparrow
Henslow's Sparrow

During the breeding seasons of 1934 to 1936, six census areas (fig. 1) totalling 150 acres, were intensively studied, and all singing males and as many nests as possible were recorded. The average number of breeding pairs for the three seasons was found to be:

Red-winged Blackbird	40 pairs
Long-billed Marsh Wren	34 pairs
Yellow Warbler	20 pairs
Catbird	18 pairs
Northern Yellow-throat	21 pairs
Cowbird	15 pairs
Goldfinch	14 pairs
English Sparrow	10 pairs
Swamp Sparrow	15 pairs
Song Sparrow	45 pairs
Red-eyed Vireo	10 pairs
Field Sparrow	17 pairs
Warbling Vireo	5 pairs
Robin	18 pairs
Mourning Dove	6 pairs
Pheasant	30 pairs
Bobwhite	10 pairs
Flicker	8 pairs
Blue Jay	8 pairs
Cardinal	3 pairs
American Bittern	4 pairs
Indigo Bunting	7 pairs
Crow	4 pairs
Woodcock	8 pairs
Bluebird	4 pairs
Total	370 pairs
Average per acre	2.5 pairs

The density of nests varied with the habitat, ranging from .45 nests per acre on old fields to 2.80 per acre on marshes.

Migration

This list gives the earliest arrival date and the latest departure date recorded during the period 1933 to 1941 for each migrant

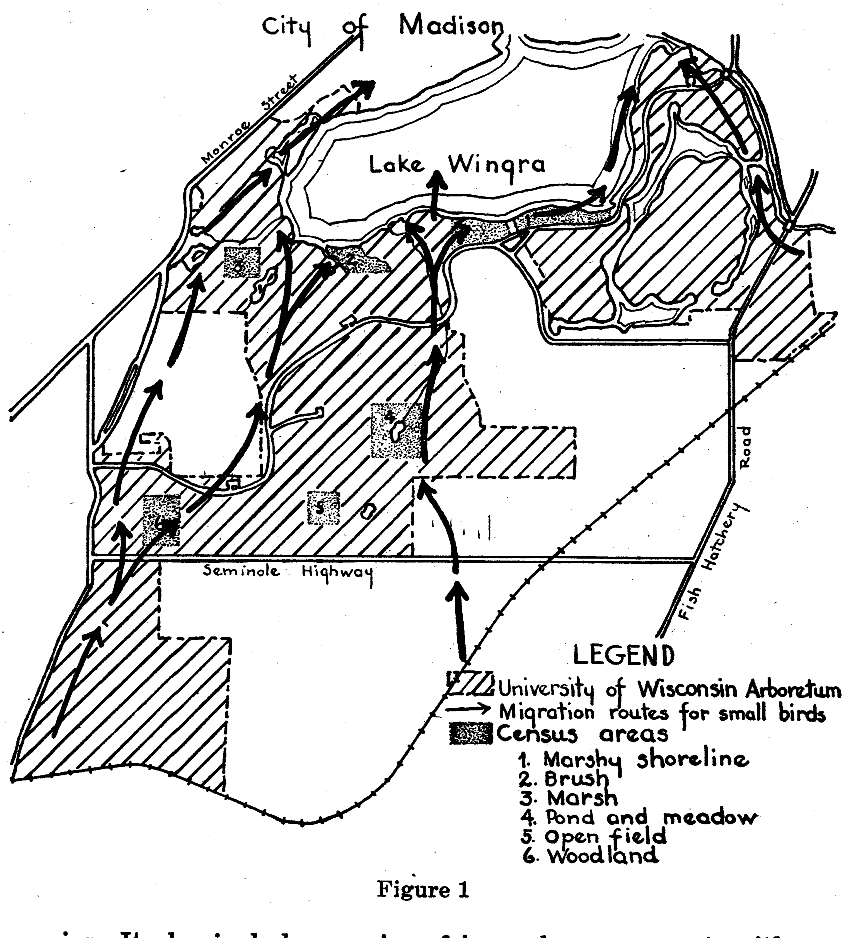


Figure 1

species. It also includes species of irregular movement, with remarks on their Arboretum status. It excludes all birds recorded under Lists 1 and 2.

The order is the order of spring arrival. Species showing an arrival date in the spring and a departure date in the fall are breeders, while species showing arrival and departure dates for both spring and fall occur here only as transient visitors. In the case of migrants which breed farther north but winter here, the fall arrival date appears under the fall column and the spring departure date appears under the spring column.

The relative abundance of each species is indicated by the following abbreviations: C = common; FC = fairly common; U = uncommon; R = rare.

Species	Abundance	Migration Dates		Remarks
		Spring	Fall	
Red-winged Blackbird	C	2/5-	-11/25	Sometimes winters
Cooper's Hawk	C	2/23-	-10/28	Sometimes breeds and winters
Bluebird	C	2/28-	-10/27	
Marsh Hawk	FC	2/28-	-11/8	3 pairs usually nest
Canada Goose	C	3/2-	-11/22	Flies over but seldom alights
Killdeer	C	3/3-	-11/30	
Song Sparrow	C	3/3-	-11/2	Sometimes winters
Western Meadowlark	U	3/4-	-10/15	A few breed
Robin	C	3/4-	-11/7	A few winter
Herring Gull	C	3/6-6/7	9/28-11/25	Immatures sometimes winter
Red-headed Woodpecker	FC	3/6-	-10/24	Sometimes winters
Bald Eagle	R	3/7-4/12	......	2 records flying over
Cowbird	C	3/7-	-9/29	
Sparrow Hawk	U	3/9-4/18	......	Sometimes winters
Red-shouldered Hawk	FC	3/10-	-11/8	1 pair nests
Woodcock	FC	3/11-	-11/7	About 30 pairs
Eastern Meadowlark	C	3/11-	-11/9	
Ring-necked Duck	FC	3/14-5/22	10/20-11/9	Sometimes in company with scaups
Lesser Scaup Duck	C	3/14-5/23	10/20-11/23	
American Golden-eye	FC	3/14-4/11	10/24-12/20	
Rusty Blackbird	C	3/14-4/29	9/28-12/20	A few winter
Fox Sparrow	C	3/14-4/20	9/29-11/7	One of the first migrant sparrows
Broad-winged Hawk	U	3/14-	-9/13	
Hooded Merganser	FC	3/16-5/20	10/24-11/25	Least common of the 3 fish ducks
American Merganser	FC	3/16-4/4	11/ 1-11/25	
Mourning Dove	C	3/16-	-10/24	Sometimes winters

Species	Abundance	Migration Dates		Remarks
		Spring	Fall	
Phoebe	C	3/16-	-10/12	Nests under nearby bridges
Purple Finch	C	3/16-5/5	10/ 5-11/7	Sometimes winters
Golden-crowned Kinglet	C	3/18-5/6	9/29-12/30	Sometimes winters
Great Blue Heron	U	3/19-	-11/9	Birds from outside rookeries feed on Arboretum
Pintail	U	3/19-4/30	10/15-11/20	
Shoveler	U	3/19-5/10	-12/28	
Northern Flicker	C	3/19-	-10/31	
Carolina Wren	R	3/20-4/17	......	Irregular visitor from Wisconsin River bottoms
Bronzed Grackle	C	3/20-	-10/28	
American Coot	C	3/21-	-11/21	A few breed
Migrant Shrike	U	3/22-		Rarely breeds
Green-winged Teal	U	3/22-4/24	-11/9	
Pied-billed Grebe	C	3/22-	-11/7	A few breed
Redhead	U	3/22-4/30	-11/9	
Canvas-back Duck	U	3/22-4/30	10/24-11/9	1 pair nested in 1927
Hermit Thrush	FC	3/22-4/29	9/12-10/16	
Whistling Swan	R	3/23-	......	One record flying over
Bufflehead	FC	3/23-4/8	10/24-11/20	
Red-breasted Merganser	FC	3/23-4/30	11/ 2-11/24	
Sharp-shinned Hawk	U	3/23-5/13	9/11-12/26	
Wilson's Snipe	FC	3/23-5/14	9/29-12/7	Sometimes winters at springs
Savannah Sparrow	FC	3/23-	-10/22	
Loon	FC	3/24-4/27	10/24-11/20	
Ruddy Duck	U	3/24-5/22	-11/9	
Blue Goose	R	3/25-5/21	11/ 2-11/10	5 records of single birds
Ring-billed Gull	C	3/25-6/7	10/12-11/23	Immatures sometimes summer

Species	Abundance	Migration Dates		Remarks
		Spring	Fall	
LeConte's Sparrow	R	3/25-4/6	......	3 records
Swamp Sparrow	C	3/25-	-10/30	
Ruby-crowned Kinglet	C	3/25-5/13	9/25-10/22	
Blue-winged Teal	FC	3/26-	-12/26	A few breed
Winter Wren	FC	3/27-5/3	10/ 3-10/28	
Field Sparrow	FC	3/28-	-10/12	
Vesper Sparrow	FC	3/29-	-10/28	
Double-crested Cormorant	U	3/29-5/10	10/ 7-11/16	
Black Duck	U	3/30-5/16	11/ 7-12/26	A few winter; a few possibly breed
Baldpate	FC	3/30-5/21	-11/9	1 winter record
Yellow-bellied Sapsucker	C	3/30-5/11	9/28-10/12	
Belted Kingfisher	FC	3/30-	-12/2	Nests nearby
Brewer's Blackbird	R	4/3-6/8	......	2 records; 1 pair nested
Bewick's Wren	R	4/4-4/8	......	
Purple Martin	C	4/6-	- 8/27	
White-throated Sparrow	C	4/7-5/25	9/20-10/24	
Tree Swallow	C	4/8-	-10/24	
Greater Scaup Duck	R	4/8-5/22	......	Sight record of 26 birds
American Bittern	FC	4/9-	-11/5	A few breed
Myrtle Warbler	C	4/11-5/22	9/29-10/23	
Duck Hawk	R	4/12-	......	3 records flying over
Black-crowned Night Heron	U	4/13-	-10/16	Birds from outside rookeries feed on Arboretum
Western House Wren	FC	4/14-	-10/12	
Towhee	FC	4/14-	-10/20	
Louisiana Water-Thrush	U	4/16-5/22	......	
Osprey	U	4/17-5/11	......	

Species	Abundance	Migration Dates		Remarks
		Spring	Fall	
Whippoorwill	F	4/18-	- 9/10	
Henslow's Sparrow	FC	4/18-	......	
Upland Plover	R	4/18-6/15	......	May nest when there are stubble fields
Gadwall	R	4/20-5/10	-11/9	
Chipping Sparrow	FC	4/20-	- 9/18	
Sora Rail	C	4/21-	-10/3	
Eastern Kingbird	FC	4/21-	- 9/4	
Rough-winged Swallow	C	4/21-	- 9/5	Does not breed on Arboretum
Barn Swallow	FC	4/21-	- 9/15	Does not breed on Arboretum
Horned Grebe	U	4/22-5/4	10/31-11/9	
Pectoral Sandpiper	U	4/22-5/10	- 8/24	
Bank Swallow	C	4/23-	- 9/7	
Bonaparte's Gull	U	4/24-4/26	......	Present for only a few days
Brown Thrasher	C	4/24-	-10/5	1 winter record
Black and White Warbler	C	4/24-5/22	10/ 1-10/12	
Orange-crowned Warbler	U	4/24-5/10	......	
Western Palm Warbler	FC	4/24-5/20	9/28-10/10	
Northern Pine Warbler	U	4/26-5/2	10/12-10/15	
Greater Yellow-legs	U	4/27-5/21	-11/7	
Lesser Yellow-legs	U	4/27-5/21	8/ 1- 9/29	
Yellow Warbler	C	4/27-	- 8/20	
Black-throated Green Warbler	FC	4/28-5/22	......	
Northern Water-Thrush	U	4/28-5/25	......	
Gambel's Sparrow	R	4/28-5/14	......	
Spotted Sandpiper	FC	4/29-	- 9/28	
Solitary Sandpiper	FC	4/29-5/12	9/23-10/3	

Species	Abundance	Migration Dates		Remarks
		Spring	Fall	
Common Tern	U	4/29-6/20	......	
Chimney Swift	FC	4/29-	-10/7	
Prairie Marsh Wren	C	4/29-	-10/12	
Blue-headed Vireo	U	4/29-5/22	9/28-10/4	
Green Heron	FC	4/30-	- 9/25	A few breed
Semi-palmated Plover	U	4/30-5/27	6/20- 8/24	
Golden-winged Warbler	U	4/30-5/26	......	
Blue-gray Gnatcatcher	FC	4/30-5/11	......	
Virginia Rail	FC	4/20-	- 9/28	
Catbird	C	5/1-	-10/7	
Black-bellied Plover	R	5/2-5/21	10/24-	
Black Tern	FC	5/2-	- 9/10	
Crested Flycatcher	U	5/2-	- 9/2	
Least Flycatcher	C	5/2-	- 9/5	
Gray-cheeked Thrush	FC	5/2-5/25	9/10- 9/28	Difficult to distinguish from Olive-backed Thrush
Olive-backed Thrush	FC	5/2-5/25	9/ 5-10/6	
Nashville Warbler	FC	5/2-5/22	9/20-10/12	
Northern Parula Warbler	U	5/2-5/16	......	
Northern Yellow-throated Warbler	C	5/2-	-10/6	1 winter record
Bobolink	C	5/2-	- 9/5	
Baltimore Oriole	FC	5/2-	- 8/28	
Rose-breasted Grosbeak	FC	5/2-	-10/3	
Lincoln Sparrow	R	5/2-5/18	......	
Wood Thrush	FC	5/3-	- 9/20	
Warbling Vireo	C	5/3-	- 9/15	
Tennessee Warbler	C	5/3-5/22	9/10-10/12	

Species	Abundance	Migration Dates		Remarks
		Spring	Fall	
Magnolia Warbler	C	5/3-5/25	9/12-10/12	
Bay-breasted Warbler	C	5/3-5/22	9/18-10/12	
Ovenbird	FC	5/3-	-10/6	
Redstart	C	5/3-	-10/12	
Black-billed Cuckoo	U	5/4-	......	
Short-billed Marsh Wren	FC	5/4-	- 9/28	
Cape May Warbler	U	5/4-5/18	......	
Black-poll Warbler	C	5/4-5/25	......	
Blackburnian Warbler	FC	5/4-5/25	9/29-	
Grasshopper Sparrow	U	5/4-	......	
White-crowned Sparrow	U	5/4-5/20	......	
Wilson's Phalarope	U	5/5-6/8	......	
Red-breasted Nuthatch	R	5/5-	-12/26	
Willow Thrush	C	5/5-5/22	......	
Chestnut-sided Warbler	FC	5/5-5/25	9/ 2- 9/28	
Least Sandpiper	U	5/5-6/10	8/ 8- 9/13	
Nighthawk	FC	5/6-	-10/6	
Alder Flycatcher	C	5/6-6/1	- 8/27	
Yellow-throated Vireo	C	5/6-	- 9/20	
Scarlet Tanager	FC	5/7-	-10/3	
Black-throated Blue Warbler	U	5/8-5/16	......	
Black Rail	R	5/9-	......	Wm. Feeney saw 2 birds 5/9/40
Lesser Snow Goose	R	5/10-5/21	......	
Red-eyed Vireo	C	5/10-	-10/6	
Indigo Bunting	C	5/10-	......	
White-rumped Sandpiper	R	5/10-5/15	......	

Species	Abundance	Migration Dates		Remarks
		Spring	Fall	
Red-backed Sandpiper	U	5/10-5/22	......	
Semi-palmated Plover	U	5/11-6/9	8/11- 9/13	
Clay-colored Sparrow	R	5/11-5/24	......	
Florida Gallinule	U	5/11-	......	
Wood Pewee	C	5/11-	-10/15	
Wilson's Warbler	FC	5/11-5/25	......	
Yellow-headed Blackbird	R	5/11-	......	
Olive-sided Flycatcher	U	5/12-5/23	......	
Ruby-throated Hummingbird	FC	5/13-	- 9/29	
Yellow-bellied Flycatcher	U	5/13-5/22	......	
Prairie Warbler	R	5/13-	......	One record
Caspian Tern	R	5/15-5/21	6/29-	
Philadelphia Vireo	FC	5/15-	......	
Cerulean Warbler	R	5/15-	......	
Mourning Warbler	FC	5/15-5/25	......	
Canadian Warbler	FC	5/15-5/27	......	
Ruddy Turnstone	R	5/16-5/24	......	
Least Bittern	U	5/19-	- 8/20	
Kentucky Warbler	R	5/19-	......	
Piping Plover	R	5/20-5/21	......	
Long-billed Dowitcher	R	5/20-	7/18- 9/26	
Sanderling	R	5/20-5/21	8/24-	
Baird's Sandpiper	R	5/21-	......	
Connecticut Warbler	FC	5/22-6/1	-10/6	
Nelson's Sparrow	R	5/24-	......	1 sight record
Orchard Oriole	R	5/26-	......	

Species	Abundance	Migration Dates		Remarks
		Spring	Fall	
Dickcissel	R	5/26-	......	
Cliff Swallow	U	5/28-	......	
Harris's Sparrow	R	5/17-	......	1 record
Yellow-billed Cuckoo	U	6/1-	......	
King Rail	R	6/17-	......	
American Egret	R	.....	8/15-	1 record
Turkey Vulture	R	.....	9/23-	1 record flying over
Pigeon Hawk	R	.....	10/13-10/17	2 records
Acadian Flycatcher	R	5/14-	......	1 record
Brown Creeper	FC	-4/30	9/28-	
Slate-colored Junco	C	-5/3	9/23-	
Tufted Titmouse	R	.....	10/ 5-	1 record
Tree Sparrow	C	-4/25	10/12-	
Rough-legged Hawk	R	.....	10/11-	
Lapland Longspur	FC	-4/10	10/24-	
Snow Bunting	U	.....	10/26-	
Northern Horned Lark	U	.....	10/26-	
Northern Shrike	R	-2/7	11/ 7-	
Redpoll	U	-3/10	12/ 5-	
Evening Grosbeak	R	-3/4	12/26-	
Saw-whet Owl	R	.....	1/27-	
Snowy Owl	R	.....	......	

Introduced Species

English Sparrow

This species was introduced at Fort Howard (near Green Bay) and Sheboygan in 1875 as well as in the East. It has long since become an abundant resident. On the Arboretum it prefers the area occupied by the Civilian Conservation Corps buildings.

Starling

The starling was introduced in New York City in 1890. It was first observed in Dane County in 1928. It is now a permanent resident, though less common in winter than in the other seasons of the year.

Chukar Partridge

No chukar partridges have been planted on the Arboretum, but numerous releases have been made in Dane County. Two birds drifted to the Arboretum and remained throughout the spring and summer of 1940.

Ring-necked Pheasant

The first release of these birds (number unknown) was made in 1923-1924 by Frank Schultz of the Izaak Walton League. Ed Lloyd planted eight in 1925. S. H. Chase released 14 at his residence in 1927. A census taken during the winter of 1929-1930 by Paul Errington showed six to be present. In 1932 J. G. Dickson planted 22, while Frank Schultz released 26 in 1933, after which no more plantings were made. Yearly censuses have disclosed a considerable increase:

1935	170
1936	179
1937	260
1938	182
1939	340
1940	299
1941	317

Hungarian Partridge

Four pairs of Hungarian partridges were released near the present headquarters by Frank Schultz and W. W. Cook in 1929. They were seen a short time later at Professor George Wagner's residence in Wingra Park. None has been observed since.

Species Recorded Previous to This Study

Wood Duck

This species was at one time quite numerous on Lake Wingra. W. H. Chase (3), hunting in this region from 1873-1896, killed 161. During this period wood duck comprised 11 per cent of his bag. He killed his last wood duck in 1894.

Ruffed Grouse

W. H. Chase (3) considered this grouse a common resident of the Lake Wingra area and bagged 94 birds between the years 1873-1894.

A. R. Cahn (2) reported that ruffed grouse were still common in the Wingra woods in 1915.

Pinnated Grouse

A. R. Cahn (2) refers to the prairie chicken as being "very common, probably nesting" in 1915. A. W. Schorger found a nest in one of the Lake Wingra marshes on April 26, 1914 (5). S. H. Chase remembers hearing "chickens" booming in the marsh up to 1931. The last record was three birds seen on December 8, 1936, during a pheasant census.

Passenger Pigeon

W. H. Chase (3) recorded this extinct bird as late as 1888, bagging four in that year.

Bell's Vireo

Two records are known for the Arboretum region. A. W. Schorger (5) collected a specimen in the Lake Wingra area on July 3, 1914, and Warner Taylor (6) found a nesting pair on June 9, 1922.

Publications Helpful in the Study of Arboretum Birds

The bird student should own and carry with him a good manual. One such is:

Peterson, Roger Tory.
1939. A field guide to the birds. 167 pp. Houghton Mifflin Company, New York.

The bird student may find a full account of the life histories of birds in the following publications which are available in libraries:

Roberts, Thomas S.
1932. The birds of Minnesota. 2 vols., 1512 pp. The University of Minnesota Press, Minneapolis, Minnesota.

Barrows, Walter B.
1912. Michigan bird life. 822 pp. Wynkoop Hallenbeck Crawford Company, Lansing, Michigan. (Out of print.)

The bird student may consult the following check lists in libraries:

Schorger, A. W.
1929 and 1931. Birds of Dane County, Wisconsin. Transactions of the Wisconsin Academy of Sciences, Arts and Letters, 24:457-499, 26:1-60.

Barger, N. R. et al.
1942. Wisconsin birds—a preliminary check list with migration charts. The Wisconsin Society of Ornithology, Madison, Wisconsin.

The following periodical deals with Wisconsin ornithology:

The Passenger Pigeon. Monthly bulletin of the Wisconsin Society of Ornithology, Madison, Wisconsin.

Literature on Arboretum Birds

1. Anderson, Harry G.
1936. 166 pp. Avifauna of the Arboretum of the University of Wisconsin. A thesis submitted for the degree of bachelor of arts. University of Wisconsin, Madison, Wisconsin.

2. Cahn, A. R.
1915. An ecological survey of the Wingra springs region. Bulletin of the Wisconsin Natural History Society, 13:123-177.

3. Leopold, Aldo.
1937. The Chase journal: an early record of Wisconsin wildlife. Transactions of the Wisconsin Academy of Sciences, Arts and Letters, 31:69-76.

4. Main, John S.
1940. The Auk, 57:424.

5. Schorger, A. W.
1929 and 1931. Birds of Dane County, Wisconsin. Transactions of the Wisconsin Academy of Sciences, Arts and Letters, 24:457-499, 26:1-60.

6. Taylor, Warner.
1922. The Auk, 39:575.

EXTINCT AND ENDANGERED MAMMALS AND BIRDS OF THE UPPER GREAT LAKES REGION

A. W. SCHORGER

The early French voyageurs called the Chippewa River *Bon Secours* (Good Succor) since in its valley game could be obtained without fail and in abundance. Subject to seasonal wanderings, the prairies and oak openings contained large herds of deer, elk, and bison. The black bear was common in all the wooded areas, while moose and caribou were to be found towards Lake Superior. Fur-bearing animals were abundant. Game-birds, though numerous, were seldom molested since the ball required to secure a sharp-tailed grouse could fell a deer as readily.

The advent of settlement initiated vast changes in the flora and fauna, and the end is not yet. The attitude towards conservation must be realistic. Agriculture is incompatible with great herds of elk and bison, and darkening flocks of pigeons. Whether a more satisfactory compromise than the present could have been reached by a premeditated plan is conjectural.

Today, among the mammals, the native stock of the bison, elk, and cougar is extinct. The restoration of the bison and cougar is impractical. The same may be said of the elk except for a few special areas.

In the preservation of most species two factors loom large. The obvious one is a favorable habitat. The other, a population "reservoir" from which a species can draw recruits, is more often overlooked. The reservoirs no longer exist and the remnants live precariously.

The elk actually flourished only in the oak openings and on the prairies. Today we try to preserve the elk in unsuitable environments. The elk placed on Grand Island have disappeared, while those introduced into the northern portion of the southern peninsula of Michigan appear to be stationary in numbers. In Wisconsin, the elk did not receive permanent protection until 1913, long after the native stock was exterminated. In 1917, forty-one elk from the Yellowstone National Park were placed on the state game farm in Vilas County. Approximately one-half of the animals died following release, yet in 1924 it was thought that the drove had increased to 75. At the present time there are possibly 35 elk in Vilas and Oneida Counties. The elk received permanent protection in Minnesota in 1890, again too late to save the native stock. In 1935, twenty-seven elk, obtained originally from Jackson's Hole, were released in the northwestern part of Minnesota. Now there are about 90 elk ranging that area.

The caribou was never numerous in Wisconsin and Michigan. The small population that did exist was maintained unquestionably by infiltrations from Ontario and Minnesota. The latter state alone has sufficient muskeg country to perpetuate the species. The various species of reindeer moss (*Cladonia*) appear to be essential winter foods for this animal in the wild. Recently ten caribou trapped in Saskatchewan were brought to Minnesota for eventual release in an attempt to secure a natural increase of the native residue represented by three cows. In view of the fact that Canadian caribou no longer wander into the region, the experiment will be watched with interest.

The moose received permanent protection in Wisconsin in 1907 and in Minnesota in 1922. No native stock exists in Wisconsin or in Michigan except on Isle Royale. Minnesota is in an enviable position. The moose is still sufficiently numerous that there is no apparent danger of a serious decrease. The difficulties in introduction are great. Eighteen moose trapped on Isle Royale in the winter of 1935-36 were liberated along the Escanaba River in the spring of 1936. A bull moose injured in transport was not released until a year later. The bull and four cows eventually wandered southward into Florence County, Wisconsin. In the fall of 1937, the bull was found shot, and in the fall of 1939, a cow met a similar fate. At times, an adequate public respect for game seems distant. All the painstaking and costly efforts to perpetuate a species can be annulled in a brief time by a few thoughtless individuals. There is hope that the moose can be restored permanently on some of the state and national forests, but the wandering habit of the animal provides another difficulty with which to cope.

The timber wolf exists in sufficient numbers that there is no immediate danger of extinction. Cessation of trapping could increase the population readily. Fortunately it is possible to exercise complete control on the national forests. Elsewhere,

where there is damage to stock, the coyote and timber wolf decline together. Deer are sufficiently numerous so that only under exceptional conditions will it be necessary to control the timber wolf on this account, should the point be reached where its existance is endangered.

The restoration of the fur-bearing mammals, the fisher and the marten, is an especially difficult problem. They were protected permanently in Minnesota in 1933 and in Wisconsin in 1921. The intervening years offer no hope of a substantial increase in their numbers in the sections where a few individuals presumably still exist. The introduction of Canadian stock into the national forests would be an experiment well worth the effort.

Many attempts have been made by states and private individuals to restock the north central states with wild turkeys. All have been failures. Habitats suitable for restoration no longer exist. Hatchery stock, aside from a pronounced tendency to end up in a barnyard with domesticated turkeys, is seldom sufficiently hardy. Experience teaches that it is necessary to start with wild, trapped birds. The expense involved and the slender chances of success scarcely justify the effort.

Man by a single plowing permanently destroyed the virgin prairie. All the knowledge of prairie ecology acquired during the past century is insufficient to enable him to restore it should there be the will. With the destruction of the prairie, the prairie chicken was forced northward into what was formerly ultramarginal territory. What with drainage and drought even this territory is being made distinctly less favorable through the growth of brush. Judicious burning and flooding appear to be essential if the prairie chicken is to be preserved. Whether the disease cycle is recent in the history of the species and whether it is becoming more or less severe in its effects are still unknown factors. The serious study that has been given to the prairie chicken should eventually bear fruit provided that "patient money" continues to be available.

The complete disappearance of breeding sandhill cranes would create a deplorable gap in our fauna. Whoever has heard the sonorous cries of a flock of cranes circling high overhead will never forget the experience. The few cranes that remain are a tribute to the thoughtfulness of landowners. If left unmolested by man, especially the poacher, there is no doubt but that the sandhill crane would multiply satisfactorily. It is known that this bird requires large areas of grasslands and marshes with pools of water, but it will be a sad commentary on our civilization if we must resort to management.

The vast environmental changes produced by man have reduced many species to remnants. Conservation since its inception under the mantle of game laws has been a continual compromise with the hunter and the poacher. The zealous attempts of a few to preserve our residual fauna for future generations is being rewarded by the gradual development of a public conscience. When the great majority of the people realize that a spruce grouse has more aesthetic than culinary value, that a fisher in the wilderness is as deserving of preservation as a squirrel in the park, then the aims of conservation can be achieved.

MARTEN (*Martes americana americana* Turton)

The marten, or American sable, occurred originally in all the timbered areas of Minnesota, Wisconsin, and Michigan. It had a decided preference for conifers and even penetrated the strip of pine timber that ran along the shore of Lake Michigan, in Illinois and Indiana.

The virtual extinction of the marten was due to the demands of the fur trade coupled with the ease with which it could be trapped. A bloody bait was irresistible. A Vermont trapper who plied his trade on the Black River, Wisconsin, in 1866, had a cruel but effective procedure. A hole was bored into the base of a tree and filled with the livers of red squirrels. "Around this hole would be driven a row of nails sharpened at the end and so turned and bent that while the marten could get his head through to reach the liver it was impossible to withdraw it, on account of the sharpened nails."[1]

The marten population is subject to violent fluctuations, passing through an 8 to 10-year cycle. No adequate explanation of this phenomenon has been advanced unless it be the fluctuations in number of its main food, rabbits. Another important food was the red squirrel. The cutting of the virgin coniferous forests, destroying habitat and food supply simultaneously, was a factor in the decline.

The marten appears to have been much more numerous than its relative, the fisher, judging from the returns of trappers and traders. This is shown in the following table:

Author	Station	Year	Marten	Fisher
Curot[2]	Yellow River, Wis.	1804	3	13
Malhiot[3]	Lac du Flambeau, Wis.	1804-5	63	9
Dubuque[4]	Prairie du Chien, Wis.	1807	62	70
Porlier[5]	Green Bay, Wis.	1814	123	29
Paul[6]	Superior	1856	1000	...
Paul[6]	Superior*	1857	1600	200
Cartwright[7]	Elk River, Wis.	1858-9	18	2
Cartwright[7]	St. Croix Valley	1870	10	8

The place that the marten held in the fur trade may be judged from the fact that the skins were sorted into *fourteen* grades depending on color and quality.[8]

A shipment of furs from Chippewa Falls, Wisconsin, in 1871, stated to have been one of the largest ever sent from the place, contained but 60 marten skins. Preferential trapping could not have been an important factor for in trade a fisher skin was valued at one and one-half to twice as much as the marten. By 1920 the marten was close to extinction in Wisconsin. Trappers, for the season 1919-20, reported taking but 21 marten, and during the last legal season, 1920-21, none. The last known capture for the state is the one shipped from Maple, Douglas County, in 1925.[9]

During the past few years I have made special inquiry at the Apostle Islands regarding the marten. In 1934, a fisherman from Madeline Island stated that a Frenchman spent a winter on Outer Island during the World War and trapped several marten. No later report was obtained. It is difficult to explain the presence of marten on islands such as Outer and Isle Royale, except by crossing on the ice.

The decline in Minnesota was almost as rapid. Errington[10] spent seven months, in the fall and spring of 1920-21, north and east of Red Lake. His trapping grounds were in Beltrami and Koochiching Counties. There were no marten left at that time. According to Surber,[11] the species still existed in southern Beltrami County up to the spring of 1918. W. J. Breckenridge[12] informs me that while there is no positive evidence of its existence in Minnesota, trappers and wardens report that a few marten remain in the Superior Forest and in the Chippewa National Forest near Leech Lake. A few were trapped the winter of 1939-40 in Ontario just north of Lake Saganaga, one being obtained for the Museum of Natural History, University of Minnesota.

* Collected from five posts in Minnesota.

The marten declined in Michigan as rapidly as it did in Wisconsin. Very recently W. E. Scott of the Wisconsin Conservation Department obtained the important information that the marten is not extinct. W. R. Spellum, taxidermist and collector of Viroqua, wrote that on November 27, 1939 while hunting in southeastern Sawyer County he saw a marten catch and eat a red squirrel; and on November 29, watched it attempt to catch a ruffed grouse.

FISHER (*Martes pennanti pennanti* Erxleben)

The fisher had much the same range as the marten. While never as numerous as the marten it was far more common than the latter in the hardwood timber. Returns from trading posts located on Lake Superior show but few fisher skins. In mixed conifers and hardwoods, especially along the river valleys, both mammals were once fairly common. Anderson,[13] who spent the winter of 1806-07 fifty miles above the mouth of the Minnesota River, mentions that both fisher and marten were trapped occasionally. Bunnell,[14] coming to the present site of La Crosse in 1842, found fisher "numerous" in the big timber of the Mississippi bottoms. While the occurrence of the marten in southern Wisconsin is conjectural, there are definite statements of the occurrence of the fisher in Milwaukee and Jefferson Counties as late as 1852;[15] and it was formerly numerous in Sauk County.[16]

A gradual change in the numerical status of the marten and fisher took place as the coniferous timber was cut and replaced by the growth of hardwoods. In the season 1917-18, Wisconsin trappers reported the capture of 559 fisher* and only 48 marten. There is then a surprisingly rapid decline to 3 fisher for 1920-21, the last legal season.[17]

Two fisher were trapped at Huron Mountain, Michigan, during the winter of 1930-31. Leopold[18] states that sign was found there along the Salmon Trout River about 1936. The fisher is reported to exist still in Michigan and Wisconsin; however the only positive statement for the entire area is that of Manweiler[19] who mentions it as part of the present fauna of the "Big Bog" in Minnesota.

* This figure must be accepted with reservation. The otter, though on the protected list at this time, was taken frequently and reported as "fisher".

WOLVERINE (*Gulo luscus* Linn.)

The wolverine is the imp of the forest. In view of all the traits attributed to it by the French-Canadians, it is surprising that they did not give to it the name *enfan du diable* (child of the devil) rather than to the wild cat. There is ample evidence of its malicious destruction of property but it is doubtful if it should carry the name glutton. Its appetite is sharp but no more so than that of the wolf and several other animals. Schoolcraft,[20] while in Minnesota in 1820, seems to have discussed this subject for he states: "The Indians said there was no animal in their country deserving this name [glutton]; the only animal they knew deserving of it, was the horse, which was eating all the time."

The wolverine was a rare animal south of Lake Superior. Doty, [21] in 1820, stated specifically that it did not occur at the head of Lake Superior but was to be found in the vicinity of Leech and Sandy Lakes in Minnesota. Michigan has been on the defensive as to its right to be called the wolverine state. Recently there was found a clear description of the capture of a specimen near Marquette in February, 1860.[22]

The most circumstantial account of the occurrence of the animal in Wisconsin relates the capture of "a large wolverine or glutton" by Charles Carron on Big Rib River in the spring of 1870. This stream rises in the eastern part of Taylor County and enters the Wisconsin at Wausau, so that the animal was taken most probably in Marathon County. The rarity of the animal was recognized and it was placed on exhibition in Stevens Point.[23] Hoy[24] states that it is occasionally taken in the timber and that one was secured in La Crosse County in 1870. The Milwaukee Public Museum, according to Cory,[25] contains two specimens labeled "Wisconsin," but lacking dates and localities. There are other and more recent reports, but some without doubt are due to confusion with the badger.

The wolverine was much more abundant in Minnesota where it persisted longer. Cory[25] quotes E. G. Kingsford to the effect that about 1895 to 1897 it was quite common in northern Minnesota. Surber[26] likewise states that it was quite common up to about 1897. The last acceptable record is for northern St. Louis County where one was taken in 1918.[27] There is always the possibility that the wolverine will enter Minnesota from Canada.

TIMBER WOLF (*Canis lycaon* Schreber)

The timber wolf ranged formerly throughout the entire timbered areas of Wisconsin, Minnesota, and Michigan and was not uncommon in the prairie regions of these states. It lived mainly on deer and rabbits. Decrease in the food supply coupled with poisoning and trapping has reduced its numbers to the point where extinction has been feared. Its smaller relative the coyote or brush wolf (*Canis latrans latrans* Say) is much more adaptable to changed conditions and is in no danger of extermination. Ranging widely, it is occasionally reported from even the oldest communities.

Under primitive conditions, Seton estimated that there was one timber wolf to two and one-half square miles. There are insufficient data to furnish a satisfactory estimate of the original population in Wisconsin. The state, in 1865, paid bounties on only 225 "wolves," mainly from the southern counties. Those reporting the highest individual numbers were Lafayette, Grant, and Dane. This is a small number compared with the 1,587 wolves submitted for bounty during the season 1938-39. Trappers' returns for the same period show the taking of 65 timber wolves.

The report of O. L. Coleman on the control of predators in Wisconsin, November, 1930, states that of the wolves presented for bounty only two percent were timber wolves while trappers take as high as 20 percent. The difference may be due to a greater effort on the part of trappers in the wildest regions to take timber wolves. W. E. Scott, to whom I am indebted for the recent data on wolves, estimates the timber wolf population of Wisconsin at 150 to 200.

The decline of the timber wolf in Wisconsin has been gradual. Quarles,[28] who settled on the prairies of Kenosha County in 1837, wrote two years later of the prairie wolf and mentions that there are "some of the large kind." The black phase, once fairly common, is now reported rarely. Timber wolves were killed in Dane and Waukesha Counties in 1871 and one as late as 1880 in Jefferson County. At the present time it is confined to about twelve of the northernmost Wisconsin counties.

The timber wolf was considered common in Gogebic and Ontonagon Counties, Michigan, in 1920.[29] The present state of the species in the Upper Peninsula parallels that in northern Wisconsin.

In Minnesota, Herrick [30] mentions that wolves were especially numerous in Wright County in the winter of 1884-85. More recently, Surber[31] reports the timber wolf as still fairly common in the remote sections of the northern third of the state. It was found occasionally in Pine County as late as 1918. The species will always be in a favored position in Minnesota due to potential immigration from Canada. The timber wolves of northern Wisconsin and Upper Michigan are virtually isolated.

COUGAR (*Felis concolor couguar* Kerr)

The cougar, commonly known as panther, was the largest member of our cat family. The reputation that it bore as a dangerous animal was without foundation as frequently a small dog would cause it to take refuge in a tree. The popular nomenclature, e.g. catamount, of the early narratives renders it difficult to decide if the cougar was intended always. The chief prey of the cougar was the deer, so that it occurred chiefly in the hardwood belt on the southern edge of the coniferous forest. It was not confined strictly to heavy timber, but ranged into the oak openings of the prairie where also deer were common.

The cougar was a rare animal in the Upper Peninsula of Michigan where it was observed last about 1850. There are so many records for Wisconsin that the species cannot have been especially rare there in the early days. Most of the records come from the Lake Winnebago district and from the valleys of the Chippewa and St. Croix Rivers. The Museum of Lawrence College at Appleton has a mounted cougar killed locally by Samuel P. Hart on November 22, 1857. This is the only specimen extant for the entire region under consideration.[32] Richard Dart[33] came to Green Lake County in 1840. That fall two panthers roaming in the vicinity were killed by the Indians. In 1839, Locke[34] examined the effigy mounds near Blue Mounds, Dane County and stated that they might have been intended for the cougar, "an animal still existing in that region." Carver[35] mentions seeing one on an island in the Chippewa River in 1767, and Fonda[36] tells of shooting one on an island in the Mississippi, near Trempealeau Mountain, in 1839. An "enormous catamount" that prowled about the Upper St. Croix River in the winter of 1866-67 was finally killed by a posse from Stillwater. The mounted animal was presented to Mr. L. A. Taylor, editor of the Prescott *Journal*.[37] The last acceptable record for the state is the cougar measuring "nine feet" in length, killed near Butternut, Ashland County, in February, 1884.[38]

There are comparatively few records for Minnesota. Herrick[39] considered the cougar killed in Chisago County in 1875 as a late occurrence. The species did not become extinct until long afterwards. Wilcox[40] mentions one killed in Becker County, in 1882, and another shot in 1897.

ELK (*Cervus canadensis canadensis* Erxleben)

The elk is the most magnificent of the American deer. Except for its greater size it resembles the European stag or red deer, names that it carried frequently in colonial times. It occurred throughout the entire region under consideration but never was common in the heavily forested areas, particularly those occupied by conifers. The favored habitats were the park-like areas and prairies. Here it was to be found in droves of hundreds, mingling freely with the bison.

The elk disappeared rapidly from southern Wisconsin after 1800. In 1837 it was considered extinct in Illinois;[41] however, during the winter of 1827-28, Fonda[42] found some Indians starving between Milwaukee and Chicago "though the country was teeming with deer, wild turkies, and elk." Le Clair[43], who went to Milwaukee in 1800, stated that at that time there were no elk or buffalo. In 1828, when Hollman[44] settled at Platteville, bear, elk, etc. were to be found in "astonishing quantities." When Hoffman[45] was at Prairie du Chien in February, 1834, he mentions the necessity of going to a distance to secure this game. Dogs for running elk were kept by the officers at Fort Crawford.

Elk were plentiful in the Chippewa valley at this time and continued common until about 1860. Copway,[46] who was at the foot of Lake Pepin in 1837, mentions seeing a drove of 500. The last dependable record for the state is for the fall of 1866 when nine were killed out of a drove of twelve found fifteen miles west of Menomonie.[47] In April, 1886, six elk, reputed to have been killed in "the Lake Superior regions", were shipped through Chetek[48], Barron County. They came most probably from Minnesota. Brayton,[49] in 1882, quoted a statement from B. H. Van Vleck that the elk is still found in the vicinity of Green Bay. Being the oldest settled community in the state, the elk disappeared relatively early, and it is highly improbable that its presence in 1882 would have escaped mention elsewhere.

Elk were formerly very abundant in Minnesota. Pond,[50] in his quaint orthography states that "the Read and Moose Dear are Plentey hear, Espeshaley the former. I have seen forty Kild in One Day By Surrounding a drove on a low spot By the River side in the Winter Season." Pike [51] depended largely on the elk for food. They were still common in certain sections of the state in 1885.[52] The elk was seen last in Marshall County in 1887[53] while the latest unquestionable record for the state is 1890. According to Surber,[54] the reports of one shot in 1908, and of three seen in Beltrami County in 1917, are open to doubt and may in actuality refer to the moose.

MOOSE (*Alces americana americana* Clinton)

Originally the moose was found throughout the Upper Peninsula of Michigan and in Wisconsin from Green Bay southwest to Green Lake County, thence northwest through Clark, Barron, and Polk Counties, to northwestern Minnesota. The ancient range in Minnesota is uncertain. Pond,[55] who was on the Minnesota River in 1773-75, mentions the "Moose Dear" among the game animals. This would extend the southern boundary appreciably. In 1857 the line extended from the extremity of Pine County to the northeastern corner of Kittson County.[56]

The presence of moose as far south as Green Lake County, Wisconsin, in 1840, is mentioned by Richard Dart:[57] "Elk and Moose were found upon Willow River, and occasionally around Green Lake." Its presence around Lake Winnebago is established by finds of moose antlers in streams and in Indian burials. It had become so rare in Polk County by 1866 that the killing of one elicited the statement that it was the first killed in the county.

There is no information on which to base an opinion that the moose was ever more than fairly common in Wisconsin and Michigan. Malhiot,[58] who had charge of the trading post at Lac du Flambeau from August, 1804 to June, 1805, records but 10 moose in the form of skins and meat. In the fall and winter of 1884 a hunter had exceptional success in the killing of five moose in Douglas County.[59] The largest population was to be found in the northwestern part of the state where undoubtedly the species was reinforced frequently by arrivals from Minnesota. In the early days the region west of Superior was excellent moose territory. Few if any native Wisconsin moose existed after 1900. From that time to the present, an occasional moose has wandered into the state from Minnesota. In 1921, a moose swimming across Allouez Bay, near Superior, to the Wisconsin shore was drowned after being roped and towed by a launch.[60]

The native stock in Michigan is extinct except on Isle Royale where the moose is still numerous.

Minnesota is in a splendid position in that it possesses a greater population of moose than all the other states of the union combined. In 1932 a careful estimate placed the number at 4000. Most of the moose are to be found in the northern tier of counties, especially Lake and Cook.

CARIBOU (*Rangifer caribou caribou* Gmelin)

The caribou was abundant formerly in Minnesota but never so in northern Wisconsin and the Upper Peninsula of Michigan. It does not thrive except in a muskeg country. Crespal,[61] who was with the French expedition sent in 1728 to chastise the Fox Indians in Wisconsin, compares a caribou, killed by the Indians in the Upper Peninsula, with a moose: "The caribou is not so tall and shaped more like the ass . . ." This is not an individual flight of French fancy for Lahontan refers specifically to the caribou as the "wild ass". Still earlier, the winter of 1661-62, Radisson[62] was in the St. Croix River district where the Indian party killed "Carriboucks."

Acceptable records for the southern shore of Lake Superior are few. Doty,[63] in 1820, listed the "rein deer" for Leech and Sandy Lakes but not for the head of Lake Superior. It was given, however, as an inhabitant of the latter area in 1831 by Schoolcraft.[64] Florantha Sproat,[65] writing from Fond du Lac (Superior) on April 18, 1842, mentions seeing a reindeer, a "beautiful animal of silver gray," just killed by an Indian. While at the Carp River, Chippewa County, Michigan, in March, 1849, Rev. Pitezel[66] was served *Cariboo* meat. Wood[67] mentions that the caribou has been recorded for Keweenaw (Isle Royale), Charlevoix (Beaver Island), Luce, Chippewa, and Dickinson Counties, Michigan. According to Cory,[68] a cow caribou was killed near Ralph, Dickinson County, in November, 1905. He with others mentions the killing of caribou in Wisconsin in 1910. These records are questionable. In 1906, twenty Newfoundland caribou were placed on the Pierce estate on the Brule River, Douglas County. While all of them are supposed to have died on the estate, several may have escaped.

The caribou was once numerous in northern Minnesota and was common until about 1900. Johnson[69] mentions that in the winter of 1895 two trappers located about 25 miles northeast of Upper Red Lake furnished sleighloads of moose and caribou meat to a lumbering camp. One drove of fully 500 caribou was seen. The men did not like the caribou meat as it had "a rank taste of peat or moss." Breckenridge[70] in 1935 reported that at least six native caribou remained in Minnesota in the muskeg country between Upper Red Lake and Lake of the Woods. This number had decreased to three by 1939 when several caribou were imported from Saskatchewan in an attempt to perpetuate the species.

It is of interest that centuries ago the range of the caribou extended to Polk County, Wisconsin. Among the bones of an extinct bison (*Bison antiquus*) found in a marl deposit near Osceola were a few of the caribou.[71]

Caribou formerly crossed from Canada to Isle Royale on the ice. The last acceptable record for the island is 1905 when a drove of nine was seen.[72]

BISON (*Bison bison bison* Linn.)

The bison or buffalo, in the popular mind, is associated with the great plains, and a statement that it once ranged nearly to the Atlantic Ocean is received with scepticism. In early days it was abundant on the prairies and "openings" of Wisconsin and Minnesota.

The range in Wisconsin has been worked out in detail.[73] Marquette,[74] in 1674, found it on the shore of Lake Michigan at modern Racine. The bison occurred as far north as Lake Winnebago where Dablon[75] found and described it in 1670-71. Writing of the fur trade along the Wisconsin River on August 22, 1682, La Salle[76] mentions "the great number of buffaloes, which are taken there every year, almost beyond belief." This indicates how early the slaughter began.

The Indian as a conservationist is somewhat of a myth. Hennepin[77] mentions that at Lake Pepin the Sioux would kill forty or fifty buffaloes and in their haste to move onward take only the tongues and some other of the best pieces. In Minnesota in March, 1807, the deer were powerless due to a deep, crusted snow through which they sank. Anderson[78] relates that the Indians tomahawked the deer for sheer sport and that as a result during the next winter not a deer was to be seen. The acquisition of firearms by the Indians, coupled with the size and unwariness of the bison, brought about its extinction in southern Wisconsin by about 1800.

Many of the early writers tell of the abundance of game in the Chippewa valley. Here, says Carver,[79] "larger droves of buffaloes and elks were feeding, than I had observed in any other part of my travels." In this region the bison persisted longest. The last were killed in Trempealeau County in 1832.

The French,[80] in 1700, built a fort near the present site of Mankato, Minnesota. While the fort was being built one-half of the men spent their time hunting buffalo, 400 of which were killed for use during the winter. Sibley[81] accompanied the Sioux on a hunt southeast of this locality in the winter of 1841. A large amount of game was killed but it included only "a few buffaloes." By 1821 the bison no longer occurred on the east bank of the Mississippi River in Minnesota. Lt. Allen,[82] while near the junction of the Crow Wing with the Mississippi in 1832, learned that during severe winter storms herds of bison sought shelter in the belt of timber on the right bank and occasionally penetrated to the river. None were seen by Featherstonhaugh[83] during his trip up the Minnesota River in the fall of 1835.

Small herds of buffalo were found occasionally in western Minnesota subsequent to 1850. According to Surber[84] the last living bison was observed in Norman County in the summer of 1880. Johnson[85] states that the bison was killed last in Marshall County in 1878 but that a small band was seen in the spring of 1881.

CANADA SPRUCE GROUSE (*Canachites canadensis canace* Linn.)

The spruce grouse is a bird of the coniferous forest. Its favorite haunt is a dense swamp of arbor vitae, spruce and tamarack. My first grouse was found near Lake Gogebic in a stand of hemlock bordering a swamp. On a mossy log, in this damp and gloomy place, strutted a handsome male. The notable decrease in numbers may be explained best, perhaps, through its common name "fool hen." Foolish it was not under primitive conditions or the species would not have survived. Man was simply another animal to be avoided by a few feet. Even today it has not learned the danger of the hurled stick or slipnoose on the end of a pole.

Its status is given succinctly by Dr. Roberts:[86] "The Spruce Grouse is in Minnesota, as elsewhere, a disappearing bird." Kumlien and Hollister,[87] writing of the bird in Wisconsin in 1903, state that it has been decreasing during the past twenty-five years, the rapid decline being difficult to explain.

The former abundance and range are based largely on general assumptions. Barrows[88] states that it was once a common bird throughout the pine regions of Michigan and abundant in the Upper Peninsula. As to Wisconsin it is very doubtful if it followed the conifers as far south as Adams County. Hoy,[89] in 1852, reported it as common about the headwaters of Wolf River and in the vicinity of Lake Superior. Writing in 1891, Kumlien[90] stated that the spruce grouse is never found in southern and central Wisconsin, and according to his observations was "far more abundant" in the Upper Peninsula of Michigan than in Wisconsin. In Minnesota about seventy years ago Trippe[91] found it abundant from Carlton County westward to the Mississippi River.

During the past two decades the spruce grouse has become a rare bird. Breckenridge,[86] while along the north shore of Lake Superior in May, 1928, failed to find it though he was informed that a few occurred inland. The species has a good chance of survival in the large swamps of northern Minnesota. Manweiler[92] listed recently the gallinaceous birds of the "Big Bog" in the following order of abundance: sharp-tailed grouse, ruffed grouse, spruce grouse, pinnated grouse.

In Wisconsin, Jackson[93] failed to find it at Mamie Lake, Vilas County in 1917 and 1918 though he obtained reports of a bird killed in each of the years 1918 and 1919. W. E. Scott has collected data from wardens and others showing that during the past two years the spruce grouse has occurred in the following northern counties: Bayfield, Ashland, Iron, Vilas, Forest, Sawyer, Price, Oneida and Langlade. It would appear that less than 200 birds remain in the state but owing to the inaccessibility of the preferred habitat this figure may be wide of the mark.

This grouse, according to Van Tyne,[94] is rare in Michigan south of the Straits of Mackinac, but there are recent records south to Ogemaw County.

PRAIRIE CHICKEN (*Tympanuchus cupido americanus* Reich)

The prairies of Wisconsin once supported a large mixed population of prairie chicken and sharp-tailed grouse. Under primeval conditions Minnesota appears to have had the latter species only. With the beginning of agriculture the prairie chicken increased greatly and pushed its range farther and farther north until it was overwhelmed by the same agency that had given it a "golden age."

The plow has destroyed its best habitat to the south, confining it to a northern belt that, if occupied at all under primitive conditions, would have been held most precariously. The bird now occupies a region far more suitable to the sharp-tailed grouse with which it is forced to compete.

It is difficult to estimate the population prior to settlement owing to the paucity of data. As early as 1842, prairie chickens were brought into Milwaukee by the sleighload and were considered as "common fare."[95] A party of hunters at Kenosha, on September 12, 1843 had 515 "grouse" in a mixed bag of game.[96] At Racine, in 1849, a single gun could obtain "sixty to ninety" daily.[97] Prairie chickens continued abundant for three decades and during this period large numbers were killed for the market. The first sharp drop in numbers came in 1857. Since that date the species has gone through the well known cyclic fluctuations.

A census of the prairie chicken population of Wisconsin made in 1929, as reported by Leopold,[98] totalled 54,850. The following year a detailed report on the species was prepared by Gross.[99] During the past decade it has been the subject of continuous study and its present status leaves little room for optimism. It is a real question if the prairie chicken can be preserved as a game bird. Hamerstrom[100] has shown clearly that the best habitat is being invaded rapidly by brush as a result of fire, drought and the activities of man.

The situation in Minnesota is identical with that in Wisconsin. Without the practice of conservation, "the days of the Prairie Chicken are numbered."[101] In 1929 Gross[102] wrote: "It is not only maintaining itself, but, unlike the nearly extinct Heath Hen, it is increasing its numbers." Today the heath hen is extinct and the prairie chicken shows a decline.

WILD TURKEY (*Meleagris gallopavo silvestris* Vieillot)

This fine bird was once common in southern Wisconsin and in Iowa. The upper limit of its range may be defined by a line running southwest from Green Bay through Green Lake and Sauk Counties, thence due west along the Minnesota-Iowa boundary, through southwestern Minnesota and southeastern South Dakota.

In 1670, Allouez[103] saw two turkeys in a tree at Lake Winneconne, Wisconsin. Dart[104] found wild turkeys in Green Lake County in 1840; and according to Canfield,[105] who came to Sauk County in 1842, turkeys occurred there formerly. An army officer[106] stationed at Prairie du Chien in 1847 wrote that "turkeys and deer are plenty in the woods." The early reports of Hennepin and Carver of the presence of turkeys at Lake Pepin are open to doubt.

Opinions on the range west of the Mississippi vary widely. Coues,[107] in 1874, stated that the northern limit could not be far from the Minnesota boundary. This is certainly true of its old range. The prairie was not a barrier. Anderson,[108] who spent the winter of 1801-2 at the present site of Des Moines states: "The little islands of wood, scattered over the boundless plains, were swarming with wild turkeys." Owen,[109] in 1852 reported briefly: "Only found on the south of the Upper Iowa." This would bring the range into extreme northeastern Iowa. Leopold[110] records its presence in Worth and Mitchell Counties about 1860. It was formerly abundant in Woodbury and Cherokee Counties. He reports one killed in the latter county as late as April, 1897. Mr. N. E. France[111] was born near what is now Livermore, Humboldt County, Iowa, in 1857. A few years ago he wrote to me that at that period game was abundant and his father did much hunting and trapping. During the severe winter of 1860, droves of elk and flocks of wild turkeys were forced southward, only a few of which ever returned.

It is difficult to prove that the wild turkey occurred in Minnesota. Hatch[112] mentions that it was reported as a resident of the extreme southwestern part of the state. Its presence there is highly probable in view of its former abundance in the Missouri valley up to southeastern South Dakota. The most definite statement is that of Peter Pond[113] who wintered on the Minnesota River in 1773-5. As to game he mentions that there are "sum turkeas". Being a New Englander, there is little likelihood of an error in identification. There must have been many advances and retreats on the northern border of the range of a species like the turkey; hence it is not improbable that there were many occasions on which it wandered into southern Minnesota.

Some idea of the former abundance of the turkey in Wisconsin may be gained from the following statement of Lockwood:[114] "It was not an uncommon thing to see a Fox Indian arrive at Prairie du Chien with a hand sled, loaded with twenty or thirty wild turkies for sale, as they were very plenty about Cassville."

The severe winter of 1842-3 nearly exterminated the turkey in Wisconsin. At about this time also settlement of the country became vigorous so that the species never recovered. According to Hoy[115] the last time that a turkey was killed near Racine was in the fall of 1846. It survived longest in Grant County where one was shot in the fall of 1872.

The turkey disappeared more gradually from Iowa. It was seen last in Appanoose County in 1902, Davis County in 1905, and Lucas County in 1910.[116] The latter date marks the extermination of the native stock in the Upper Mississippi Valley.

SANDHILL CRANE (*Grus canadensis tabida* Peters)

The sandhill crane, up to 1850, was a common breeding bird in the states bordering the Upper Great Lakes. It occurred in largest numbers on the wide prairies, though confined to the marshes mainly during the nesting period. While having a varied diet, seeds are the preferred food in spring and fall. The decline in numbers is due to a variety of causes. Wary and intolerant of civilization, its habitat became restricted. Only two eggs are laid and the nest appears to be highly susceptible to predation and to abandonment on disturbance. It is a desirable bird for the table and large numbers were killed for this purpose. Today it is sometimes called "northern turkey" in the prairie provinces of Canada. Even here, where it occurs in far greater numbers than in the Lake States, there is distinct pessimism as to its survival.[117]

The sandhill crane still nests in a few isolated areas in Wood, Jackson, Adams, Oconto, Marquette, and Green Lake Counties, Wisconsin, and along the St. Croix River. Henika [118] believes that the total breeding population of Wisconsin is limited to 25 pairs. Hamerstrom[119] reports approximately 12 pairs occupying the breeding areas northwest of Necedah in Jackson, Monroe, Wood, and Juneau Counties. The flocks of migrants numbering 25 to 300 birds that alight on the resting grounds in autumn give an erroneous impression as to the actual breeding population.

The situation in Minnesota and Michigan is no more favorable. One or two pairs still nest in Norman and Pennington Counties, Minnesota. It is doubtful if the entire state has more than 10 pairs of breeding birds. Michigan has approximately 10 pairs nesting in the Seney marshes, Schoolcraft County, Upper Peninsula. In the lower peninsula a few pairs still nest in Washtenaw, Livingston, Ingham, Jackson, and Calhoun Counties.[120] The state has possibly 20 breeding pairs.

The paper by Hamerstrom is one of the very few studies made of the present habitat of the sandhill crane with a view to its preservation. The size of the range of a pair of breeding birds is impressive. Reversion of the areas studied to game and forestry management would undoubtedly destroy a large part of the present breeding grounds through the growth of brush.

PASSENGER PIGEON (*Ectopistes migratorius* Linn.)

No American bird has left as dramatic an impression as the wild or passenger pigeon. The flocks numbered millions and the nestings covered many square miles of forest. Their numbers were so great that the belief existed that this was one bird that could not be exterminated. Yet when the end was in sight, it is astonishing how little comment was made on its disappearance during the decade 1890 to 1900.

The passenger pigeon lived largely on beechnuts and acorns. In the Upper Great Lakes region a good beechnut crop occurred usually in the fall of odd years and thus provided abundant food for nesting during the spring of even years. The beech being confined in its range to Michigan and eastern Wisconsin, the nestings took place in these states in even years. The nestings in the remainder of Wisconsin and Minnesota depended upon the supply of acorns. In Minnesota the nestings were confined largely to the hardwood timber in the southeastern part of the state.

One of the largest nestings that has been described took place in central Wisconsin in 1871.[121] It is estimated that the nesting area covered 850 square miles and contained 136,000,000 breeding birds. The last nestings of large size occurred in the same region in 1882.

It is a popular opinion that the end of the pigeon came suddenly as the result of a disease or a natural disaster such as drowning. This is far from the truth. Man alone was responsible for the extinction. Organized bands of trappers followed the pigeons from their wintering grounds in the South to the nestings in the North. Here the old birds were trapped and the squabs removed from the nests by tens of thousands to supply the gun clubs and city markets.

The data that has been assembled show a gradual and not a sharp decline. In 1885 there was a fairly large nesting in the southeastern corner of Langlade County, Wisconsin, and in 1887 an attempted nesting in Waushara County was broken up by indiscriminate shooting. In 1890, pigeons appeared at various places in Wisconsin, as many as "thousands" being reported. They arrived at Sparta in 1892 in sufficient numbers to raise the hope that there would be a nesting. The succeeding years produced reports of fewer and fewer birds up to 1899. In September of this year, the last "acceptable" pigeon for Wisconsin was killed near Babcock.[122]

The extinction of the passenger pigeon must be accepted as one of the inevitable accompaniments of civilization. This was a bird the very existence of which depended upon huge numbers. Before this was understood the population had been reduced to a point below which the single egg laid could not maintain the race. Agriculture could tolerate but a fraction of their primitive numbers as cutting of the forests reduced the natural food supply. Wilson estimated that a flock of 2,230,272,000 birds seen by him would consume daily 17,424,000 bushels of mash. We have our agriculture but have lost a fine species.

Footnotes

1 Bartlett, W. W. History . . . the Chippewa Valley. Chippewa Falls (1929) p. 219.

2 Curot, M. Wis. Hist. Coll. 20 (1911) 396-471.

3 Malhoit, F. V. *Ibid.* 19 (1910) 163-233.

4 Dubuque, J. *Ibid.* 19 (1910) 321.

5 Porlier, J. *Ibid.* 19 (1910) 357.

6 Paul, A. Superior *Chronicle*, June 3, 1856; Sept. 29, 1857.

7 Cartwright, David W. Natural History of Western Wild Animals. Toledo (1875) pp. 245 and 272.

8 Hubbard, G. S. Autobiography. Chicago (1911) p. 17.

9 Scott, W. E. Wis. Conservation Bull. 4, No. 10 (Oct. 1939) 27.

10 Errington, Paul. *In litt.* Jan. 31, 1940.

11 Surber, T. The Mammals of Minnesota. St. Paul (1932) p. 48.

12 Breckenridge, W. J. *In litt.* Jan. 29, 1940.

13 Anderson, T. G. Wis. Hist. Coll. 9 (1882) 159.

14 Bunnell, L. H. Winona and its Environs. Winona (1897) p. 200.

15 Lapham, I. A. Trans. Wis. State Agr. Soc. 2 (1853) 338.

16 Canfield, W. H. Outline Sketches of Sauk County. Third Sketch [1870] p. 38.

17 Scott, W. E. *L.c.* p. 27.

18 Leopold, A. Report on Huron Mountain Club. [1939].

19 Manweiler, J. Minn. Conservationist, No. 63 (Dec. 1938) 25.

20 Schoolcraft, H. R. Summary Narrative of an Exploratory Expedition to the Sources of the Mississippi River in 1820. Philadelphia (1855) p. 141.

[21] Doty, James D. Wis. Hist. Coll. 7 (1876) 195-206.
[22] Schorger, A. W. J. of Mammal. 20 (1939) 503.
[23] Stevens Point *Pinery.* April 1, 1870.
[24] Hoy, P. R. Wis. Acad. Sciences. 5 (1882) 255-7.
[25] Cory, C. B. Mammals of Illinois and Wisconsin. (1912) p. 355.
[26] Surber, T. *L.c.* p. 50.
[27] Johnson, C. E. J. of Mammal. 4 (1923) 54.
[28] Quarles, J. V. Wis. Mag. Hist. (1933) 310.
[29] Dice, L. R. and Sherman, H. B. Occ. Paper No. 109, Museum of Zoology, Ann Arbor, Feb. 25, 1922.
[30] Herrick, C. L. Mammals of Minnesota. (1892) p. 79.
[31] Surber, T. *L.c.* p. 55.
[32] Schorger, A. W. J. of Mammal. 19 (1938) 252.
[33] Dart, Richard. Proc. Wis. Hist. Soc. for 1909 (1910) 257.
[34] Locke, J. Senate Doc. 239 (1840) p. 140.
[35] Carver, J. Travels, Walpole (1813) p. 230.
[36] Fonda, J. H. Wis. Hist. Coll. 5 (1868) 269.
[37] Prescott *Journal* May 2, 1868.
[38] Ashland *Press* March 8, 1884.
[39] Herrick, C. L. *L.c.* p. 68.
[40] Wilcox, A. H. A Pioneer History of Becker County. St. Paul (1907) pp. 72-76.
[41] Illinois in 1837. Philadelphia (1837) p. 39.
[42] Fonda, J. H. *L.c.* p. 31.
[43] Le Clair, A. Wis. Hist. Coll. 11 (1888) 240.
[44] Hollman, F. G. Autobiography. [Platteville, 1922 ?] p. 3.
[45] Hoffman, C. F. A Winter in the Far West. London, Vol. 2 (1835) 8.
[46] Copway, G. The Traditional History of the Ojibway Nation. London (1850) p. 35.
[47] Menomonie *Dunn County News* Dec. 1, 1866.
[48] Chetek *Alert* April 3, 1886.
[49] Brayton, A. W. Report of the Geological Survey of Ohio. Zoology. Vol. 4, Part 1 (1882) p. 80.
[50] Pond, Peter. Conn. Mag. 10 (1906) 258.
[51] Pike, Z. M. Expeditions . . . 1805-6-7. Coues edition, N. Y. (1895).
[52] Herrick, C. L. *L.c.* p. 280.
[53] Johnson, C. E. J. of Mammal. 11 (1930) 449.
[54] Surber, T. *L.c.* p. 9.
[55] Pond, Peter. *L.c.*
[56] Surber, T. *L.c.* p. 77.
[57] Dart, Richard. *L.c.* p. 260.
[58] Malhiot, F. B. *L.c.*
[59] Bayfield *Press* Jan. 17, 1885.
[60] McNaughton, J. W. Wis. Conservationist. 3, No. 6 (Jan. 1922) 12.
[61] Crespal, E. Wis. Hist. Coll. 10 (1885) 49.
[62] Radisson, *Ibid.* 11 (1888) 79.
[63] Doty, James D. *Ibid.* 7 (1876) 196 and 201.
[64] Schoolcraft, H. C. Personal Memoirs. Philadelphia (1851) p. 310.
[65] Sproat, Florantha T. Wis. Mag. Hist. 16 (1932) 207.
[66] Pitezel, Rev. J. H. Lights and Shades of Missionary Life. Cincinnati (1860) p. 195.
[67] Wood, N. A. Check List of Michigan Mammals. Occasional Paper No. 4, Museum of Zoology, Ann Arbor, April 1, 1914. p. 3.
[68] Cory, C. B. *L.c.* p. 81.
[69] Johnson, C. E. J. of Mammal. 11 (1930) 450.
[70] Breckenridge, W. J. *Ibid.* 16 (1935) 327.
[71] Eddy, S. and Jenks, A. E. Science 81 (May 31, 1935) 535.

[72] Adams, C. C. An Ecological Survey of Isle Royale. (1909) p. 396.

[73] Schroger, A. W. Wis. Acad. Sciences. (1937) 117-130.

[74] Marquette, Jacques. Jesuit Relations, Vol. 59 (1900) 171.

[75] Dablon, Pere. *Ibid.* Vol. 55 (1899) 195.

[76] La Salle, R. In Margry's Decouvertes et Establissements des Francais (1614-1754). Paris Vol. 2 (1876-1885) 254.

[77] Hennepin, Louis. A New Discovery. London (1698) p. 160.

[78] Anderson, T. G. Wis. Hist. Coll. 9 (1882) 159.

[79] Carver, J. Travels. London (1781) p. 103.

[80] Penicault, M. Hist. Coll. of Louisiana and Florida, N.S. New York (1869) p. 70.

[81] Sibley, H. H. Coll. Min. Hist. Soc. 3 (1880) 265.

[82] Allen, Lt. James. Senate Doc. 323, 23rd Congress (1834) p. 53.

[83] Featherstonhaugh, G. W. A Canoe Voyage up the Minnay Sotor. London (1847).

[84] Surber, T. *L.c.* p. 79.

[85] Johnson, C. E. J. of Mammal. 11 (1930) 451.

[86] Roberts, T. S. The Birds of Minnesota. Vol. 1 (1932) 367.

[87] Kumlien, L. and Hollister, N. Birds of Wisconsin. (1903) p. 56.

[88] Barrows, W. B. Birds of Michigan. (1912) p. 223.

[89] Hoy, P. R. Trans. Wis. State Agr. Soc. for 1852. Vol. 2 (1853) 358.

[90] Kumlien, L. Wis. Naturalist. Vol. 1 (1891) 146.

[91] Trippe, M. T. Proc. Essex Institute. 6 (1871) 113.

[92] Manweiler, J. Minn. Conservationist, No. 63 (Dec. 1938) p. 25.

[93] Jackson, H. H. T. Auk. 40 (1923) 481.

[94] Van Tyne, J. Check List of the Birds of Michigan. Occasional Paper No. 379, Museum Zoology (June 16, 1938) p. 11.

[95] Milwaukee *Sentinel* Jan. 29, 1842.

[96] Southport (Kenosha) *American* Sept. 14, 1843.

[97] Porter's Spirit of the Times. 19 (Aug. 11, 1849) 295.

[98] Leopold, A. Game Survey of the North Central States. (1931) p. 170.

[99] Gross, A. O. Progress Report of the Wisconsin Prairie Chicken Investigation. Madison (1930).

[100] Hamerstrom, F. N. Wilson Bull. 51 (1939) 105-120.

[101] Roberts, T. S. *L.c.* p. 388.

[102] Gross, A. O. Bird-Lore. 31 (1929)) 383.

[103] Allouez. Wis. Hist. Coll. 16 (1902) 69.

[104] Dart, Richard. *L.c.* p. 260.

[105] Canfield, W. H. *L.c.* p. 4.

[106] H., A. S. Porter's Spirit of the Times. 17 (Aug. 23, 1847) 333.

[107] Coues, E. Birds of the Northwest. (1847) p. 392.

[108] Anderson, T. G. Wis. Hist. Coll. 9 (1882) 152.

[109] Owen, D. D. Report of a Geological Survey of Wisconsin, Iowa, and Minesota. Philadelphia (1852) p. 622.

[110] Leopold, A. Report on a Game Survey of Iowa. Mss. (1932).

[111] France, N. E. *In litt.* Platteville, Wis. July 3, 1935.

[112] Hatch, P. L. Bull. Minn. Acad. Nat. Sciences. 1 (1874) 61.

[113] Pond, Peter. *L.c.* p. 258.

[114] Lockwood, J. H. Wis. Hist. Coll. 2 (1856) 132.

[115] Hoy, P. R. *L.c.* p. 257.

[116] Leopold, A. *L.c.*

[117] Taverner, P. A. Birds of Western Canada. (1926) p. 126.

[118] Henika, F. S. Proc. North Am. Wildlife Conference. Washington, (1936) p. 25.

[119] Hamerstrom, F. N. Wilson Bull. 50 (1938) 175.

[120] Van Tyne, J. *L.c.* p. 12.

[121] Schorger, A. W. Proc. Linn. Soc. N. Y. No. 48 (Oct. 1937) 1-26.

[122] Schorger, A. W. Auk. 55 (1938) 531.

MUTATIONS IN MINKS[1]

MAX SHACKELFORD

Department of Genetics, University of Wisconsin

(Read at Meeting of the Academy, April 5, 1941)

The standard color phase of ranch-bred minks is dark brown, but may vary from light brown to near black. This range of coloring characterizes also the geographical races of the American mink (*Mustela vison*) from which domestic minks have been derived. A stripe down the back, the tail and the feet are darker than other parts of the body. The eyes, nose and claws are dark brown. There are often white spots on the chin, throat, breast and belly, although some individuals are free of all white marking.

A number of color variations have arisen from ranch-bred minks. One of these, the "platinum," first appeared on the ranch of Mr. William Whittingham of Arpin, Wisconsin, in 1929. Considerable numbers of these platinum minks are now being bred on the ranches of Mr. Whittingham and Mr. Guy S. Ingham of Spencer, Wisconsin.

The platinum mink may be described as a light bluish gray in color. The eyes are dark brown, ventral white spots are often evident, and a stripe down the back, the tail and the feet are darker than other parts of the body. The data obtained from 55 litters indicate definitely that platinum is inherited as a simple autosomal recessive to the dark color phase. Microscopical examination of the hairs of platinum minks reveals a clumping of the dark pigment granules, similar to the condition in the maltese cat and other "blue" mammals and some birds.

Another mink observed on the Guy S. Ingham ranch resembles the "chocolate" color common in other mammals. The general body color, eyes, nose, and claws of this individual were distinctly lighter brown than the lightest of the standard dark minks. No breeding tests have been made with this animal, but its standard dark parents have produced other chocolate kits, which suggests that the condition is recessive to dark. The lighter color of this mink is due to the pigment granules being smaller, fewer in number and lighter brown than in dark minks.

---

[1] Paper No. 283 from the Department of Genetics, Wisconsin Agricultural Experiment Station, under a project of the University Fox and Mink Research Program.

RURAL AGGLOMERATED SETTLEMENTS IN THE EASTERN LAKE SHORE RED CLAY DAIRY REGION OF WISCONSIN

KENNETH BERTRAND

In the older and more densely settled parts of the United States an important cultural phase of the landscape is the large number of small rural hamlets and villages which dot the countryside. These rural agglomerated settlements which date from the beginning of white settlement in their respective regions have been relatively neglected as objects of study by geographers. The Eastern Lake Shore Red Clay Dairy Region of Wisconsin, an historically old, densely settled area of 2,500 square miles, makes a very satisfactory unit for such an investigation.[1]

Physiographically, the region consists of a preglacial cuestiform plain modified by the effects of multiple glaciation. The most recent deposits of red till and/or red lake clay have resulted in an extremely low relief and a heavy but fertile red clay soil which are in marked contrast to surrounding regions. Settled for over 100 years, the region has had a long and varied history which has had significant effect on the development of agglomerated settlements. Farms in this highly developed dairy region average less than 100 acres in size. For much of the region there are more than 40 rural persons per square mile, making this the most densely settled area of major size in Wisconsin.

All of the agglomerated settlements included in this study are essentially rural, and are closely related to the agricultural umland which they serve as markets.[2] None of the 136 towns here considered is exactly like any of the others, yet most of them possess common characteristics. These contrasts and similarities in various combinations of situation, site, morphology, and function permit an orderly classification. The settlements vary in size from small crossroads hamlets of three or four houses

[1] This region was first delimited by Loyal Durand, Jr., "The Geographic Regions of Wisconsin," Ph.D. thesis, University of Wisconsin, 1930, pp. 223-235. Published in part in "Wisconsin Dairying," Bull. 120, Wisconsin Crop and Livestock Reporting Service, pp. 29-32, 1931. A detailed study of the region was submitted as a Ph.D. thesis at the University of Wisconsin by the author in 1940.

[2] Four quarry towns and six lake shore towns are being dealt with in separate studies.

clustered about a church, general store, and tavern to the largest towns of approximately 2,000 people. The primary *raison d'etre* and the functional development, both reflected in the present structure and function of the settlements, permit a four-way classification of the towns: mill towns, bridge towns, rural hamlets, and railroad towns.

MILL TOWNS

As lumbermen and agricultural settlers began to move into the region after 1834,[3] a pressing need developed for mills to saw the timber that was being cleared from the land and to grind the grain that was grown on newly cultivated fields. Except for military roads, land routes were poorly maintained trails, and long hauls were arduous and hazardous undertakings. Small mills serving a relatively limited area grew up at any point which promised sufficient water power. Frequently, but by no means always, the mill served as a nucleus for a settlement whose fortunes rose and fell with the mill. As the land was cleared, the water table dropped, the rate of run-off increased, and streams which once turned wheels were reduced during dry periods to a mere trickle. Consequently, most of the mills on the smaller streams ceased operation, and any towns which may have been built about them either died or remained stagnant. Other towns can no longer be included in this classification, having grown beyond the simple function of the mill town until the old nucleus is only a minor part of the town or has completely vanished. Although no mill town is incorporated, Mishicott, the largest, has perhaps 200 people. None are located on rail lines.

On the dip slope of the Niagara Cuesta where the relatively steep gradient of the streams provide numerous power sites, seventeen mill towns are located. On the other hand, only one is found in the Fox-Winnebago Lowland, where, except for the industrial region of the lower Fox River, stream gradients are extremely low.

The mill towns have been built on a variety of sites. Some were actually located at a rapids, but many were built at points where the valley sides were steep and high enough to permit

[3] Although permanent settlement had begun at Green Bay in 1745, the first major influx of settlers did not take place until the government land office was opened at Green Bay in 1834. Many of the buyers were Yankee speculators interested in timber and probable future town sites. The great influx of German immigrants did not begin until 1850. See maps by Guy-Harold Smith, *Geog. Rev.*, Vol. 18, p. 421, 1928.

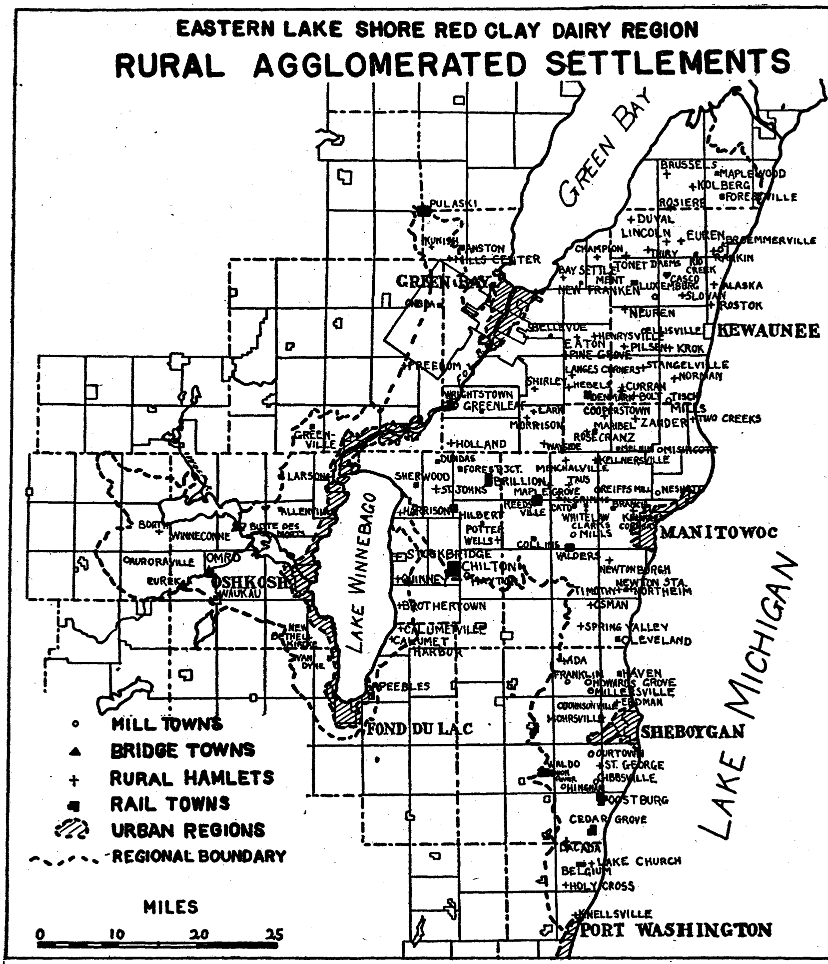


Figure 1

the impounding of water sufficient for a head. The towns may be classified according to three types of sites, (1) valley sites, (2) valley bottoms, and (3) broad, open valleys. Ten of the seventeen mill towns in this area are included in the first group. The valley is wide, yet has definite slopes by which the mill pond is enclosed and on which the town is built. Only two towns are located in a valley bottom. This type is differentiated from the first in that the town is confined to the broader valley bottom and has not spread up the valley sides. Six towns possess sites in broad, open, gently sloping valleys with ill-defined slopes.

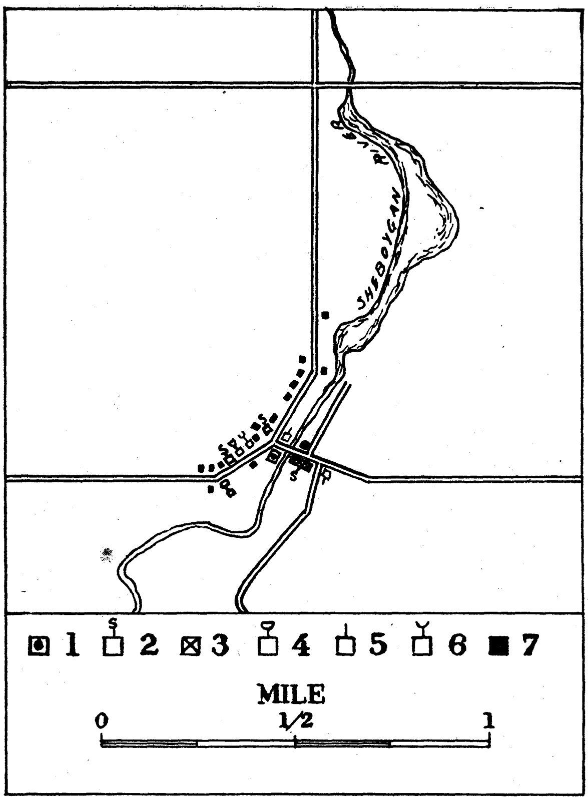


Fig. 2. Franklin, Sheboygan County, a typical mill town. The valley bottom is narrow, and the town occupies sloping valley sides. Key: 1, mill; 2, sales establishments; 3, services establishments; 4, taverns; 5, public buildings; 6, cheese factory; 7, dwellings.

Regardless of the detailed morphology, all of the mill towns are focused on the mill, for the universal practice of bridging the stream just below the dam resulted in a desirable convergence of roads at that point. The road which crossed the stream converged with one or more that paralleled the valley, giving to the town the pattern which has persisted to the present. Due to the irregular course of the stream or to the steep grades of the valley sides, the road pattern and the resultant town pattern are more or less irregular, conforming wherever possible to the rectangular pattern of the survey system. Although each town has a pattern peculiar to its own particular site, the town patterns may be grouped into three general classes. One includes five towns which are built on the road crossing the stream. A second type is composed of six towns which are built on the road paralleling one side of the stream. The third type is a combination of the first two in which seven of the towns have grown so as to occupy both the crossroad and the road paralleling the stream. The mill pond, the dam, the mill,[4] steep valley sides, and the bridge are conspicuous parts of the mill towns. Only two, Mishicott and Hingham, have expanded beyond the primary road pattern to the extent of the developing a grid of secondary streets.

The function of the small mills scattered over the region is almost, but not entirely, over. For example, the mill at Neshoto in Manitowoc County saws about 20,000 to 30,000 board feet of lumber during a period of six to eight weeks each spring.[5] The logs are cut from the swampy woodlots, which are still numerous in the vicinity. Water power is used exclusively both for sawing logs and for grinding feed. Few mill towns are any larger today than they were fifty years ago, and they have had to change their function to agricultural market and service towns to exist at all. Except for Mishicott and Hingham, none are large enough to boast a residential area as such. These towns and Tisch Mills possess a small business section composed of a variety of shops and stores all catering to farm trade. Most of the towns consist of a general store, a blacksmith and machine shop, a garage, a couple of taverns, the old mill, and a half dozen houses. Some include a cheese factory, others a school or church or both.

Bridge Towns

Four rural towns within the red clay region have grown up at points where land traffic must of necessity converge to reach a relatively easy point to cross the Fox River or its tributary, the Wolf. Wrightstown is located on the incised valley of the lower Fox River at a point where narrow bits of riverine terrace lie at the foot of the steep clay banks which border both sides of the stream. To the first low level bridge,[6] these terraces provided easy approaches. Eureka, Omro, and Winneconne are situated in the Winnebago Lowland across which the Wolf and upper Fox

[4] Although frame structures are more common, brick buildings are to be found among the two or three-story mills that have replaced the original timbered, one-story structures. Concrete or masonry dams have replaced the original log barriers.

[5] By contrast in 1854 a steam and a water mill at Neshoto produced 3,500,000 board feet of lumber, 50,000 feet of laths, 700,000 shingles, and 24,000 railroad ties. (Plumb, Ralph G., History of Manitowoc County, Wisconsin, p. 38, 1904).

[6] The present structure, opened in 1935, extends from the east terrace to the west upland.

Rivers flow in a winding sluggish course bordered by expanses of marshland and interspersed by shallow lakes. The towns are located at bridge points where subdued, overidden bedrock or glacial features pinch out the marsh lands and narrow the valley.

Both river and land traffic have provided an impetus for town growth. The old Indian waterway of the Fox-Wisconsin Rivers was of paramount importance to the French fur trade and continued to serve the region as an important route until the advent of the railroads in the Civil War decade. Canoes, durham boats, and steamboats followed in order as a means of travel on the waterway which connects the Great Lakes and the Mississippi River. Before the Civil War the easiest means of reaching the north central part of the state from the northern terminus of the railroad at Fond du Lac was by steamboat via Lake Winnebago, the upper Fox, and Wolf Rivers. With the exploitation of the great Wolf River pineries, enormous quantities of logs were floated down the Wolf and Fox Rivers to mills on the waterway, particularly at Oshkosh.

The earliest travel on land by white men followed the Indian trails which crossed the waterway at the present bridge towns in the Winnebago Lowland. The early military road from Fort Howard at Green Bay to Fort Winnebago at the portage between the Fox and Wisconsin Rivers passed through the site of Wrightstown. With the construction of a road in 1839 from Appleton to the river bank opposite Wrightstown, it became an important road junction. Although the rectangular government survey modified the road pattern, the convergence of traffic on the bridge points persisted. Hoel S. Wright established a ferry at Wrightstown in 1836, and ferries were established at the other bridge towns in 1849. As settlement and traffic increased, the four bridge towns were given more permanent site quality by the construction of floating bridges at Wrightstown in 1840, Omro in 1850, Eureka in 1854, and Winneconne in 1855. These have long since been replaced by more substantial structures.

The structural form of each town is more or less modified by the terrain. Street patterns, essentially rectangular, are partially oriented to the stream course. Built on two levels, the uplands and the stream terraces, Wrightstown is most irregular in structure and in street pattern. Having grown up on both ends of the crossing, all bridge towns present a divided nature, two distinct sections separated by the river. Moreover, with the possible exception of Wrightstown, all bridge towns have developed to a greater degree on the right bank of the river, the side on which the business section is located. This can be partly explained by the fact that from 1832 until 1836 the land north and west of the Fox River was Indian Territory from which white settlers were expelled by Federal troops. Indian trading posts therefore developed on the right bank at Eureka, Omro, and Wrightstown. The present site of Winneconne was the designated place of payment of Federal grants to the Menomonee Indians,

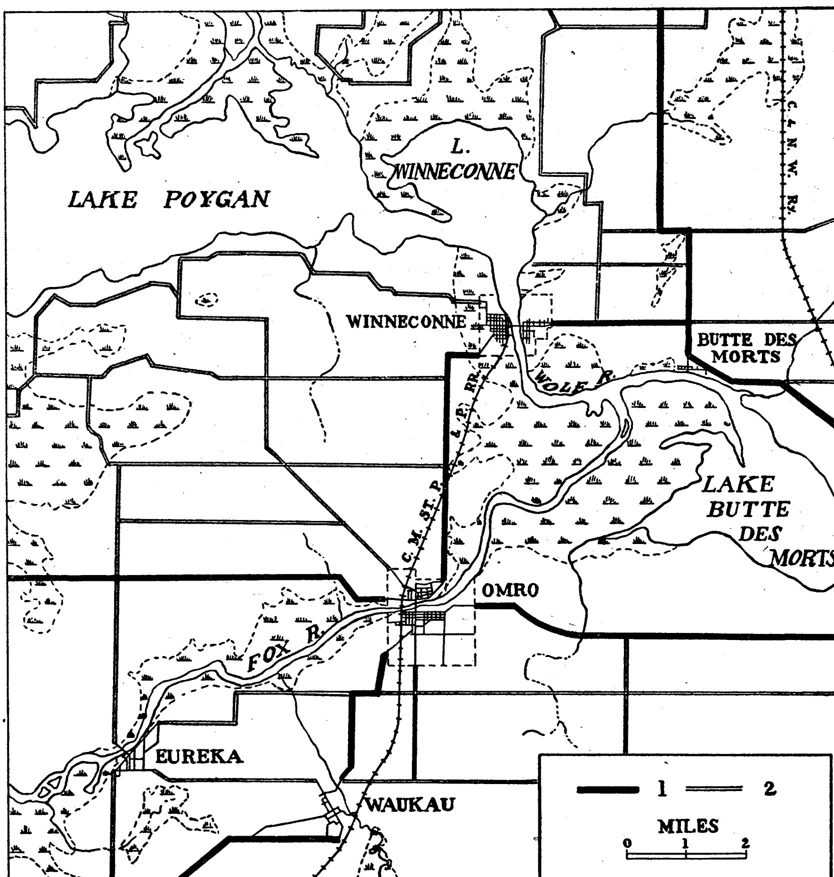


Fig. 3. Map of the Winnebago Lowland showing the location of bridge towns at points where the marshes bordering the river are pinched out. Note the convergence of roads at these points. Key: 1, state highway; 2, county highways. Town roads are not shown.

and at this place the blacksmith shop of Joseph Jourdain, who mended arms and implements of the Indians, served as a nucleus for the future town. An additional factor in the unequal development of the two sides of the towns can be found in the impetus supplied by the railroad, which terminated on the right bank at Omro from 1861 to 1868. Since 1868 this terminus has been on the right bank at Winneconne. In the case of Wrightstown the railroad and the now defunct inter-urban line on the left bank have resulted in a development of that side practically equal to that of the original settlement on the right bank.

Agricultural settlement and lumbering in the region took place simultaneously. By 1850 saw mills had been established in each of the bridge towns, and logs rafted down from the Wolf River pineries added to the local supply. A flour mill constructed at Omro in 1856 and a carriage and spoke factory indicate a growing importance of the agricultural umland at an early date. As the Wolf River pineries were depleted and as the railroads gradually replaced the steamboat, the lumber industry and the river traffic declined. In consequence the population of bridge towns in the Winnebago Lowland declined until 1920.

TABLE SHOWING DECLINE AND RISE OF POPULATION IN RIVER TOWNS*

Town	1870	1880	1890	1900	1910	1920	1930	1940
Omro	1,838	1,476	1,232	1,358	1,285	1,042	1,255	1,401
Winneconne	1,159	978	1,086	1,042	940	745	821	931

Any port function that may have flourished has ceased to exist, and the former river zone is represented, if at all, by old, dilapidated wharves and rotting rows of piling. In all but Eureka, which is not served by a rail line, heavy commercial zones including coal yards, lumber yards, stock loading pens, gasoline bulk plants, and a few industries have grown up along the railroad. Except for their site which has resulted in the concentration of highway traffic at the bridge towns, they are similar in function and appearance to the other rural towns located on railroads. A pea cannery and a condensery are located along the railroad in Winneconne; Omro boasts a feed mill on the river bank and a co-operative creamery. A cheese factory and a general dairy products plant operate in Wrightstown while Eureka has no industries. All trace of the original lumber industry has vanished. Retail and wholesale establishments are all based on the farm

* From the United States Census.

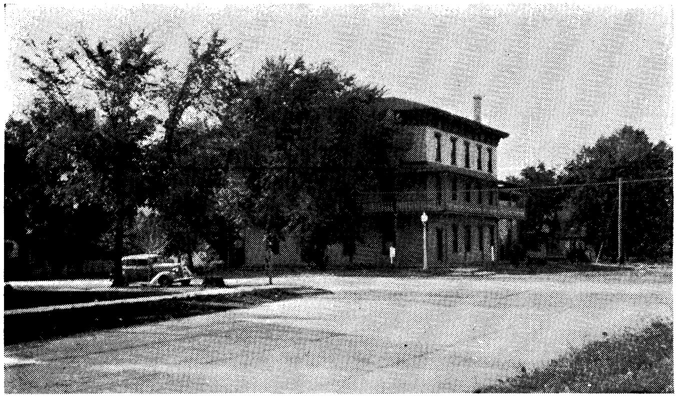


Figure 4. The greater importance of Winneconne during the height of the river traffic is reflected in this vacant hotel.

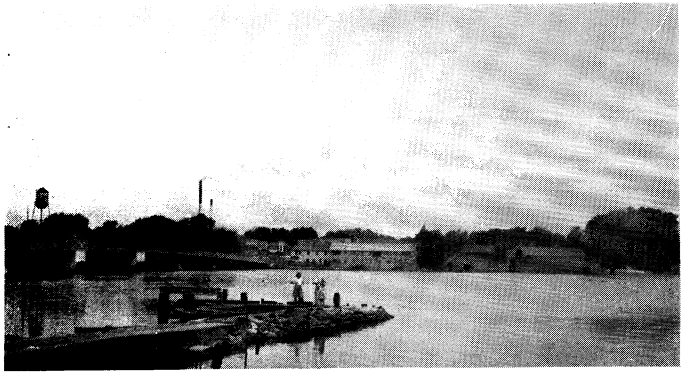


Figure 5. The right bank of the Wolf River at Winneconne. The railroad station at the left has doors opening on the river to facilitate the transfer of cargo from the boats to the cars. Although the bridge is equipped with a draw it is rarely used. From left to right, the smoke stacks belong to the pea cannery and to the condensery.

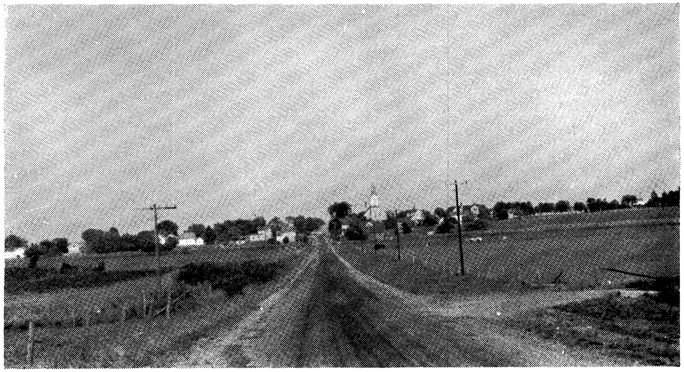


Figure 6. The hamlet of Lake Church. Note the church, the school, and the cemetery.

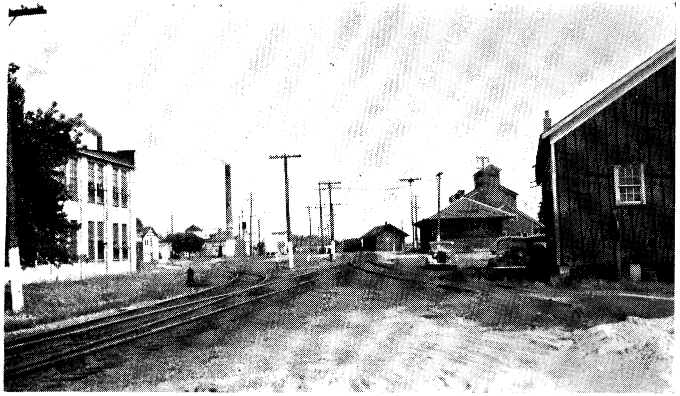


Figure 9. The railroad zone at Chilton. At the left is the aluminum goods plant, behind which is located the pea cannery. The large smoke stack marks the plant of the Carnation Milk condensery, which is located at the edge of town.

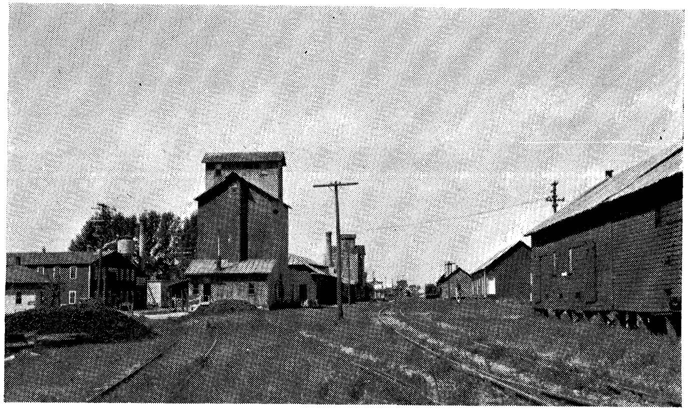


Figure 10. The railroad zone at Luxemburg. Note the elevators and the old planing mill on the left, gasoline bulk stations and sugar beet loaders in the distance.

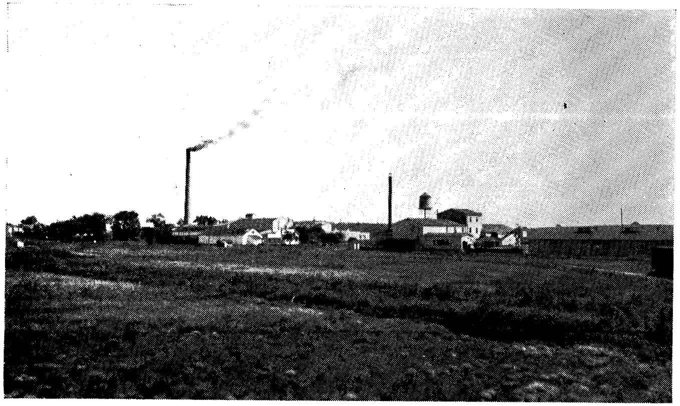


Figure 11. A milk condensery and pea cannery located at the edge of Valders which can be seen behind the trees on the left. These buildings are typical of those for their respective type of industry.

Figure 12. The winding main street of Denmark which follows the line of an early road upon which the town was built.

trade of the umland. The residential sections, in general, reflect the age of the towns.

Rural Hamlets

Rural hamlets are here considered to be those small agglomerated settlements commonly located at road junctions in rural areas and which generally include a garage and machine shop, a general store, a tavern, a cheese factory, a church, and an indefinite number of houses. Functioning mainly as local retail markets and service towns, the rural hamlets are distinguished from other towns by a general lack of industry other than cheese making. The rural hamlets lack the heavy commercial establishments characteristic of rural towns located on railroads. Although the rural hamlets are small, size is not a distinctive feature of this type of settlement, for mill towns, in general, are comparable in size. Stockbridge, the largest and only incorporated rural hamlet, has a population of 377, a figure which exceeds that of some rail towns.

Most of the 70 rural hamlets in the region are located east of the Fox River and Lake Winnebago. There is at least one in almost every civil town,[7] and some civil towns have as many as three hamlets. Sixty-six of the rural hamlets are located at road junctions. With few exceptions, all are located on level to gently rolling land which has provided no particular site quality not possessed by other localities that might have been selected for a settlement. Some rural hamlets, such as Mills Center, have grown up around a mill, but they have long since become rural hamlets in function and appearance. No trace of the mill remains.

Such names as St. Johns, St. George, Holy Cross, Lake Church, and New Bethel Kirche bespeak the origin of a surprising number of rural hamlets. Such towns are usually the center of an agricultural community which was settled as a unit by some foreign group. The bands of immigrants were frequently led by a clergyman, and generally the group built a church on a centrally located site at a relatively early date. Because historic data are lacking for most of the rural hamlets, it is difficult to determine just how many of them were built around a church nucleus. Apparently some grew up about an early general store or cheese factory, and still others are former mill towns. Of the 70 hamlets in the region, 37 have a centrally located church, which may or

[7] In Wisconsin the civil units of rural government are called towns.

may not have provided the nucleus, since many are not of known origin. The remaining 33 hamlets have either outgrown the original church nucleus or were not organized around such. Many began as stopping places along the old military roads which were built in the 1830's. The greatest percentage of hamlets are located at road junctions, where business has been able to attract farm trade from several directions. Business places have sprung up at church sites, to which large numbers of people are attracted every Sunday. Store keepers say that even now the major part of their business is done on Sunday mornings, though this predominance of Sabbath Day business has decreased of late years, since the automobile has made possible quick trips to the store at any time.

In a region with such low relief, the road pattern appears to be the dominant factor in the morphology of the settlement. Except for Bay Settlement, Stockbridge, Brothertown, and Quinney, all of the rural hamlets were organized after the Federal Land Survey was made and so conform to the rectangular road pattern of the survey. Only where a road has followed a pre-survey trail or where some topographic feature has interrupted the regular pattern do the town plans deviate from the rectangular. The various patterns and their frequency of recurrence are shown in Figure 7. Only two rural hamlets, Stockbridge in Calumet County and Kellnersville in Manitowoc County, have expanded to the point of developing a rectangular grid of secondary streets. Where the church is present it generally dominates the hamlet, especially in the case of Catholic churches and to a lesser degree, Lutheran churches. Large brick buildings with high steeples are most common. Both of these denominations commonly support a parochial school. The church, the school, the parsonage, and the sisters' home or school teacher's residence comprise the most imposing part of the hamlet. The cemetery commonly adjoins the church property. (Fig. 6.)

Other than a residence for local business men and retired farmers, the main function of the rural hamlet is that of a local market and service center. Even in the largest hamlet professional services are not available. The small cluster of business places in all hamlets, regardless of whether or not they contain a church, include one or more taverns, a feed store, a blacksmith shop, and a garage. Frequently the horseshoeing and car repairing are done by one man, and farm machinery is commonly sold either by the blacksmith or the garage operator. Hardware

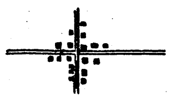
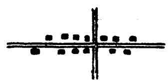
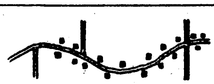
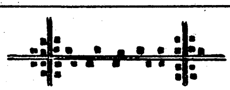
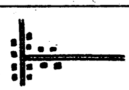
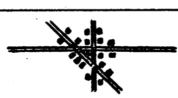
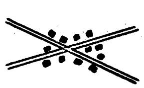
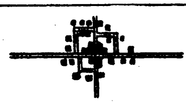
PATTERN	NUMBER	PER CENT
	27	38.6
	11	18.6
IRREGULAR	7	10.0
	6	8.5
	4	5.7
	4	5.7
	4	5.7
	3	4.2
	2	2.8
TOTAL	70	99.8

Fig. 7. A table showing the recurring patterns of rural hamlets.

stores, meat markets, harness shops, tin shops, and barber shops are frequently found in the larger hamlets. Faded old signs and vacant stores tell of an ever narrowing of the market scope of the rural hamlets.[8] Some hamlets possess a small fire station;

[8] An extreme example of declining functions is to be found in a vacant store whose faded sign advertises caskets and undertaking supplies in Cooperstown.

others are the site of the town hall. Stockbridge has a drug store, and is one of the three hamlets having a bank.

As a general rule, the only manufacturing carried on in the rural hamlets is cheese making. Cheese factories are located in 53 of the 70 rural hamlets. Although other distinctly local industries[9] do exist in six of the 70 rural hamlets, they are declining and all indications point to a gradual extinction.

Rural Towns Located on a Railroad

The most distinctive feature of the towns included in this group is that they are located on railroads which dominate both morphology and function and are responsible for the growth of the towns. Unlike the rural hamlets, the towns located on railroads possess distinctive zones of heavy commercial and industrial establishments, and the functions are consequently broadened.

The sites of the rural towns located on railroads vary in accordance with the origins of the towns. Some of these towns, such as Forest Junction and Hilbert, owe their origin to the railroad. Many of the towns that grew up along the line of a newly completed road took the names of company officials. Others existed as mill towns or rural hamlets prior to the building of the railroad.

The fact that towns existed prior to the building of the railroad has resulted in many cases in a dual site and a bi-nuclear settlement with a second center at the railroad, connected to the original by a strassendorf development.[10]

Because of their more complex development, it is much more difficult to generalize about the structural form of the rural towns located on railroads than it is to do so for the rural hamlets. The greatest similarity of the towns is found in the presence of a heavy commercial zone along the railroad. Other morphological factors vary as to site and degree of development of the settlements. Of the 39 towns in this class eleven are bi-nuclear. In nine of these, one part is centered on the railroad and the second

[9] These include feed mills at Nuren and Calumetville, portable saw mills at Eaton and Wayside, and permanent steam driven saw mills dating back 60 years at Rosecrans and Kellnersville. If local demand arises, the saw mills employ from four to eight men sawing the logs of surrounding farmers one to three weeks in winter.

[10] Francis Creek developed about a tavern on the portion of the old military road between Manitowoc and Green Bay. A secondary nucleus, now connected to the first by a strassendorf, developed later about the station of the Chicago and Northwestern Railroad. See Folge, Louis, *History of Manitowoc County, Wisconsin*, p. 343, Chicago, 1912.

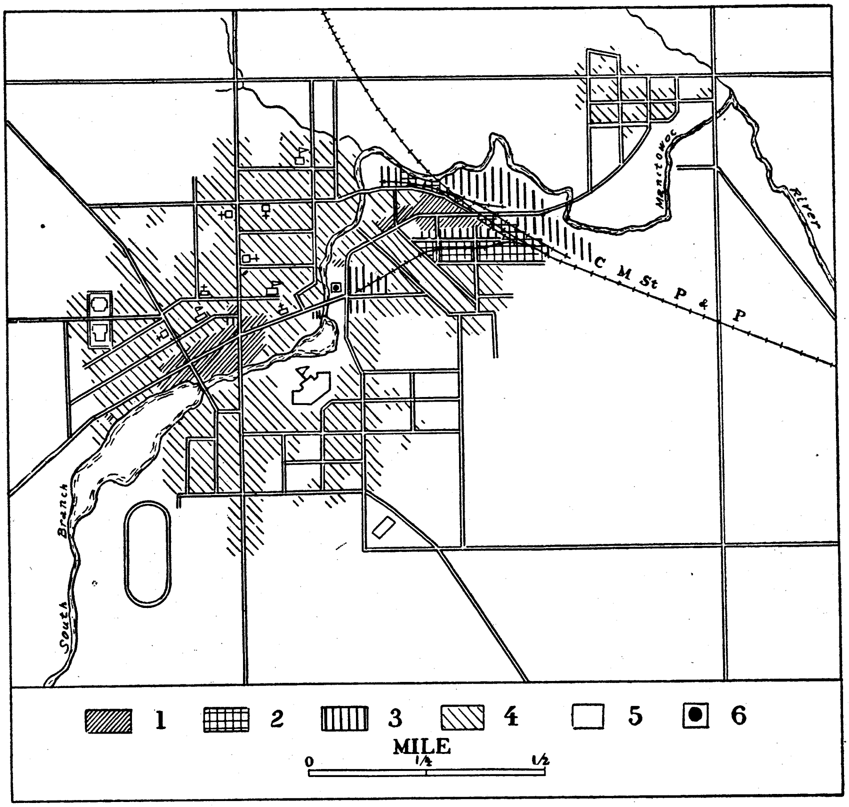


Fig. 8. Map of Chilton and Gravesville showing land use areas. These two towns began as rival mill sites shortly before 1850. Victory in a county seat contest with Gravesville brought continued growth to Chilton while its rival stagnated. When the railroad was constructed between the two towns, Chilton spread eastward until its former rival became but a suburb. Note the bi-nuclear structure of Chilton centered at the original water power site and at the railroad station. Key: 1, retail commercial; 2, heavy commercial; 3, industrial; 4, residential; 5, public buildings; 6, public utilities.

nucleus of the town is located at a highway junction. In some instances the highway nucleus preceded the railroad, and in others it has developed as a result of modern automobile traffic on major highways. In the latter cases, the business places are of the type that cater to the passing traffic. The present incorporated limits of Waldo include the railroad nucleus of the town proper and the mill town formerly known as Onion River. The original bi-nuclear arrangement of Chilton has been engulfed by the growing town, but the pattern is retained in the dual business section of the town.[11] The bi-nuclear arrangement is lacking in towns in which the railroad passed through the original center. In such instances the original site has played an important part in the present morphology. Casco, as an example, originated as a waterpower site, but since the railroad follows the valley, the linear arrangement of the town along the valley bottom has been maintained.

Towns vary greatly in size and degree of development, both of which are reflected in the structural form. They vary in size from a mere cluster of buildings to the incorporated municipality of Chilton with 2,203 people in 1940. Fifteen of the 39 towns have not grown beyond the primary road pattern upon which the town was developed. The following patterns, strassendorf, diagonal crossroads, double crossroads, and double T road junctions are each represented by one of these towns. Four possess a radial pattern, and a similar number form a T pattern. Three are located on crossroads. Of the 24 towns which have developed beyond the primary road pattern, 18 have developed a grid of secondary streets. The pattern of this grid varies considerably from the true rectangular, which characterizes ten of the towns, to an extremely irregular pattern. Forest Junction, which is wedged between a diagonal railroad junction, and Valders are characterized by a modified triangular grid. Oriented to the railroad, Collins has a rectangular grid, which is superimposed diagonally over the rectangular grid of the land survey. Other than that it conforms to the street pattern, no generalization can be made regarding the outline of the towns.

Like all towns in the region, those located on a railroad, in addition to being places of residence, are primarily local agricultural market and service towns. They carry on heavy commercial activities that are lacking in non-rail towns. The heavy commercial establishments include grain elevators, coal yards, lumber yards, pickle stations, sugar beet loaders, and stockyards.

---

[11] Both physiographic and historical factors entered into the development of Chilton and the present structure of the town. Moses Stanton, a negro, and his Indian wife settled at a waterpower site on the Manitowoc River, where he built a sawmill in 1846 and a grist mill in 1848 which served as a nucleus for the development of a village called Stantonville. Gravesville was laid out less than a mile to the northeast by LeRoy Graves in 1849. A year later he too erected a sawmill on the Manitowoc River. When the county was fully organized a heated political battle developed between the neighboring settlements over the location of the county seat. Stantonville, later renamed Chilton, won the contest, and continued to grow while Gravesville declined. When the railroad was constructed between the two towns, Chilton spread eastward until now its former rival is but a suburb. (See Watrous, Col. J. A., "Chilton's History, a Frontier Epic," Milwaukee *Sentinel*, April 11, 1910.)

Twenty-four of the 39 towns have grain elevators, and four of them have more than one. Three of the towns have a cheese warehouse each. In the larger towns manufacturing is an added function. Like the heavy commercial establishments, the manufacturing plants are for the most part based on a local source of raw material or on the local market. Twenty of the towns have cheese factories, six have milk condenseries, and thirteen have canning factories. The other industries include the manufacture of soil pulverizers, furnaces, aluminum goods, shoes, beer, and concrete blocks. Three towns have planing mills, one of which has been recently closed. A veneer plant is located at Rio Creek. Commercial lime kilns are located in or on the edge of three towns. In the larger towns, in addition to a greater variety of technical services, professional services are available. Retail business of the towns, as in all towns in the area, definitely caters to the farm trade.

Functional areas are best developed in the larger towns, but all towns located on a railroad have three such zones which are more or less well defined: a heavy commercial zone, a retail commercial zone, and a residential zone. The most characteristic is the industrial and heavy commercial zone along the railroad. Included within this zone are the long low sheds of the lumber and coal yards, the towering concrete or frame grain elevators, stock loading pens, sugar beet loaders, warehouses, and other heavy commercial establishments. Within the railroad zone of the larger towns are to be found one or more industrial plants (Fig. 9). The most typical and most common are the condenseries and canning factories, generally located along the railroad on the edge of town (Fig. 11). Both establishments are large and require a considerable amount of ground, which, except on the edge of town, was not generally available at the late date of their development. Industries less common are the older industries dating back to the development of the settlement such as wood-using industries and foundries or machine shops, which are located in the railroad zone in the built-up older parts of town (Fig. 10). Some more modern industries, such as the shoe factory at Belgium and the aluminum goods plant at Chilton, are located within the built-up zone if and where sufficient land is available (Fig. 9). Also along the railroad on the outer edge of town are to be found one or more batteries of gasoline storage tanks legislated to a safe distance by city ordinance.

Only in the larger towns is the business district a zone of continuously built-up business places. Much more commonly, dwellings are interspersed with the retail establishments. Generally centered at the town's main intersection, the retail commercial zone consists mostly of two-story and fire-proof buildings, but there are many frame buildings. The large towns have one or more banks; office space is rented above the stores by men offering professional services. Garage and implement stores are present in every town.

The third functional zone, common to all towns regardless of classification, is the residential area. The quality of the area depends on the size and prosperity of the town, but in every town there are a few houses or a cluster of houses which are modest yet comfortable and well kept and belong to the wealthier business men. As a general rule, however, the bulk of the houses are second rate. The shady streets are generally gravelled, but unpaved. Cement sidewalks are general. In this zone are located the churches and schools of the settlement.

THE NATURE OF TWO ASSOCIATED WISCONSIN SOILS AS INFLUENCED BY POST-GLACIAL EROSION, TOPOGRAPHY, AND SUBSTRATUM

LEWIS B. NELSON

Contribution from the Department of Soils, University of Wisconsin. A portion of this paper was part of a thesis submitted to the faculty of the University of Wisconsin in partial fulfillment of the requirements for the degree of doctor of philosophy. Published with the permission of the Director of the Wisconsin Agricultural Experiment Station.

The marked differences in profile characteristics and crop relationships between two of the major agricultural soils of north-central Wisconsin, namely, the Marathon (Gloucester, shallow phase)[1] and Spencer (Colby)[1] silt loams, have generally been ascribed to differences in parent material. The previous Marathon has been thought to be almost entirely residual from crystalline, granitic rocks in contrast to the impermeable Spencer which developed on clayey drift of early (pre-Wisconsin age) glaciations. Geologically, the Marathon area has been mapped as a part of the Wisconsin "Driftless" or unglaciated area (1, 3, 4)[2]. The following quotations from soil survey reports describe these views: "In the central part of Marathon county there is a considerable area which is usually spoken of as an unglaciated region and in which the soils are largely of residual origin. Over this area, however, it is not uncommon to find a few glacial bowlders, and there is other evidence that this region was influenced to some, though a very slight, extent by glacial action." (2, p. 23) "While a few glacial bowlders are sometimes found, the glacial action over this region was so slight as to have no appreciable influence on the formation of the soil." (5, p. 34)

Detailed soil fertility and drainage investigations of these soils showed that the above explanation of their origin was inadequate in several respects. For instance, on the uplands, numerous areas of Spencer (glaciated) were found to be entirely surrounded by Marathon (unglaciated) soils, and wide variations in illuviation and drainage were found in the areas mapped as Marathon. Since the relations of these two soils were significant

[1] The names, Marathon and Colby, first used by Weidman in his 1903 report, have been used in state soil survey reports; the corresponding names, Gloucester and Spencer, have been used in U.S. Bureau of Soils reports. The names, Marathon and Spencer, are given preference in this paper because the names Gloucester and Colby are applied to different soils in other states.

[2] Figures in parentheses refer to "Literature Cited", p. 72.

in agricultural and experimental work, a study of their profiles, relative locations, and development was made.

PROCEDURE

Work in a field experiment program made possible a fairly

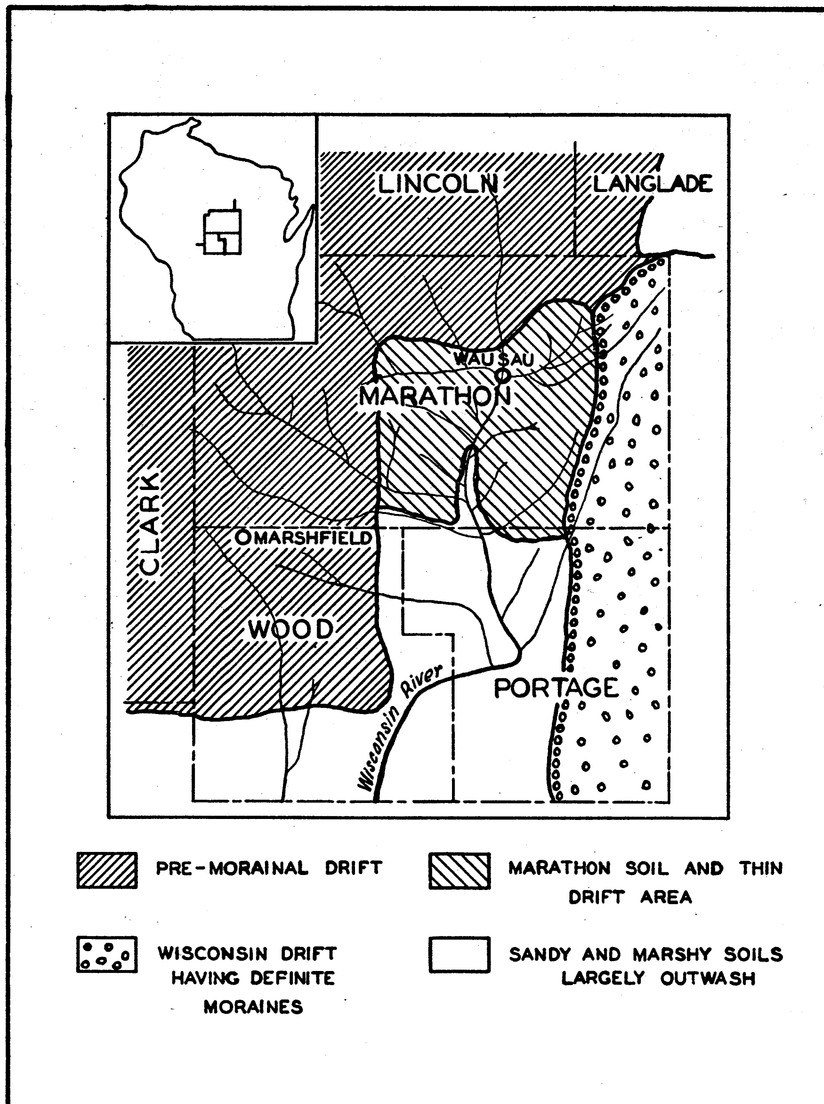


Fig. 1. Deposits of glacial drift and general stream pattern in central Wisconsin.

complete study of an area of about 1000 square miles in central, southwestern, and eastern Marathon and northwestern Wood county (Fig. 1). This area comprises about one-sixth of the total acreage mapped as Spencer and Marathon soils in northern Wood, northeastern Clark, western Marathon, and in Taylor, Price, Rusk, and Barron counties in north-central Wisconsin.

Previous soil surveys by Whitson, et al, (5, 6), and Geib, et al, (2), and Weidman (3), and the geological treatise by Weidman (4), were utilized in detail in the experimental work and soil studies. Numerous observations of the soil profiles and the underlying material were made. Particular attention was paid to the depth of glacial covering, presence or absence of mottling in the soil profiles, the amount of illuviation as shown by the depth, cementation, compactness or imperviousness of the B_2 horizon, and the nature and perviousness of the underlying material. The relation of topography and location of streams and drainage channels to the distribution of the soils was studied in the field and on topographical maps made by the United States Geological Survey.

RESULTS

The soils of the region studied, with the exception of 300 square miles of Marathon soils in central and eastern Marathon county, belong to the Spencer series. The Spencer soils consist of the typical or level, and the rolling phase of the Spencer silt loam. The so-called typical silt loam was found to be planosol occurring only on the slopes of less than two per cent.

The A_1 horizon of the level phase Spencer silt loam is a grayish-brown, friable silt loam having a granular structure. The lighter-colored A_1 horizon occurs at a depth of 4 inches and is a friable silt loam with a platy structure. The B_1 begins at about 8 inches, and is strongly mottled, reddish-brown or yellowish-brown silt loam with a distinctly platy structure. A characteristic, whitish-gray, silty deposit of silica is found on the outside of the particles and in the fissures and cracks immediately overlying the heavier B_2. At approximately 20 inches, this gives way to the dense B_2 which is a more or less mottled, reddish-gray silty clay, very compact, and tightly cemented with sesquioxides. Its structure is somewhat columnar when dry, it has a low water-holding capacity, is seldom penetrated by plant roots, and is very impervious to water as shown by infiltration measurements. The C horizon begins at a depth of 40 or 50 inches and consists of a sticky, impervious gray or red sandy clay locally with gray and yellow mottling. Small glacial stones are common throughout the profile, and lenses of sand are locally found in the B_2 and C horizons. The underlying till varies in depth from six to one hundred feet.

The rolling phase of the Spencer silt loam was found on rolling land whose average slope was 4 or 5 per cent. Its profile differs from the level Spencer silt loam in that it has a less mottled B_1 and B_2, a more reddish color of the B_2 horizon, and a slightly less illuviated and cemented B_2 horizon.

The parent material of the Spencer soils was found in all instances to be a sandy and clayey till which, according to Weidman (4), was deposited by at least three early, pre-Wisconsin glaciations. Other workers have considered this drift to be deposited by only one glaciation, probably of Illinoian age (1). In any case, it is a rather smooth drift and is now considered to be of much later origin than previously thought. The term "pre-moraine" instead of "pre-Wisconsin" has been suggested for it by Professor F. T. Thwaites. At present the depth of the non-calcareous zone in the drift varies from 3 to 20 or more feet. The depth of the till with which the level Spencer silt loam is associated, was found to vary from 6 to 100 feet, while that of the rolling phase often was much shallower, the minimum depth being around 3 feet. Underlying the till are large areas of coarse and fine-grained granites, and Cambrian sandstone which, regardless of their porosity, apparently exert no influence upon the nature of the overlying till and soil.

The level Spencer silt loam was found to be limited to uplands that have not been encroached upon by active drainage systems (Fig. 1). Hilly moraines, kettle holes, kames, eskers, and other glacial surface features are lacking on these uplands at present. The rolling phase was found on areas nearer to the deep drainage systems which are now actively dissecting the area (Fig. 2).

The profile of the Marathon soils differs distinctly from that of the adjacent Spencer soils, particularly in the lack of mottling, and the presence of a more shallow, less strongly cemented, and more pervious B_2 horizon in the Marathon. However, the Marathon silt loam as mapped in reconnaissance surveys is quite variable, ranging from a heavily illuviated soil, having a solum 2 to 2½ feet in depth with a heavy B_2 horizon, to one having a youthful profile with no B_2 horizon. Rounded glacial stones were found intermixed throughout the solums of all profiles studied. The B_2 horizons were found to be underlain for the most part by a decomposed, coarse-grained granitic bedrock, which had been considered to be similar to the parent material of the soil itself. This granite weathers very easily into a granular, porous mass

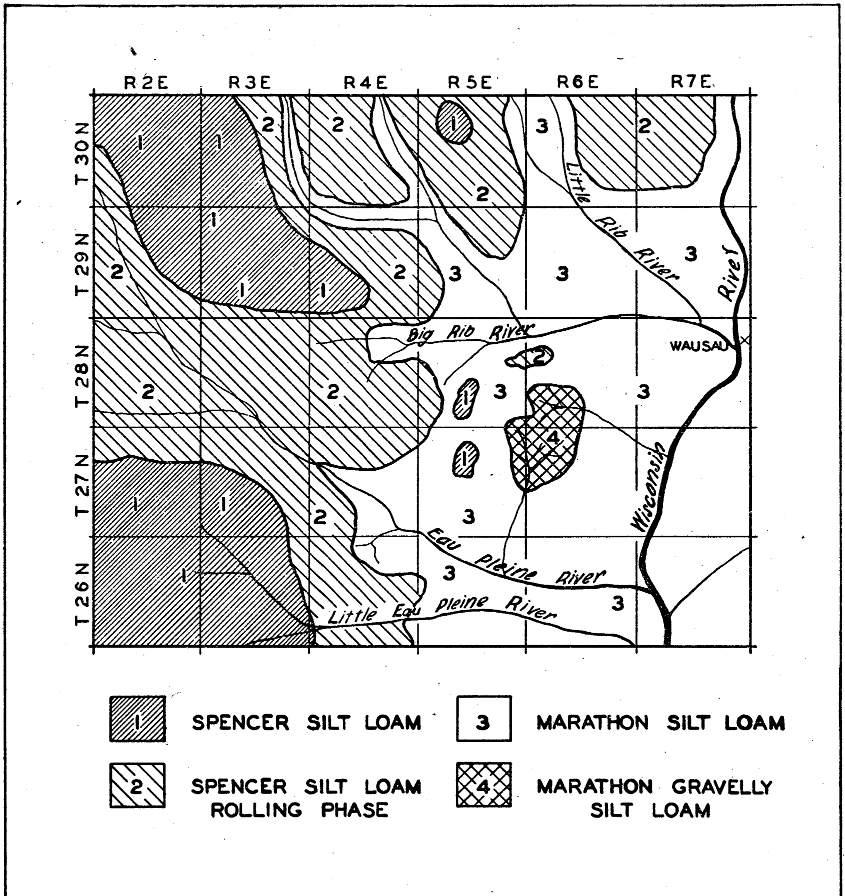


Fig. 2. Central portion of Marathon county, Wisconsin, showing location of soils in relation to stream channels.

which grades slowly into a less decomposed, less porous material, and finally into solid, unweathered rock at a depth of ten or fifteen feet. Infiltration measurements showed that the weathered granite is extremely pervious to water movement.

The location of the Marathon soils, the amount of illuviation as shown by the depth, compactness, and cementation of the B_2 horizon, and the depth of the solum with its glacial stones were found to vary according to the proximity of the soil to the numerous streams which dissect central Marathon county.

The Wisconsin river flows in a southerly direction through the

Marathon area (Fig. 2). A number of tributaries, the Pine, Trapp, Big and Little Eau Claire rivers flow into the Wisconsin from the southeast. Tributaries from the southwest, the Big Rib, Little Rib, and Big and Little Eau Pleine rivers, further dissect the area. The valleys cut by all of these streams in pre-glacial times apparently were not greatly altered by glaciation. This region is notable, along the upper Wisconsin river, for the number of deep-channeled streams per unit area. On the steeper slopes close to these streams, the youthful Marathon soils having a solum of about one foot in depth were found. On the gentle slopes more distant from the streams, the soil had a heavy, deep B horizon, which increased in depth with distance from the stream, until the Marathon soil graded into soils of the Spencer series (Fig. 2).

On undissected uplands between the streams and within the borders of the Marathon soil area, isolated local areas of both the level and rolling phases of the Spencer silt loam were found, for the most part, surrounded by soils of the Marathon series (Fig. 2). In some instances, a regular succession of soils was found; the level, mottled Spencer silt loam on the flat upland; the rolling phase Spencer on the more rolling slopes; the non-mottled Marathon soil with a heavy, deep B horizon on steeper, more dissected areas; and, finally, on the valley sides near the stream, the more youthful and less illuviated form of the Marathon.

Small areas of Marathon gravelly silt loam were found upon hummocky, much dissected, granite hills located at points where two drainage systems are at present intersecting. This soil, devoid of glacial stones, consists of a brown or dark-brown silt loam, six to ten inches in depth overlying granite. The granite, to a depth of six or eight feet, has decomposed into a coarse-grained, loose mass of angular fragments of about one-half inch in diameter.

DISCUSSION

The prevalence of a wide variety of glacial stones over the whole of the Marathon and Spencer area points to the conclusion that glaciation and deposition of drift occurred over the entire area. The part occupied chiefly by the Marathon soils was formerly included in the "Driftless Area," but glacial stones found high on the monadnock quartzite hills of the region show that the ice was once quite deep over much of the area. The presence of a pre-glacial granitic peneplain is suggested by level uplands of uniform height. This pre-glacial peneplain was probably dissected by pre-glacial streams and drainage ways, forming a topography somewhat similar to that now existing. Apparently the glacial till was then deposited more or less uniformly over the area but the greater fall to the level of the streams in the Marathon area caused post-glacial erosion to proceed more rapidly there than in the Spencer area. The depth of till was never great enough to cause the streams to be diverted for any appreciable period from their pre-glacial drainage ways.

The depth of drift remaining in the Marathon area varies considerably. With the exception of glacial outwash, only a thin mantle of glacial material is present near the Wisconsin River or its deep channeled tributaries. In some places, this glacial covering has been entirely removed by post-glacial erosion. Farther back from the stream channels or toward their heads, erosion has been less active and glaciated material over two and one-half feet in depth is found. The uplands not encroached upon by drainage systems, have lost much less of their original drift deposits and are still covered with relatively deep glacial drift. It is also highly probable that the original deposit of till was thinner over some local areas and on the slopes to the pre-glacial drainage-ways.

The poorly-drained Spencer silt loam appears to be limited to the uplands with their deeper drift covering. Because of the lack of erosion, the topography has remained level and the surface runoff is greatly reduced. The lack of soil removal and the increase in percolating water have led, in such locations, to the formation of a planosol with a cemented, deep, and impervious B_2 horizon. This horizon, and the clayey underlying till, have inhibited water movement to the extent that a highly mottled, poorly-aerated soil has resulted. The combination of insufficient surface with poor internal drainage has greatly lowered the agricultural value of this soil.

The rolling phase of the Spencer silt loam occurs where the smaller tributaries of the Wisconsin River are cutting back into the regions of deeper till (Fig. 2). The B_2 horizon appears to be sufficiently impervious, and the underlying clayey till of ample depth to seriously impede the internal drainage of the soil. Under these conditions, mottling is still a dominant feature, although it is somewhat less pronounced than in the level Spencer. As a consequence of the rolling nature of the topography, excellent surface drainage has resulted, and these soils are therefore more desirable for farming than the level Spencer soils.

The Marathon silt loam, for the most part, is limited to areas in close proximity to well-developed drainage systems (Fig. 1). Here, the erosion has been rapid and the glacial mantle exists at depths of two and one-half feet or less. Because of the increased rate of post-glacial erosion and the porous nature of the underlying granite, profile development has been slow and the B_2 is either quite friable or non-existent. As a consequence of the permeable subsoil and the porous underlying granite, the internal drainage is excellent, and mottling is entirely absent. With an increase in the steepness of the slopes there is a corresponding decrease in the thickness of the glacial mantle, and more youthful, less-illuviated soil profiles result. This is strikingly demonstrated by the absence of B_2 horizons in the soils of the steeper slopes close to the deep drainage systems.

The borders between the more mature phases of non-mottled Marathon silt loam and the mottled, rolling phase, Spencer silt loam are in most places sharp and well defined. The depth of glaciated material seems to be the dominant factor in determining the type of soil. Evidently, where the glaciated material is deeper than two and one-half feet, it impedes the drainage sufficiently to result in the formation of the mottled, rolling phase, Spencer silt loam.

The Marathon gravelly silt loam shows the least profile development of all the soils of the area. This type occurs on tracts devoid of glacial material and is found only between two active drainage systems which are cutting down the divide between them (Fig. 1). This would indicate that post-glacial erosion has been largely responsible for the lack of drift. The water-retaining power of the soil mantle and the underlying decomposed granite is extremely low and is a limiting factor in crop production.

Eventually, as the drainage systems deepen and erosion progresses, the soils will undergo a cycle of successive changes. As the regions of deeper till are eroded, the level Spencer silt loam will pass into the rolling phase of the Spencer silt loam. When the glacial material has been reduced to a depth of about two and one-half feet, at which point the underlying porous material, where present, appears to exert its favorable influence on water movement, the non-mottled, more-illuviated phases of the Marathon silt loam will supersede the rolling phase of the Spencer silt loam. As geologic time progresses, more and more till will be removed and the less-illuviated phases of the Marathon silt loam will form. Finally, as the drainage systems intersect, the last traces of glacial material will be removed and the very immature, drouthy Marathon gravelly silt loam will be formed. The areas farthest and most protected from the deep drainage systems will retain their glacial covering longest.

SUMMARY

The results of a field study of the influence of post-glacial erosion, topography, and substratum upon the formation and character of the Spencer (Colby), and Marathon (Gloucester) soils of central Wisconsin is presented. The region occupied by these soils, including a portion previously thought to be a part of the Wisconsin "Driftless Area," apparently was entirely covered by a clayey till laid down by an early pre-moraine ice invasion. Differential post-glacial erosion, varying with the proximity of the drift to deep-channeled pre-glacial drainage systems, has since occurred, which, coupled with the original depth of drift, is closely related to the distribution of present-day soils. Where post-glacial erosion has been slight, and relatively deep drift is found, the poorly-drained, mottled level phase Spencer is found; where the topography is rolling and post-glacial erosion has been more active, the more shallow rolling phase Spencer occurs. Where the present glacial covering is so thin that the underlying, porous, decomposed granite is within 30 inches of the surface, the entirely different, well-drained, non-mottled Marathon occurs. Where all the till has been removed the drouthy Marathon gravelly silt loam is formed.

As the drainage systems deepen and erosion progresses, the soils in this area appear to pass, in regular succession, from the Spencer, level phase, through the rolling phase, to the Marathon silt loam and finally to the Marathon gravelly silt loam. This relation of a number of soils ranging from a strongly-illuviated planosol to a rather coarse, steep, and drouthy soil is the key to soil formation in the area studied and to the distribution of soils with regard to topography, altitude, and location of streams.

ACKNOWLEDGMENT

The writer wishes to express his appreciation for the helpful suggestions and criticisms tendered by Professor R. J. Muckenhirn and the late Professor F. L. Musbach under whose general direction this work was done. Grateful acknowledgment is further made of suggestions given by Professor F. T. Thwaites and F. D. Hole of the Department of Geology of the University of Wisconsin.

Literature Cited

1. Antevs, Ernst. Maps of the Pleistocene glaciations. Geol. Soc. Am. Bul. Vol. 40, 631-720, 1929.

2. Geib, W. J., Taylor, A. E., et al. Reconnoissance soil survey of south part of north-central Wisconsin. U. S. Dept. Agr. Soil Survey Report, 1917.

3. Weidman, Samuel. Preliminary report on the soils and agricultural conditions of north-central Wisconsin. Wis. Geol. and Nat. Hist. Sur. Bul. No. 11. 1903.

4. Weidman, Samuel. Geology of north-central Wisconsin. Wis. Geol. and Nat. Hist. Sur. Vol. 16, 1907.

5. Whitson, A. R., Geib, W. J., et al. Reconnoissance soil survey of south part of north-central Wisconsin. Wis. Geol. and Nat. Hist. Sur. Bul. No. 52-A. 1918.

6. Whitson, A. R., Geib, W. J., et al. Soil survey of Wood county, Wisconsin. Wis. Geol. and Nat. Hist. Sur. Bul. No. 52-B. 1918.

FACTORS INFLUENCING INJURY TO CRANBERRY PLANTS DURING FLOODING

NEIL E. STEVENS AND NOEL F. THOMPSON

For many years, submerging the cranberry plants on which they were feeding was the standard control measure for the black-headed fireworm (*Rhopobota vacciniana* Pack). Except in extreme cases this was used only during the larval stage of the first brood. Since this usually occurred in June, the "June reflow" became almost a routine practice of many cranberry growers. During the past two decades, however, the demonstrated effectiveness of certain insecticides, together with improved machinery for their application, led to a decided reduction in the amount of flooding for insect control.

The June reflow has never been abandoned, and during the past two years, interest in this method of control has greatly increased. This increase is due in part to the threatened shortages of certain important insecticides, and in part to the realization that the reflow had apparently held in check other insects than those at which it was specifically directed.

Injury to the cranberry plants themselves has frequently occurred during the June reflow. The symptoms of water injury are all too well known to many cranberry growers. Blossom buds are most easily injured; they may be killed outright, in which case the whole bud turns brown and never opens; or they may be injured on one side only, in which case the distorted bud opens but rarely forms a berry. In extreme cases, the tender young leaves soon turn brown.

Injury of this type was unusually severe in the Mather-Warrens district of Wisconsin during early June of 1942. In the present paper, the factors believed to be important in relation to this injury are reviewed in the light of observations made in Wisconsin during that season. Since the careful studies of Bergman[1] and of Franklin[2] on this subject in 1919, there has apparently been no question that the injury is due to the actual drowning of the plant parts due to lack of oxygen in the flooding water. Thus the factors which may influence injury include not only those which affect the plant directly, but all those which affect the amount of O_2 in the water.

The factors which will be discussed in this connection are temperature, light, the initial O_2 content of the water used in flooding, the color of the flooding water, and the carbonate content of the flooding water itself. Of the importance of this last factor we have only recently become convinced.

Temperature

High temperatures are more liable to produce injury both because the plants respire faster at higher temperatures and because the O_2 holding capacity of the water declines with rising temperature. The importance of the temperature of the water relative to its effectiveness in killing insects has long been recognized. Dr. Franklin's[3] recommendations for use in Massachusetts indicate that twice as long a submergence is necessary at 65° F. as at 85° F. Injury to the plant also occurs much more quickly at the higher temperatures, a fact well known to cranberry growers, who almost invariably take it into consideration, sometimes to the exclusion of other factors, which may be of critical importance.

Light

The importance of light as a factor in the oxygen content of flooding water on cranberry marshes was emphasized by Bergman[1] in 1919. He pointed out that the O_2 content of the water in which cranberry plants are submerged falls at night or on very cloudy days, and rises on clear days. This is evident from the figures given in Table 1, based on data obtained in Wisconsin in 1942.

The rise in the amount of dissolved O_2 is of course due to the photosynthetic action of the cranberry plants themselves. O_2 is a waste product of photosynthesis and within limits, the more rapid the photosynthesis, the greater the amount of O_2 dissolved in the flooding water and available for the respiration of the plants.

In general, it has been the experience of Wisconsin growers that it is safer to flood in clear or partially clear weather, but for reasons which will be discussed later, this relation is not so direct or simple as in Massachusetts.

Initial Oxygen Content of the Flooding Water

It has long been recognized in Wisconsin that on certain marshes it is never safe to hold the flooding water for any such

TABLE 1

Dissolved O_2 in Flooding Water of

Various Wisconsin Marshes During Submergence (1942)

Marsh No.	Date	Temperature (Fahrenheit)	A. M.									P. M.					Reservoir
			4	5	6	7	8	9	10	11	12	1	2	3	4	5	
4	6/ 6/42		...	...	...	...	...	...	...	...	...	...	...	6.4	6.2	...	5.6
	6/ 7/42	65° — 72°	5.5	5.7	5.7	5.8	6.0	6.4	7.0	7.3	8.1	7.7	8.3	8.3	8.3	8.0	to
	6/ 8/42		4.2	4.9	5.1	5.7	6.1	6.9	...	...	...	...	...	...	...	...	6.6
		Vi	nes	sub	mer	ged	60 h	ours	—N	o in	jury	to	bud	s.			
34	6/ 9/42	70° — 83°	...	...	3.7	4.1	4.5	5.7	5.9	6.5	6.7	6.9	6.7	6.7	6.9	6.5	4.2
	6/10/42		1.8	1.9	...	2.7	...	3.2	4.2	...	...	...	...	...	...	...	......
		V	ines	sub	mer	ged	36	hou	rs—	No i	nju	ry t	o b	uds.			
32	6/ 4/42	72° — 81°	...	...	2.8	...	3.2	...	2.4	...	3.2	...	3.4	...	4.2	...	1.8
		Vines	sub	mer	ged	24 h	our	s—1	0 %	to	25	% i	nju	red	bud	s.	
9	6/14/42	62° — 72°	...	...	...	...	1.4	1.0	1.1	1.5	2.1	2.7	2.6	2.5	...	...	0.8
		Vines	sub	mer	ged	10 h	our	s—3	0 %	to 3	5%	inju	red	bu	ds.		

lengths of time as those recommended for Massachusetts, 8 to 12 hours being the recognized limit of safety. On the other hand, there are marshes which have been flooded while the buds were in the "hook stage" for 60 to 72 hours without any trace of injury.

One striking difference is the O_2 content of the water in the reservoir at flooding time (See Table 2). Reference to this table will show that during the season of 1942 there were being used for flooding cranberries in Wisconsin, water with O_2 content at the surface of the reservoir as high as the saturation point, and others as low as 1.8. It is probably needless to add that it is in marshes which have water with lower O_2 content that the short flooding periods are necessary.

DIFFERENCE IN O_2 CONTENT OF WATER AT DIFFERENT DEPTHS IN RESERVOIRS

One of the most important facts observed in our studies of reservoir water was the difference in the O_2 content of the water at different levels. This is noticeable only if the water is fairly still, and is apparently most pronounced if the water is colored and the bottom of the reservoir contains much organic matter (See Table 3). Obviously, any grower who floods with water from the bottom of a reservoir of this type is sacrificing O_2 content for the sake of using cooler water.

TABLE 2
Reservoir Water Data

Reservoir Number	(1942) Date	pH	Transparency*	Temperature (Degrees F.)	O_2 at Surface	Free CO_2	Bound CO_2
1	July 7	5.4	Clear	67	7.7	4	5.0
2	July 11	4.8	23	85	5.4	..	6.5
4	July 4	7.4	29	..	8.9	2	28.0
9N	July 8	4.6	20	..	2.8	21	6.0
9M	July 8	...	..	..	1.8	53	0.
16	July 6	6.3	..	60	6.1	4	9.5
22	July 11	5.5	21	85	6.8	..	7.5
32	July 13	5.4	31	74	4.0	13	9.0
34	July 13	6.8	..	..	5.7	6	13.0
38	July 11	5.2	23	90	5.4	..	7.5
44	July 10	5.4	17	67	2.5	20	4.5
45	July 9	4.4	14	67	1.8	34	7.0
60	July 10	4.6	12	82	3.1	22	4.0
61	July 10	5.6	19	71	4.4	12	6.0
64	July 13	5.4	..	..	2.0	22	15.0
71	July 10	5.6	16	69	4.1	16	3.5
72U	July 8	4.2	21	..	4.7	15	7.5
80L	July 10	6.0	24	70	4.8	8	8.0
80U	July 10	5.6	22	72	3.5	41	0.
81	July 7	8.7	..	65	9.0	25	27.0
91	July 11	5.0	20	82	3.4	..	7.0
B1	July 11	5.0	25	78	4.0	..	6.5
B2	July 8	5.2	36	..	6.2	6	5.2
B3	July 8	4.4	17	..	2.0	27	8.0
H	July 6	6.7	..	65	7.8	7	27.0

*See text for explanation.

"COLOR" OF THE WATER

In his discussion of the causes of the severe injury from flooding in Massachusetts on June 17, 1919, Dr. Franklin[2] called attention to the importance of the color of the water. Since once the plants are submerged the only known source of O_2 is that given off by the plants themselves as a result of photosynthesis, anything that tends to limit that activity tends to cut down the amount of O_2 available to the plants.

TABLE 3

O_2 Content of Reservoir Water at Various Depths

Reservoir Number	Depth			
	6 inches	1 foot	2 feet	3 feet
B1	4.0	...	...	0.8
B2	...	4.7	...	4.6
B3	...	2.0	...	0.5
H	7.8	...	...	4.6
1	7.7	...	...	7.6
2	5.4	...	1.5	...
16	6.1	...	...	5.4
22	6.8	...	3.5	...
32	4.0	...	...	3.0
38	5.4	...	3.2	...
44	2.5	...	0.1	...
60	3.1	...	0.8	...
61	...	4.4	...	1.0
64	2.0	...	1.2	...
71	4.1	...	3.2	...
80L	...	4.8	3.7	...
80U	...	3.5	3.0	...
91	3.4	...	1.2	...

While we have as yet no exact measurements of the degree to which light is reduced by water of different colors, it is certain that dark colored water will transmit light much less effectively than clear water. Birge and Juday[5] have pointed out that in general, light transmission decreases as color rises, and that in general stain affects transmission much more than it does transparency.

It is evident from Table 2 that the water of many Wisconsin cranberry reservoirs is dark colored, also that there is considerable difference in their color. Undoubtedly, all other conditions being equal, dark colored water would be somewhat less favorable than clear water. In Table 2, the color of the water is indicated by the depth in inches that a 150 mm. white porcelain plate could be seen. The plate was lowered until it disappeared, then raised until just visible, and the average depth recorded.

DISSOLVED CARBONATES IN THE FLOODING WATER

The rate at which plants are able to carry on photosynthesis may be limited by the amount of CO_2 available as well as by light and temperature. In fact, under the conditions prevailing outdoors in the summer, the small amount of CO_2 in the air (only 3 to 4 parts per 10,000) is recognized as often being the limiting factor in the rate of photosynthesis. In greenhouses, plants have been successfully "fertilized" by adding CO_2 to the air in which they were growing.

It has been repeatedly proved, also, that plants submerged in water can secure a part of the CO_2 they need from bicarbonates dissolved in the water. Our observations of the past summer have convinced us that lack of adequate bicarbonates in the flooding water may often be a critical factor in producing the shortage of O_2 which results in water injury. Reference to Table 2, column 8 shows that the water of many Wisconsin reservoirs is very low in carbonates (bound CO_2). Among these are the marshes which developed so little dissolved O_2 during the days in which observations were made (9 and 32). (See Table 1.)

That the lack of adequate dissolved bicarbonate in certain water does act as a limiting factor in the photosynthesis of submerged cranberry plants was readily proved by a simple experiment carried out July 9 and 10 with water from a reservoir on Marsh No. 9. In this experiment, sods of cranberry vines of approximately equal size were placed in tubs filled with water from the reservoir. The tubs themselves were then partly submerged in the water and left over night. The next morning, the water in each tub was tested for dissolved CO_2 and bound CO_2 (See Table No. 2). Tub No. 1 was left as a check. Tub No. 2 was covered so as to cut off all the light and to the water of Tub No. 3 was added enough sodium bicarbonate to raise the pH to 7, and the bound CO_2 content to a level well above that of most flooding water. The results are all clearly evident in Table 4 and Figure 1. That the water in Tub No. 1 contained more O_2 than was found on the marsh itself on June 14 is explained by the conditions of the experiment. The water was dipped into the tub and the amount of water was smaller relative to the quantity of vines. With no light available, the O_2 in Tub No. 2 was soon exhausted. The photosynthesis in the plants in Tub No. 3 was so much more rapid that the O_2 content of the water reached the saturation point on both days, while that in Tub No. 1 rose only to 5.5 and 4.8.

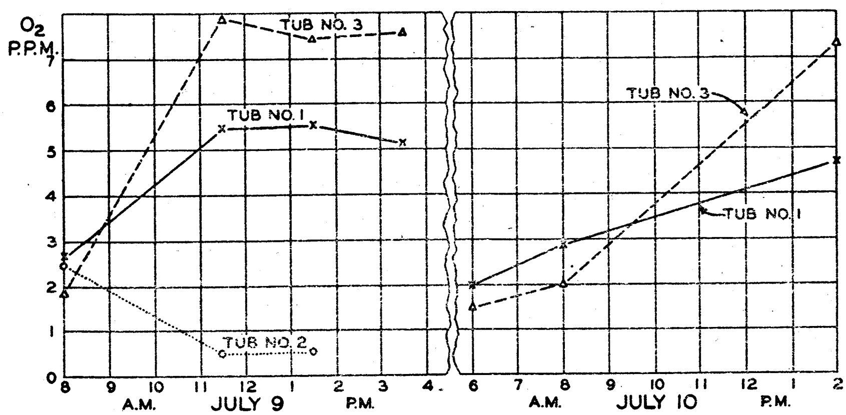


Fig. 1. Results of adding sodium bicarbonate to flooding water.

TABLE 4

Results from Adding Sodium Bicarbonate to Flooding Water

Tub No.		July 9, 1942					July 10, 1942		
		A. M.		P. M.			A. M.		P. M.
		8:00	11:30	1:30	2:30	3:30	6:00	8:00	2:00
1	O_2	2.7	5.4	5.5	...	5.1	2.0	2.9	4.8
	Bound CO_2	...	....	....	5.5	...	...	6.0	7.5
	pH	...	....	....	...	5.3	...	5.4	.....
	Temp.	...	....	....	...	...	...	....	85° F.
2	O_2	2.5	0.5	0.6	Discon	tinued			
3	O_2	1.9	7.9	7.4	...	7.6	1.5	2.0	7.3
	Bound CO_2	...	47.5	55.0	...	...	...	71.0	76.5
	pH	...	....	....	...	7.0	...	6.8	.....
	Temp.	...	....	....	...	...	...	....	85° F.

Sods were cut and placed in washtubs about 4 p.m. July 8. The tubs were then partially submerged in the reservoir and filled with reservoir water. About 8:30 a.m. on July 9, Tub No. 2 was covered by a piece of plywood to exclude most of the light, and to the water in Tub No. 3 was added about 4/5 oz. of sodium bicarbonate.

RELATION OF THE FOREGOING OBSERVATIONS TO ILLUMINATION DURING THE FLOODING PERIOD

Certain Wisconsin growers are convinced that it makes little difference whether they flood in clear weather or cloudy. Others believe that clear hot days are more likely to produce injury than cloudy ones. With water that is very low in carbonates, this may well be the case. Obviously, if the flooding waters lack dissolved CO_2 or bicarbonates in sufficient amounts to permit photosynthesis, the process can not go on no matter how strong the light. Moreover, considerably less than full sunlight is often adequate for photosynthesis. Under these conditions, the added heat derived from the bright sun may well add to the injury.

Possible Relation of Heavy Rainfall to Water Injury

To anyone who observed conditions on the Mather-Warrens district during early June, 1942, it was hard to avoid the conclusion that the injury was aggravated by the excessive rains of late May and early June.

TABLE 5
Rainfall at Mather, Wisconsin in May and June, 1942
(Data from Alex Grimshaw—Weather Observer)

	MAY				JUNE						
	28	29	30	31	1	2	3	4	5	6	7
Rainfall: (Inches)	.19	.59	1.34	.76	.12	1.91	..	T	.53	.82	.98

Rain water, when it falls, has a very high O_2 content, and usually a very low content of bound CO_2. Mixed with water of high bound CO_2 content, as that of the Wisconsin River, it would be rather beneficial than otherwise, but mixed with water already low in carbonates and containing organic matter which would soon exhaust the O_2, it might well be actually harmful.

Practical Suggestions Based on the Foregoing Observations

The most obvious conclusion from the observations recorded above is that experience on one marsh does not furnish a safe guide for use on another unless conditions are known to be very similar.

While in general, injury to submerged plants is less likely to occur if flooding is done on clear, or at least only partly cloudy days, there appear to be certain Wisconsin marshes where the photosynthesis of the plants is so limited by other factors that little is gained by the presence of abundant light. Among these limiting factors appears to be extreme scarcity of bicarbonates in the flooding water.

In most reservoirs where there is little movement of the water and the amount of dissolved oxygen is small, the lower levels of water are extremely deficient in oxygen. The practice of draining flooding water from the bottom of the reservoir for the sake of obtaining cooler water thus appears to be very dangerous.

If experience has proved that the flooding period must be very short, the best practice would appear to be to flood the marsh during one night or early morning, and remove it the following night or early evening.

Citations

1. Bergman, H. F., "The Effect of Cloudiness", 32nd Annual Report of the Cape Cod Cranberry Growers Association. (Page 19-30) 1920.
2. Franklin, H. J., State Bog Report, 32nd Annual Report of the Cape Cod Cranberry Growers Association. (Page 11-18) 1920.
3. Franklin, H. J., "Cape Cod Cranberry Insects", Massachusetts Agricultural Experiment Station Bulletin Number 239. 1928.
4. Birge, E. A., and C. Juday, "Solar Radiation and Inland Lakes", 4th Report Trans. Wisconsin Academy of Science. (27: 523-562) 1932.
5. Birge, E. A., and C. Juday, "Transmission of Solar Radiation by the Waters of Inland Lakes", 4th Report Trans. Wisconsin Academy of Science. (24:509-580) 1929.

NOTES ON WISCONSIN PARASITIC FUNGI. II.

H. C. GREENE

The collections on which these notes are based were made principally in the southern counties during the seasons of 1940 and 1941.

UROPHLYCTIS PLURIANNULATA (B. & C.) Farl. on *Zizia aurea*. Waukesha Co., Eagleville, August 2. Rare. A single previous Wisconsin collection from Kenosha Co., 1907.

PLASMOPARA OBDUCENS Schroet. on *Impatiens pallida*. Sauk Co., Parfrey's Glen, September 6. Although Davis lists this host for P. OBDUCENS there were no Wisconsin specimens in the Herbarium.

ERYSIPHE POLYGONI DC. on *Aquilegia canadensis*. Dane Co., near Sauk City, September 28. Tracy and Galloway, in an article entitled "Notes on Western Erysipheae and Peronosporeae", in Jour. Mycol. *4*: 35 (1888), mention E. POLYGONI as occurring on *Aquilegia canadensis* in Wisconsin. Since no specimens were found in the Davis Herbarium or in the University Herbarium, it seems that Davis based his citation of this host on the report of Tracy and Galloway.

Presumed ERYSIPHE GALEOPSIDIS DC. has been observed on *Stachys palustris* and *Mentha arvensis* var. *canadensis* in several localities over a considerable period of time. The asci, characteristically, lack mature spores, but it has not been determined whether the haustoria are lobed.

ACHILLEA MILLEFOLIUM has been found at Eagleville, Waukesha Co., bearing Erysiphe heavily parasitized by CICINNOBOLUS CESATI DeBary. E. CICHORACEARUM DC. is reported on this host in Seymour's Index, but has not so far been collected in recognizable condition in Wisconsin.

MICROSPHAERA ALNI (DC.) Wint. var EXTENSA (C. & P.) Salm. on *Quercus rubra*. Dane Co., near Sauk City, September 28; Columbia Co., Gibraltar Rock, October 5. Trelease in 1882 reported this variety from Madison, Dane Co., but apparently it has not been found in the interim. The flexuous appendages, exceeding in length three times the diameter of the perithecium, are striking.

UNCINULA SALICIS (DC.) Wint. on *Salix rostrata.* Dane Co., Madison, September 27. Only one previous Wisconsin collection on this host, but it is probably not uncommon.

DOTHIDELLA BETULINA (Fr.) Sacc. on *Betula pumila* var. *glandulifera.* Dane Co., Madison, April 10. Davis in his "Notes" XIV, p. 185, states "A collection on living leaves of *Betula pumila* from Danbury corresponds with immature specimens of DOTHIDELLA BETULINA." This writer found no mature specimens from Wisconsin in the Herbarium. In October 1939, at Madison, leaves of *B. pumila* var. *glandulifera* were found heavily infected with presumed DOTHIDELLA BETULINA. A number of such leaves were overwintered in cheesecloth bags in the field. In April 1940 the fungus was reexamined and found to have matured, establishing the presence of D. BETULINA in Wisconsin.

PHYLLACHORA GRAMINIS (Pers.) Fckl. on *Sporobolus cryptandrus.* Sauk Co., Cactus Bluff (opposite Mazomanie), September 13. Previous Wisconsin collections are immature.

PHYLLACHORA BOUTELOUAE Rehm on *Bouteloua hirsuta.* Sauk Co., the "Owl's Head" near Merrimac, September 6. Collected once before in Wisconsin by Davis and Greene at Poynette in Columbia Co., 1935. P. BOUTELOUAE differs from P. GRAMINIS in having larger asci and spores. Theissen and Sydow in their monograph of the Dothideales, *Ann. Mycol.* 13: (1915), describe P. BOUTELOUAE Rehm as with asci 75-90 $\times$ 9-11μ, and spores 9-11 $\times$ 6-7μ. In a footnote they state that the species has been cited by Spegazzini as having asci 100-120 $\times$ 10μ, and spores 14-16 $\times$ 7-8μ. Davis, in an unpublished note on the 1935 collection, gives the asci as 65-85 $\times$ 8-10μ, and the spores 10-13 $\times$ 6-8μ. The Merrimac collection has asci 75-85 $\times$ 8-10μ, and spores 12-15 $\times$ 6-8μ.

RHYTISMA ILICIS-CANADENSIS Sacc. on *Nemopanthus mucronata.* Coll. E. J. Backus, Juneau Co., Rocky Arbor State Park, October 13. Immature when collected. Overwintered leaves in May showed mature R. ILICIS-CANADENSIS. Previous collections in the Herbarium are all immature.

PUCCINIA ANEMONES-VIRGINIANAE Schw. on *Anemone cylindrica.* Waukesha Co., Eagleville, June 20. In 1885 Trelease reported this host for P. ANEMONES-VIRGINIANAE, but Davis did not collect it, and there were no Wisconsin specimens in the Herbarium.

PUCCINIA VIOLAE (Schum.) DC. I. on *Viola blanda.* Coll. R. B. Stevens, Sauk Co., Parfrey's Glen, May 14, 1938. There were no collections of the aecial stage on this host in the Herbarium.

PUCCINIA XANTHII Schw. on *Ambrosia psilostachya.* Dane Co., near Sauk City, September 20. Rare on this host in Wisconsin. One earlier collection from Sauk Co.

ASTEROMELLA ANDREWSII Petr. (PHYLLOSTICTA GENTIANAECOLA (DC.) Ell. & Ev.) has been found on both *Gentiana andrewsii* and *G. puberula.* One specimen on *G. andrewsii* shows well formed conidia 4.5-5 $\times$ 5.5-7μ. A specimen of the same fungus, collected by Davis in Wisconsin, was described by Ellis and Everhart in their "North American Phyllostictas" (1900) as having conidia elliptical, hyaline, 3.5-5 $\times$ 1.5-2μ. They state that in the Wisconsin collection the conidia are not well developed, but give the dimensions of conidia in a West Virginia specimen as being 7.5-5μ, which corresponds to the recent Wisconsin material.

Panicum scribnerianum growing near Mazomanie, Dane Co., September 1940, had an extremely heavy infestation of ostiolate pycnidia, with microconidia of a bacillary type. Overwintered plants were collected in May 1941, but showed no further development of the fungus, save for a thickening of the pycnidial walls and almost complete closure of the ostioles. Infected plants similar to those of 1940 were collected again in October 1941.

A single collection of PHYLLOSTICTA DESMODII Ell. & Ev. was made some thirty years ago on a host at that time identified as *Desmodium canescens.* Dr. N. C. Fassett has examined this and states the host is undoubtedly *D. illinoense,* thus eliminating *D. canescens.*

A collection of a fungus, said to be PHOMOPSIS JUNIPEROVERA Hahn, on *Juniperus virginiana,* made at the Central State Nursery at Wisconsin Rapids, has been examined. In its principal microscopic characters it corresponds well with the fungus mentioned, but this writer has been unable to demonstrate the scolecospores which are supposed to be a diagnostic feature.

Peck, from the Herbarium of the New York State Museum, determined and distributed a fungus on *Archangelica atropurpurea (Angelica atropurpurea)* which he called STIGMATEA OSTRUTHII (Fr.) Oudem. The specimen was collected in October at N. Greenbush, but no year date is given. Examination of the material shows it is identical with a fungus which occurs commonly in the fall on the same host in central and southern Wisconsin. Small, hypophyllous, ostiolate pycnidia are massed on the living leaves, causing a blackish discoloration of considerable areas. Some of the pycnidia contain very small spermatia-like conidia. This writer has overwintered such infected leaves in the field on two occasions without obtaining any positive results. Peck's specimen shows no evidence whatever of asci and since the original description of STIGMATEA OSTRUTHII is admittedly based on immature material, the existence of such a fungus seems doubtful.

Trelease, in his "Preliminary List of Wisconsin Parasitic Fungi," published in 1885, reported ASCOCHYTA VIOLAE Sacc. & Speg. on leaves of *Viola pubescens* from Madison. No further Wisconsin collections of A. VIOLAE have been recorded. In May 1940 Ascochyta was found on *Viola sp.* at Mt. Vernon, Dane Co. The pycnidia are somewhat less than the 180-200μ diam. of the Saccardian description, but correspondence in other features is close, and the fungus should probably be referred to ASCOCHYTA VIOLAE.

A fungus has been observed on the leaves of *Cornus sp.* *(C. paniculata?)* which perhaps belongs in the genus STAGONOPSIS Sacc. The flesh-colored pycnidia are mostly epiphyllous on rather ill-defined grayish spots, globose, 40-70μ diam., with hyaline, subfusoid conidia, 2-4-, mostly 3-septate, 15-25 $\times$ 3.5-5μ. This is not STAGONOPSIS PALLIDA (B. & C.) Sacc., described on *Cornus sp.* from Alabama, since the latter had spores regularly 7-8-septate. In view of the uncertain identity of the host, formal description awaits collection of additional material.

The fungus (or fungi?) that has been assigned to DAVISIELLA ELYMINA (Davis) Petr. is widespread in Phyllachora in Wisconsin. In his "Notes" V., p. 701, Davis, describing the fungus in Phyllachora on *Elymus virginicus,* states that the sporules are oblong, hyaline, often 4-guttulate, becoming uniseptate, 7-10 $\times$ 2½-3μ. He proposed the name CYTODIPLOSPORA ELYMINA, with the suggestion that it occured as a part of the life cycle of Phyllachora. Petrak was of the opinion that this bore a parasitic relation to the Phyllachora and proposed for it a new genus, Davisiella *(Ann. Mycol.* 22: 133-4). Davis observed a similar development two or three times in loculi of Phyllachora on *Calamagrostis canadensis,* but not in sufficient abundance to secure a specimen. In "Notes" XX, p. 7, Davis states (in part) "there was reference to a form on Calamagrostis with sporules 10-20μ in length. In a collection from DeSoto, Sept. 2, 1932 on *Muhlenbergia racemosa* the sporules are 10-16 $\times$ 2-3μ. A collection on *Oryzopsis asperifolia* from Crivitz, Aug. 25, 1931, shows sporules 12-20, mostly about 17μ long, nucleate but not yet septate. DAVISIELLA DOMINGENSIS Petr. & Cif. was described as having conidia 13-20 $\times$ 2-2½μ (Ann. Myc. 30: 277). In collections on *Andropogon furcatus* from Sauk Co. (Greene & Davis) the sporules are 3-septate." In a collection on *Hystrix patula* from Troy Center, Walworth Co., Sept. 20, 1941, the sporules are likewise 3-septate, about 15-17 $\times$ 4μ. On the other hand a specimen from Eagleville, Waukesha Co., August 12, 1941 in the locules of PHYLLACHORA VULGATA Theiss. & Syd. on *Muhlenbergia foliosa,* has well developed 1-septate conidia of the dimensions of those first described on *Elymus virginicus.* It seems likely that more than one fungus is involved.

The variable SEPTORIA POPULI Desm. has been found* on *Populus nigra* at Madison. Davis, "Notes" XIV, p. 281 reports this on dubious *P. nigra* from Sauk City. The spots here are somewhat larger, but the fungus is the same as that of the Sauk City collection.

The late J. J. Davis described a fungus occurring in Wisconsin on various species of Ribes as CYLINDROSPORIUM RIBIS (*Trans. Wis. Acad. Sci.* 16: 759). In an appendix to the description he stated that this form might prove to be SEPTORIA SIBIRICA Thuem. with undeveloped pycnidial wall. In a later publication he states "The fungus recorded in the provisional list under the name CYLINDROSPORIUM RIBIS Davis is evidently conspecific with Brenckle's *Fungi Dakotenses 320* which was determined by Saccardo as SEPTORIA SIBIRICA Thuem. Saccardo gives a description in *Annales Mycologici* 13: 122. This seems quite different from European material distributed under this name." Professor Ehrlich of the University of Idaho has been engaged in a study of certain fungi on Ribes and has examined a number of specimens of SEPTORIA SIBIRICA, both American and European, from the Wisconsin Herbarium. He finds the American material to be good Cylindrosporium and states in a personal communication "The Idaho fungus in question is similar but not identical with Dr. Davis' CYLINDROSPORIUM RIBIS. In view of the inconsistency among European specimens distributed under the name SEPTORIA SIBIRICA and in the absence of authentic Thuemen material, it seems to me that there is no sound basis for deciding whether the two names actually apply to the same species. In view of this circumstance, it seems best to me to designate our American material, at least for the present, as CYLINDROSPORIUM RIBIS Davis." A fungus collected on *Ribes sativum* at Eagleville, Waukesha Co., June 1941 is certainly Cylindrosporium, and I am therefore inclined to agree with Professor Ehrlich.

SEPTORIA ANEMONES Desm. on *Anemone virginiana.* Walworth Co., East Troy, July 20; on *Anemone quinquefolia,* Dane Co., Madison, June 9. This is rarely collected, being so far found only on the above-named hosts in North America and on *Anemone nemorosa* in Europe. Our only North American collections are from Wisconsin.

SEPTORIA TENUISSIMA Wint. ? on *Boehmeria cylindrica.* Sauk Co., Parfrey's Glen, August 21. The sporules of this specimen average somewhat longer than the 20-28μ of Winter's description. Final determination must await collection of further material.

SEPTORIA ZIZIAE Ell. & Ev. ? on *Zizia cordata.* Waukesha Co., Eagle, October 1. Seymour's citation is based on a report of the fungus by Brenckle (Mycologia *10*: 220, 1918). I am unable to trace a description of this species in the Sylloge Fungorum or in the Journal of Mycology, and it is not among the specimens distributed by Ellis and Everhart in *North American Fungi.* In the specimen at hand the spots are irregularly rounded, grayish with a narrow pale brown border, about 3-5 mm. diam. Pycnidia gregarious, black, subrostrate, 115-130μ diam.; sporules straight, filiform, 25-35 $\times$ 1μ, ejected in slender cirrhi in water mounts.

SEPTORIA SOLIDAGINICOLA Pk. on *Solidago patula.* Waukesha Co., Eagleville, August 12. A rare host. Davis made one earlier collection at Cecil, Shawano Co. He notes that it has few sporules. The leaf lesions of the Eagleville specimen are strikingly conspicuous, but it likewise has few sporules.

GLOEOSPORIUM RAMOSUM Ell. & Ev. on *Polygala sanguinea.* Dane Co., near Paoli, September 1. One earlier collection from Nekoosa, Wood Co.

PESTALOTIA FUNEREA Desm. has been observed developing on the languishing foliage of *Juniperus virginiana.* Guba, in his monograph of the genus Pestalotia, states that there is some evidence in favor of a parasitic habit for P. FUNEREA. This material, however, definitely suggests a saprophytic state.

OVULARIA ISARIOIDES (Ell. & Ev.) Sacc. on *Staphylea trifolia.* Columbia Co., Gibraltar Rock, June 26. A rare and interesting fungus.

OPHIOCLADIUM HORDEI Cav. on *Phalaris arundinacea.* Dane Co., near Sauk City, August 29. Originally described as occurring on *Hordeum sativum* in Europe. Davis collected O. HORDEI in two localities and placed his specimens in the Herbarium as OPHIOCLADIUM HORDEI Cav. var. PHALARIDIS ined. where they remain thus labelled. Later in 1937 (*Trans. Wis. Acad. Sci.* 30: 15), he published the collections simply as OPHIOCLADIUM HORDEI Cav. This writer has carefully examined the Davis specimens and his own later one, but does not find sufficient difference from the original description to warrant varietal distinction. Apparently Davis reached the same conclusion, but neglected to relabel his specimens.

CLADOSPORIUM AROMATICUM Ell. & Ev. collected on *Rhus glabra* at Eagleville, Waukesha Co., July 27, is entirely hypophyllous, while all other collections in the University Herbarium are epiphyllous, the state set forth in the original description. The host plant was growing on an exposed hillside and the fungus developed during a period of extreme dryness, which may account for its position.

RAMULARIA SUBRUFA Ell. & Holw. on *Smilax herbacea.* Sauk Co., Devil's Lake, August 19. The fungus here caused little discoloration of the leaves, and is hypophyllous in rather large, diffuse, ill-defined patches. Previous collections have had small spots, sharply delimited by vein islets.

ALTERNARIA VIOLAE Gall. & Dorsett was collected by J. B. Carpenter on *Viola* sp. (cult.) at Madison, Dane Co. in October 1939. This is perhaps dubiously parasitic, although the lesions on which it appears are well marked.

PUCCINIA ANDROPOGONIS Schw. I on *Castilleja sessiliflora.* Columbia Co., Gibraltar Rock, June 27. Reported for this host by Trelease, but no interim Wisconsin collections are in the Herbarium.

ADDITIONAL HOSTS

PERONOSPORA PARASITICA (Pers.) Fr. on *Sisymbrium canescens* var. *brachycarpon.* Coll. L. H. Shinners, Jefferson Co., Ft. Atkinson, June 21. P. PARASITICA is not listed on this host in Seymour's Index, but there is a specimen in the Wisconsin Herbarium, collected by Dr. F. L. Wellman at Wichita, Kansas in May 1929.

SPHAEROTHECA HUMULI (DC.) Burr. on *Agrimonia pubescens* (*A. mollis* of Gray's Manual). Plant growing in a dry oak opening. Waukesha Co., Eagleville, July 10.

SPHAEROTHECA HUMULI (DC.) Burr. var. *fuliginea* (Schl.) Salm. on *Castilleja sessiliflora.* Columbia Co., Gibraltar Rock, September 4. There is no previous report of Sphaerotheca on this host.

ERYSIPHE POLYGONI DC. on *Thalictrum glaucum* (cult.). Dane Co., Madison, October 1939. Coll. & Det. by J. B. Carpenter.

ERYSIPHE POLYGONI DC. on *Thalictrum aquilegifolium* (cult.). Dane Co., Madison, October 30, 1938. Coll. & Det. by J. B. Carpenter.

ERYSIPHE POLIGONI DC. on *Muehlenbeckia platyclada* (cult.). Dane Co., Madison, November 15. Greenhouse, University Dept. of Botany.

ERYSIPHE CICHORACEARUM DC. on *Aster macrophyllus.* Waukesha Co., Big Bend, August 29. Davis made a collection of E. CICHORACEARUM on this host at Jacksonport, Door Co., in 1932, but did not record it in his notes.

ERYSIPHE CICHORACEARUM DC. on *Aster novi-belgii* (cult.). Dane Co., Madison, October 20, 1938. Coll. & Det. by J. B. Carpenter.

ERYSIPHE CICHORACEARUM DC. on *Helianthus kellermani* (cult.). Abundant material was collected by Mr. S. C. Wadmond at Delavan, Walworth Co., in September 1941. Davis does not mention this host in his published notes, although there is a small specimen in the University Herbarium collected by him in 1916 at Madison.

ERYSIPHE CICHORACEARUM DC. on *Tragopogon porrifolius* (cult.). Dane Co., Madison, October 10, 1939. Coll. & Det. by J. B. Carpenter.

ERYSIPHE CICHORACEARUM DC. on *Zinnia elegans* (cult.). Dane Co., Madison, October 30, 1938. Coll. & Det. by J. B. Carpenter.

ERYSIPHE CICHORACEARUM DC. on *Cirsium altissimum.* Waukesha Co., Big Bend, August 29.

MICROSPHAERA DIFFUSA C. & P. on *Symphoricarpos albus* var. *laevigatus* (cult.). Door Co., Sturgeon Bay, October 20, 1939. Coll. & Det. by J. B. Carpenter. Davis made a small collection of this fungus on the seeds of the above-mentioned host at Hayward, Sawyer Co., in 1924, but did not report it. The Door Co. collection is on the leaves. This writer has not yet observed M. DIFFUSA on the snowberry in southern Wisconsin, although it is not uncommon on the cultivated Indian currant, *Symphoricarpos orbiculatus*.

MICROSPHAERA ALNI (Wallr.) Wint. on *Ligustrum vulgare* (cult.). Dane Co., Madison, November 16.

PHYLLACTINIA CORYLEA (Pers.) Karst. on *Quercus rubra*. Dane Co., near Sauk City, October 10. Davis made a collection on this host at Madison in 1928, but failed to report it.

CLAVICEPS PURPUREA (Fr.) Tul. Sclerotia on *Agropyron smithii*. Milwaukee Co., Milwaukee, September 7; Fond du Lac Co., Campbellsport, September 4. Coll. L. H. Shinners.

PHYLLACHORA GRAMINIS (Pers.) Fckl. on *Bouteloua curtipendula*. Dane Co., near Sauk City, October 2. Immature when collected. Overwintered leaves examined in April 1941 showed mature asci and ascopores. Davis does not report PHYLLACHORA GRAMINIS on this host from Wisconsin, although there are in the University Herbarium two specimens that are labelled as being immature.

PHYLLACHORA VULGATA Theiss. & Syd. on *Muhlenbergia cuspidata*. Coll. N. C. Fassett, St. Croix Co., Burkhart, August 2, 1934; Buffalo Co., Alma, August 7, 1926. Coll. J. W. Thomson, Monroe Co., Norwalk, September 2, 1937.

PHYLLACHORA VULGATA Theiss. & Syd. on *Muhlenbergia mexicana*. Grant Co., Mississippi River bottoms (opposite Dubuque), September 8, 1930. Coll. N. C. Fassett.

SPHACELOTHECA SORGHI (Lk.) Clint. on *Sorghum vulgare* var. *sudanense*. Dane Co., Madison, September 25. Coll. & Det. by D. W. Chamberlain.

COLEOSPORIUM SOLIDAGINIS (Schw.) Thüm. II, III on *Solidago riddellii*. Waukesha Co., Eagleville, October 8.

COLEOSPORIUM SOLIDAGINIS (Schw.) Thüm. II, III, on *Aster pilosus*. Dane Co., Madison, October 5. Coll. L. H. Shinners. The host was formerly confused with *A. ericoides* L.

UROMYCES SILPHII (Burr.) Arth. I on *Silphium laciniatum*. Waukesha Co., Eagle, June 10; Jefferson Co., Lake Mills, June 27.

In both of these localities the fungus was also found on *Silphium terebinthinaceum*. The only previous collection on the latter host was made by Davis in June 1886 at Barnes Prairie, near Racine.

PUCCINIA LIATRIDIS (Webber) Bethel I on *Liatris pycnostachya*. Waukesha Co., Eagle, July 6.

PUCCINIA RUBIGO-VERA (DC.) Wint. I on *Hydrophyllum virginianum*. Langlade Co., Kempster, June 20. Coll. R. L. Krause. This form is listed by Arthur under the trinomial P. RUBIGO-VERA APOCRYPTA (E. & T.) Arth.

PUCCINIA MENTHAE Pers. II, III on *Mentha piperita*. Burnett Co., Sec. 22, T38N, R16W, September 19, 1928. Coll. N. C. Fassett.

PUCCINIA ASTERIS Duby on *Aster oblongifolius*. Dane Co., near Sauk City, June 26; Lafayette Co., Platteville, September 13.

PUCCINIA ASTERIS Duby on *Aster lucidulus (A. puniceus* var. *lucidulus* of Gray's Manual). Walworth Co., East Troy, September 5.

PUCCINIA ASTERIS Duby on *Aster lindleyanus*. Vilas Co., Sayner, August 9. Coll. & Det. by M. P. Backus.

PUCCINIA HELIANTHI Schw. III on *Helianthus laetiflorus* (cult.). Lafayette Co., Platteville, September 13. Coll. L. H. Shinners.

PUCCINIA HELIANTHI Schw. III on *Helianthus "multiflorus"* (cult.). Dane Co., Madison, October 2, 1938. Coll. & Det. by J. B. Carpenter.

GYMNOSPORANGIUM GLOBOSUM Farl. I on *Crataegus crus-galli*. Dane Co., Madison, August 22. Coll. & Det. by M. P. Backus.

PHYLLOSTICTA IRIDIS Ell. & Mart. on *Iris virginica* var. *shrevei*. Jefferson Co., Lake Mills, September 17. *Iris versicolor* of Gray's Manual is in part *I. virginica* var. *shrevei*. In Wisconsin, however, the natural range of true *I. versicolor* is the extreme north border of the state. It seems likely that previous collections of PHYLLOSTICTA IRIDIS from southern Wisconsin, labelled as being on *I. versicolor*, are on *I. virginica* var. *shrevei*.

ASCOCHYTA GRAMINICOLA Sacc. on *Hierochloe odorata*. Waukesha Co., Eagleville, May 10. Examination of herbarium specimens of *H. odorata* shows the same parasite on a collection made by Dr. N. C. Fassett at Hubbleton, Jefferson Co., May 26, 1928. There is also a fungus specimen on *Torresia odorata (H. odorata)* collected in 1928 at Scott, Sask. and labelled ASCOCHYTA sp. by the collector. Davis determined it as ASCOCHYTA GRAMINICOLA Sacc., and it is identical with the Wisconsin specimens.

SEPTORIA SALICINA Pk. on *Salix fragilis.* Waukesha Co., Eagleville, July 26; Walworth Co., near Mukwonago, August 3; Jefferson Co., Lake Mills, August 7. This writer is unable to see a satisfactory distinction between SEPTORIA SALICINA Pk. and SEPTORIA DIDYMA Fckl. var. SANTONENSIS Pass.

SEPTORIA URTICAE Desm. & Rob. on *Urtica gracilis.* Dane Co., Madison, October 23. Coll. & Det. E. A. Kerr.

SEPTORIA DIVARICATA Ell. & Ev. on *Phlox paniculata* × *maculata* (cult.). Barron Co., Barron, October 10, 1941. Coll. A. Benson, Det. J. B. Carpenter.

SEPTORIA CORNICOLA Desm. on *Cornus stolonifera.* Waukesha Co., Eagleville, July 26; Dane Co., Mazomanie, August 14.

SEPTORIA MENTHICOLA Sacc. & Let. on *Blephilia ciliata.* Waukesha Co., Eagle, June 23.

SEPTORIA LIATRIDIS Ell. & Davis on *Liatris pycnostachya.* Waukesha Co., Eagle, August 4; Jefferson Co., Lake Mills, August 7.

SEFTORIA ATROPURPUREA Pk. on *Aster novae-angliae.* Waukesha Co., Eagleville, September 1.

GLOEOSPORIUM SEPTORIOIDES Sacc. on *Quercus ellipsoidalis.* Waukesha Co., Eagleville, August 10.

COLLETOTRICHUM GRAMINICOLUM (Ces.) Wils. on *Elymus canadensis.* Dane Co., Madison, October 1930. Coll. M. P. Backus.

COLLETOTRICHUM VIOLAE-ROTUNDIFOLIAE (Sacc.) Davis on *Viola sororia.* Dane Co., Middleton, May 1926. Coll. M. B. Linford. This specimen was placed in the Herbarium by Davis, but was overlooked in his host record.

COLLETOTRICHUM SOLITARIUM Ell. & Barth. on *Solidago riddellii.* Walworth Co., East Troy, September 19. Also found on *Solidago nemoralis,* Walworth Co., Troy Center, September 20. There is one earlier collection on *S. nemoralis* made at Nekoosa, Wood Co.

CERCOSPORA CYPRIPEDII Ell. & Dearn. on *Cypripedium reginae.* Coll. J. T. Curtis, Vilas Co., Land 'o Lakes, August 16; Coll. H. C. Greene, Walworth Co., East Troy, September 5. Specimens in the Herbarium labelled merely as on *Cypipedium sp.,* collected by Davis in 1911 at Gaslyn and Spooner, appear likewise to be on *Cypripedium reginae* (fide Prof. Curtis).

CERCOSPORA CYPRIPEDII Ell. & Dearn. on *Cypripedium pubescens.* Coll. J. T. Curtis, Vilas Co., Land o' Lakes, July 31.

CERCOSPORA POLYGONACEA Ell. & Ev. on *Polygonum tenue.* Sauk Co., Prairie du Sac, August 26; Columbia Co., near Lodi, September 6. Determined by Professor Chupp.

CERCOSPORA BETICOLA Sacc. on *Beta vulgaris* var. *cicla* (cult.). Waukesha Co., Eagleville, September 6. Common, but included because the host has not been mentioned previously in notes on Wisconsin parasitic fungi.

CERCOSPORA BETICOLA Sacc. on *Proboscidea louisiana (Martynia louisiana)* (cult.). Dane Co., Madison, September 1914. Coll. & Det. V. W. Pool & M. B. McKay.

CERCOSPORA SQUALIDULA Pk. on *Clematis integrifolia* (cult.). Dane Co., Madison, October 16. Determined by Professor Chupp.

CERCOSPORA VIOLAE Sacc. on *Viola tricolor* (cult.). Door Co., Sturgeon Bay, August 2, 1938. Coll. C. N. Clayton, Det. J. B. Carpenter.

CERCOSPORA RACEMOSA Ell. & Mart. on *Teucrium occidentale.* Dane Co., near Sauk City, August 20. Host identification is based on the treatment appearing in Deam's "Flora of Indiana". It seems extremely likely that previous Wisconsin collections have been made on this host, although there is no report to that effect.

ADDITIONAL SPECIES

MYCOSPHAERELLA PONTEDERIAE (Pk.) House *Sphaerella pontederiae* Pk., 40th Rep. N. Y. State Mus., p. 69 (1886). On leaves of *Nuphar advena.* Dane Co., Verona, August 19. This fungus appears to be truly parasitic.

MYCOSPHAERELLA IMPATIENTIS (Pk. & Clint.) House *Sphaerella impatientis* Pk. & Clint. 30th Rep. N. Y. State Mus., p. 67 (1877). On living leaves of *Impatiens biflora.* Walworth Co., East Troy, July 20. No specimens of this fungus were available for inspection in the Wisconsin Herbarium, but the material corresponds exactly with the amplified description appearing on p. 501 in Vol. 1 of the "Sylloge Fungorum".

FABRAEA MACULATA (Lev.) Atk. on *Crataegus oxyacantha.* For several seasons on the University Campus in Madison a fungus was observed abundantly infesting the foliage of *Crataegus oxyacantha* (cult.). The small purplish, immarginate spots were at once macroscopically suggestive of Entomosporium, but examination showed a Gloeosporium with conidia of the micro type, bacillary, 3-4 × 1.5-2μ. In November 1940, large stromatic cushions of hyphae were observed developing beneath each acervulus. Leaves were collected and overwintered until May 1941, at which time asci with mature 1-septate spores had developed. The fungus corresponds with the description of STIGMATEA MESPILI Sor. Atkinson (Science N. S. *30*:452, 1909) expresses the opinion that Stigmatea incorrectly designates the form in question and refers it to FABRAEA MESPILI (Sor.) Atk. FABRAEA MESPILI is supposedly the perfect stage of ENTOMOSPORIUM MESPILI (DC). Sacc. while FABRAEA MACULATA is the perfect stage of ENTOMOSPORUM MACULATUM Lev. Atkinson thinks that E. MESPILI and E. MACULATUM are in all probability conspecific, which presumably would make FABRAEA MESPILI and FABRAEA MACULATA identical. Although the Entomosporium stage has not been observed, it is felt that the ascigerous stage is sufficiently well-defined to warrant the record. (Although ENTOMOSPORIUM THUEMENII (Cke.) Saac. is the form commonly reported on hawthorn, E. MESPILI also is reported on *Crataegus oxyacantha.*)

USTILAGO VILFAE Wint. on *Sporobolus neglectus.* Dane Co., Cross Plains, October 23. Coll. L. H. Shinners.

ENTYLOMA ERYNGII (Cda.) DeBary on *Eryngium yuccifolium.* Dane Co., Paoli, August 29, 1941; September 29, 1940. The small yellow, immarginate spots are distinct, but there is no host hypertrophy.

ENTYLOMA ASTER-SERICEAE Zund. on *Aster sericeus.* Dane Co., near Sauk City, September 29; Columbia Co., Gibraltar Rock, October 5; Adams Co., Friendship, August 22; Walworth Co., Troy Center, September 20. Entyloma has not been previously reported on this host.

MELAMPSORA EUPHORBIAE (Schub.) Cast. II on *Euphorbia cyparissias.* Dane Co., Pine Bluff, November 14. Coll. R. I. Evans, Det. M. P. Backus.

PHRAGMIDIUM IVESIAE Syd. I, II, III on *Potentilla recta.* Waukesha Co., Eagleville, July 2; Dane Co., Paoli, August 19.

PUCCINIA PURPUREA Cke. II on *Sorghum vulgare* var. *sudanense.* Dane Co., Madison, October 23. Coll. & Det. D. W. Chamberlain. Sorghum rust is uncommon in the northern United States.

PUCCINIA LAPSANAE (Cke.) Fckl. II, III on *Lapsana communis.* Fond du Lac Co., Wolf Lake, July 17, 1938. Coll. L. H. Shinners.

NYCTALIS ASTEROPHORA Fr. on *Coprinus comatus.* Dane Co., Madison, October 5. Coll. E. M. Gilbert. Also on various species of Russula, as shown by specimens in the University Herbarium.

PHOMA IOWANA Sacc. on *Aster lucidulus (A. puniceus* var. *lucidulus* of Gray's Manual). Waukesha Co., Eagleville, September 14. A specimen of *Aster ptarmicoides* collected by A. B. Stout in the Town of Delton, Sauk Co., August 19, 1905, shows pycnidia which perhaps should also be referred to PHOMA IOWANA. These hosts are the same two cited by Saccardo in connection with the original description. This fungus should probably be transferred to Phyllosticta, since it is not caulivorous, but develops on the foliage.

SEPTORIA DEARNESSII Ell. & Ev. on *Angelica atropurpurea.* Waukesha Co., Eagleville, October 8. The sporules measure up to 32μ long, as do those of the same fungus distributed in Bartholomew's *Fungi Columbiani* as No. 3873, and collected by Dearness at London, Ont., the type locality. It seems likely that the original description was based on somewhat immature material.

SEPTORIA ERYNGICOLA Oud. & Sacc. on *Eryngium yuccifolium.* Dane Co., near Paoli, August 29. Apparently not hitherto reported as occurring in North America.

SEPTORIA ANGULARIS Dearn. & Barth. on *Solidago graminifolia.* Waukesha Co., Eagleville, September 14. Previously reported only on *Solidago latifolia.* The lesions are identical.

COLLETOTRICHUM VERMICULARIOIDES Hals. on *Linaria vulgaris.* Sauk Co., Parfrey's Glen, September 6. On stems and lower leaves. It appears to be parasitic and lethal.

MONOCHAETIA DISCOSIOIDES (Ell. & Ev.) Sacc. on *Geum triflorum.* Waukesha Co., Eagle, June 29. Comparison of this collection with PESTALOZZIA DISCOSIOIDES Ell. & Ev. (North American Fungi, 2nd series, No. 2180), on leaves of cultivated rose, shows conidia which are identical, except for a considerably shorter basal stalk in those of the fungus on *Geum triflorum.* The conidium is remarkable among others in this group for the extremely short ($3\text{-}5\mu$), rigid seta jutting obliquely from the terminal cell. The spots on the *G. triflorum* leaves are 1-3 mm. diam., well-defined, with a narrow dark brown border and a pale brown center on which the acervuli are produced.

CERCOSPORA GEI Fckl. on *Geum triflorum.* Waukesha Co., Eagleville, September 7. Determined by Professor Chupp who states this is the first collection of this species that he has seen from the Western Hemisphere.

CERCOSPORA VARIICOLOR Wint. on *Paeonia albiflora* (cult.). Dane Co., Madison, October 2, 1938. Coll. & Det. J. B. Carpenter.

CERCOSPORA CROTONOPHILA Speg. on *Croton glandulosus* var. *septentrionalis*. Columbia Co., Lodi, September 10. Professor Chupp states that this is definitely not CERCOSPORA CROTONIFOLIA Cke., reported on this host in Seymour's Index, but does correspond in its principal characters with Spegazzini's species.

CERCOSPORA BARTHOLOMAEI Ell. & Kell. on *Rhus toxicodendron*. Iowa Co., Arena, September 22. Identification confirmed by Professor Chupp.

CERCOSPORA CAROTAE (Pass.) Solheim on *Daucus carota* var. *sativa*. Waukesha Co., Eagleville, August 22. Undoubtedly very common, but apparently not hitherto reported.

CERCOSPORA DIODIAE Cke. on *Diodia teres*. Iowa Co., Arena, August 23. Professor Chupp has no record of other collections north of Missouri.

GLOEOSPORIUM ONCIDII Oud. has been found on leaves of *Oncidium sphacelatum*, and GLOESOPORIUM CINTUM B. & C. (= GLOMERELLA CINCTA) on leaves of *Dendrobium nobile* in a University of Wisconsin greenhouse. The two forms appear to intergrade. Davis has previously reported G. CINCTUM on DENDROBIUM MOSCHATUM. Very likely all of these were imported with their hosts and can scarcely be considered established representatives of the parasitic fungus flora of Wisconsin.

SPORONEMA TRIFOLII n. sp. Pycnidia amphigenous, scattered or gregarious, innate, often somewhat flattened, wall imperfectly defined in a looser or denser mass of stromatic tissue, 60-170μ diam., mostly 90-150μ diam., borne on elongate, brown or blackish-brown spots which tend to follow the veins, and often extend to the leaf margin; conidia hyaline, continuous, cylindric, straight or slightly curved, 4-9 $\times$ 1.3-3μ, very variable, mostly 5.5-7.5 $\times$ 1.5-2.5μ, borne on slender, hyaline, mostly simple, densely aggregated conidiophores, 14-17 $\times$ 1.5-2.5μ. On leaves of *Trifolium pratense*.

SPORONEMA TRIFOLII sp. nov. Pycnidiis amphiginis, sparsis vel gregariis, innatis, irregularibus, imperfecte limitatis in plus minusve stromaticis hyphis, 60-170μ diam., plerumque 90-150μ diam., Maculis late enlongatis, bruneis vel atro-bruneis, neuros sequentibus, saepe ad marginem tendentibus; sporulis hyalinis, continuis, cylindraceis, rectis vel leviter curvulis, 4-9 $\times$ 1.3-3μ, variabilibus; conidiophoris hyalinis, plerumque simplicibus, dense aggregatis, 14-17 $\times$ 1.5-2.5μ.

Dr. F. R. Jones called the writer's attention to this Sporonema. It occurs on red clover exclusively, so far as known, and probably represents the imperfect stage of a Pyrenopeziza. Apparently it usually occurs in association with ASCOCHYTA TRIFOLII or GLOEOSPORIUM TRIFOLII, although leaves of Manitoba material seem to bear the Sporonema alone. The description is based on a specimen in the University of Wisconsin Herbarium collected and determined by J. J. Davis as GLOEOSPORUM TRIFOLII Pk. and later redetermined as ASOCHYTA TRIFOLII (Pk.) The specimen was taken at Minocqua, Wis., July 3, 1914. In connection with ASCOCHYTA TRIFOLII, Davis in his "Notes" IV, p. 674, states "What appears to be a state of this, probably immature, has been collected with sporules but about 8 $\times$ 2½μ, continuous, and what is possibly a spermogonial or microconidial state occurs frequently with sporules 4-8 $\times$ 1-1½μ, continuous. In this form the distal portion of the pycnidium is imperfect and it is much like the fungus on Medicago known as SPORONEMA PHACIDIOIDES Desm." SPORONEMA PHACIDIOIDES is the imperfect stage of PYRENOPZIZA MEDICAGINIS Fckl. and occurs on alfalfa exclusively, but it is apparent that Davis observed the fruiting bodies of SPORONEMA TRIFOLII. All the specimens of S. TRIFOLII from Wisconsin in the University Herbarium are on specimens labelled ASCOCHYTA TRIFOLII, and are from the northern part of the state.

Herbarium of the University of Wisconsin.
January, 1942.

CATS WITH ABNORMALLY ARRANGED VISCERA

HAROLD R. WOLFE

Department of Zoology, University of Wisconsin

Recently two articles on abnormal arrangements of the viscera of cats have appeared. Rifenburgh, Lawson and Ogden (1937) described a cat with an "upside-down stomach." This condition was due to a diaphragmatic hernia which allowed for the entrance of the small intestine, the pancreas and the spleen into the right pleural cavity. The rest of the digestive organs were found in the abdominal cavity. There was but one kidney, the left one, which was approximately three times the size of a normal one. Wragg (1938) described a cat with completely reversed viscera and with an aortic loop arising from a larger right ventricle and arching to the right.

Other animals have been found with anomalous conditions of the internal organs. The transposition of the viscera, known as *situs viscerum inversus,* is not uncommon in human beings. Bailey and Miller (1929) state in their textbook of Embryology that there are two hundred cases on record. The functions of the organs of these individuals were unimpaired. Hansen (1939) described a "reversed" cryptobranchus in which the internal organs were found on the sides opposite that of the normal animal.

The reversed position of the viscera and diaphragmatic hernia are rare conditions in cats. Because of this rarity it seems advisable to give a detailed description along with photographs of the structures of the abdominal and pleural cavities of two female cats that were found by students in a comparative anatomy class. The two specimens were adults but looked scrawny though this condition could not definitely be attributed to their abnormalities. Both of these cats had diaphragmatic herniae with a transposition of some of the visceral organs to the side opposite that of a normal individual. These two specimens were found in successive years, one in 1927 and the other in 1928. They were both received from nearby farmers and there is a possibility that they were related though there was a difference in the degree of their abnormality. Since these cats were found approximately two thousand others have been dissected without a single case of such an abnormal arrangement of the viscera.

The two cats will be described separately since their abnormalities were dissimilar. The first one to be described will be that of the cat found in 1927.

CAT 1

The general shape of the abdominal and pleural cavities was slightly different from that of a normal cat. The abdominal cavity was much shorter and slightly narrower than that of a normal cat while the pleural cavity was considerably longer and wider. These size differences were due, no doubt, to the presence in the left pleural cavity of much of the abdominal organs.

A hernia, approximately one inch in diameter, was present in the center of the diaphragm. The entire small intestine and ascending colon entered the left pleural cavity through this opening. Also present in the cavity were part of the greater omentum, the pancreas, the cystic lobe and the left lateral and left median lobes of the liver. The small intestine reached as far anteriorly as the first rib. The left lung was much reduced in size and pressed against the dorsal body wall but it apparently had been functional to a slight extent. The anterior portion of the duodenum and pancreas were lying against the cranial surface of the diaphragm on the left side of the left pleural cavity. Parallel and just anterior to these structures, passing from left to right, was the ascending colon. The portions of the liver mentioned above were on the right side and the ileum, jejenum and ascending colon were median in position.

The presence of these numerous structures in the left pleural cavity crowded the mediastinal septum to the right so that the heart was on the right side. The right lung was elongated and the right pleural cavity was longer and considerably narrower than that of a normal specimen. The aortic arch and pulmonary artery were apparently normal.

The abdominal cavity contained the stomach, part of the greater omentum, the transverse and descending colon, the right lateral liver lobe, the spleen and the urogenital organs. The stomach was on the left side of the body just caudal to the diaphragm and reversed in position so that the greater curvature was toward the right and the pyloric region was more anterior than the cardiac region. The portions of the liver were on the right side and did not overlap the stomach. The posterior quarter of the abdominal cavity contained only the colon and uro-

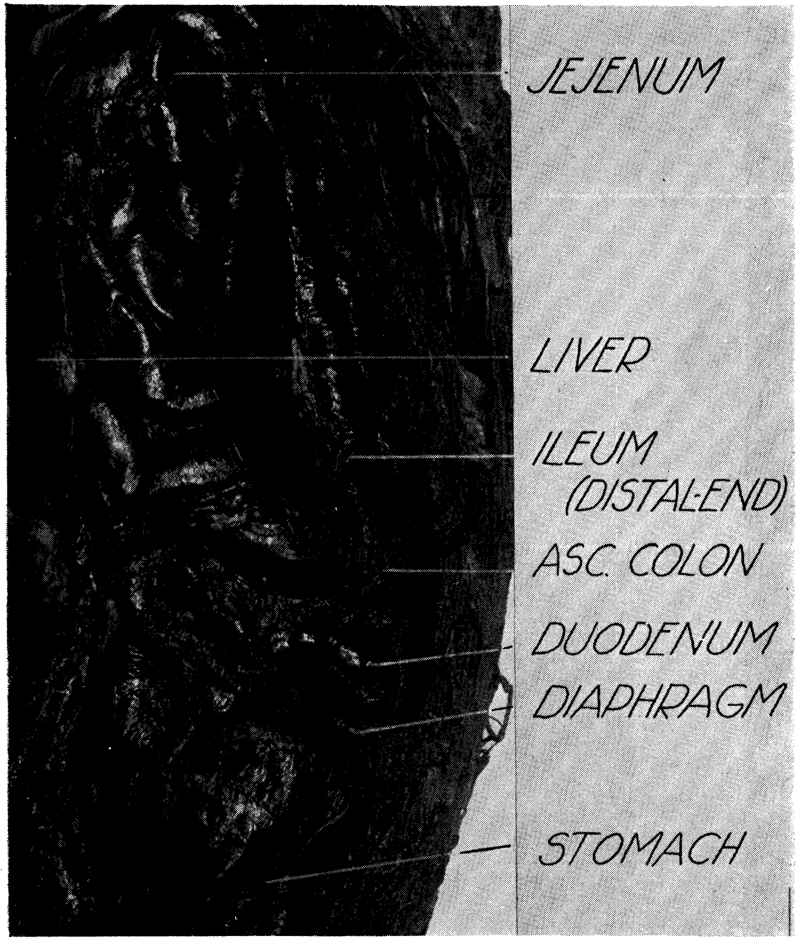


Plate 1. Photograph: ventral view of viscera of cat no. 1.

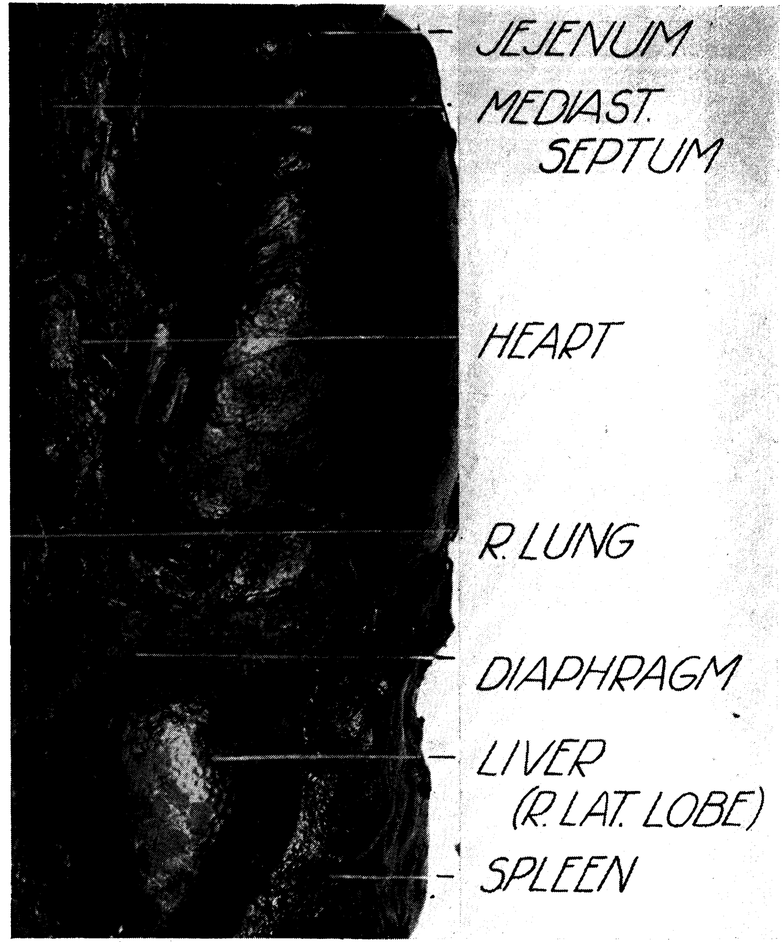
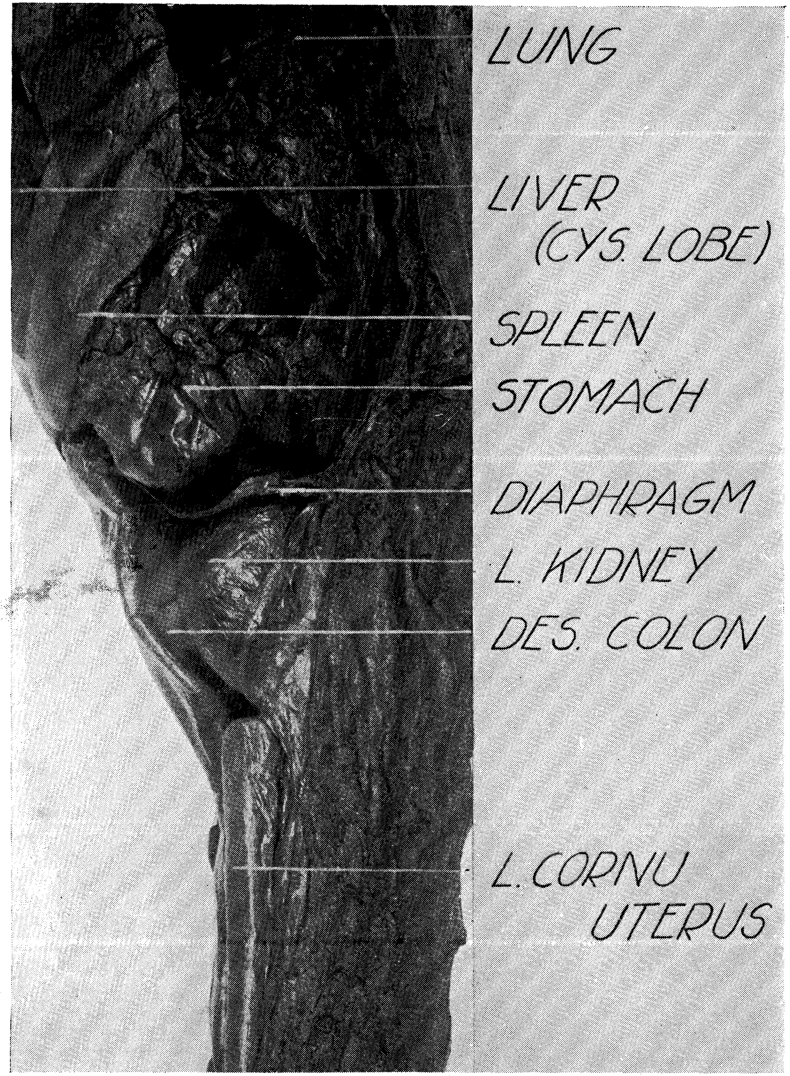
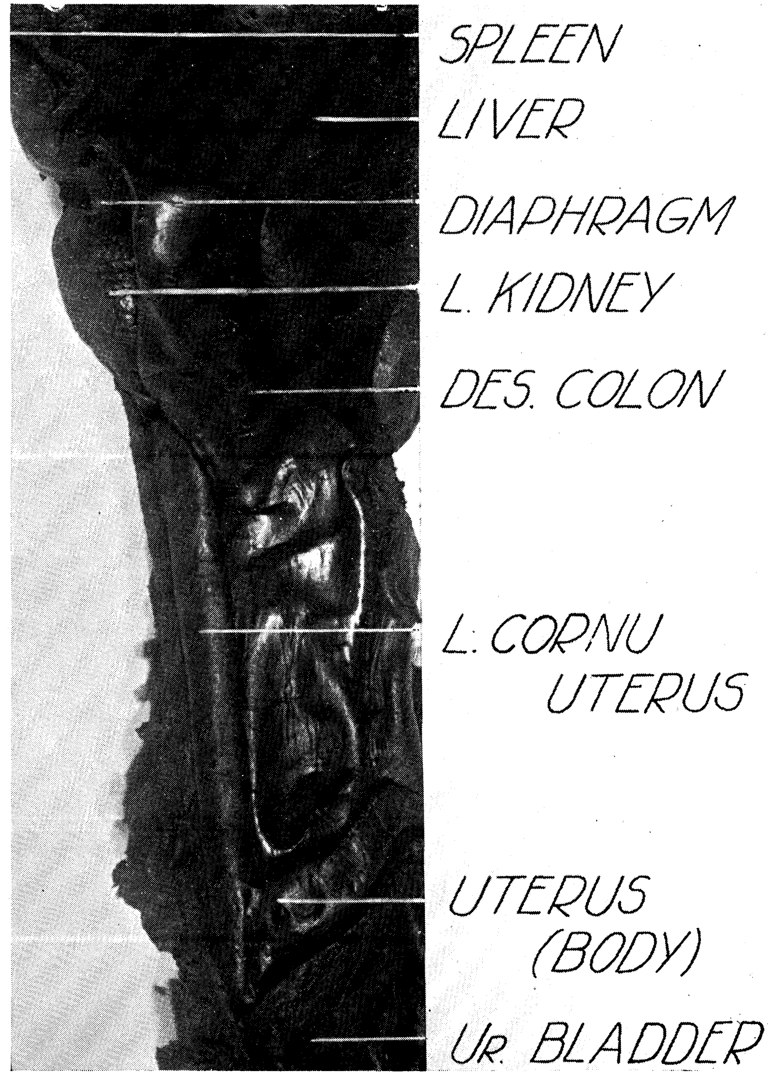


Plate 2. Photograph: right latero-ventral view of viscera of cat no 1.


LUNG
LIVER
(CYS. LOBE)
SPLEEN
STOMACH
DIAPHRAGM
L. KIDNEY
DES. COLON
L. CORNU
UTERUS


SPLEEN
LIVER
DIAPHRAGM
L. KIDNEY
DES. COLON
L. CORNU
UTERUS
UTERUS
(BODY)
Ur. BLADDER

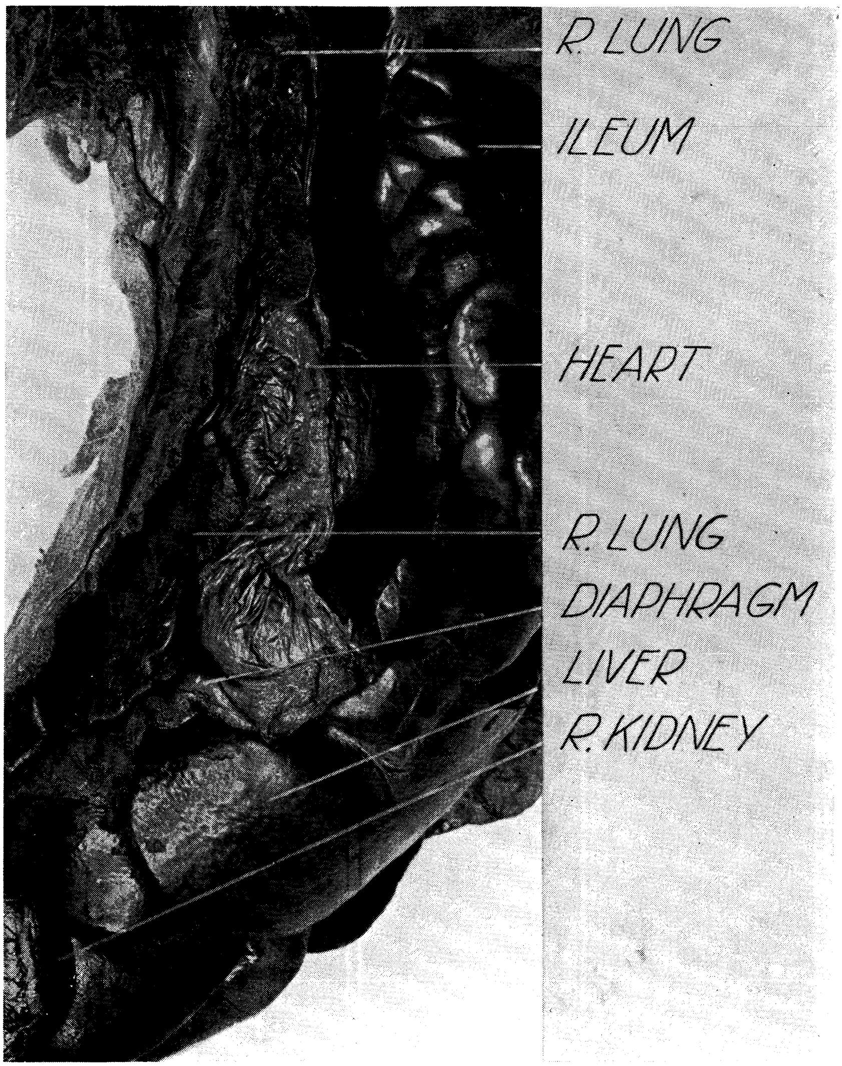


Plate 5. Photograph: right latero-ventral view of viscera of cat no. 2.

genital ducts. The right kidney was closely adherent to the caudal division of the right lateral liver lobe so that it appeared at first to be the part of the liver.

CAT 2

The abnormalities in this cat were similar in some respects to those of the first cat described. While the size and shape of the thoracic basket were approximately the same as those of the other cat, the abdominal cavity was very different from it and from that of a normal animal. Crowded into the left pleural cavity through a hernia of about one inch in diameter were the stomach, greater omentum, entire small intestine, ascending and transverse colon, pancreas, spleen, and the left lateral, the median, and three-fourths of the cystic liver lobes. The stomach was located on the anterior surface of the diaphragm on the left side of the body with the greater curvature facing anteriorly. Instead of being pear-shaped it was of uniform size throughout, though sharply bent in the middle. The pylorus was close to the diaphragm on the extreme left side and the duodenum passed anteriorly from that point. Lying ventral to the stomach and duodenum was the spleen. The portions of the liver present were on the right side and the other digestive structures were centrally located. The left lung, lying against the dorsal body wall was small but may have been slightly functional. The position of the heart and the size of the right lung were similar to those described for the first cat.

The posterior three-fourths of the abdominal cavity was very much constricted. An enlarged descending colon, about one-fourth of the cystic lobe of the liver and the right lateral liver lobe were in the anterior region of this cavity. The portions of the liver present were on the right side of the cavity and overlapped the anterior and median portions of the right kidney. The anterior portion of the descending colon entered the abdominal cavity through the hernia and bent toward the mid-line. From that point it followed a median course and was bordered on either side by a large cornu of the uterus. The body of the uterus was on the left side so that the right cornu was diagonal in position and the left one vertical. The left kidney was just posterior to the caudal border of the diaphragm on the extreme left side.

The astounding survival under such adverse conditions seems quite remarkable for as far as one could judge these two cats enjoyed a normal cat's life. The adaptations and adjustment that were made did not seem to interfere with the functions of the organs. The only definite, structural abnormalities that were found in regard to size of organs were the small left lungs of the two cats and the somewhat enlarged colon of one of them.

The author wishes to express his appreciation to Dr. Joseph G. Baier, Jr., of the Milwaukee Extension Division of the University of Wisconsin for his kindness in taking most of the photographs, and to Professor Wagner of the Department of Zoology for the specimens described.

Literature Cited

Bailey, F. R., and Miller, A. M. 1929. A Textbook of Embryology. William Wood and Company.

Hansen, Ira B. 1939. A Reversed Cryptobranchus. Science, Vol. 89, p. 128.

Rifenburgh, S. A., Lawson, W. P., and Ogden, R. P. 1937. A Cat with an "Upside-down Stomach." Indiana Acad. of Sci. Proceed., Vol. 47, pp. 285-286.

Wragg, Helen A. 1939. A Reversed Cat. Vol. 88, p. 475, Science.

THE SUMMER STANDING CROP OF PLANTS AND ANIMALS IN FOUR WISCONSIN LAKES*

CHANCEY JUDAY

INTRODUCTION

Quantitative studies of the biota of several Wisconsin lakes have been in progress for a considerable number of years and the data obtained in four of these investigations are now complete enough to give an approximate idea of the ratio of the aquatic plants to the aquatic animals in summer. Generally speaking aquatic animals are dependent, either directly or indirectly, on aquatic plants for their sustenance; a certain amount of organic matter that may serve as food may be blown into the water by the wind, while another portion may be washed in from the drainage basin or brought in by streams. By far the greater part of the material that is utilized by the aquatic animals, however, is manufactured autotrophically by the aquatic plants of the lake. The relative abundance of the aquatic plants, therefore, becomes a problem of great importance to the animal population of the lake. The manufacturers of the organic matter, namely the plants, include both the phytoplankton and the large aquatic plants that grow in the shallow water, while the animals range from protozoa to fish; the former constitute the producers and the latter the consumers of organic matter. The ratio between the two groups shows the trophic conditions of the consumers. Data are most complete for two lakes in northern Wisconsin (Weber and Nebish) situated near the Trout Lake Limnological Laboratory; with the exception of their fish populations, similar data have been obtained on two lakes in the southern part of the state, namely Green and Mendota. The two northern lakes have soft waters and the southern fairly hard waters so that direct comparisons of the biological productivity of the two types of water can be made. Plankton observations have been made regularly during the months of July and August from 1931 to 1941, inclusive, on the two northern lakes; from time to time during this 11-year period assessments of the large aquatic plants, the bottom fauna and the fish have also been taken,

* From the Department of Zoology and the Limnological Laboratory of the Wisconsin Geological and Natural History Survey. Notes and reports No. 117.

so the results give a fairly complete knowledge of the quantitative relationships between the constituents of the biota of these two lakes in summer. Since 1938 the plankton observations have been continued during the other 10 months of the year, but they are not included in the present report; they are reserved for a later paper.

The quantitative investigations on Green and Mendota have included the plankton, the bottom fauna and the large aquatic plants, but no estimates of their fish populations have yet been made; most of the quantitative studies on these two lakes were made between 1912 and 1924, with a few additional observations in more recent years. Data regarding the dissolved organic matter were obtained on the two southern lakes between 1922 and 1924 and on the two northern lakes between 1925 and 1936.

ACKNOWLEDGMENTS

Several research assistants have taken part in these investigations, but the list is too long to mention each of them by name. Data regarding the large aquatic plants of Weber Lake have been obtained from Dr. L. R. Wilson, Dr. John E. Potzger and from Mr. L. A. Fraser on those of Nebish Lake. Rickett's reports have been used for the large aquatics of Green and Mendota. Dr. B. P. Domogalla contributed some chemical data on Green and Mendota in addition to those given in his two published papers. Dr. G. Eisenhart has supervised the computations and assisted in making plans for the fish population studies. The Works Projects Administration has given assistance in some phases of the investigations. Financial aid has been received from the Division of Fishery Biology, United States Fish and Wildlife Service, the Wisconsin Conservation Department, the Brittingham Trust Fund, the University Research Committee and the Wisconsin Alumni Research Foundation.

METHODS

Plankton. On Weber and Nebish lakes the plankton was taken with a high speed Foerst centrifuge; this instrument has a bowl 75 mm. in inside diameter and a speed of about 18,000 r.p.m. so that it develops a centrifugal force of approximately 12,500 times gravity. This is sufficient to remove the plankton organisms, including about three-quarters of the bacteria, as well as a considerable portion of the organic detritus in a particulate form, and inorganic material in the form of silt; thus the term *seston* is more appropriate for these catches than plankton. These centrifuge catches were dried, weighed and ashed for the purpose of determining the approximate amount of organic matter in them. Chemical analyses of some of the material have also been made in order to get some idea of its food value. The centrifuge used on Green Lake did not have such a high speed but corrections were made for this difference. A large clarifier type of centrifuge was used on Lake Mendota. It had substantially the same efficiency as the high speed instrument. Plankton observations covering the entire depths of the four lakes were made once a week during the summer, and sometimes twice a week on Lake Mendota. The quantitative data given in the tables thus represent averages of seven to ten sets of samples taken principally in July and August each year; a few sets taken in late June and early September have also been used.

Quantitative determinations of the zooplankton were made simultaneously with a plankton trap. They showed that the rotifers and microcrustacea constituted about 6.5 per cent of the organic content of the centrifuge catches in the two northern lakes and 6.0 per cent in the two southern lakes; these two percentages have been used, therefore, in computing the standing crop of zooplankton. Both the phytoplankton and the organic detritus recovered by the centrifuge are utilized for food by such forms as protozoa, rotifers, microcrustacea, insect larvae and bivalve mollusks; from the food standpoint, then, it is not necessary to distinguish between the living and dead phytoplankton organisms and the organic detritus that may be present.

Bottom flora and fauna. Petersen and Ekman dredges were used for the quantitative studies of the large aquatic plants and the bottom-dwelling animals. In certain localities a square made of strap iron 25 mm. wide and measuring 50 cm. on a side was used for samples of the large aquatics. This square, covering one-fourth square meter, was thrown overboard at random in shallow water and all of the plants inside it were collected by hand. This method was employed chiefly by Rickett in his studies on Green and Mendota. All of the samples of large aquatics in Weber and most of those in Nebish were taken with the regular Petersen dredge which sank into the bottom far enough to bring up the roots as well as the stems of the plants, hence both are included in the weights given for the large aquatics. For the bottom fauna, the Petersen dredge was employed in the shallow water where the bottom consisted of sand and gravel, and the Ekman dredge in the deeper water where the bottom deposit consisted chiefly of mud. A large percentage of the catches came from the shallow water where a greater variation in numbers and in forms was noted; the average number of samples was 11 per hectare of lake surface.

Fish. Fish population studies have been confined to the two smaller northern lakes; the southern lakes are so large that no attempt has yet been made to estimate their fish populations. In the northern lakes the general method of Dr. David H. Thompson of Illinois has been employed. The fish were caught in modified fyke nets, marked either by placing a numbered metal tag on the gill cover or by clipping a certain fin, and then liberated at a central station. When about 1000 specimens had been marked in Weber Lake and about twice that number in Nebish Lake, fishing operations were discontinued for a week to allow the marked fish to redistribute themselves; this was followed by a second period of fishing which lasted about two weeks. The ratio of marked to unmarked fish caught in the second period of fishing made it possible to compute the total fish population by means of Schnabel's formulae (1938). Experiments have shown that this method is accurate enough for all practical purposes, since the error is less than 10 per cent.

Dissolved organic matter. This material includes the organic matter in true solution and that which is in such a finely divided state that it cannot be recovered with the high speed centrifuge; it also includes about a quarter of the bacteria, but they make only a small contribution because they are usually found in such small numbers in the open water, ranging from 100 to 500 per cubic centimeter as determined by the plate method. The quantity of this unrecoverable organic matter was ascertained by evaporating samples of water from different depths and then determining the amount of organic carbon, organic nitrogen and ether extract (fat) in these residues. The quantity of organic N $\times$ 6.25 gives the crude protein. In computing the organic matter from these determinations, the following percentages of carbon were assigned to the three primary constituents: crude protein, 53 per cent; ether extract, 75 per cent; carbohydrate, 50 per cent. Deducting the organic content of the plankton from the sum of these three items leaves what has been called the "dissolved organic matter" in these lake investigations; as already indicated it does contain a certain amount of particulate matter.

The weight data included in the tables for the various biotic constituents give the wet weight in kilograms per hectare on an ash-free basis. The wet weights best represent the natural status of the animals and plants in the water; such weights were obtained directly for the large aquatics, the bottom fauna and the fish. The wet weight of the plankton was obtained by multiplying the dry weight of the organic matter by the factor 10; this factor is based on results which show that the water content of a number of plankton organisms ranges from 90 to 95 per cent. In fact substantially the same percentages of water have been found in the large aquatics, the bottom fauna and the fish; thus the wet weights given in the tables can be converted to dry weights by dividing them by 10. The percentage of ash in the several biotic constituents varies widely, ranging from less than 5 per cent of the dry weight in some of the plankton organisms to more than 50 per cent in Chara; so it was deemed best to state the results on an ash-free basis which gives a better picture of the organic content of the lake as a whole and which is also advantageous in considering the producer-consumer relationships.

Character of Lakes

Table 1 gives some of the physical characteristics of the four lakes. It will be noted that Weber and Nebish are much smaller and shallower than Green and Mendota. Weber Lake is the smallest and shallowest of the four and it belongs to the seepage type; that is, it has neither an inlet nor an outlet. It loses water only by evaporation and by seepage through the ground. The drainage basin is very small so that most of its water supply comes from the rain and snow precipitated on its surface. This reduction of the land factors of its environment to a minimum

TABLE 1. Physical characteristics of the four lakes on which quantitative studies of the biota have been made. The color was determined by the platinum-cobalt standard; a 30 cm. white disc was used to determine the transparency and the depth at which the disc disappeared from view is indicated in meters.

Lake	Area in hectares	Depth in meters		Volume in cubic meters	Color	Transparency
		Maximum	Mean			
Weber	15.6	13.5	7.2	1,132,900	3	6.6
Nebish	38.5	15.8	5.2	2,015,300	8	5.6
Green	2972.4	68.0	33.1	974,325,000	4	3.7
Mendota	3940.0	25.6	12.1	478,370,000	8	2.2

gives Weber Lake unique characteristics and makes it as complete a self-contained aquatic habitat as nature can provide.

Nebish Lake is two and a half times as large as Weber and has a somewhat greater maximum depth, but a smaller mean depth. Its drainage basin is small also and it has no inlet. At unusually high stages of the water there is an overflow into a small detached basin which has no visible outlet but which has margins and bottom without a water tight seal. As a result the overflow water which it receives from Nebish escapes rapidly by seepage through the ground. Aside from this unique type of outlet discharge, Nebish Lake is equally as isolated from its land environment as Weber Lake.

Green and Mendota are much larger than the two northern lakes; they have inlets and outlets and relatively large drainage basins; thus they belong to the drainage type of lakes and are subject to a much greater influence of land factors in their environment than the two northern lakes. Green Lake has a maximum depth of 68 meters and it is the deepest lake within the borders of the state. Its large volume is shown by the fact that its mean depth is 33.1 meters.

Table 2 gives some of the chemical characteristics of the waters of the four lakes. Weber and Nebish have very soft waters, the former especially; they are situated in a region where the upper part of the glacial deposit contains relatively small amounts of carbonates. While the deeper deposits contain larger amounts of carbonates, the lake basin seal keeps the deeper ground waters from entering these two lakes and giving the water a larger mineral content. The bed rock in this region consists of

TABLE 2. Chemical characteristics of the waters of the four lakes on which biological studies were made. The conductivity or specific conductance is expressed in reciprocal megohms; the dissolved substances are indicated in milligrams per liter of water.

Lake	Conductivity	pH	Bound CO_2	SiO_2	Ca	Mg	Sol. P	NO_3
Weber	10	6.4	1.3	0.1	0.7	0.6	0.003	0.014
Nebish	19	7.0	4.0	0.2	2.3	1.7	0.002	0.014
Green	275	8.5	75.2	8.4	21.2	25.7	0.004	0.024
Mendota	270	8.6	69.0	0.5	22.4	24.2	0.005	0.025

granite which is covered by glacial deposits ranging from 42 to 70 meters in depth.

Green and Mendota are situated in limestone regions so that their waters have a much larger mineral content than those of the northern lakes. Carbonates are plentiful in their drainage basins so that the inflowing waters add a substantial amount of inorganic material to these two lakes. Because of their location in limestone areas, they both have fairly hard waters.

QUANTITATIVE DATA

Weber Lake

Some of the results obtained in the quantitative studies of the biota of Weber Lake are given in Table 3. These investigations covered the standing crop of the various forms during the months of July and August in the years indicated in the table. In one year an additional set of plankton samples was taken during the last week in June and in two other years sets were taken in the first week of September; these extra observations have been used in computing the summer means of these years since they correspond so closely in time with the other samples. The second column in the table gives results for 1936-38, inclusive, because complete assessments of the bottom flora and fauna were not made annually during this period; in fact the complete survey of these two groups of organisms extended from 1936 to 1939, thus these two items are given the same values in the 1936-38 column and in the 1939 column. Complete assessments

TABLE 3. Average amount of organic matter in standing crop of plants and animals in Weber Lake in summer; the quantity of dissolved organic matter is also given. The results are stated in kilograms per hectare of lake surface on a wet weight, ash-free basis.

	1933	1936-38	1939	1940
Total plankton	624	921	1026	1143
Phytoplankton	583	861	959	1069
Zooplankton	41	60	67	74
Bottom flora	366	447	447	553
Bottom fauna	73	123	123	147
Fish	38	29	17	23
Dissolved organic matter	2663	2264	......	2866
Total weight of plants	949	1308	1406	1622
Total weight of animals	152	212	207	244
Ratio of plants to animals	6.2	6.1	6.8	6.6
Ratio of plants to animals, excluding fish	8.3	7.1	7.4	7.3
Ratio of other animals to fish	3.0	6.3	11.1	9.6

were made in 1933 and again in 1940, however, as indicated in the table.

The table shows that there was almost a twofold increase in the standing crop of plankton between 1933 and 1940. This increase was due in part, at least between 1936 and 1940, to the use of fertilizers; the lake is small enough to permit experiments of this character without excessive cost of materials. From 1932 to 1935 inclusive, mineral fertilizers were used, such as superphosphate, lime, nitrogen compounds and potash, but they seemed to have no effect upon the standing crop of plankton. The mean quantity of organic matter in the plankton during these four summers ranged from a maximum of 722 kg/ha, wet weight, in 1932 to a minimum of 604 kg/ha in 1935, with a mean of 651 kg/ha for the four-year period; the mean for the summer of 1931, the year before any fertilizers were added, was 675 kg/ha, or 24 kg/ha larger than the mean of the four following summers (1932-35) when mineral fertilizers were used.

In July and August, 1936, an organic fertilizer in the form of soybean meal was added to the lake and there was an appreciable increase in the standing crop of plankton; the mean was 952 kg/ha as compared with 651 kg/ha for the four previous summers in which mineral fertilizers were applied; this represented an increase of 45 per cent. The average standing crop was three per cent smaller in 1937 than in 1936 and only about 7 per cent smaller in 1938 than in 1936, but no fertilizers were added during these two summers; apparently the soybean meal was effective for three summers. In 1939 cottonseed meal was used and a further increase in the plankton crop was observed as shown in the table; the mean for that summer was 1026 kg/ha. There was a further increase to 1143 kg/ha in 1940 although no fertilizer was added in that summer. Likewise no fertilizer was added in 1941 and the mean crop of plankton declined to 824 kg/ha. From this result it appears that the cottonseed meal was effective for only two instead of three summers as noted for the soybean meal. However, this difference may be due in part to the fact that only one ton of cottonseed meal was added as compared with one and a half tons of soybean meal.

Corresponding to an increase in the standing crop of plankton from 1936 to 1940 was a similar increase in the weight of the bottom flora and fauna as indicated in the table. During this time the bottom flora increased from 366 kg/ha in 1933 to 553 kg/ha in 1940, while the bottom fauna rose from 73 kg/ha in 1933 to 147 kg/ha in 1940, a twofold increase. The fish, on the other hand, declined in weight from 38 kg/ha in 1933 to a minimum of 17 kg/ha in 1939, with a slight increase to 23 kg/ha in 1940. The total weight of plants (phytoplankton and large aquatics) increased from 949 kg/ha in 1933 to 1622 kg/ha in 1940, an increase of 71 per cent, while that of the animals rose from 152 kg/ha in 1933 to 244 kg/ha in 1940, an increase of a little more than 60 per cent. The somewhat lower percentage gain in the animals was due chiefly to the decrease in the weight of the fish.

The third line from the bottom of Table 3 shows the ratios of the wet weight of the plants to that of the animals on an ash-free basis. The plants include the combined weight of the phytoplankton and the large aquatics and the animals that of the zooplankton, the bottom fauna and the fish. It will be noted that these ratios are remarkably uniform for the eight-year period covered by these observations, ranging from a low of 6.1 in 1936-38 to a high of 6.8 in 1939. They mean that each kilogram of animals had a potential food resource of 6 to 7 kilograms of plants, and this ratio remained almost constant in spite of the annual changes found in the total weight of these two groups during the eight summers. That is, they reached a biological balance when the weight of the plants was between 6 and 7 times that of the animals. Apparently the biotic potential of the plants was such that they were able to take advantage of the more favorable trophic conditions produced by the addition of the organic fertilizers and the biotic potential of the animals, with the exception of the fish, enabled them to respond promptly to the improved food conditions resulting from the increase in the plants.

The second line from the bottom of Table 3 shows the relation of plants to animals when fish are excluded from consideration. Since fish are chiefly animal consumers, their exclusion gives a better idea of the more direct relations between plants and animals from a food and feeder standpoint; in addition also the fish populations of Green and Mendota are not known and these ratios with fish excluded can be compared directly with similar ratios for the two southern lakes. In Weber Lake the ratios with the fish excluded show a somewhat larger variation than with the fish included, yet they are reasonably close, ranging from 8.3

in 1933 to 7.1 in 1936-38. These ratios are really an index of the efficiency of the animals in utilizing the plant material for grazing purposes.

The last line in Table 3 shows the relation of the weight of the food directly available for fish (zooplankton and bottom fauna) to the weight of the fish. While the quantity of food gradually increased from 1933 to 1940, the weight of the fish declined during this time, reaching a minimum in 1939 with a moderate increase in 1940. The ratio of available food to fish rose from 3.0 in 1933 to 11.1 in 1939, which was more than a threefold increase. Thus the fish did not respond as promptly to the improved food conditions as the other animals which suggests that other factors than food were involved in the decrease of the fish population. Couey (1935) found that more than 80

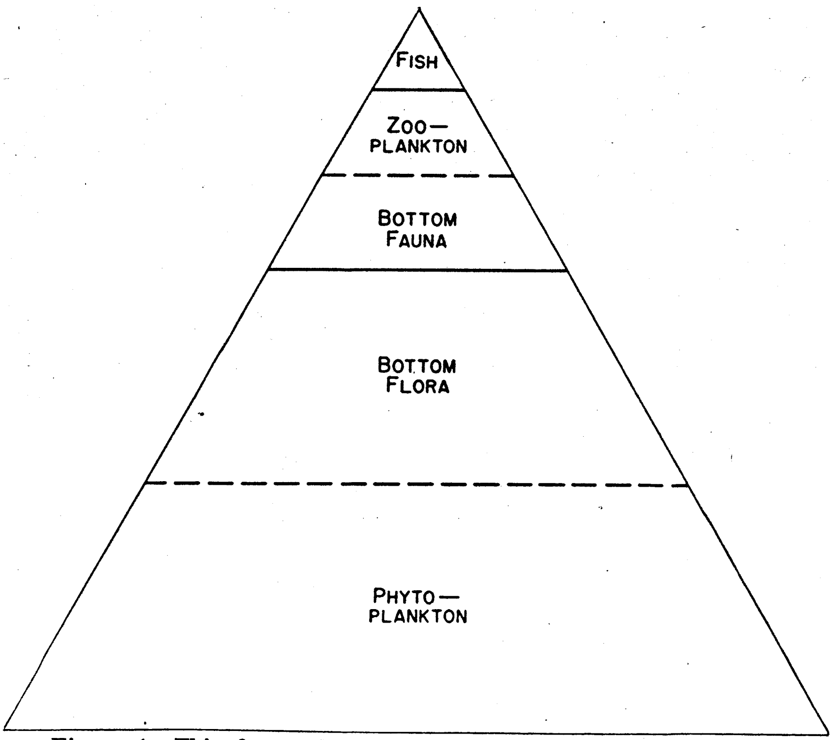


Figure 1. This figure shows the weight relationships of the various constituents of the biota of Weber Lake; it is based on the weights given in the 1940 column of Table 3. The weight of each constituent is proportional to the total area of the triangle; the original diagram was platted on a scale of 1 kg/ha = 12.4 sq. mm.

per cent of the food of the yellow perch of Weber Lake consisted of aquatic insect larvae and Cladocera; the same was true of the smallmouthed black bass, the only species of fish found in the lake at the time of his investigations (1931-32). Both of these food organisms showed an increase between 1933 and 1940, yet there was a decline in the weight of the fish.

Figure 1 shows graphically the weight relationships of the various constituents of the biota of Weber Lake during the months of July and August, 1940; it serves to illustrate what may be called the "pyramid of aquatic life" in the lake during those months. The entire area of the triangle represents the total weight of plants and animals, namely, 1872 kg/ha; the areas included in the various divisions of the triangle are proportional to the weight contributed to the total by each group. The original diagram was platted on a scale of 1 kg/ha = 12.4 sq. mm. The lower part of the diagram shows the broad foundation of aquatic plants on which the animal population rests; the two groups of plants (phytoplankton and large aquatics) are separated by a broken line in order to indicate the relative weight of each group. The upper part of the triangle represents the amount of organic matter contributed by the animals; the zooplankton and bottom fauna are separated by a broken line, while the fish are set off with a solid line since they may be regarded as the end product of all the biological processes that take place in the lake. The diagram shows clearly what a small proportion of the total weight of the biota is contributed by the animals, with the fish forming only a small cap for the pyramid. The percentage of organic matter contributed by the various groups of organisms is indicated in Table 5. The phytoplankton and the large aquatics together furnished substantially 87 per cent of the material and the animals 13 per cent, of which the fish constituted only 1.23 per cent.

This type of diagram does not show the food relationships between the plants and the animals nor those existing among the animals themselves. Most of the animals are vegetarians and feed directly on the plants, but some forms are carnivorous and prey upon other animals; the fishes particularly are chiefly carnivorous and only a few species of them are vegetarians.

In addition to the organic content of these groups of plants and animals the dissolved organic matter needs to be taken into consideration. The quantity of this material found in Weber Lake is given in Table 3. The mean for 21 series of samples taken between 1925 and 1936, inclusive, is 2866 kg/ha as indicated in the 1940 column of the table. This quantity is 52 per cent larger than the organic content of the standing crop of plants and animals in that year. Somewhat smaller amounts were found in 1933 and in 1936, yet the dissolved organic matter was more than twice as large as the organic content of the plants and animals in 1933 and 49 per cent larger in 1936.

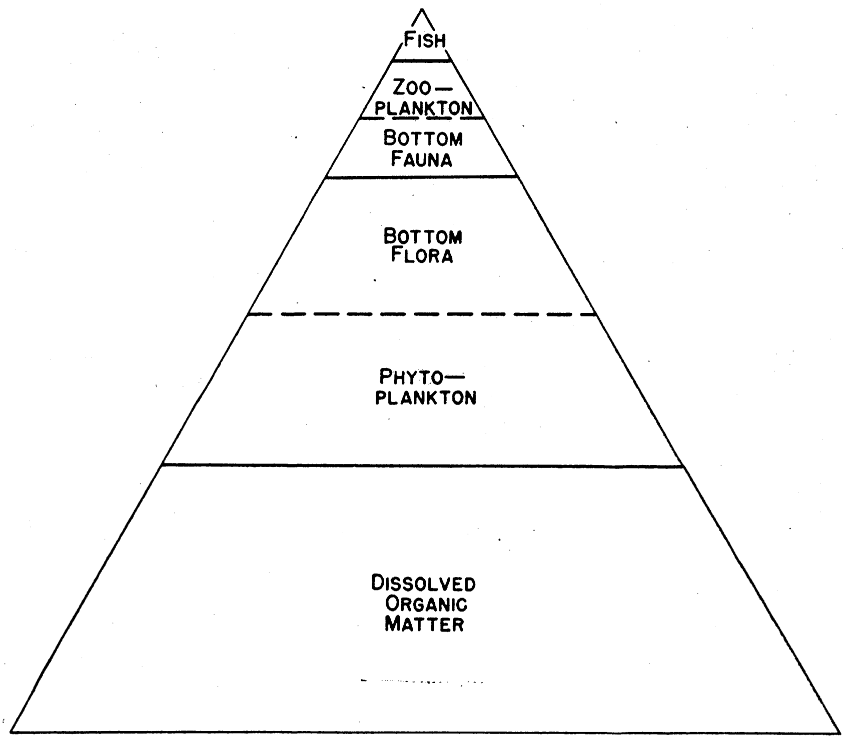


Figure 2. This figure shows the weight relationships of the biota and the dissolved organic content of Weber Lake. The weight of each constituent is proportional to the total area of the triangle. The original diagram was platted on a scale of 1 kg/ha = 4.9 sq. mm.

Figure 2 shows the quantitative relationships of the plants and animals to each other and also to the dissolved organic content of the water of Weber Lake. It gives a general picture of the organic content of the water together with those of the bottom flora and fauna. The diagram shows clearly what a large proportion of the pyramid is required to represent the quantity of dissolved organic matter and it also demonstrates what a small role the animals play in that part of the organic content of the lake which is included in these studies. Percentages for the various items in this organic matter budget are given in Table 5. The dissolved organic matter makes up a little more than 60 per cent of the total included in the diagram, while the fish constitute only one-half of one per cent and the other animals a little less than 5 per cent.

With the exception of the comparatively small number of bacteria which it contains, the dissolved organic matter consists of material that is on its way back to the elemental status from which it came originally, namely, water, carbon dioxide and nitrogen compounds. The major part of it comes from the phytoplankton and thus represents the surplus of organic matter produced by these organisms which has not been used by the animal consumers up to this stage; that which is still in a particulate state is available for the food of some animals, especially some of the zooplankton forms.

Up to the present time, the survey of the bottom deposits in the deeper water has been limited to the upper 15 cm. so that nothing is known of the total depth of the deposits or their organic content at greater depths. In the upper 15 cm. chemical analyses show that 43.3 per cent of the dry weight of the mud consists of organic matter with the following composition: 12.1 per cent crude protein; 1.2 per cent ether extract; 30.0 per cent carbohydrate (Juday, et al., 1941). According to Steiner and Meloche (1935) about half of the organic matter is ligneous in character. Henrici and McCoy (1938) found that the average dry weight of one cubic centimeter of the upper 15 cm. of the Weber Lake deposits was 0.032 gram. The typical mud deposits are limited to the region below a depth of 8 m. which has an area of 79,200 sq. m. Computations based on the foregoing data indicate that the organic content of the upper 15 cm. of the deposits within the 8 m. contour line amounts to 1,644,952 kilograms, wet weight. Since some of this organic matter is derived from the 0-8 m. zone as well as from the deep water, the whole lake must be taken into account in computing the average amount per unit of area; that is, the organic matter deposited on the bottom in the shallow water is eventually carried out to the deeper water by the action of the waves and currents. Taking the area of the entire lake into consideration, the organic content of the upper 15 cm. of the bottom deposits amounts to an average of 105,378 kg/ha, wet weight.

Just how long a period it has taken to form the upper 15 cm. of the deposit can only be conjectured. Conger (1939) estimated that the rate of deposition in Crystal, a nearby seepage lake, was only about 0.25 mm. per year on the basis of 10,000 years of elapsed time since the close of the glacial period or half that amount on a 20,000 year basis. At the rate of 0.25 mm. per year the upper 15 cm. in Weber Lake would represent an accumulation extending over a period of 600 years or twice that number of years on a 20,000 year scale. This upper layer is not as compact as the deeper layers of the deposits so that it probably represents a somewhat shorter period of time than the average for the total deposit; it is evident however, that the upper 15 cm. of the deposit in a lake having the characteristics of Weber would require a few hundred years, at least, for its deposition.

Twenhofel and Broughton (1939) found much smaller amounts of organic matter in the strata below a depth of 15 cm. in the deposits of Crystal Lake and it seems reasonable to suppose that the same is true of the deeper strata in the Weber Lake deposits. Henrici and McCoy (1938) found a considerably larger bacterial flora in the upper 9 cm. of the bottom deposits of Weber than between 9 and 21 cm. which may be regarded as an indication that organic substances are more plentiful in the upper 9 cm. of the deposits.

Nebish Lake

The results of the quantitative investigations made on Nebish Lake during July and August, 1941, are given in Table 4. Regular observations on the plankton of this lake were begun in 1931 and have been continued each summer up to and including 1941. The general purpose of these studies was to use the plankton results for comparison with those obtained on Weber Lake where fertilizers were being used; the waters of the two lakes are similar in their physical and chemical characteristics, but that of Nebish Lake has a somewhat larger mineral content than that of Weber (Table 2). Also they are only about 8 km. apart so that they are both subject to the same general climatic conditions; likewise both are surrounded by second growth timber.

TABLE 4. Average amount of organic matter in standing crop of plants and animals in Nebish Lake in July and August, 1941; the quantity of dissolved organic matter is also indicated. The results are stated in kilograms per hectare of lake surface, wet weight, on an ash-free basis.

Total plankton	650
Phytoplankton	608
Zooplankton	42
Bottom flora	590
Bottom fauna	122
Fish	35
Dissolved organic matter	3829
Total weight of plants	1198
Total weight of animals	199
Ratio of plants to animals	6.0
Ratio of plants to animals, excluding fish	7.3
Ratio of other animals to fish	4.7

While some quantitative studies of the bottom fauna were made in 1931 and 1935, the number of samples taken each year was not large enough for the estimation of the bottom population of the entire lake. A cursory survey of the large aquatic plants of Nebish Lake was made in 1935 also, but it was chiefly qualitative in character. Thus no complete quantitative survey of these two groups of organisms was made until the summer of 1941. The investigation also included estimates of the fish populations each summer from 1938 to 1941. The results of the 1941 survey are given in Table 4.

During the 11 years covered by the plankton studies of Nebish Lake, the quantity of organic matter in the standing crop varied from a minimum of 525 kg/ha, wet weight, in 1931 to a maximum of 1002 kg/ha in 1940, with a mean of 714 kg/ha for the entire period. The table shows that the average standing crop of 1941 was below the general mean, namely 650 kg/ha. The bottom flora of Nebish in 1941 yielded a somewhat larger crop than that of Weber Lake in 1940, or 590 as compared with 553 kg/ha. The weight of the bottom fauna, on the other hand, was appreciably smaller in Nebish in 1941 than in Weber in 1940; it amounted to 122 kg/ha in the former as compared with 147 kg/ha in the latter. The standing crop of fish was larger in Nebish than in Weber, namely 35 to 23 kg/ha.

The dissolved organic content of the water was about one-third larger in Nebish than in Weber, or 3829 kg/ha in the former as compared with 2866 kg/ha in the latter. The quantity in the

Nebish Lake water was nearly three times as large as the organic content of the plants and animals combined. The ratio of plants to animals in Nebish Lake was just a little below the minimum of Weber Lake, or 6.0 as compared with 6.1. Excluding the fish the 1941 ratio of plants to other animals is substantially the same for Nebish as for those of Weber Lake in 1939 and 1940, or 7.3 as compared with 7.4. The ratio of the weight of the zooplankton and bottom fauna to that of fish in Nebish Lake is 4.7, which is larger than that found in Weber Lake in 1933, but much smaller than those of Weber in 1939 and 1940. The ratio of plants, zooplankton and bottom fauna to fish in Nebish Lake was 37.1; in a general way this represents the potential food resource of each kilogram of fish. The weight of the fish in Nebish Lake constituted 2.5 per cent of the total weight of plants and animals; this is twice as large as the percentage found in Weber Lake, namely 1.2 per cent (Table 5).

TABLE 5. The percentages which the various forms contribute to the total weight of plants and animals per unit of area and to the total quantity of organic matter (plants, animals and dissolved organic matter) in Weber and Nebish lakes.

	Weber Lake, 1940 Per cent of plants and animals	Per cent of total organic matter
Plankton	61.26	24.15
Phytoplankton	57.29	22.59
Zooplankton	3.97	1.56
Bottom flora	29.63	11.69
Bottom fauna	7.88	3.11
Fish	1.23	0.49
Dissolved organic matter	....	60.56
	Nebish Lake, 1941	
Plankton	46.53	12.44
Phytoplankton	43.53	11.63
Zooplankton	3.00	0.81
Bottom flora	42.24	11.30
Bottom fauna	8.73	2.33
Fish	2.50	0.67
Dissolved organic matter	....	73.26

The weight relations between the various constituents of the biota of Nebish Lake are shown graphically in Figure 3; it corresponds to Figure 1 for Weber Lake. A comparison of these two figures shows that the phytoplankton constitutes a smaller

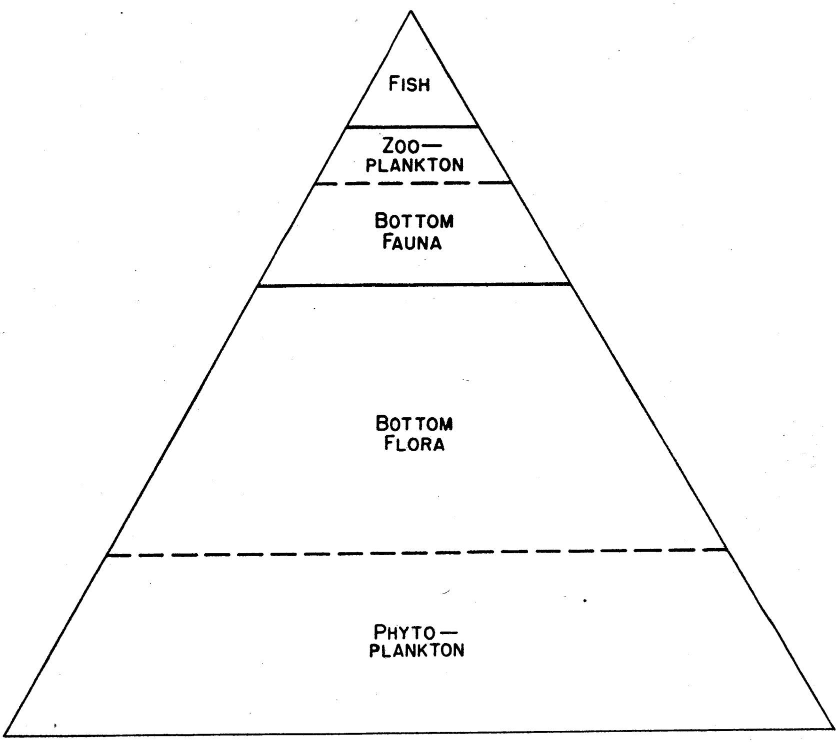


Figure 3. This figure shows the weight relationships of the various constituents of the biota of Nebish Lake; it is based on the weights given in Table 4. The weight of each constituent is proportional to the total area of the triangle. The original diagram was platted on a scale of 1 kg/ha = 16.6 sq. mm.

proportion of the plant base of the pyramid of Nebish than that of Weber Lake, but the reverse is true of the bottom flora of the two lakes; a small part of these differences is due to the slightly different scales on which the two diagrams are platted. In both lakes the animals constitute substantially the same proportion of the total biota; in Nebish Lake the animals represent 13.2 per cent of the total weight and in Weber Lake 13.0 per cent. The cap of the pyramid which represents the fish of each lake is somewhat larger in the Nebish than in the Weber Lake diagram.

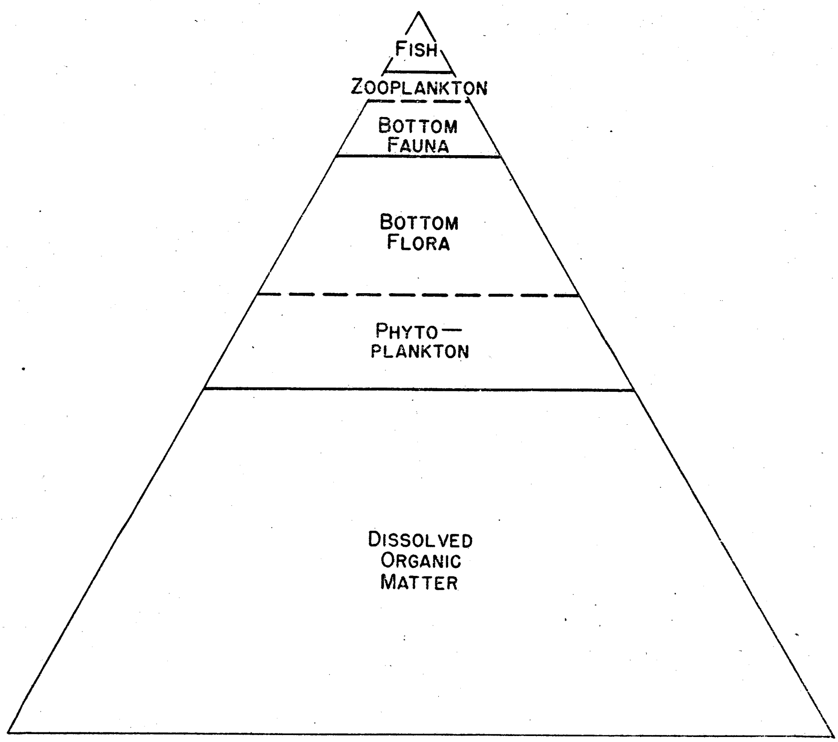


Figure 4. This figure shows the weight relationships of the biota and the dissolved organic matter of Nebish Lake. The weight of each constituent is proportional to the total area of the triangle. The original diagram was platted on a scale of 1 kg/ha = 4.4 sq. mm.

Figure 4 shows the relative proportions of the plants, the animals and the dissolved organic matter of Nebish Lake; it corresponds to Figure 2 of Weber Lake, thus including the total organic content of the water as well as the bottom flora and fauna. It will be noted that the dissolved organic matter base of the pyramid is appreciably larger than that of Weber Lake and that the plant and animal portions are correspondingly smaller. In Nebish Lake the dissolved organic matter makes up 73 per cent of the total organic content, while in Weber Lake it constitutes only 60 per cent (Table 5).

As a result of the larger percentage of dissolved organic matter in the water of Nebish Lake, no special comparisons between the plants and animals of the two lakes as shown by these two figures can be made; but they serve to show what a small proportion of the organic content of the two lakes is contributed by the animals. In Nebish Lake the animals constitute 3.8 per cent of the total organic matter represented in the pyramid, of which 0.7 of one per cent consists of fish, while in Weber Lake the animals contribute 5.1 per cent, with a little less than 0.5 of one per cent consisting of the fish.

The weights of the fish populations of Weber and Nebish lakes seem unusually small, but they compare favorably with some of the results that have been reported by other investigators. Tarzwell (1940) reported the weights of the fish populations of several lakes and among them are seven, three situated in Nova Scotia and four in Michigan, which had standing crops ranging from 19 to 49 kg/ha; the records for these seven lakes are based on poisoning experiments and thus represent the actual weights of the fish populations.

Data are not available for the computation of the organic content of the bottom deposits of Nebish Lake. The organic content of the upper 15 cm. was 54.3 per cent of the dry weight as compared with 43.3 per cent in the deposits of Weber Lake. The organic matter of the bottom deposits of Nebish Lake consisted of 16.6 per cent crude protein, 2.2 per cent ether extract and 35.5 per cent carbohydrate.

Green Lake

Green Lake ranks second in area in this group of four lakes; it is first in maximum and mean depths as well as in volume (Table 1). The water has only a small amount of color as determined by the platinum-cobalt standard and it has a medium transparency as compared with the other three lakes. The mineral content of the water is much larger than in Weber and Nebish so that it ranks as a fairly hard water lake (Table 2).

The results of the biological survey of Green Lake are given in Table 6. The standing crop of plankton was larger than those of the other three lakes, amounting to 2944 kg/ha, wet weight. This is more than four times as large as the standing crop of Nebish Lake and two and a half times as large as that of Weber in 1940. It is also about one-third larger than that of Lake Mendota. The large crop of plankton in Green Lake when given on a unit area basis is due in part to the much greater depth of this body of water. Light conditions are such in Green Lake that the zone of photosynthesis or region of phytoplankton production extends to a depth of about 15 m. in summer, but the

TABLE 6. Average amount of organic matter in the standing crop of plants and animals and in the dissolved organic matter of Green Lake and of Lake Mendota. In Green Lake the plankton samples were taken in July and August, 1921-24 inclusive, and in Mendota in July and August, 1915-16. The amounts are given in kilograms per hectare of lake surface on a wet-weight, ash-free basis.

	Green	Mendota
Total plankton	2944	1995
Phytoplankton	2767	1875
Zooplankton	177	120
Bottom flora	4218	4600
Bottom fauna	138	414
Dissolved organic matter	27,901	15,201
Total weight of plants	6985	6475
Total weight of animals, excluding fish	315	534
Ratio of plants to animals, excluding fish	22.2	12.1

0-15 m. stratum includes only about one-third of the total volume of the lake. The large volume of water below this depth contains a certain amount of phytoplankton and a moderate population of zooplankton organisms so that the microscopic life of the lower water contributes a substantial amount of material to the plankton crop of the upper stratum when results are expressed in terms of a unit area of surface.

The table indicates that the standing crop of large aquatic plants was seven to ten times as large as those of Weber and Nebish lakes, but it was somewhat smaller than that of Lake Mendota. The main constituent of this crop in Green Lake was Chara which has a large percentage of ash, namely 41.0 per cent of the dry weight (Schuette and Alder 1929); this accounts in part for the smaller organic content of this crop of large aquatics as compared with that of Lake Mendota. In connection with the bottom flora, it may be noted that *Oscillatoria prolifica* was found growing saprophytically in a grayish mat 2 mm. thick on the bottom of Green Lake where the water was 65 to 68 meters in depth. (Juday 1934.)

The weight of the bottom fauna of Green Lake was smaller than that of Weber Lake in 1940, but larger than those of previous years; it was about 10 per cent larger than the weight of the bottom fauna of Nebish Lake in 1941 but only one-third as large as that of Lake Mendota. This comparatively small weight of the bottom fauna is due, in part at least, to the depth of the water, the steep slope of the bottom and the low temperature of the bottom water which ranges from 2° in winter to about 6° C. in summer. Environmental conditions in Green Lake favor the Tanytarsus rather than the Chironomus type of bottom fauna and it is a well established fact that the former type of lake does not support as large a bottom population as the latter.

The dissolved organic content of the water of Green Lake is unusually large, amounting to 27,901 kg/ha on a wet weight basis; this is almost four times the total weight of the plants and animals, namely 7300 kg/ha. Again this large amount of dissolved organic matter per unit area is partly explained by the greater depth, hence greater volume, of the lake. While the quantity of dry organic matter in this dissolved material was only about two-thirds as large per unit volume in Green Lake as in Lake Mendota, yet the amount per unit of surface was much larger in the former than in the latter because of the larger volume of water in the former; on a dry weight basis the dissolved organic matter in Green Lake was 8.42 mg/1 as compared with 12.52 mg/1 in Lake Mendota.

Table 6 shows that the ratio of plants to animals in Green Lake, excluding fish, is 22.2, which is much larger than in the other three lakes; this means that there are 22.2 kilograms of organic matter in the phytoplankton and large aquatics to one kilogram of organic matter in the zooplankton and bottom fauna. Such a large ratio indicates that the animal population of Green Lake is much less efficient in converting the plants into animal material than those of the other three lakes. The relatively small weight of the bottom fauna was chiefly responsible for this situation.

Lake Mendota

Lake Mendota is the largest of these four lakes; it has a medium depth, with a maximum of 25.6 m. and a mean of 12.1 m. (Table 1). The color of the water is low, the same as that of Nebish Lake; the transparency is also low in the summer, with a mean of 2.2 m. for the disc readings. The mineral content of the water is substantially the same as that of Green Lake, so that it has a fairly hard water (Table 2).

The wet weight of the standing crop of plankton was three to five times as large as those of Weber and Nebish lakes, but it was more than 30 per cent smaller than that of Green Lake.

The standing crop of large aquatic plants was larger than those of the other three lakes; it exceeded that of Green Lake by about 8 per cent and it was eight to twelve times as large as those of Weber and Nebish lakes (Table 6). A much larger bottom fauna was found in Lake Mendota than in the other three lakes; its weight was 414 kg/ha as compared with 73 to 147 kg/ha in the others. While a large part of the hypolimnion of Mendota is devoid of dissolved oxygen for three months or more each summer, the lower layer of water does not become too foul for the bottom-dwelling organisms during this time; in fact large numbers of Limnodrilus, Tubifex, Pisidium, Chironomus and Chaoborus (Corethra) occupy the bottom zone at this time (Juday 1921); it is thus a Chironomus type of euthropic lake.

The quantity of dissolved organic matter in the water of Lake Mendota amounted to 15,201 kg/ha, which is only a little more than half as much as found in Green Lake, but it is two to seven times as large as noted in Weber and Nebish lakes. It is a little more than twice the organic content of the plants and animals, excluding the fish.

The ratio of plants to animals, excluding the fish, is 12.1, which is much smaller than that found in Green Lake, but it is almost twice as large as those of Weber and Nebish lakes. This indicates that the efficiency of Lake Mendota in converting aquatic plants into zooplankton and bottom fauna, the two main direct sources of food for fish, is much higher than that of Green Lake, but it is much lower than those of Weber and Nebish lakes.

Discussion of Results

Plants

By means of energy derived from subsurface solar radiation, most of the fundamental foodstuffs of a lake are manufactured autotrophically by aquatic plants from substances dissolved in the water or from materials present in the subaqueous soils. A certain amount of organic matter comes from outside sources, such as that blown into the lake by wind and that which is brought in by drainage waters from the shores and by inflowing streams in the form of particulate and dissolved organic matter. The aquatic chlorophyll-bearing organisms, however, constitute the chief producers of the primary organic content of the lake and this material, either directly or indirectly, is the main source of the food of the animals. In addition to that which is consumed by animals, the plants themselves use a certain amount of the organic material which they manufacture in their own metabolic processes; experiments have shown that this is about one-third of the total quantity of organic matter manufactured by them, which leaves two-thirds available as food for the animals. These food relationships raise the question of the ratio of the weight of the standing crop of plants to that of animals; in other words, what is the ratio of producers to consumers?

Turning first to a consideration of the trophic conditions of the plants in the two types of lakes dealt with in this report, Table 2 shows the marked difference in the mineral content of their waters. The data listed in the other tables give direct evidence of the dynamic response of the aquatic vegetation to the differences in the chemical factors of their environment. That is, the standing crop of plants per unit of area was found to be much smaller in the soft than in the hard water lakes. There is some difference in the climatic conditions of the two regions in which the lakes are situated. The northern soft water lakes have a somewhat shorter growing season; their waters begin to cool earlier in the autumn and they become covered with ice some three weeks earlier than the southern lakes. In the spring also, they retain their ice cover about three weeks longer than the southern lakes; thus they are subject to low winter temperatures at least six weeks longer each year than the two southern lakes. On the whole however, the climatic factor can hardly be regarded as having much importance in determining the marked difference in the size of the standing crop of plants in the northern soft water lakes as compared with that of the southern hard water lakes.

The data indicate that the mineral content of the water is the chief factor in determining the plant production of these two groups of lakes. Just which minerals play the most important role in limiting the plant crop of the northern lakes has not been determined. Phosphorus and nitrogen compounds are generally considered as the chief limiting factors. Table 2 shows that the difference in the soluble or phosphate phosphorus content of the two types of water is about twofold. This is the form of phosphorus that can be used directly by the plants; the organic form can not be utilized until it is liberated from its organic combination or "regenerated." The nitrate content of the waters of the two southern lakes is about twice as large as that of the northern lakes, so that both of these factors need to be taken into consideration with reference to the size of the plant crops in the four lakes. Fertilizing experiments on Weber Lake, however, show that both phosphorus and nitrogen compounds did not stimulate the growth of aquatic plants in that body of water; thus there is some doubt about their serving as limiting factors in the two soft water lakes.

In 1932 for example, enough superphosphate was added to Weber Lake to raise the phosphate content of the water to approximately ten times the amount found in 1931 when no fertilizers were used, but no response from the phytoplankton was observed. In the summer of 1933 both superphosphate and lime were added without any response; superphosphate, lime and nitrate were added in 1934 and no effect on the phytoplankton was noted. In 1935 similar negative results were obtained with nitrate and potash; in fact the phytoplankton crop of this year was smaller than in the three previous summers. Thus the small standing crop of phytoplankton of Weber Lake can hardly be attributed to any of these four mineral factors.

In the summer of 1936, 1360 kilos of soybean meal were used and a prompt response was obtained from the phytoplankton; the average standing crop was 50 per cent larger than in the three previous summers. The mean standing crop of phytoplankton for 1933-35, inclusive, was 586 kg/ha, while the 1936 crop was 890 kg/ha. Also the effect of the soybean meal seemed to last through the summers of 1937 and 1938 as well, since the phytoplankton showed only a three per cent decrease during the first and a seven per cent decrease during the latter summer. During the summer of 1939, 907 kilos of cottonseed meal were added to the water and a further favorable response was noted in the phytoplankton when the mean standing crop rose to 959 kg/ha, an increase of almost 8 per cent over the average of 1936. It rose to a maximum of 1069 kg/ha in 1940 without the addition of any more fertilizer, which was an increase of more than 11 per cent over the mean crop of 1936 and almost twice as large as the mean crop of 1933-35, namely, 586 kg/ha, when mineral fertilizers were being added. There was a sharp decline in the standing crop of phytoplankton in 1941, the amount falling to 770 kg/ha, a decrease of 28 per cent as compared with the 1940 crop; no fertilizer was added in 1941. These experiments seem to warrant the conclusion that an organic fertilizer, carrying both mineral and organic constituents, is necessary to stimulate the growth of the phytoplankton in Weber Lake and presumably this would be true of similar soft water lakes in this region. An increase in the standing crop of large aquatic plants was also noted between 1936 and 1940 which indicates that they also were affected by the organic fertilizers (Table 3).

The larger quantities of calcium and magnesium present in the hard waters may play a rôle also since they exist chiefly as carbonates and bicarbonates and thus make a much larger stock of carbon dioxide available for the plants of hard water lakes than in the soft waters. They affect the hydrogen ion concentration of water, but pH is generally not regarded as an important factor in determining the productivity of lakes. Some of the trace elements, such as copper, boron, lithium, zinc and manganese, may have some effect in determining the productive capacity of the water, but this problem has not been fully investigated. Chemical analyses show that there is a concentration of boron, for example, in the phytoplankton and large aquatic plants, but the significance of the concentration has not been determined up to the present time. Much more extended studies will be necessary to determine what specific mineral factors are responsible for the differences in the productivity of the two types of water found in these four lakes.

While the mineral content of the water plays a major part in the total productivity of the two hard water lakes, there is a certain advantage in their greater depth and volume when the results are expressed in units of surface area; that is, the vigorously growing phytoplankton organisms are confined to the upper stratum of water where the solar radiation is great enough to enable them to carry on photosynthesis. Those that die or become senile settle into the lower water on their way to the bottom and thus contribute to the phytoplankton content of the lower strata of a deep lake. In a shallow lake they reach the bottom more promptly and become eliminated from the lower water. In Green Lake for example, the phytoplankton crop of the upper 10 m. of water amounted to 1086 kg/ha as compared with the 2767 kg/ha of the total quantity shown in Table 6. That is, about 38 per cent of the total crop of phytoplankton was found in the 0-10 m. stratum, with 62 per cent below this depth. This upper stratum represents the greater part of the zone of photosynthesis, so that it was occupied by the actively growing phytoplankton organisms. The water of Green Lake absorbs solar radiation at such a rate that the amount is reduced to one per cent of the total delivered at the surface at a depth of about 11 m. and it seems probable that very little photosynthetic activity is found below this depth.

Because Lake Mendota is much shallower than Green Lake, the accumulation of phytoplankton in the lower water is not so marked. In Lake Mendota subsurface radiation is reduced to one per cent of the amount delivered to the surface at depths ranging from 4 m. to 8 m., depending upon the transparency of the water; it seems probable, therefore, that very little or no photosynthesis takes place below a depth of 10 m. Observations showed that the 0-13 m. stratum of Lake Mendota contained about 72 per cent of the standing crop of phytoplankton in early August, leaving only 28 per cent for the 14-25 m. region. The amount in the 0-13 stratum was 1673 kg/ha, or more than twice as large as the standing crops of phytoplankton in Weber and Nebish lakes, especially before organic fertilizers were added to Weber Lake. Thus, while there is some advantage in the yield of phytoplankton per unit of surface area due to the greater depth of water in Green Lake, this advantage is almost negligible in the case of Lake Mendota and the chemical content of the water must be regarded as the chief factor in the greater phytoplankton production in the latter lake.

The mineral content of the water plays an important part in determining not only the quantity but also the character of the lake flora. The summer standing crop of phytoplankton in the two soft water lakes consists chiefly of green algae (Chlorophyceae) and diatoms (Bacillarieae); the blue-greens (Myxophyceae) may be the dominant forms at certain times during the summer, but they are usually species of Chroococcus and they have not reached bloom proportions at any time during the period of these observations. The summer phytoplankton of the southern hard water lakes is dominated by Microcystis, Coelosphaerium, Lyngbya and Anabaena which are the blue-greens that usually produce the blooms on the lakes in the southern part of the state. In the northern soft water lakes, the large aquatic plants are usually limited to eight or ten species, while 30 or more species are found in the southern hard water lakes. Most of the soft water species are specific to that type of water.

From the food standpoint, the phytoplankton and the large aquatic plants present different problems to the animal population. The phytoplankton organisms, both living and dead, are distributed throughout the open water and are thus available in substantially all parts of the lake; they are the chief source of food for the microcrustacea and rotifers that occupy not only the upper but also the lower strata of water even in deep lakes and for the vegetarians that live on the bottom. A residue of unconsumed phytoplankton is deposited on the bottom and this is available for those organisms which ingest the bottom material and digest the organic content of this mud insofar as they are able to do so; much of this organic residue is ligneous in character, however, and not readily digested.

The large aquatic plants, on the other hand, occupy the shallower water where the subsurface illumination is great enough for them to carry on photosynthesis, so that they are available for food and for an attachment substratum only to the animals that are found in the shallow water zone; certain of these animals feed directly on the large aquatics, while others feed chiefly on the algae and bacteria attached to them. Thus the large aquatics furnish a more limited source of food than the phytoplankton. The quantities listed in the tables represent substantially the annual crop of large aquatics, while the data listed for the phytoplankton represent the average standing crop which is subject to a frequent turnover during the summer; under favorable conditions the algal cells may divide once, perhaps twice, each day during a vigorous period of growth. Taking into account the seasonal changes in light, temperature and other factors, it seems probable that the turnover in the standing crop of plankton averages once a week during July and August so that the summer yield would be about eight times the weight indicated for the standing crop in the tables; the turnover in the southern lakes would probably be more frequent than this.

The standing crop of large aquatics was determined chiefly in August when they had practically completed their annual growth; thus the weights given for them in the tables may be considered as the annual yield. They die off during the autumn and early winter and settle to the bottom where decomposition takes place. Through the action of waves and currents a large percentage of this material is transported from the shallower to the deeper water for final deposition. As they break up they contribute organic detritus to the water and thus furnish a certain amount of food to the free swimming animals; that which remains on the bottom, both in the shallow and in the deep water, becomes a source of food for the bottom dwelling animals. Steiner and Meloche found that 10 to 20 per cent of some of the large aquatics consisted of ligneous material and this fraction is probably of little food value. Schuette also found 15 to 19 per cent of crude fiber in some of the large aquatics of Lake Mendota and this material is also regarded as having little food value.

Animals

Similar differences have been noted in the standing crop of animals in the two types of lakes. The weight of the zooplankton is appreciably smaller in the soft than in the hard water lakes, but the bottom fauna varies. In Green Lake for example, the bottom animals weigh substantially the same as those of the two soft water lakes; this indicates that depth and probably temperature are more important factors in determining the size of the standing crop of bottom animals than the hardness of the water. A somewhat smaller variety of animals is found in the soft than in the hard water lakes and a few show a specificity for the soft waters. The cladoceran Holopedium is confined chiefly, though not entirely, to soft waters; it has been found in considerable numbers in a typical marl lake in central Wisconsin. The most marked differences have been noted in the mollusk populations of the two types of lakes; no large bivalves, for example, have been found in the soft water lakes. Morrison (1932) reported that the characteristic mollusks of the soft water lakes were species of the small bivalve Pisidium and snails belonging to the genus Campeloma. He noted that Pisidium was very tolerant of acidity and lived in the softest water with a reaction of pH 5.7 and as little as 1.5 p.p.m. of bound carbon dioxide; their shells were very thin and fragile, however. Both Pisidium and Campeloma occur in Weber and Nebish lakes, the former in considerable numbers. The mollusk populations of the two hard water lakes are much larger and more varied than in the two northern lakes.

The ratios of plants to animals given in the tables show that an equilibrium is established between them in Weber and Nebish lakes when the weight of the former is about seven or eight times as large as that of the latter, excluding the weight of the fish from the animal population. The food relations of the two groups of organisms are not as simple as these ratios might indicate, however, because some of the animals are predatory and do not feed directly on plants; this is especially true of the fishes where there may be two or three up to half a dozen links in the food chain connecting them with plants. Because most of the fishes are carnivorous, it is best to exclude them in order to get a better trophic index of the food-feeder relationship between plants and animals. In other words their exclusion gives a better idea of the direct utilization by the consumers of the material manufactured by the producers; such an index, therefore, shows more clearly the extent and effectiveness of the grazing activities of the vegetarian animals. Some of the zooplankton and bottom forms are predators also, but they constitute a rather small percentage of these forms and do not require any special consideration.

These ratios of plants to animals may also be regarded as indexes of the conversion of plant material into animals, which in a way represents the efficiency of a lake in the production of animals. As indicated in the tables the ratio of plants to animals, excluding fish, was found to be 12.1 in Lake Mendota and 22.2 in Green Lake, as compared with 7.3 in Nebish Lake and an average of 7.5 in Weber Lake. This means that the two hard water lakes have a much lower efficiency in the conversion of plants to animals than the two soft water lakes. According to these ratios Lake Mendota is only a little more than half as efficient in the use of its plant material and Green Lake only one-third as efficient as the two soft water lakes. The much greater depth and the low temperature of the bottom water of Green Lake seem to be factors in limiting the size of the standing crop of bottom fauna, thereby lowering the efficiency; with a bottom fauna as large as that of Lake Mendota, the ratio of plants to animals would be 11.7 instead of 22.2, which would bring Green Lake into line with the index of Lake Mendota, namely 12.1. Just why the two hard water lakes are so much less efficient than the two soft water ones is not evident from the data in hand.

Dissolved Organic Matter

The heterogeneous mixture of substances designated as dissolved organic matter represents chiefly the organic matter that is in various stages of decomposition and that which comes from the excretions of the aquatic organisms resulting from their metabolic activities. Most of it may be considered as belonging to the final stages in the cycle of organic matter in lake waters. Aside from a relatively small number of bacteria, it consists of degradation products on their way to conversion into water, carbon dioxide and mineral salts, the original building blocks from which the organic matter was built up by the producers in the process of photosynthesis. Four different items are represented in this material: (1) a small percentage of the bacteria; (2) minute particles of decomposing organic material which cannot be recovered with a high speed centrifuge; (3) particles small enough to be regarded as colloids; and (4) organic matter in true solution. The first and second stages of this material are still available for the food of some of the aquatic animals, such as microcrustacea, rotifers, protozoa and some members of the bottom fauna; the third and fourth stages can be utilized only by bacteria, and when so utilized they again enter the food cycle because the bacteria may be consumed by certain animal forms.

The dissolved organic matter is in a constant state of flux; it is continually receiving both decomposing and excretory material from the biota on the one hand and losing organic substances that change over to inorganic compounds on the other. Since the amount of dissolved organic matter remains fairly constant in a lake during the summer as well as from year to year, the quantity being added is in substantial equilibrium with that which is removed at the end of the degradation process. There was an increase in the amount of this material in the water of Weber Lake when organic fertilizers were used to stimulate the growth of the phytoplankton; also unusually large increases in the standing crop of phytoplankton may add appreciable amounts to the dissolved organic matter, especially at the end of such a plankton pulse when these organisms have completed their life cycle and are declining in numbers.

The dissolved organic matter contains a large percentage of organic material that is not readily oxidized by bacteria. Steiner and Meloche (1935) found that the plankton, the chief source of this organic matter, contained 10 to 20 per cent of ligneous substances which are more resistant to decomposition than the other organic constituents and this ligneous portion thus tends to lag in the process of decomposition. ZoBell (1940) noted that the remains of plankton organisms were more readily oxidized by bacteria than the dissolved organic matter found in the lake water. Also ZoBell and Stadler (1940) state that lignin is attacked less readily than the other major organic constituents found in lakes, but that it is slowly decomposed by certain bacteria present in lake water and in bottom deposits. Their experiments showed that these bacteria oxidized from 4.4 to 17.4 per cent of highly purified lignins in 30 days at 28° C. when the lignin concentrations were comparable to those found in lake waters.

The slowness of the decomposition of the dissolved organic matter may also be due in part to the low concentration of this material in the lake waters. In the four lakes included in this report, the range is from a minimum of 3.7 mg/1 in Weber Lake to a maximum of 12.5 mg/1, dry weight, in Lake Mendota; Nebish Lake yielded 7.3 mg/1 and Green Lake 8.4 mg/1. ZoBell (1940) states that many bacteria indigenous to natural waters can maintain themselves indefinitely when subcultured in lake water with less than 10 mg/1 of total organic matter, but this concentration seems to be in the neighborhood of their threshold of multiplication. He found also that the lower the concentration of the oxidizable material is, the more refractory it is to bacterial decomposition. It will be noted that three of the four lakes being considered in this report had less than 10 mg/1 of dissolved organic matter; only Lake Mendota exceeded that amount.

SUMMARY

1. The size of the standing crop of plants and animals in two soft water lakes is compared with that in two hard water lakes.

2. The plant crop in the two hard waters weighed three to five times as much as that of the soft water lakes. The soft waters had only about one-fourth as many species of large aquatic plants as the hard waters.

3. On an average the animal population of the hard waters, excluding the fish, weighed two to three times as much as that of the soft waters.

4. The ratio of the weight of the plants to that of the animals, excluding the fish, was 7.3 in one soft water lake and 7.5 in the other, while it was 12.1 in one hard water lake and 22.2 in the other. Thus the soft water lakes were approximately two to three times as efficient in converting their plant material into animals as the hard water lakes.

5. The ratio of other animals (food) to fish was 4.7 in one soft water lake and ranged from 3.0 to 11.1 in the other; the fish populations of the hard water lakes were not determined. The fish constitute a very small cap for the pyramid of life in the two soft water lakes as shown in the figures, making up 1.2 per cent in one and 2.5 per cent of the total weight of plants and animals in the other.

6. The dissolved organic matter, which is chiefly a degradation product, is much larger in the hard than in the soft water lakes.

Literature

Birge, E. A. and C. Juday. 1922. Inland lakes of Wisconsin: The plankton. I. Its quantity and chemical composition. Bull. 64, Wis. Geol. & Nat. Hist. Survey. 222 pp. Madison.

Birge, E. A. and C. Juday. 1926. Organic content of lake water. Bull. Bur. Fish. 42: 185-205.

Birge, E. A. and C. Juday. 1934. Particulate and dissolved organic matter in inland lakes. Ecol. Monog. 4: 440-474.

Conger, Paul S. 1939. The contribution of diatoms to the sediments of Crystal Lake, Vilas County, Wisconsin. Amer. Jour. Sci. 237: 324-340.

Couey, F. M. 1935. Fish food studies of a number of northeastern Wisconsin lakes. Trans. Wis. Acad. Sci., Arts & Lett. 29: 131-172.

Domogalla, B. P. and E. B. Fred. 1926. Ammonia and nitrate studies of lakes near Madison, Wisconsin. Jour. Amer. Soc. Agron. 18: 897-911.

Domogalla, B. P., E. B. Fred and W. H. Peterson. 1926. Seasonal variations in the ammonia and nitrate content of lake waters. Jour. Amer. Water Works Assoc. 15: 369-385.

Henrici, Arthur T. and Elizabeth McCoy. 1938. The distribution of heterotrophic bacteria in the bottom deposits of some lakes. Trans. Wis. Acad. Sci., Arts & Lett. 31: 323-361.

Juday, C. 1921. Quantitative studies of the bottom fauna in the deeper water of Lake Mendota. Trans. Wis. Acad. Sci., Arts & Lett. 20: 461-493.

Juday, C. 1924. Summary of quantitative investigations on Green Lake, Wisconsin. Revue ges. Hydrobiol. & Hydrog. 12: 2-12.

Juday, C. 1934. The depth distribution of some aquatic plants. Ecology. 15: 325.

Juday, C. and E. A. Birge. 1941. Hydrography and morphometry of some northeastern Wisconsin lakes. Trans. Wis. Acad. Sci., Arts & Lett. 33: 21-72.

Juday, C., E. A. Birge and V. W. Meloche. 1941. Chemical analyses of the bottom deposits of Wisconsin lakes. II. Second report. Trans. Wis. Acad. Sci., Arts & Lett. 33: 99-114.

Morrison, J. P. E. 1932. A report on the Mollusca of the northeastern Wisconsin lake district. Trans. Wis. Acad. Sci., Arts & Lett. 27: 359-396.

Muttkowski, R. A. 1918. The fauna of Lake Mendota: A qualitative and quantitative survey with special reference to the insects. Trans. Wis. Acad. Sci., Arts & Lett. 19: 374-482.

Potzger, John E. and Willard A. Van Engel. 1942. Study of the rooted aquatic vegetation of Weber Lake, Vilas County, Wisconsin. Trans. Wis. Acad. Sci., Arts & Lett. 34: pp. 149-166.

Rickett, H. W. 1922. A quantitative study of the larger aquatic plants of Lake Mendota. Trans. Wis. Acad. Sci., Arts & Lett. 20: 501-527.

Rickett, H. W. 1924. A quantitative study of the larger aquatic plants of Green Lake, Wisconsin. Trans. Wis. Acad. Sci., Arts & Lett. 21: 384-414.

Schnabel, Zoe Emily (Mrs. G. E. Albert). 1938. Estimation of total fish population of a lake. Amer. Math. Monthly. 45: 348-352.

Schuette, H. A. and Alice Hoffman. 1921. Notes on the chemical composition of some of the larger aquatic plants of Lake Mendota. I. Cladophora and Myriophyllum. Trans. Wis. Acad. Sci., Arts & Lett. 20: 529-531.

Schuette, H. A. and Hugo Alder. 1928. Notes on the chemical composition of the larger aquatic plants of Lake Mendota. II. Vallisneria and Potamogeton. Trans. Wis. Acad. Sci., Arts & Lett. 23: 249-254.

Schuette, H. A. and Hugo Alder. 1929. Notes on the chemical composition of some of the larger aquatic plants of Lake Mendota. III. *Castalia odorata* and *Najas flexilis*. Trans. Wis. Acad. Sci., Arts & Lett. 24: 135-139.

Schuette, H. A. and Hugo Alder. 1929. A note on the chemical composition of Chara from Green Lake, Wisconsin. Trans. Wis. Acad. Sci., Arts & Lett. 24: 141-145.

Steiner, John F. and V. W. Meloche. 1935. A study of ligneous substances in lacustrine materials. Trans. Wis. Acad. Sci., Arts & Lett. 29: 389-402.

Tarzwell, Clarence M. 1940. The fish population of a small pond in northern Alabama. Trans. Fifth No. Amer. Wildlife Conf. Pp. 245-251.

Twenhofel, W. H. and W. A. Broughton. 1939. The sediments of Crystal Lake, an oligotrophic lake in Vilas County, Wisconsin. Amer. Jour. Sci. 237: 231-252.

ZoBell, Claude E. 1940. Some factors which influence oxygen consumption by bacteria in lake water. Biol. Bull. 78: 388-402.

ZoBell, Claude E. and Janice Stadler. 1940. The oxidation of lignin by lake bacteria. Archiv f. Hydrobiol. 37: 163-171.

THE GROWTH, FOOD, DISTRIBUTION AND RELATIVE ABUNDANCE OF THE FISHES OF LAKE GENEVA, WISCONSIN, IN 1941*

MERLIN N. NELSON AND ARTHUR D. HASLER

The Lake Geneva Institute of Natural Science and Department of Zoology, University of Wisconsin

INTRODUCTION

A study of the fishes of Lake Geneva was undertaken in the summer of 1941 to determine something of their relative abundance, rate of growth, foods, and general habitat relations. It was hoped that this survey could be extended over a period of years and its results used as the basis of a fish management policy for the lake, but due to exigencies of war this is not possible and we have decided to release these findings.

Lake Geneva is the center of a popular and well developed summer resort area whose use may be expected to increase during the war period because it is less than a two-hour drive by train or car from Chicago. It is located in Walworth County, Wisconsin, has an area of 8½ square miles, a shore line of about 26 miles, and a maximum depth of 143 feet. The lake is about 9 miles long with the city of Lake Geneva near the east end, and the village of Williams Bay near the west end. The shores are mostly rocky. The zone of aquatic rooted vegetation extends out to a depth of 25 or 30 feet, consequently, in the summer most of the fish inhabit a very limited zone.

Most of the fish handled in this survey were taken along the north shore of the west half of the lake, extending from the "Narrows," near the center, to the west end. A large number of gill net sets were also made in the deeper parts of the lake and a few along the south shore.

Each of the three gill nets used was 125 feet long, five feet deep, and consisted of five 25-foot sections with a different mesh size for each section. The mesh sizes used were ¾, 1, 1¼, 1½ and 2 inches square. Most of the sets were on the bottom, although a number of sets were suspended at various depths. Two

* This study was made possible by a grant from Mr. Frank W. Schwinn, Williams Bay, Wisconsin. Prof. G. van Biesbroeck, Otto Schisling, Hanspeter Thomsen, and the Wisconsin Conservation Department gave aid in the conduct of the project.

methods were used in putting the nets out. For bottom sets, each end of the net was tied to a five-pound anchor from which a rope extended to a buoy at the surface. Other sets were suspended from the buoys with ropes, the length of which determined the depth at which the net was set. To prevent excessive sagging, three smaller buoys were attached to the top line of the net.

Five different sets were made with a fyke net. This net was hung on 7 frames (2 square frames and 5 hoops), 6 feet in diameter. From the middle of the first frame, a wing 90 feet long, 5 feet deep, and with 1 inch meshes extended into shore. The sets were all made at right angles to the shore and in water not exceeding 25 feet in depth. This net was very successful in the capture of bluegills, pumpkinseeds, and rock bass. Only an occasional northern pike or black bass was taken.

Upon removal from the nets, the fish were taken immediately to the field laboratory. Here scale samples were collected and records kept of the species, locality, standard length, weight, sex, gear, and date of collection of each fish. A representative number of stomachs for each species was preserved in formalin.

Net Fishing in Lake Geneva

Samples of the larger fish of Lake Geneva were taken with gill nets and a fyke net as described above. Gill net fishing was begun on July 1 and was continued until September 3. The nets were set only on week days because of the many fishermen and speed boats on the lake over week ends. Table I shows the numbers and kinds of fish taken at different depths with the gill nets. Cisco (*Leucichthys artedi*) made up 62 per cent in numbers of the total catch and northern pike (*Esox lucius*) was second, contributing 18 per cent. The smallmouth bass (*Micropterus dolomieu*) furnished 6 per cent. Other kinds were taken in still smaller numbers, notably white bass (*Lepibema chrysops*). In

TABLE I. Number of fish caught in gill nets at different depths.

Species	No. of Fish	Depth in Feet											
		10	20	30	40	50	60	70	80	90	100	110	120
Northern Pike	76		11	25	34	6							
Largemouth Bass	8		5	2	1								
Smallmouth Bass	26		6	11	8	1							
White Bass	18			2	12	4							
Yellow Perch	9		4	1		2	2						
Rainbow Trout	2						2						
Cisco	233			7			16	49	102	35	18	6	0
Rock Bass	25												

addition to these fish a black bullhead (*Ameiurus melas*) and one common sucker (*Catostomus commersonnii*) were taken.

When the nets were set in water more than 60 feet deep, only cisco were caught. In the shallower water it is likely that the net catches do not give more than a very rough estimate of the relative abundance of the different kind. This selectivity arises from two principal causes. (1) In order to be caught a fish must move into the net under its own power and gill nets like all other stationary tackle are more likely to catch those kinds which move more actively than those which are more sedentary in habit; (2) certain fish avoid capture by being more wary (largemouth bass, *Huro salmoides*), or are less easily entangled by lacking spines or projections.

The catch per 24 hours of gill net fishing for each mesh size is given in Table II. The total number of hours of gill net fishing for both cisco and all other fish caught was 1096. Since cisco were taken almost exclusively where the water depth was 50 feet or more and the other fish in depths of less than 50 feet, the number of hours of fishing done in each area was taken and the catch per day determined.

TABLE II. Average catch per gill net per 24 hours and the number of fish caught by gill net fishing. July-August, 1941.

Mesh	Cisco	Northern Pike	Smallmouth Black Bass	Rock Bass
¾	3.46 (69)	.22 (5)	.10 (2)	
1	11.95 (239)	.65 (15)	.14 (3)	.10 (2)
1¼	.65 (13)	1.30 (30)	.24 (6)	.53 (12)
1½	.10 (2)	1.30 (30)	.17 (4)	.58 (13)
2	.19 (4)	.70 (16)	.65 (15)	.14 (3)
Total	16.35 (327)	4.17 (96)	1.30 (30)	1.35 (30)

Number of hours fished for cisco = 480; for all others, 550.
The numbers in parentheses = number of fish caught in each mesh.

The fyke net catches consisted principally of pan fish taken between depths of 10 and 30 feet. Rock bass (*Ambloplites rupestris*) composed 81 per cent (191 specimens) of the total catch, bluegills (*Lepomis macrochirus*) 13 per cent (30 specimens), and pumpkinseeds (*Lepomis gibbosus*) 7 per cent (14 specimens). Rock bass were caught at the rate of 48 per 24-hour net setting; bluegills, 8 and pumpkinseeds, 3.5.

FOOD

Northern pike—Stomachs examined: 96; number containing food: 27. Length: 12.3-35.2 inches; average 19.2. Stomachs of the larger n. pike contained cisco almost exclusively. Of 14 specimens weighing from 3 to 10 pounds, 13 contained cisco exclusively and 1 contained mimic shiners exclusively. The stomach contents of 13 smaller n. pike, weighing from 1¼ to 3 pounds, was more varied. In 7 stomachs, only cisco and mimic shiners were found, however, the other 6 contained 3 yellow perch (*Perca flavescens*), 1 smallmouth bass, 1 rock bass, 1 unidentified centrarchid, and 1 crayfish.

Smallmouth bass—Stomachs examined: 28; number containing food: 17. Length: 5.1-13.1; average 8.9 inches. Mimic shiners were found in 9 stomachs, unidentified fish remains in 2 and crayfish in 9 stomachs.

Largemouth bass—Stomachs examined: 8; number containing food: 3. Length: 7.6-12.8; average 9.3 inches. Mimic shiners were found in 1 stomach and crayfish in 2 stomachs.

White bass—Stomachs examined: 19; number containing food: 10. Length: 10.4-16.7; average 12.2 inches. Black bass sp. were found in 2 stomachs, mimic shiners in 6 and crayfish in 4 stomachs.

Yellow perch—Stomachs examined: 11; number containing food: 6. Length: 5.1-7.4; average 6.1 inches. A smallmouth bass was found in 1 stomach, mimic shiners in 4 and midge larvae in 1 stomach.

Rock bass—Stomachs examined: 47; number containing food: 24. Length: 3.7-9.3; average 6.0 inches. Black bass sp. were found in 4 stomachs, mimic shiners in 8 and crayfish in 14 stomachs.

Bluegills—Stomachs examined: 9; number containing food: 6. Length: 4.3-7.7; average 5.8 inches. Aquatic vegetation (*Chara*) occurred in 5 stomachs, insects (midge larvae, mayfly and stonefly naiads, insect fragments) in 3, and snails in 1 stomach.

Cisco—Stomachs examined: 35; number containing food: 32. Length: 5.8-9.4; average 8.3 inches. Copepods and cladocerans constituted the most important part of the contents of the stomachs analyzed. An average number of 983 copepods was found in each of the 27 stomachs in which they occurred and an average of 599 cladocerans (water fleas) were counted in 24 stomachs. Midge larvae occurred in 15 stomachs, insects (mayfly and stonefly naiads and adult insect fragments) in 4, snails in 1 and aquatic vegetation (*Chara*) in 1 stomach.

Growth

Ages were determined for only 50 of each of the total number of n. pike, rock bass and cisco taken. The number of specimens caught of each species was divided into one half inch length frequencies and the scales of a proportionate number of specimens from each length frequency was selected for age determinations. By a simple proportion, the number of fish belonging to each age group was determined. Age determinations were made for all of the scale samples collected from the smallmouth bass, white bass, and bluegills since the number of each species from which scales were collected was small.

Northern Pike—(See Table III-A.) A legal length of 18 inches is attained by many during their 2nd year of life and by all early during their 3rd year. Van Engel (1940) reported a similar growth rate for other lakes of southern Wisconsin. In northern lakes, however, he found that the legal length is not reached until after the 3rd and 4th years of life. Eighty-six per cent of the total number of n. pike caught had attained 18 inches of length or over. Sixty per cent of all of the specimens were in their 3rd year of life or belonged to the 1939 year class.*

A weight of 1.2 pounds was attained at 18 inches of length. The largest specimen weighed 14 pounds, measured 39.8 inches total length and was in its 8th year of life.

Smallmouth bass—(See Table III-D.) The legal length of 10 inches is attained by some of the smallmouth bass late in the 3rd year of life, by all in the 4th year. The average growth rate of smallmouth bass in 19 Wisconsin lakes and 1 river was reported by Bennett (1938) to be such that a legal length of 10 inches was attained during the 4th year.

* Fish hatched in 1939.

TABLE III. Numerical representation of year classes of fish taken in 1941.

Year class	1940	1939	1938	1937	1936	1935	1934	1933
Age Group	I	II	III	IV	V	VI	VII	VIII
A. NORTHERN PIKE No. aged	13	32	2			2	1	
Estimated number in year class	28	58	4			2	1	
Mean standard length at capture	14.1	20.2	21.9			32.4	35.2	
B. CISCO No. aged	8	30	7	4	1			
Estimated number in year class	43	162	38	22	5			
Standard length at capture	6.4	8.3	8.9	9.5	9.5			
C. ROCK BASS No. aged		1	9	14	16	8		2
Estimated number in year class		4	40	62	71	35		9
Standard length at capture		3.7	4.6	5.8	6.8	7.7		9.3
D. SMALLMOUTH BASS No. aged	2	17	5	4				
Standard length at capture	4.5	8.0	9.0	12.1				

*Standard length is from tip of nose to end of vertebral column.

Thirty-two per cent of the smallmouth bass caught were of legal length or over. As was the case with n. pike the 1939 year class was the strongest of the group since 61 per cent belonged to this class and had attained an average standard length of 8 inches by 1941. This was further verified by Thomsen (1941) who observed in a two weeks' creel census that 50 per cent of the smallmouth bass caught by anglers were less than 10 inches long.

White bass—A legal length of 7 inches is attained by some of the white bass during the 2nd year of life and by all during the 3rd year. Although no specimens less than two years old were captured, each of the single specimens caught during their 3rd and 4th years of life had attained standard lengths of over 10 inches. Most of the specimens belonged to the 1935 year class (Age Group VI) and had attained a standard length of 12 inches.

The largest specimen caught had reached a standard length of 12.7 inches, weighed 1.43 pounds and was in its 8th summer of life.

Rock bass—(See Table III-C.) A legal length of 7 inches is attained by rock bass during their 5th and 6th years of life. In Nebish Lake, Wisconsin, this length is reached some time during the 9th year of life (Hile, 1941).

Sixty per cent of the rock bass caught belonged to the 1936 and 1937 year classes. Eighty per cent of the total number were of legal length or over. Thomsen (loc. cit.) reported that of 293 rock bass caught by anglers during the period of his creel census, 79 per cent were of legal length or over.

Bluegills—A legal length of 6 inches is attained during the 4th year of life. Eighty-three per cent of the number caught were of this length or over. The 1938 year class was the strongest group in the catches. A similarly high percentage of legal fish caught by anglers was reported by Thomsen. Of 270 bluegills caught, 80 per cent were of legal size.

Cisco—(See Table III-B.) A length of 10 inches is reached during the 3rd year of life. Eighty-four per cent of the number caught were of this size or over. Sixty per cent of the total number taken belonged to the comparatively strong 1939 year class. The growth rate of cisco in Lake Geneva exceeds that of cisco in three other Wisconsin lakes, as determined by Hile (1936) (Muskellunge, Trout, and Silver Lakes); however, is not as rapid as that of Clear Lake in which the cisco are nearly 1.5 inches longer than the ones of Lake Geneva at the end of the 3rd summer of life.

Distribution

Net settings varied from 10 to 110 feet in depth. Because of the many fishermen and speedboats, the nets were always set at least 5 feet below the surface to prevent damage to them by motor boats. Consequently no catches were made in depths of less than 5 feet, and as a result data for the fish occurring in the shallower water is lacking. Distribution of the fishes is based entirely on the gill net catches. This is given in Table I for each species caught with the exception of bluegills, pumpkinseeds, a single black bullhead, and a single common sucker. Sufficient samples of these species were not taken to warrant including them in the distribution table.

Oxygen determinations were made from water samples taken at 15-foot intervals down to a depth of 100 feet or well into the hypolimnion. At this depth the oxygen concentration in late July was 5.7 mg./1. or sufficiently high to support fish life.

Northern pike—N. pike occurred most frequently in depths of 20 to 40 feet. Within this depth range much variation in size of the fish was noted. Beyond the 40-foot depth the specimens caught weighed 3 pounds or more, while with few exceptions the smaller n. pike were taken between depths of 10 and 20 feet.

It is probable that the n. pike taken at depths greater than 40 feet had foraged out from the somewhat shallower water in search of cisco which were observed to comprise the sole diet of all n. pike that weighed 3 pounds or over.

Black bass—Smallmouth bass were taken most frequently between depths of 20 and 30 feet, although the catches indicate that they range quite freely between depths of 10 and 40 feet. Only one fish was taken beyond the 40-foot depth, although Pearse (1921) reported them as deep as 85 feet. Seven of the largemouth bass caught were taken between the 10 and 30-foot depths and one between 30 and 40 feet. This number is too small, however, to give a reliable indication of their distribution. Hook and line fishing for this species is superior to nets. Thomsen reported 228 in his 1941 creel census.

White bass—White bass were taken most frequently between depths of 30 and 40 feet, although ranging out to 50 feet.

Yellow perch—Yellow perch exhibited the greatest diversity of habitat. Although only 11 yellow perch were caught they occurred in depths ranging from 10 to 60 feet. Pearse (loc. cit.) reported their occurrence to almost twice this maximum depth or between 115 and 120 feet.

Rock bass—Rock bass occurred most frequently out to a depth of 30 feet, although they were caught in small numbers between 30 and 40-foot depths. According to Pearse, they have occurred at 65 feet.

Cisco—Cisco were taken almost exclusively in the deep waters. Eighty per cent of the total catch was taken between 60 and 90 feet, and 90 per cent between 60 and 110 feet. No cisco were caught in any set beyond a depth of 110 feet. One catch of 5 cisco was made at a depth of 21 feet. Although numerous other sets were made between 20 and 50 feet, no more cisco were caught above the low limit of 50 feet. The temperature at this level was 10.8° C. in late July. The temperature of the water where the greatest numbers were caught was 6.6° C.

Relative Abundance

The relative abundance of 8 species of the game and pan fish based on the gill net catches is given in Table II. From this it may be seen that cisco is the most abundant species in the lake, while n. pike, rock bass and smallmouth bass made up 77 per cent of the game and pan fish catch. A creel census by Thomsen (loc. cit.) showed that these three species made up 67 per cent of the total number of fish caught by anglers in mid-August, 1941. The relative abundance of the rock bass, bluegills and pumpkinseeds is better shown by the fyke net catches.

Although Thomsen's creel census showed that only slightly more rock bass were caught than bluegills, it is evident from all of the information gathered that the ratio is well in favor of the rock bass. White bass although not reported by Thomsen are common, while yellow perch, largemouth bass, pumpkinseeds and rainbow trout constitute a minor part of the game and pan fish population. Gar and carp were not caught, however both were reported present by local residents and anglers.

It is interesting to compare the results of this survey with those of Pearse whose survey of Lake Geneva was made 21 years ago. Listed in the order of their abundance, based on gill net catches, the following species were reported by Pearse: yellow perch, rock bass, smallmouth bass, cisco, walleyed pike (*Stizostedion vitreum*), common sucker, n. pike, bluegills, pumpkinseeds, largemouth bass, and brook trout.

Since Pearse's report, yellow perch have declined until they are among the least abundant species present. Walleyed pike have almost completely disappeared in spite of a very heavy artificial propagation program. None was caught in the gill or fyke nets, Thomsen did not report any in his creel census and many of the older fishermen and fish guides have reported only an occasional walleyed pike caught during the past 12 years.*

*Scales from a confiscated walleye were sent to us by Mr. R. E. Johnson of Williams Bay. It was 10 years old and had grown very little in the past 4 years. He estimated it measured 34 inches and weighed 9 lbs.

N. pike on the other hand are now the most abundant of the game fish, although Pearse reported them less abundant than either smallmouth bass or walleyed pike. Bluegills have at least held their own and may have increased somewhat. The rock bass, smallmouth bass, largemouth bass and pumpkinseeds appear to have remained more nearly constant in relative abundance. White bass although not reported by Pearse are common. No brook trout were taken in the present survey, however two rainbow trout were taken and these were not recorded by Pearse (Mr. R. E. Johnson has reported good spawning runs in Williams Bay Creek). Thomsen reported a small number of crappies caught by fishermen, although none was recorded by Pearse nor were any caught in our nets. Pearse stated that the shiner minnows, *Notropis hudsonius,* were present in small numbers. No minnows of this species were observed by the writers, however the mimic shiners, *Notropis volucellus volucellus,* were extremely abundant.

Lake Management

Lake Geneva is particularly fortunate in not having a large population of rough fish. Measures taken to maintain good fishing can therefore be confined to attempts to establish favorable ratios among the game and pan fish with the dominant species consisting of the most desirable game and pan fish. With the exception of cisco, rock bass and northern pike were the most abundant species present. Rock bass compete directly with the smallmouth and largemouth bass for food and prey upon them to an undetermined extent. N. pike, if allowed to become too abundant, are likely to compete with the black bass and prey upon them more heavily than they are now doing.* Therefore the following recommendations for the control of these *two* species are made for a definite test period.

(1) No closed season.

(2) No bag limits.

(3) Removal of any legal size limits.

Further pertinent questions which should be answered before a sound lake management policy can be formulated are:

(1) An intense creel census taken throughout the summer. Extended over a period of years this would show the fluctuations in the numbers of fish of each species caught by anglers, the adequateness of existing fishing regulations and the effect of

* Moreover, rock bass and n. pike are sufficiently abundant to permit heavier exploitation.

measures taken to increase or decrease the abundance of any particular species.

(2) Comparison between net and hook and line fishing to arrive at a closer estimate of the population of each species.

(3) Further stomach analysis particularly of the game fish and of rock bass to determine the degree of intercompetition for food and of predation.

(4) Close observations during the spawning season to determine the degree of success attained by each species in reproducing themselves.

Discussion

Food, Growth and Distribution

Mimic shiners, crayfish and cisco were the principal sources of food for the game fish and rock bass in Lake Geneva. While mimic shiners occurred in some of the stomachs of each of the species of game fish and of rock bass examined, cisco occurred only in the stomachs of the n. pike, and with one exception formed the complete food diet of n. pike weighing over 3 pounds. Game and pan fish were found in the stomachs of the smaller n. pike, white bass, rock bass and yellow perch. Aquatic vegetation *(Chara)* was found in most of the bluegill stomachs analyzed. This plant was quite abundant in Lake Geneva, occurring as deep as 30 feet. Copepoda, cladocera and midge larvae, in the order listed were the most important food items found in the stomachs of the cisco. Mayfly and stonefly naiads, adult insects and snails made up a minor portion of the stomach contents.

Growth of the game and pan fish in Lake Geneva exceeded the average growth rate, as found by other workers, for fish in many Wisconsin lakes, and compared well with all of them. Due to the restricted habitat of the smaller game and pan fish particularly a high degree of competition for food existed between the young fish of all species, and the growth was relatively slow. By the end of the second year of life, however, most species attained sufficient size to feed freely upon the mimic shiners, crayfish, and cisco with a resulting increase in the rate of growth. At present the abundance of mimic shiners and cisco insures a good food supply.

It is noteworthy that there was an exceptionally good hatch of fish (see Table III) of several species in 1939 since they made up a strong year class in the 1941 captures. It would be interesting to study the re-occurrence of strong year classes and attempt to correlate them with phenomena controllable by management policies.

SUMMARY

1. Northern pike, smallmouth bass and rock bass are the three most abundant game and pan fishes in Lake Geneva.
2. The game fish habitat during July and August is restricted to a narrow belt around the shore constituting about 15 per cent of the total lake area.
3. Good growth was made by all of the game and pan fish in Lake Geneva.
4. Crayfish, cisco, minnows and plankton constitute the chief sources of food.
5. Competition for food is probably strongest between the white bass, rock bass, and black bass.
6. The 1939 year class of smallmouth bass, northern pike and cisco was the largest of the year classes represented in the 1941 catch.
7. Walleyed pike have become very scarce during the past twenty years, as have yellow perch. Northern pike have become an abundant game fish in Lake Geneva.
8. In the summer months cisco occur almost exclusively beyond the fifty-foot depths, while only occasional game and pan fish were taken beyond this depth.
9. A longer open season, removal of bag and size limits for rock bass and northern pike are recommended for a definite test period.

BIBLIOGRAPHY

Bennett, G. W. 1938. Growth of the smallmouthed black bass, *Micropterus dolomieu* Lacepede, in Wisconsin waters. Copeia, 1938: 157-170.

Hile, R. 1936. Age and growth of the cisco, *Leucicthys artedi* (Le Sueur), in the lakes of the northeastern Highlands, Wisconsin. U. S. Bur. Fish. Bull. 48: 211-317.

Hile, Ralph. 1941. Age and growth of the rock bass, *Ambloplites rupestris* (Rafinesque), in Nebish Lake, Wisconsin. Trans. Wis. Acad. Sci. Arts & Lett. 33: 189-337.

Pearse, A. S. 1921. The distribution and food of the fishes of three Wisconsin lakes in summer. Univ. of Wis. Studies in Science No. 3, Madison.

Thomsen, H. P. 1941. Analysis of game fish catch in Lake Geneva. Released by: Geneva Lake Property Owners Association.

Van Engel, W. A. 1940. The rate of growth of the northern pike, *Esox lucius* Linnaeus, in Wisconsin waters. Copeia, 1940: 177-188.

STUDY OF THE ROOTED AQUATIC VEGETATION OF WEBER LAKE, VILAS COUNTY, WISCONSIN*

J. E. POTZGER, BUTLER UNIVERSITY

WILLARD A. VAN ENGEL, UNIVERSITY OF WISCONSIN

The region of northern Wisconsin of which Vilas county constitutes a prominent part is pitted with numerous depressions or kettle holes as evidence of the activity of late Wisconsin glaciation. Many of these depressions have been and are now lakes, the most representative of which in the county is Trout Lake. Extensive studies have been made over a number of years, involving most of the larger bodies of water in that region, by members of the Wisconsin Geological and Natural History Survey. The investigations included not only the flora and fauna but also such physical features of the water as penetration of light, acidity, gas content, and others. The present study of Weber Lake is one of a series of investigations made over a period of years. They are planned by Doctor C. Juday, director of the Limnological Laboratories at Trout Lake. Weber Lake is located about three miles east of Trout Lake along highway N, in T. 41 N., R. 7 E., Sec. 28. The last section of Figure 1 shows the general outline of the small lake, comprising only 15.61 ha., with a shoreline of 1.6 km., and water totalling approximately 1,132,900 cu.m.

HISTORY AND CHARACTERISTICS OF THE LAKE

Weber Lake has for several years been closed to fishing because of extensive continued studies on fish population by members of Wisconsin Geological and Natural History Survey. During the year 1940 the water level was considerably higher than it had been in 1935, when a similar study of the vegetation was made by L. R. Wilson. Water now covers completely a former wide shoreline up to the shrub zone of the water-free beach line. Outside of a small, muddy bay-like indentation at the southeastern end of the lake, the shore is sandy and easily accessible. The bottom consists of fine quartz sand which is covered by a comparatively thin layer of black sediment even twenty to thirty

* This is contribution 123 from the Botanical Laboratories of Butler University, Indianapolis, Indiana, and reports 106 of the Limnological Laboratory of the Wisconsin Geological and Natural History Survey, University of Wisconsin.

Fig. 1. Showing 29 transects with 16 two-meter sampling stations at each, and location along the shore.

A. *Gratiola lutea* f. *pusilla*
B. *Juncus pelocarpus* f. *submersus*
C. *Sparganium angustifolium*
D. *Carex sp.?*
E. *Elatine minima*
F. *Myriophyllum tenellum*
G. *Isoetes macrospora*
H. *Eriocaulon septangulare*
I. *Lobelia Dortmanna*

Figures in squares indicate sampling station and amount of plant material taken of a given species

1. ¼ gram or less
2. ¼ to ½ gram
3. ½ to 1 gram
4. 1 to 2 grams
5. More than 2 grams

1

	A	B	C	D	E	F	G	H	I	Depth M
1	1	1								½
2		3							1	¾
3		3								1
4	1	4	3							1¼
5	1	4	2		1					½
6	2	3			1					1⅝
7	2	2			1					1¾
8	1					5	4		1	2⅕
9	1					4	1			2½
10							2			3¼
11							1			3½
12										4⅝
13										
14										
15										
16										

2

	A	B	C	D	E	F	G	H	I	Depth M
1		2								½
2	1	5								¾
3	4	4			1					⅞
4	1	4	5		1					1⅛
5	3	3	4		4			2		1⅛
6	2	2			3		1			1⅜
7	2				3					1⅝
8	2					3	2		2	1⅞
9	1					1	1			2⅛
10							1			2¼
11							1			3
12							1			3¼
13										
14										
15										
16										

3

	A	B	C	D	E	F	G	H	I	Depth M
1				4						½
2	1	1				3	4			¾
3	3	4			1					⅞
4		3			1		1		1	1⅛
5	1	1			3					1¼
6	4	1			2		2			1½
7	1	1			2					1½
8	1	1				2	2			1⅞
9	1					4				2⅛
10						1				2½
11										2¾
12										
13										
14										
15										
16										

4

	A	B	C	D	E	F	G	H	I	Depth M
1		1								½
2	1	4						1		⅞
3	1	1			1			1	1	1⅛
4	1	1			2					1¼
5	1				4		2			1⅜
6					3		1			1½
7	2						2			1¾
8							2		1	2
9										2¼
10							1		1	
11							1			3
12										3⅛
13										
14										
15										
16										

5

	A	B	C	D	E	F	G	H	I	Depth M
1		1								½
2	1	4								¾
3	3	2								⅞
4		2	1		2		1			1⅛
5	2	1			2			1		1¼
6	1				2					1½
7					1		1			⅝
8	1					3	1		1	1¾
9	2					3	1			1⅞
10	1					2	1		1	2
11	1					1	2		1	2⅛
12										2¼
13						1	1		1	2½
14		1					1			2⅞
15										4⅞
16										

6

	A	B	C	D	E	F	G	H	I	Depth M
1		1								½
2	2	4					1			⅞
3	1	4			2					1
4	1	2	5		3					1⅛
5	1				4					1⅜
6	1				1					1½
7	1				1	3	2			1⅝
8	2					4	1			1¾
9	1					3	1		1	1⅞
10	1					3	1			2
11	1					4	2		1	2¼
12							5			2¼
13						4	5		1	2⅜
14						3			1	2½
15							1			2¾
16										3½

7

	A	B	C	D	E	F	G	H	I	Depth M
1	1	4								⅝
2	3	3								⅞
3	1	5	1		2					1
4	1				2					1¼
5	1				2		1			1½
6	3					4	2			1⅝
7						3	2			1⅞
8	1					3	1			2
9	1					3				2⅛
10						3	1		1	2⅜
11							1			2⅝
12							1			2½
13						2	1			2⅞
14						2				3
15										3⅝
16										

8

	A	B	C	D	E	F	G	H	I	Depth M
1	2	3								⅝
2	2	4			1					1
3		3	3		3					1⅛
4	1	1			4					1⅜
5	1				1		1			1½
6		1								1¾
7	1	1					1			1⅞
8							1			2⅛
9							1			2¼
10							1			2¼
11							1			2½
12							1			2⅜
13										2⅞
14										
15										
16										

9

	A	B	C	D	E	F	G	H	I	Depth M
1	1	4								⅝
2	3	5			1					⅞
3	1	1			1					1⅛
4		1			2					1¼
5	2				1					1½
6	1					3	1			1⅝
7	1					4	2		1	1¾
8	1					3	1		1	1⅞
9	1		1			3	1		1	2
10	1					3	1			2⅛
11	1					4	1		1	2¼
12						2	1			2¼
13						1	1			2½
14							3			2⅝
15							1			2¾
16							1			2⅞

10

	A	B	C	D	E	F	G	H	I	Depth M
1										
2	1	4								⅞
3	1	4			1					1
4	1				3					1¼
5		1			1					1⅜
6	2				1	3	1		1	1½
7	1				2	5	1			1⅝
8	2					2	1			1¾
9	2					3	1			1⅞
10	1									2
11										2
12										2¼
13										2⅜
14										2⅜
15										2¾
16										

11

	A	B	C	D	E	F	G	H	I	Depth M
1			2							½
2	3	4	1					1		⅞
3	4	1								1
4	1	4			3	1	1			1⅛
5	1	1			4		1	1		1¼
6					1	1				1⅜
7	3					4	1		1	1½
8	3					3	1		1	1⅝
9	1					1	2			1¾
10	1						1			2
11							1			2¼
12							1			2¼
13							1			2⅜
14										2½
15										
16										

12

	A	B	C	D	E	F	G	H	I	Depth M
1		2	2							½
2	2	4								⅞
3	1	1	1		2					1
4	4	1			1				1	1⅛
5	1	1			1					1⅜
6	1					4			1	1½
7	1					4	1			1¾
8	1					3	1			1⅞
9						3	1			2
10						3	1			2⅛
11						3	1		1	2¼
12							1			2½
13							1			2⅝
14										2¾
15										
16										

13

	A	B	C	D	E	F	G	H	I	Depth M
1										½
2	2	5				1		2		⅞
3	1				4					1⅛
4	4	1			1					1¼
5	1				1					1⅜
6	1				1	4			1	1½
7	1					5				1⅝
8	1				3	4	1		1	1¾
9	1					4			1	1⅞
10	1					4			1	2⅛
11						2			1	2⅜
12										2¾
13										
14										
15										
16										

14

	A	B	C	D	E	F	G	H	I	Depth M
1	1	1								½
2			2							1
3	3	3	2		2					1
4	1	4			1					1⅛
5	3	2			1		1			1¼
6	2	1			1	3				1⅜
7	2				1	3	1		1	1½
8	1				1	4			1	1⅞
9	1					4	1			1¾
10	1	1				4	1		1	2
11						3	3		1	2½
12						1	1			2¾
13										3¼
14										
15										
16										

15

	A	B	C	D	E	F	G	H	I	Depth M
1								3		⅝
2	3	4						4		⅞
3	1	1			2			1		1
4	3	1			1					1¼
5	2	1			3					1¼
6	2	1			1	3				1⅜
7	1					5	2			1⅝
8	1					4	1		1	1¾
9	1					2	2		1	1⅞
10	1					2	1			2
11	2					2	1		1	2¼
12						1	1			2½
13										2⅞
14										
15										
16										

16

	A	B	C	D	E	F	G	H	I	Depth M
1		3								⅝
2	5	5								⅞
3	2	4						1		⅞
4	1	1	3	1	1					1⅛
5	1	2			4					1¼
6	2		1		1	3				1¼
7	1	1				4	3			1½
8	1					4	2			1⅝
9	1					4				1⅝
10	3						4		1	1⅝
11	1					2	2			1⅞
12	1					2	2			2¼
13							1			2⅝
14										
15							1			4¼
16										4⅞

17

	A	B	C	D	E	F	G	H	I	Depth M
1			1							½
2	4	3						1	1	⅞
3	2	3			1		1			1
4	1	1	4		2					1⅛
5	2	4			2		1			1¼
6	1	3	1		3	2	1	1		1⅜
7	2	1			1	4	3			1½
8	2	1				4	3			1⅝
9	1					4	1		1	1¾
10	1					3	1		1	2
11						4	3		1	2½
12						4	4			3
13						2	1			3½
14							2			4⅛
15										4⅞
16										

18

	A	B	C	D	E	F	G	H	I	Depth M
1										¾
2										1
3	1	1			1	1				1⅛
4	2	1			1					1¼
5	3				1	2	3		1	1½
6		1			1					1⅜
7	1					3	3			1⅝
8	1					4				1¾
9	1					2				1⅞
10	1					1	4		1	2
11							1		1	2½
12							1			3⅛
13										3⅝
14										
15										
16										

19

	A	B	C	D	E	F	G	H	I	Depth M
1										½
2		1								1
3		1								1⅛
4		1			1					1⅛
5	2				1		1			1⅜
6	2				1		1			1½
7	1	1				4	1		1	1¾
8	1					3	2		1	2
9						1	2			2¼
10						4	4			2⅝
11							1			3¼
12							1			3¾
13										4
14										
15										
16										

20

	A	B	C	D	E	F	G	H	I	Depth M
1		5								¾
2	4	3			1					⅞
3	1	2			3					1⅛
4	1	3	3		4					1¼
5	3	1			4		2			1½
6	1				1	3	1			1⅝
7						5	5			2
8						1	5		1	2⅜
9							5			3⅜
10							3			4⅛
11										4¾
12										
13										
14										
15										
16										

21

	A	B	C	D	E	F	G	H	I	Depth M
1										½
2	1	3								¾
3	5	5			1					⅞
4	1	1			2				1	1⅛
5	1	1			4		2			1¼
6	1	1			3		1			1½
7	1					4	3		1	1¾
8	1					5	2			2
9						1				2½
10							1			3
11							5			3⅝
12										4
13										
14										
15										
16										

22

	A	B	C	D	E	F	G	H	I	Depth M
1	1	2						1		¾
2		1			1					1
3	1	1			1					1¼
4		1			4					1⅜
5	1	1			1	1	1			1½
6	2					4	3		1	2
7	1					3	2		1	2⅛
8						2	2		1	2⅝
9							4			3⅛
10							2			3⅜
11										4¼
12										
13										
14										
15										
16										

23

	A	B	C	D	E	F	G	H	I	Depth M
1	2	3								⅝
2	3	2					1			¾
3	1	4		2	2					1
4	2	3	1		3			3		1⅛
5	1	3			4					1¼
6		2			3					2½
7	2	1			1		5			2⅜
8	1	3			1					2⅞
9					1		4			2¼
10										3
11							1			2⅝
12							1			3⅝
13							1			4¼
14										4⅝
15										
16										

24

	A	B	C	D	E	F	G	H	I	Depth M
1		3								¾
2	2	3								⅞
3	1	1			1					1
4	1	1	1		2					1¼
5					5					1⅜
6	1	1				2	2		1	1⅝
7						2	4		1	1⅞
8							1			2⅛
9							1			2¾
10							2			3⅜
11		1								3⅞
12										4⅜
13										5
14										
15										
16										

25

	A	B	C	D	E	F	G	H	I	Depth M
1	2	3								¾
2	1	1			1					1
3	2	1			1					1⅛
4	2		3		3					1¼
5	2				1	3	2		1	1½
6	2					2	2		2	1½
7	1		1			4	1		1	1⅝
8	1					4	2		1	1¾
9	1					1	1			2
10	1						2		1	2¼
11							2			2⅝
12							1			3¼
13							1			3⅜
14							1			4⅜
15										5
16										

26

	A	B	C	D	E	F	G	H	I	Depth M
1	1	1			1					¾
2	1	1			1					1⅛
3	1				1	1				1¼
4	1				1					1¾
5	2				1	4	1		1	1½
6	2					3	1			1¾
7	2	1				4	1			1⅞
8						1	5			2½
9							4			3
10							1			
11							1			4
12							1			2½
13										5½
14										
15										
16										

27

	A	B	C	D	E	F	G	H	I	Depth M
1	1	5			1					¾
2	4	5								⅞
3	4	4			1		1	2		1
4		3	3		1					1⅛
5		3	5		1					1¼
6		1			1					1½
7	1	1			1					1¾
8						1	4		1	2½
9						2	1		1	2¾
10							5			3½
11							5			4
12										4⅝
13										
14										
15										
16										

28

	A	B	C	D	E	F	G	H	I	Depth M
1		1								¾
2	1	3			1		1	3		1
3	2	2			1					1⅛
4	1	1			1	1		1		1⅜
5		1	1				1			1½
6	1					1	5			1⅞
7	1					3	4	1	1	2
8						5	1			2⅜
9							1			3
10										3⅜
11										
12										
13										
14										
15										
16										

29

	A	B	C	D	E	F	G	H	I	Depth M
1		2	1					1		½
2	1	2						1		¾
3	2	2		1				2		1
4	1	2	2		1					1⅛
5		1	4		3			3		1⅜
6	2	2	4		3		1			1½
7	1	1	1				3			1¾
8	1					2	3			1⅞
9	1	1				4	4			2
10	2					4	4		1	2¼
11						3	1			2⅝
12						2	1			3¼
13							3			3⅜
14										4⅜
15										
16										

meters from the shore. There is one exception to this general condition at the southern and southeastern shoreline where the floor consists chiefly of densely-packed gravel.

Cultural Influences

Weber Lake has for years been free of the modifying activity of campers and fishermen, but scientific experimental studies involved the addition of fertilizer to the water as follows: 1932—750 pounds of superphosphate; 1933—500 pounds superphosphate, and 2,000 pounds of lime; 1934—500 pounds of superphosphate, 1,300 pounds of lime, 900 pounds of ammonium sulphate; 1935—1,000 pounds muriate of potash (July), 1,200 pounds cyanimid (August); 1936—3,000 pounds soybean meal; 1939—2,000 pounds cotton seed meal. The aim was to increase plankton life and indirectly the productivity of the fish in the lake. If the experiment succeeded in this aim, one might expect a modified penetration of light to the bottom in 1940 as compared with 1932.

Gross Characteristics of the Rooted Aquatic Plants*

The vegetation is made up of eight species, viz., *Gratiola lutea* forma *pusilla* (Fassett) Pennell, *Juncus pelocarpus* forma *submersus* Fassett, *Sparganium angustifolium* Michx., *Elatine minima* (Nutt.) Fisch. & Meyer, *Myriophyllum tenellum* Bigel, *Isoetes macrospora* Dur., *Eriocaulon septangulare* With., *Lobelia Dortmanna* L., and a sedge-like species (Fig. 2). Only Sparganium has vegetative parts rising to the surface of the water, all others are small, submerged plants, none more than four cm. in height (this characterization is not correct with respect to observations made in 1941). Sparganium grows in intermittent colonies, totalling 76 for the whole lake, one of these comprising a large bed approximately 50 meters in extent.

Methods

Plan of Sampling

The problem of studying an adequate number of quadrats, sufficiently representative in area to warrant basing conclusions on them with respect to sociological and quantitative factors applying to the vegetation as a whole is not easily solved by estimate. A preliminary sampling survey showed that the vegetation complex is comparatively simple, for only eight species play a prominent part, and their distribution is uniformly the

---

* The nomenclature is that of Fassett's Manual of Aquatic Plants, 1940.

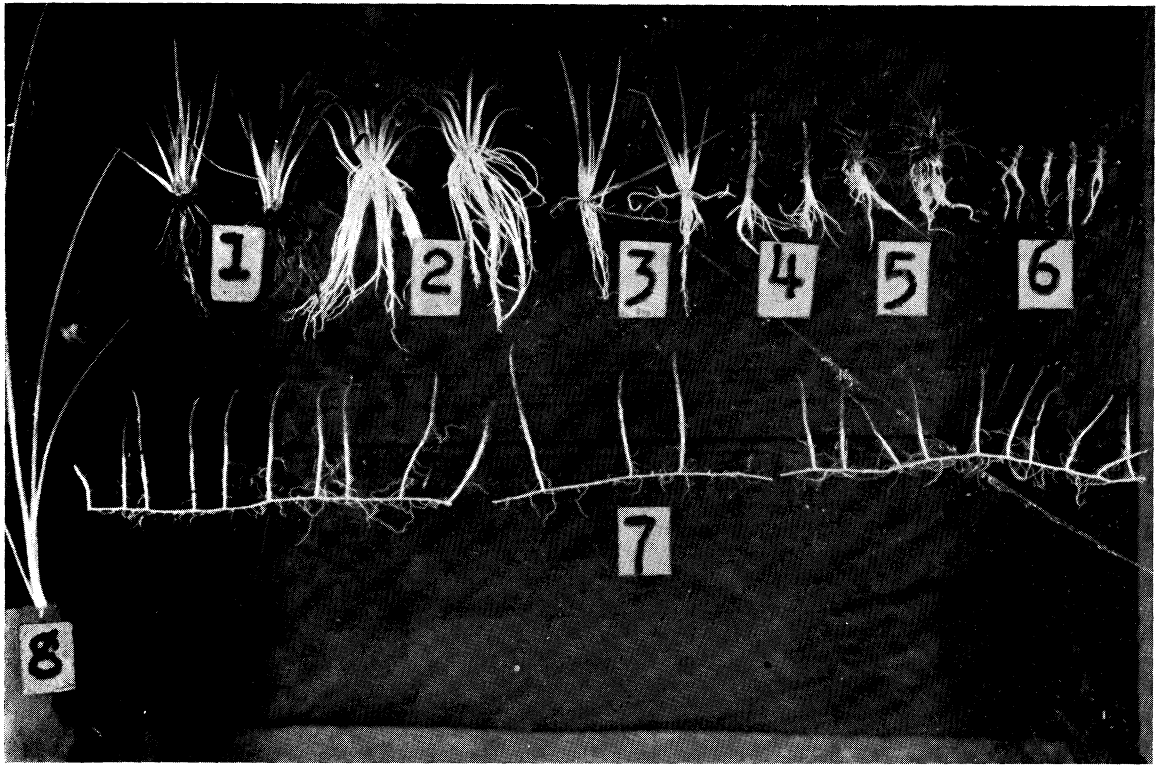


Fig. 2. Showing eight of the nine species constituting the rooted aquatic plants in Weber Lake.

1. *Isoetes macrospora*
2. *Lobelia Dortmanna*
3. *Juncus pelocarpus* f. *submersus*
4. *Gratiola lutea* f. *pusilla*
5. *Eriocaulon septangulare*
6. *Elatine minima*
7. *Myriophyllum tenellum*
8. *Carex sp.?*

Plants about 1/5 natural size.

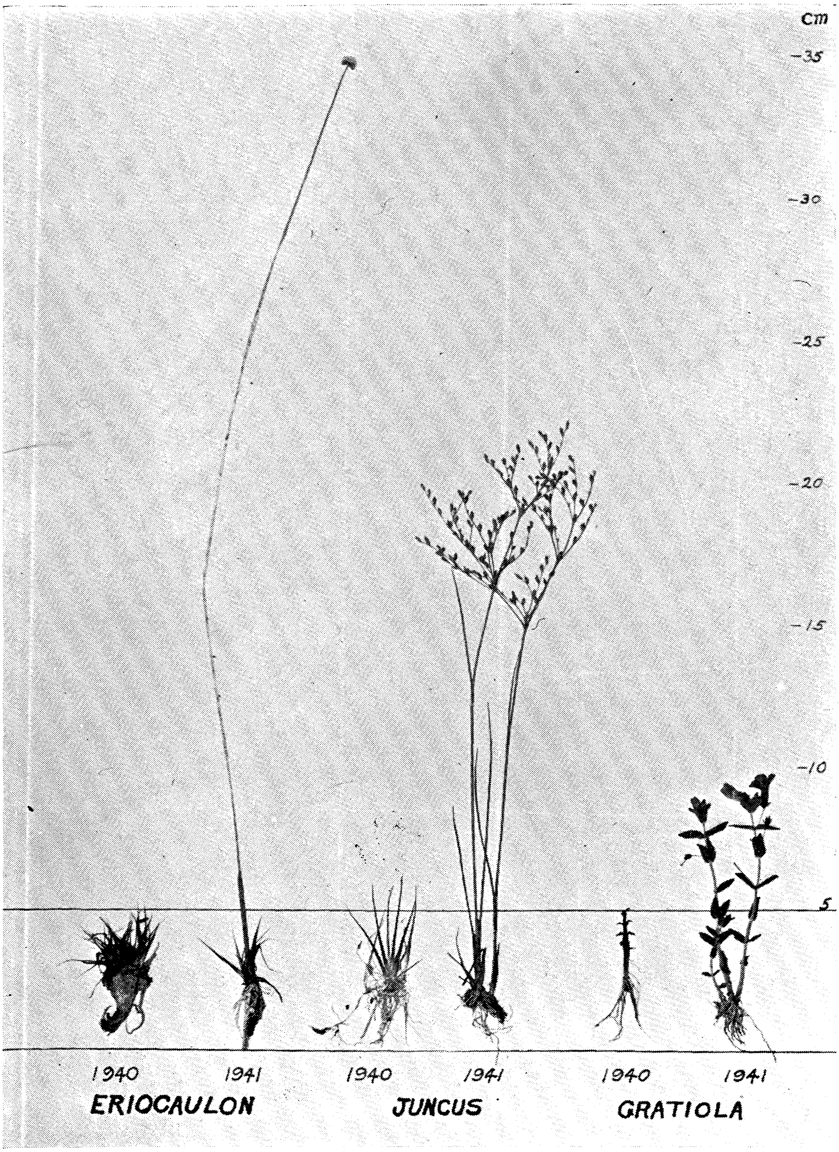


Fig. 3. Showing difference in size of plants during a year of high water stage (1940) and a year of low water stage (1941) in Zone I.

same along definite belts (Tables 1, 2; Fig. 1.). It seemed, therefore, that 29 transect lines, placed at 50-meter intervals, should be adequate to assure reliable quantitative data which would reflect the true status of sociological phenomena. Sampling was along a given transect at every two meter linear distance, extending into the lake as far as plants were encountered.

Locating Quadrats and Transects

Transect stations were located by numbered stakes driven into the sand at the water's edge. This method placed the first sample on the outside of the now partially submerged shrub zone. Fish-net floats were fastened to a stout line at two meter intervals for a distance of 34 meters. The line was fastened to a wooden float (a piece of two by four) which was fastened to an anchor by a rope sliding readily through two holes in the float. This proved a very efficient method of locating sampling stations definitely, and permitted accurate collecting even on very windy days. Collections were made the week of August 2, 1940. The work was carried out by two persons, one rowing the boat, recording depth at which samples were taken, marking the wrapping paper, and taking care of the samples, the other operating the dredge and calling the depth at which samples were taken. The rope fastened to the dredge was marked by bands at every

TABLE 1

Dry weight of various species in total samples at any given 2-meter belt (linear distance from shore). Weight in grams.

Number 2-m intervals from shore	Gratiola lutea	Juncus pelocarpus	Sparganium angustifolium	Lobelia Dortmanna	Elatine minima	Myriophyllum tenellum	Isoetes macrospora	Eriocaulon septangulare
1	1.6557	17.5367	.8158	......	.0437	....	....	1.2306
2	15.8454	31.8322	.2998	.2729	.1930	.5409	1.3532	3.2025
3	10.8700	22.0349	1.3536	.0058	4.5392	.0008	.1072	.8039
4	7.7573	11.5644	12.5929	.2570	10.7398	.1849	.0719	.5152
5	5.9922	7.7561	5.9884	.2795	15.8455	2.2859	3.0480	1.5037
6	6.9418	2.7230	1.2867	.6057	5.5477	12.7862	5.6800	.0666
7	4.1272	.4303	.0063	.6217	1.7450	27.6873	20.8655	.0694
8	3.6565	.7135	....	1.3548	.8352	24.1503	18.2242	......
9	1.5436	.0101	.0029	.4054	.2934	13.3654	12.6809	......
10	1.5420	.2446	....	.5304	....	11.2831	17.4362	......
11	.7283	.0001	....	.4179	....	7.3409	10.9974	......
12	.0051	....	....	......	....	1.9387	9.4221	......
13	....	....	....	.1032	......	1.7214	5.7[illegible]09	......
14	....	.0121	....	.1132	....	1.0459	1.5270	......
15	....	....	....	......	....	....	.2681	......
16	....	....	....	......	....	....	.0423	......

TABLE 2

Dry weight in grams of various species taken at a given depth zone, and percent this represents of the total.

	Dry Weight in Grams						Percent of Total				
	Weight and No. Samples	Zone I 0-1 m.	Zone II 1-2 m.	ZoneIII 2-3 m.	Zone IV 3-5 m.	Total	Zone I 0-1 m.	Zone II 1-2 m.	Zone III 2-3 m.	Zone IV 3-5 m.	Total
Gratiola lutea f. pusilla	Weight	22.8193	35.5715	2.2683		60.6591	37.00	58.00	5.00		12.2
	No. samples	37	147	33		213					
Juncus pelocarpus f. submersus	Weight	54.4307	36.4467	1.1781	.0001	92.0556	59.00	39.6	1.3		18.6
	No. samples	46	100	8	1	155					
Eriocaulon septangulare	Weight	3.7207	3.6018	.0694		7.3919	50.3	48.8	.9		1.4
	No. samples	11	12	1		24					
Elatine minima	Weight	.1284	39.8215	.8320	.0006	40.7825	1.0	97.0	2.0		8.2
	No. samples	7	111	4	1	123					
Sparganium angustifolium	Weight	.8500	21.4935	.0029		22.3464	3.8	96.0	.2		4.5
	No. samples	4	24	1		29					

Myriophyllum tenellum	Weight	.5409	59.8869	42.6937	1.2102	104.3317	.5	57.4	41.0	1.1	21.1
	No. samples	2	71	55	5	133					
Isoetes macrospora	Weight	1.3402	30.0636	46.9863	29.2800	107.6701	1.24	27.93	43.64	27.2	21.7
	No. samples	3	80	80	32	195					
Lobelia Dortmanna	Weight	.2725	2.7868	1.9178		4.9771	5.47	55.99	38.51		11.0
	No. samples	2	33	32		67					
Carex sp. ?	Weight	54.3144	.3347			54.6491	99.4	.6			11.5
	No. samples	1	2			3					
	Total	138.4162	230.0070	95.9485	30.4909	494.8635	28.63	53.49	14.73	3.15	

Note:—2.721 gms. of mosses not included in above tabulations.

quarter meter, this facilitated reading depths at 1/8 meter intervals. Total number of samples taken was 355.

EQUIPMENT

At the Limnological Laboratory we had at our disposal a heavy Petersen and a lighter modified Petersen dredge. Both of these machines were tried out for efficiency in denuding a given area in order to secure accurate quantitative results. It seemed apparent that even a small error would be magnified tremendously when quantitative results are translated into the total area of the lake. Preliminary studies showed that the modified Petersen would not be satisfactory for accurate sampling. It is too light to settle sufficiently deep into the soil to denude a quadrat completely, and the open sides and top permitted large numbers of the small plants to float out of the dredge as it was being lifted. Both of these objectionable features were eliminated in the extremely heavy and closed Petersen dredge. In order to test the efficiency of the two dredges, ten samples were taken with each in the dense Gratiola-Juncus association in the six meter (linear distance from shore) belt where the vegetation was visible from the boat, so that apparently similar vegetation mats could be selected. The results show definitely that the modified Petersen is not efficient in the collecting work involved in this study. The ten samples, wet weight, blotted only with paper towels, totalled 168.995 grams with the Petersen, and only 33.59 grams for the modified Petersen. Further, there is the probability that the modified Petersen may denude more efficiently the plants of the Isoetes association than those of the matted smaller plants in the Juncus-Gratiola association, which would introduce an error in the abundance figures of the various species. Using the Petersen from a rowboat is extremely hard manual labor, which in the present study was performed primarily by Mr. Van Engel.

COLLECTING AND PRESERVING THE SAMPLES

Preliminary sampling showed that even the Petersen dredge may at times permit small plants to escape from between the jaws, and so a small silk dip net was added to the equipment, to facilitate picking up escaped plants when they rose to the surface after a sample was taken.

During the active work of sampling the dredge was first emptied into a large iron pan, because the heavy, tight-fitting Petersen retains not only the plants but also the soil and water.

The collection was then poured into a small box, approximately 12 by 12 inches, with a copper screen bottom. This permitted easy washing out of the mud and gathering of the plants. Heavy wrapping paper, marked with transect and quadrat numbers, was used to keep each collection separate. At the laboratory each sample was segregated into the various species, these were wrapped in paper towels, marked properly with collecting data, and were then placed into a large cheesecloth sack to prevent loss of small packages. This procedure also made possible suspending the sack between two small trees where wind and sun hastened drying. Molding of plants is a serious problem in the high humidity of the Trout Lake region. The dried plants were shipped to the Botanical Laboratory of Butler University, where each sample was weighed to the fourth place on a chain-o-matic scales.

Larger quantities of the various species were taken to establish the approximate water content of each, based on air-dried weight of the plants. Results are shown in Table 3.

RESULTS

A glance at one or all of the tables presenting the sampling work, will show a definite tendency for species to distribute themselves along zone lines in linear distance from the shore, forming typical associations. Beginning with the Gratiola-Juncus association in the zone nearest shore, the succession into deeper water is from Sparganium-Elatine to Myriophyllum-Isoetes associations. Eriocaulon occupies a secondary position in the Gratiola-Juncus association and Lobelia in the Myriophyllum-Isoetes association. Eriocaulon usually grows in dense, small, scattered colonies.

TABLE 3

Water content of various aquatic plants from Weber Lake.

Species	Weight in Grams		
	Wet Weight	Dry Weight	Percent Loss
Elatine minima	63.72	5.75	90.9
Eriocaulon septangulare	50.36	4.32	91.4
Gratiola lutea f. *pusilla*	19.41	1.78	90.8
Isoetes macrospora	86.79	6.57	92.4
Juncus pelocarpus f. *submersus*	49.71	6.66	86.6
Myriophyllum tenellum	42.84	4.44	89.6
Sparganium angustifolium	64.01	4.99	92.2

The tendency for species to form associations along certain belts is also shown in Table 4 and Figure 1, where fidelity of appearance in the 29 transects is presented. No species declined abruptly within a narrow margin, except the *Carex sp. ?*, which had such disjunct distribution that one cannot well base any serious argument on its distribution characteristics.

TABLE 4

Fidelity and frequency index (F.I.). Showing number of transects in which certain species appear in each 2-meter belt (linear distance from shore). Total number of transects 29. Total number of samples involved 355.

Number 2-m. intervals from shore	Gratiola lutea f. pusilla	Juncus pelocarpus f. submersus	Sparganium angustifolium	Lobelia Dortmanna	Elatine minima	Myriophyllum tenellum	Isoetes macrospora	Eriocaulon septangulare
1	9	20	4	..	2	..	..	4
2	25	26	2	2	7	2	4	7
3	26	27	4	1	23	2	2	5
4	24	26	12	3	28	2	3	2
5	24	18	5	3	28	4	14	4
6	23	13	3	6	20	16	16	1
7	26	9	2	9	10	21	24	1
8	21	3	..	14	3	25	26	..
9	17	1	1	6	3	21	22	..
10	13	1	..	10	..	14	23	..
11	6	1	..	9	..	11	23	..
12	1	..	..	..	..	6	18	..
13	..	..	..	2	..	4	12	..
14	..	1	..	1	..	2	5	..
15	..	..	..	1	..	3	..	..
16	..	..	..	..	..	1	..	..
F.I. in %	61	41	9.3	18	34.6	36.6	54.3	7

The F.I. is low for nearly all plants (Table 4, Figure 1). Gratiola with 61 per cent ranking high, and Isoetes with 54.3 per cent is second. All others are present in 1/3 or less of the samples. This, again, indicates zonation. However, the range of distribution according to depth of water is large for all species (Tables 1, 5; Figure 1). For Isoetes the range is from 1¾ to 4⅝ meters.

The higher water level in the lake during 1940 inundated the former exposed beach and this permitted some general observations on migration to and invasion of former unoccupied lake bottom by the various species of plants. *Gratiola lutea, Juncus pelocarpus*, and *Elatine minima* are moving shoreward, they have invaded more protected places along old Chamaedaphne hummocks or compacted soil between dead, matted roots and clumps of tightly-packed humus. Juncus was a frequent invader of tightly packed sand, appearing in water only three inches in depth. No plants were observed in loose sand, which seemed to indicate that stability of the substratum had a definite influence on the establishment of plants in a new area. Along the steeper slope at transects 25, 26, 27 (Fig. 1) organic matter had accumulated in a deep layer and no plants were advancing shoreward at this place.

Table 2 shows the distribution of the various species and the vegetation as a whole in four zones, determined by depth of water. The one to two-meter zone with 53.49 per cent of the total is the most productive, five of the nine species have greatest abundance in this zone. Next most productive is the zone 0-1-

TABLE 5

Showing transects, sampling intervals and depth of water where species disappeared.

a. Sample where plant ceased.
b. Depth of water in meters where plant ceased.

Transects	Gratiola lutea		Juncus pelocarpus		Sparganium angustifolium		Elatine minima		Myriophyllum tenellum		Isoetes macrospora		Eriocaulon septangulare		Lobelia Dortmanna	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
1	9	2½	7	1¾	5	1½	7	1¾	9	2½	11	3½			8	2¼
2	9	2⅛	8	1⅞			7	1⅝	9	2⅛	11	3½	5	1¼	8	1⅞
3	9	2⅛	8	1⅛			7	1½	10	2½	8	1⅞			4	1⅛
4	7	1¾	4	1¼			6	1½			11	3	3	1⅛	10	2½
5	11	2⅛	5	1⅛			7	1⅝	13	2½	14	2⅞	5	1¼	13	2½
6	11	2¼	4	1⅛	4	1⅛	7	1⅝	14	2½	15	2¾			14	2½
7	9	2⅛	3	1	3	1	5	1½	14	3	13	2⅞			10	2⅜
8	7	1⅞	7	1⅞	3	1⅛	5	1½	11	2½	12	2¾				
9	11	2¼	4	1¼	9	2	5	1½	13	2½	16	3			11	2¼
10	10	2	5	1⅜			7	1⅝	9	1⅞	14	2⅜			6	1½
11	10	2	5	1¼	2	⅞	6	1⅜	9	1¾	13	2⅜	5	1¼	8	1⅝
12	11	2¼	5	1⅜	3	1	5	1⅜	11	2¼	13	2⅝			11	2¼
13	10	2⅛	4	1¼			8	1¾	11	2⅜	8	1¾	2	⅞	11	2⅜
14	10	2	10	2	3	1	8	1⅞	12	2¾	12	2¾			11	2¼
15	11	2¼	6	1⅜			6	1⅜	12	2½	12	2½	3	1	11	2¼
16	12	2¼	7	1½	6	1½	6	1½	12	2¼	15	4¼	3	⅞	10	1⅝
17	10	2	8	1⅝	6	1⅜	7	1½	12	3	14	4⅛	6	1⅜	11	2½
18	10	2	6	1⅜			6	1⅜	10	2	12	3⅛			11	2½
19	8	2	7	1¾			6	1½	10	2⅝	12	3¾			8	2
20	6	1⅝	5	1½	4	1¼	6	1⅝	8	2¾	10	4⅛	1	¾	8	2¾
21	8	2	6	1½			6	1½	9	2½	10	3			7	1¾
22	7	2⅛	5	1½			5	1½	8	2⅝	10	3⅞	1	¾	8	2⅝
23	8	2⅞	8	2⅞	4	1⅛	9	2¼			13	4¼	4	1⅛		
24	6	1⅝	11	3⅞	4	1¼	5	1⅜	7	1⅞	10	3⅜			7	1⅞
25	10	2¼	3	1⅛	7	1⅝	5	1½	9	2	14	4⅝			10	2¼
26	7	1⅞	7	1⅞			5	1½	8	2½	12	4½			5	1½
27	7	1¾	7	1¾	5	1¼	7	1¾	9	2¾	11	4	3	1	9	2¾
28	7	2	5	1½	5	1½	4	1⅜	8	2⅜	9	3	4	1⅜	7	2
29	10	2¼	9	2	7	1¾	6	1½	12	3¼	13	3¾	8	1⅞	10	2¼
Range	1⅝-2⅞		1-3⅞		⅞-2		1⅜-2¼		1¾-3¼		1¾-4⅝		¾-1⅞		1⅛-2¾	

meter. Least bulk was in the 3-5-meter zone. Only Isoetes produced the most abundant crop in the 2-3-meter zone.

Wave action as causal indirect factor in determining distribution of plants is indicated by the greater depth at which plants disappeared along the shore of the eastern half of the lake as compared with the western half (Table 6; Fig. 1). The plants of Weber Lake are, outside of Sparganium, all small, and must apparently be rooted in sand; and so sediments in excess of their above-surface vegetative parts apparently halt their migration into deeper water. One wonders how these plants can exist even in their present range, for Myriophyllum and Isoetes are frequently etiolated to a narrow band at the tips (Fig. 2).

Observations in 1941

Weber Lake was visited briefly the end of August in 1941, and surprising changes were noted in the water level, and the physical characteristics of the plants near shore. The deficiency in rainfall during the past year caused a decided lowering of the water level, changing our 1940 two-meter linear distance belt into exposed beach line. Gratiola, Juncus, and Eriocaulon flowered abundantly, and the plants were from two to ten times taller than last year (Fig. 3). It is, thus, very likely if sampling had been carried out this year that the total bulk of plants obtained would have been much greater, at least for Gratiola, Juncus, and Eriocaulon, and the 0-1-meter zone would have been the most productive.

Juncus pelocarpus was in 1940 universally the forma *submersus,* this year the plants in the 1940 two-meter belt were almost universally the straight species, and flowered luxuriantly.

Discussion

Little need be said of the small number of species constituting the vegetation in Weber Lake, the factors in cause have been discussed by Wilson (1935). His paper also shows that lakes in the region in general very frequently support only a few species, number depending on the stage of development of the lake, abundance of plants increasing with accumulation of sediments; and the flexuous types succeeding the rosette type. Wilson (1935) records for Silver Lake 14, Little John Lake 13, Sweeney Lake 27 species. The youthful condition of Weber Lake is also expressed by the presence of only one flexuous species, *Sparganium angustifolium.* Theoretically one would expect to find Sparganium invading areas of deeper organic deposits, but table 5 and figure 1

TABLE 6.
Showing depths of water at which plants disappeared along the 29 transects and in which half of the lake the transect is located.

Depth in meters	Transects where plants disappeared at the depth specified	West half of lake	East half of lake
2½	11	11	
2⅝			
2¾	3-10-12-13	10-12-13	3
2⅞	8-15	8-15	
3			
3⅛	4		4
3¼	9-14	9-14	
3⅜			
3½	6	6	
3⅝	7-18-21	7-18	21
3¾	28		28
3⅞			
4	19	19	
4⅛			
4¼	22		22
4⅜	23-24-29		23-24-29
4½			
4⅝	1-2-27		1-2-27
4¾	20		20
4⅞	5-16-17	16-17	5
5	25		25
5⅛	26		26

show that it is not found beyond the two-meter zone. Its distribution is no doubt controlled by the seedling stage requirements. If the seedlings demand sand for placement of roots, this taller species would still be controlled by a rosette type of habitat, which is also indicated by the fact that it has recently invaded the newly inundated shore area (Table 1; Fig. 1).

It should be pointed out, however, that while Weber Lake appears to the casual observer as almost barren, the vegetation may at times form a dense cover, almost completely occupying the surface of the soil. Even such tiny plants as *Elatine minima* yielded over two grams dry weight per 729 cm^2, and *Isoetes macrospora* totalled even 8.5 gms. for a like area. So we must say that plant life is abundant in Weber Lake but of small size. Taking total area of the lake, dry weight yield of plants was 5.73 gms. for a m^2 surface. This is much in excess of the dry weight yields for a like area reported by Wilson (1935) for several lakes of that region. He reports the following: Silver Lake .08 gms., Muskellunge Lake .45 gms., Little John Lake .52 gms. However, he states that the modified Petersen dredge was used in the sampling work, and since we found the efficiency of this dredge poor in dense mats of small plants, we can assume that the plant crop was much greater in all these lakes than the figures indicate.

Isoetes gave the largest yield in Weber Lake, and *Juncus pelocarpus* f. *submersus* was second in this respect. This was not due to a greater abundance of these species but rather to the greater bulk of the individual plant as compared with Gratiola and Elatine. If sampling had been made in 1941, *Juncus pelocarpus,* which was then the typical species, would without doubt have exceeded the total weight of Isoetes because of the extremely larger size of the individual plant in 1941.

One is hardly justified to use the entire 4-meter zone of vegetation as a unit on which to base frequency and fidelity studies, for there are really very definite zone limits to the various associations, and type species of these behave as relics or early invaders in the adjoining zones (Tables 1, 4; Fig. 1). Gratiola has apparently the greatest potentiality for extending its range with considerable importance from the shallow waters near shore to a depth of 2.5 m. (Table 5; Fig. 1), thus occupying soils almost devoid of organic sediments to soils covered by as much as an inch of organic matter.

For species like *Sparganium angustifolium, Eriocaulon septangulare,* and *Lobelia Dortmanna* the F.I. and fidelity are low. One wonders why such species as *Myriophyllum tenellum* are so unimportant near shore. Perhaps the competition with matformers like Gratiola and Juncus is too great for a rhizome plant like Myriophyllum, and so it finds a more tolerable association with a scattered growing plant like Isoetes. Using the belt of optimum expression of a given association, F.I. and fidelity are high except for Sparganium (Table 4; Fig. 1) one can, of course, readily understand why a plant like Elatine is limited to the sandy bottoms of the near-shore waters, for it seldom grows above one to two cm. in height, so deep organic sediments would prevent invasion and ecesis.

The plants collected in the first two-meter belt were invaders since the high water inundated the beach during the past few years. The chief migrants are *Gratiola lutea* f. *pusilla, Juncus pelocarpus* f. *submersus,* but also *Sparganium angustifolium, Elatine minima,* and *Eriocaulon septangulare* have appeared in this belt (table 1; fig. 1), perhaps there was a similar shift from one belt into the other in the deeper water zones.

The question of cause of distributional phenomena in vegetation also here remain a topic for speculation; causes of control are usually complexes which do not yield readily to complete analysis. Light, mineral content of the soil, acidity of the water have been discussed at length for the Wisconsin lakes by Wilson (1935, 1937) and so need hardly be repeated. From the observations of summer 1940 it appears that in Weber Lake the major control is a physical factor of the lake bottom, and indirectly of wave action. The fact that all species were rooted in sand indicates that organic matter could have provided mineral nutrients only indirectly by filtration through the sand; but at the same time it becomes an inhibiting factor when accumulation exceeds the photosynthetic parts of the small plants. Wilson (1937) reports decrease in plants in Sweeney Lake during periods of heavy deposition of organic matter. In many instances the plants in Weber Lake were etiolated to a small tip region (Fig. 2). This inhibiting effect of loose organic sediment is also indicated along the southeastern shore where not a single plant was observed, even though the water and light factors must have been favorable to growth of plants. Control by purely physical effects of the sediments is further indicated by the difference in depth of water at which plants ceased along the western and eastern shorelines (Table 6; Fig. 1). Along the more disturbed eastern shore, plants penetrated on an average into water which is deeper by two meters than that along the western half. Apparently sediment is stirred up continually along the eastern shore and carried by undercurrents to be settled out in the deeper water; while along the western shore sediments are less disturbed and so settle out nearer to shore; and their physical presence inhibits the small plants from invading soils in deeper water which from a light standpoint they could still invade. Wilson (1937) also recognizes for Sweeney Lake that certain aquatic plants are obligated to be rooted in sand when he writes, "The ecological conditions along the south and eastern shores resemble most nearly those of the youthful lakes in the region—the exposure to wave action is the chief factor in the perpetuation of the inorganic sediments upon which these plants are growing." Colonies of Sparganium, likewise, are twice as numerous along the western than along the eastern shore. One might, thus, be justified to assume that early maturity in Weber Lake will appear sooner on the western than on the eastern shoreline, and that flexuous species are likely to invade first the western half of the lake.

The distribution of bulk of plants differs strikingly in Weber Lake from that in Sweeney (Wilson, 1937), Silver, Little John, and Muskellunge lakes as reported by Wilson (1935) where ⅔ to ¾ of the crop was in the two zones involving water one to three meters in depth. The observations made at Weber Lake in 1941 indicate that distribution of bulk by zones *per se* is a very changeable feature, being governed by high or low water level. Only repeated studies at the same lake during periods of non-fluctuating water level can establish the truth about the distribution of bulk of plants in the various zones, and comparisons of results obtained in different seasons in a number of lakes are really not possible. The real issue involved is whether productivity of a given zone is a habitat-controlled phenomenon which may vary with difference in water level only temporarily until adjustment could be made during a prolonged period of a given change in water level, or whether it is merely a variation induced by changing water level as such.

Summary

1. The paper presents a study of the rooted aquatic plants in Weber Lake, Vilas County, Wisconsin, involving such phyto-

sociological factors as zonation, frequency, fidelity, association, and abundance.

2. The 1.6 km. long shoreline was studied along 29 transects, separated from one another by approximately 50 meters. Samples were taken along each transect at every two-meter linear distance from shore until plants ceased.
3. Sampling was carried out with the Petersen dredge. The bite of this instrument denuded an area of 729 cm^2.
4. The plants segregated into three major associations, which in their maximum expression form belts marked by increasing distance from shore, and could be classified as Juncus-Gratiola, Elatine-Sparganium, and Myriophyllum-Isoetes associations. The dominants of one belt extend with reduced abundance into the flanking belts.
5. Depth of water at which plants disappeared ranges from $2\frac{1}{2}$ to $5\frac{1}{8}$ meters.
6. All plants are rooted in sand, and it is suggested that the physical effects of organic sediments control the extent of plants into deeper water by covering the photosynthetic parts.
7. The average depth of water at which plants disappear along the western half of the lake is $3\frac{1}{4}$ meters and $4\frac{1}{2}$ for the eastern half. Wave action along the eastern shore apparently keeps organic matter suspended which is then transported to deeper water; while along the less disturbed western shore it remains where it first settles out.
8. Dry weight of plants totals 5.73 gms. per m^2 (computed) for the total area of the lake, or 57.3 kg. per hectare.
9. The bulk of material collected was distributed as follows: Zone I, water less than a meter in depth, 28.63 per cent; Zone II, water one to two meters in depth, 53.49 per cent; Zone III, water two to three meters in depth, 14.73 per cent; Zone IV, water three to five meters in depth, 3.15 per cent.
10. Change in water level in a given lake is considered a vital factor in determining in any one season the tendency of distribution of bulk of plants by zones. So that comparison of lakes not studied approximately the same time, and under similar rainfall and lake level conditions is very likely of little significance with respect to zonal distribution of abundance of plants, and perhaps even of bulk as such.

ACKNOWLEDGMENTS

To Dr. C. Juday we express our thanks for suggesting the research, for advice, critical reading of the manuscript, for continued interest in the work, and for the map and computation of area of Weber Lake; to Mr. Charles Lines (posthumous) for assistance in determining the area denuded by the Petersen and modified Petersen dredges; to Mr. Sidney Gottlieb for assistance in the work of collecting. Appreciation is also expressed to the Wisconsin Geological and Natural History Survey for the opportunity to serve on the staff, and for the facilities provided necessary to carry out the work, likewise to the Wisconsin Alumni Research Foundation whose grant of funds supported this investigation. We thank Dr. Norman C. Fassett for identifying the species of Isoetes and Sparganium. To Mr. Carl C. Hartman, commercial artist of Indianapolis, we are indebted for lettering of figure 1.

LITERATURE CITED

Wilson, L. R. 1935. Lake development and plant succession in Vilas County, Wisconsin. Ecol. Mon. 5:207-247.

. . . . . 1937. A quantitative and ecological study of the larger aquatic plants of Sweeney Lake, Oneida County, Wisconsin. Bull. Torr. Bot. Club 64:109-208.

. . . . . Rooted aquatic plants and their relation to the limnology of freshwater lakes. Pub. 10. The Am. Assn. Adv. Sci. 107-122.

LIMNOLOGICAL OBSERVATIONS ON THREE LAKES IN EASTERN VILAS COUNTY, WISCONSIN

THOMAS H. FLANIGON

From the Limnological Laboratory of the Wisconsin Geological and Natural History Survey. Notes and Reports No. 114.

INTRODUCTION

During the summer of 1941 a limnological survey of six lakes in Vilas County, Wisconsin was conducted for the Town of State Line, Wisconsin. The results of this survey together with recommendations for management of the lakes were presented in a mimeographed report (Flanigon, 1942) to the Town of State Line. More complete data were obtained on three of these lakes, and although the sounding of the lakes was done from a row boat and without the aid of surveying instruments, the general observations are believed worthy of publication at this time since it will probably be many years before these lakes will be sounded through the ice by state agencies and the hydrographic and morphometric data from that source made available. All three of the lakes are soft water seepage lakes.

ACKNOWLEDGMENTS

The writer wishes to thank the Town of State Line and the Land O'Lakes Chamber of Commerce for the financing of the field work; Mr. Lyman Williamson, Junior Biologist of the Wisconsin Conservation Department and Dr. Chancey Juday for their many valuable suggestions and assistance; and the Wisconsin Conservation Department for the financing of the laboratory work and the generous use of their equipment for the survey.

METHODS

Soundings were taken with a calibrated line from a row boat and consequently are only approximately accurate, but sufficiently so for practical purposes. Difficulty was frequently encountered in keeping the boat on a straight line. The outline maps were copied from aerial survey photographs and enlarged with a pantograph. The soundings were recorded on this map and the contour lines were drawn. The surface areas of the lakes, as well as the areas at different depths, were determined by planimeter measurements of tracings of the enlarged maps. The length of the shoreline was determined by means of a Universal Map Measurer. The volumes were determined from the maps by the same method employed by Juday (1914 and 1941).

TABLE I.

Physical and chemical characteristics of the waters of the lakes studied. Temperatures are expressed in degrees Centigrade, chemical analyses in parts per million, and depths in meters.

Lake	Date 1941	Depth	Temperature	Transparency	pH	Free CO_2	Bound CO_2	Dis. O_2
Crampton	7-29	0	27.8	3.4	6.8	1.7	1.8	6.7
		3	21.8		6.7	1.0	2.0	7.7
		6	10.5		5.6	13.0	2.2	1.2
		16	6.2		5.6	18.4	3.1	0.0
Merrill	6-25	0	24.9	3.7	6.9	1.0	2.4	7.1
		1			6.8	0.7	2.0	7.3
		2			6.8	0.5	1.9	7.6
		3			6.8	0.5	1.9	7.7
		5			6.7	1.4	1.4	9.3
		6			6.3	8.0	2.9	4.9
	9-2	0	19.5	3.1	6.4	1.2	2.9	7.7
		5	17.2		6.3	1.8	2.4	7.8
		6	13.0		5.6	9.5	1.7	4.8
Wood	6-25	0	27.0	3.0	6.2	1.7	1.4	6.6
		1			6.4	2.4	0.8	6.7
		2			6.4	2.8	0.9	6.6
		3			6.2	2.9	0.7	7.1
	8-27	0	19.8	5.2		1.7	1.3	7.5
		5	18.2			1.5	1.5	7.0
		6	14.2			9.2	1.5	2.8
		7	9.2			25.0	3.1	1.4

All chemical analyses were determined by methods outlined in Standard Methods for the Examination of Water and Sewage (1936) and are stated in parts per million. pH was measured with a Hellige pH Comparator. Transparency of the water was determined by a nine-inch Secchi disc. These data are presented in Table I.

Fishes were captured with fyke nets with single leads and without wings. The nets were set with the leads perpendicular to the shore. Three nets were operated concurrently in Merrill and Wood Lakes and four nets in Crampton Lake. One of the nets was of one-inch mesh bar measure and the other two or three nets were of three-eighths-inch bar measure. Scientific and common names of fishes are in compliance with those used by Hubbs and Lagler (1941).

Zooplankton samples were taken with a tow net of 44 mesh to the inch. Both vertical and horizontal hauls were made. Benthos sampling was done with an Ekman dredge.

Scientific and common names of the aquatic plants follow Fassett's Manual of Aquatic Plants (1940).

Crampton Lake

Crampton Lake (Fig. 1) has an area of 21.35 hectares (52.7 acres), a maximum depth of 16.7 meters (54.8 feet), and a mean depth of 4.1 meters (13.5 feet). The total volume of water is approximately 1,076,000 cubic meters (1,405,000 cubic yards). The water was very soft (bound carbon dioxide 1.8 to 3.1 ppm) and slightly acid. A thermocline was present between four and seven meters. Two deep spots were observed. The two large, shallow bays on the south side of the lake have mud bottoms. The remainder of the lake bottom is sand and gravel around the periphery and mud in the deeper water.

The zooplankters observed included *Daphnia hyalina, Daphnia pulex, Diaphanosoma, Leptodora, Cyclops, Diaptomus, Epischura,* nauplii, and *Corethra* (*Chaoborus*) larvae. *Daphnia hyalina* was the dominant organism.

Benthos included *Corethra, Chironomus, Ephoron,* and *Sialis* larvae, *Pisidium,* and fresh-water sponges. Empty caddis fly cases were plentiful. *Corethra* and *Chironomus* larvae were the dominant forms.

The aquatic plants in Crampton Lake were abundant and well dispersed over the shallower water. The species observed included *Sparganium* (bur reed), *Potamogeton* (pondweed), *Scirpus* (bulrush), *Eriocaulon septangulare* (pipewort), *Pontederia cordata* (pickerel-weed), *Polygonum coccineum* (water smartweed), *Nymphaea odorata* (water lily), *Nuphar variegatum* (yellow water lily), *Chamaedaphne calyculata* (leatherleaf), *Vaccinium macrocarpon* (cranberry), and another sedge.

The five species of fishes present were *Micropterus d. dolomieu* (northern smallmouth bass), *Huro salmoides* (largemouth bass), *Lepomis m. macrochirus* (common bluegill), *Perca flavescens*

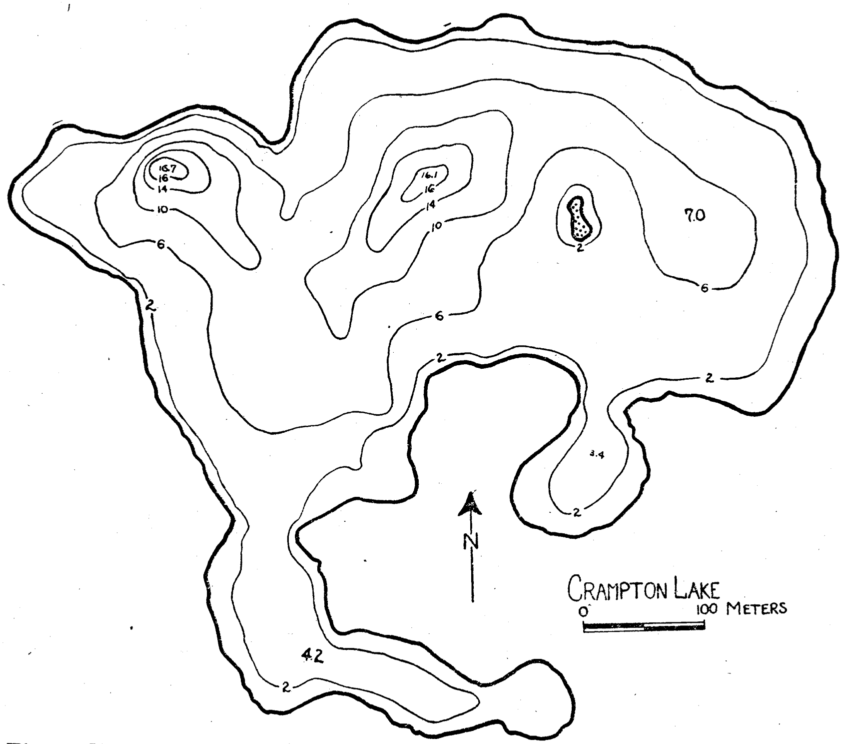


Fig. 1. Hydrographic map of Crampton Lake. Depths are indicated in meters.

(yellow perch), and *Stizostedion v. vitreum* (yellow pikeperch). A total of 19 net lifts over 31 net days captured 436 fishes for an average of 14 fishes per net per day. The dominant species was *Huro salmoides,* with *Micropterus dolomieu* next in rank. *Stizostedion vitreum* were rare and are probably making accidental entrance into the lake.

MERRILL LAKE

Merrill Lake (Fig. 2) is characterized by being of uniform depth. The bottom drops quickly a few meters from shore to a depth of six meters and the rest of the lake is nearly level. Sand, gravel, and boulders make up most of the shore and the bottom in the shallower water; the bottom in the deeper water is mud. There is a small gravel bar near the southwest shore. The lake has an area of 10.6 hectares (26.2 acres). The maximum depth of 7.3 meters (24 feet) was found in several places; the mean depth is 4.1 meters (16 feet). The water was clear, very soft

CRAMPTON LAKE

T. 43 N., R. 8 E., Sec. 14, 15

Length	684 m.	Mean depth	4.10 m.
Breadth	574 m.	Length of shoreline	3.04 km.
Area	21.35 ha.	Shore development	1.85
Maximum depth	16.7 m.	Number of soundings	224

Depth	Area		Stratum	Area between contours	Volume	
Meters	Hectares	Per Cent of total	Meters	Hectares	Cubic meters	Per Cent of total
0	21.35	100.0	0-2	4.10	386,000	35.9
2	17.25	80.9	2-6	10.39	466,600	43.4
6	6.86	32.1	6-10	4.94	171,300	15.9
10	1.92	8.9	10-14	1.39	47,600	4.4
14	0.53	2.5	14-16	0.43	4,600	0.4
16	0.10	0.5	16-16.7	0.10	230	0.02
				Total	1,076,330	

(bound carbon dioxide 1.4 to 2.9 ppm), slightly acid, and contained abundant dissolved oxygen at all depths.

Merrill Lake is not a very productive lake. Only one species

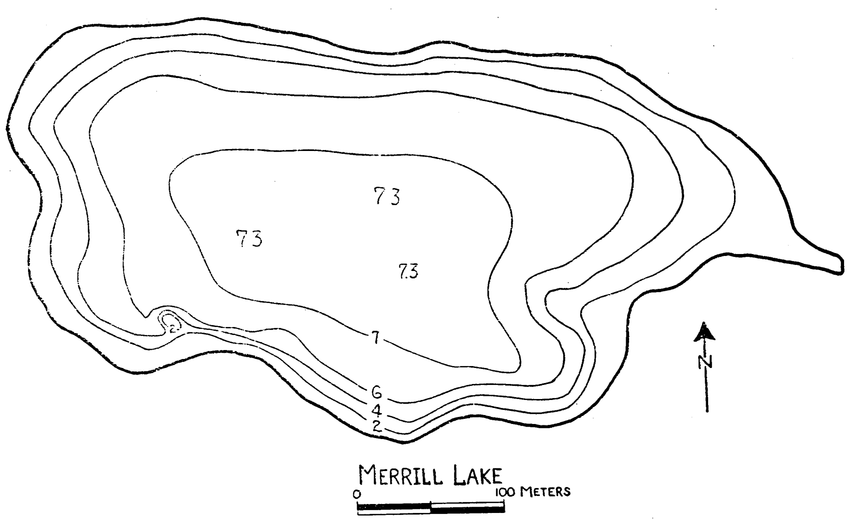


Fig. 2. Hydrographic map of Merrill Lake. Depths are indicated in meters.

MERRILL LAKE
T. 43 N., R. 9 E., Sec. 34

Length	572 m.	Mean depth	4.87 m.
Breadth	270 m.	Length of shoreline	1.44 km.
Area	10.6 ha.	Shore development	1.24
Maximum depth	7.3 m.	Number of soundings	100

Depth	Area		Stratum	Area between contours	Volume	
Meters	Hectares	Per Cent of total	Meters	Hectares	Cubic meters	Per Cent of total
0	10.6	100.0	0-2	1.8	193,100	37.4
2	8.8	82.8	2-4	1.4	161,400	31.3
4	7.4	69.9	4-6	1.8	129,800	25.1
6	5.6	53.4	6-7	3.2	29,100	5.5
7	2.4	22.9	7-7.3	2.4	2,400	0.5
				Total	515,800	

of benthos, *Corethra* larvae, was observed; these were not very abundant. The zooplankters included *Daphnia hyalina, Diaphanosoma, Leptodora, Cyclops, Diaptomus, Epischura,* and nauplii. *Daphnia hyalina* and *Leptodora* were the dominant organisms. The total zooplankton content was low.

Only a very few aquatic plants were present; most of these were confined to the small bay at the east end of the lake and the gravel bar. The species observed were *Eriocaulon septangulare, Nymphaea odorata, Chamaedaphne calyculata,* and a sedge.

The fish population of Merrill Lake is very small. Five species of fishes were observed but only 185 fishes were captured in 23 net lifts over a period of 27 net days. This is an average of only 4.5 fishes per net per day. *Huro salmoides, Perca flavescens,* and *Catostomus c. commersonnii* (common white sucker) were the dominant forms. *Lepomis m. macrochirus* and *Pomoxis nigromaculatus* (black crappie) were also present, but rare.

WOOD LAKE

Wood Lake (Fig. 3) is approaching typical bog lake conditions. Although it has a wide margin of *Sphagnum* and *Chamaedaphne,* it still retains a small gravel and rock bar near the center and a few meters of sloping sandy shore along the east side. The water is from one-half to nearly two meters deep at the edge of the mat. The lake has an area of 5.94 hectares (14.7 acres).

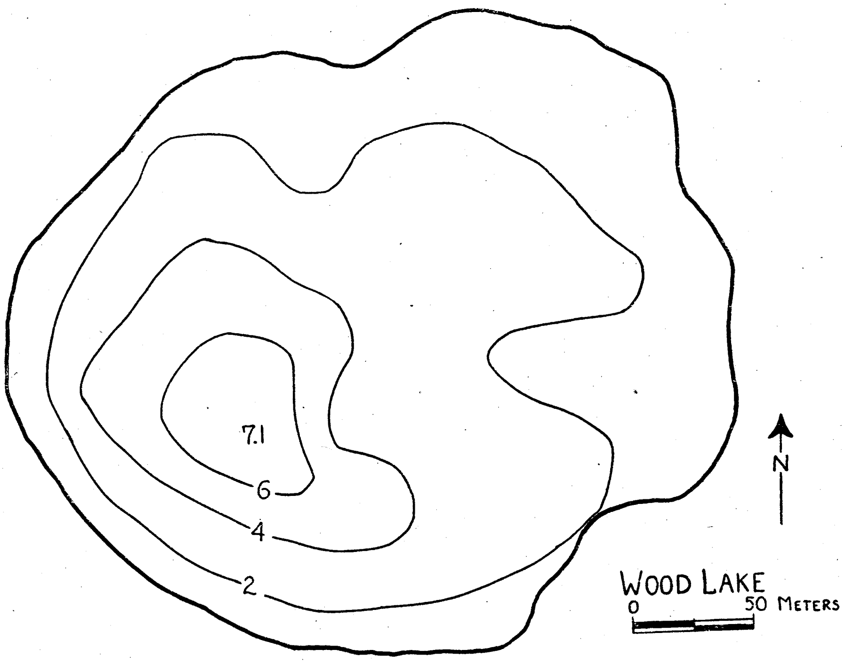


Fig. 3. Hydrographic map of Wood Lake. Depths are indicated in meters.

WOOD LAKE
T. 43 N., R. 9 E., Sec. 34

Length	302 m.	Mean depth	2.35 m.
Breadth	267 m.	Length of shoreline	900 m.
Area	5.94 ha.	Shore development	1.04
Maximum depth	7.1 m.	Number of soundings	77

Depth	Area		Stratum	Area between contours	Volume	
Meters	Hectares	Per Cent of total	Meters	Hectares	Cubic meters	Per Cent of total
0	5.94	100.0	0-2	2.96	87,530	62.6
2	2.98	49.9	2-4	1.94	38,670	27.7
4	1.05	17.2	4-6	0.76	12,480	8.9
6	0.28	0.5	6-7.1	0.28	1,030	0.7
				Total	139,710	

Although the maximum depth is 7.1 meters (23.3 feet), the mean depth is only 2.35 meters (7.7 feet). The total volume of water is 139,710 cubic meters (182,500 cubic yards). The lake is nearly circular, the shore development being 1.04. The water was clear, acid, and soft (bound carbon dioxide 1.3 to 3.1 ppm).

The productivity of Wood Lake is high. Both the zooplankton and the benthos are abundant. *Daphnia hyalina, Holopedium, Polyphemus, Bosmina, Cyclops, Diaptomus,* nauplii, and *Corethra* larvae were observed. A very large population of the rotifer *Conochilus* was present for several days in July. Species of benthos included *Chironomus, Corethra, Tanypus, Pisidium,* annelids, fresh-water sponges, and empty caddis fly cases. *Corethra* larvae were the dominant organisms in the deeper water and *Pisidium* and annelids were the dominant forms in the shallower water.

Calla palustris (water arum), *Polygonum natans* (water smartweed), *Nymphaea odorata,* and a moss were observed but were not very abundant. The principal components of the bog mat were *Sphagnum, Chamaedaphne calyculata,* and *Vaccinium macrocarpon.*

Only three species of fishes were observed in the lake. *Perca flavescens* was the dominant form; *Huro salmoides* was next in rank. *Lepomis m. macrochirus* was captured only occasionally. Fifteen net lifts over a period of 27 net days captured 279 fishes for an average of 10 fishes per net per day. Although a few adult bass were caught by hook and line fishing, none were captured in the nets. Bass fingerlings of the same year's hatch were frequently taken in the nets.

SUMMARY

The observations presented are part of the results of a limnological survey of a group of lakes in Vilas County, Wisconsin conducted as part of a fish management program for the Town of State Line, Wisconsin. Hydrographic maps and the morphometry of the basins of three lakes are presented. Crampton Lake with an area of 21.35 hectares is the largest and most productive lake studied. Plankton, benthos, and aquatic plants were abundant and helped the lake support a good bass population. Merrill Lake has an area of 10.6 hectares. It is the least productive lake of the three considered. Benthos, plankton, and aquatic plants were not plentiful. The fish population was the smallest encountered. Wood Lake is a bog lake of 5.94 hectares. The benthos and plankton content was high but the aquatic plants were not plentiful. *Perca flavescens* was the dominant piscine species.

LITERATURE

American Public Health Association. 1936. Standard methods for the examination of water and sewage. New York. 309 pp.

Fassett, Norman C. 1940. A manual of aquatic plants. McGraw-Hill Book Co., Inc. New York. 382 pp.

Flanigon, T. H. 1942. Limnological survey of six lakes in Vilas County, Wisconsin, with respect to a fish management program. Mimeographed. 28 pp.

Hubbs, C. L., and K. F. Lagler. 1941. Guide to the fishes of the Great Lakes and tributary waters. Cranbrook Institute of Science. Bull. 18. 100 pp., 118 figs.

Juday, C. 1914. The inland lakes of Wisconsin. The hydrography and morphometry of the lakes. Bull. 27. Wis. Geol. & Nat. Hist. Survey. 137 pp., 27 maps, 8 figs.

Juday, C., and E. A. Birge. 1941. Hydrography and morphometry of some northeastern Wisconsin lakes. Trans. Wis. Acad. Sci., Arts & Let. 33: 21-72. 30 figs.

MICROFOSSIL STUDIES OF THREE NORTHCENTRAL WISCONSIN BOGS

L. R. WILSON AND R. M. WEBSTER

From Coe College and the Limnological Laboratory of the Wisconsin Geological and Natural History Survey. Notes and reports No. 111.

INTRODUCTION

The region of northcentral Wisconsin is one of pine forests with smaller areas of hardwoods. Pine and hemlock are, or recently were, important species, and the region may be described as being part of the lake forest (Weaver and Clements, 1929). Hemlock at present is but a minor element but appears to have been more important before lumbering was begun. Upon the heavier soils the forests contain an important hardwood element which includes sugar maple, yellow and white birch, basswood, American elm, and red oak. Mixed with the hardwoods is white pine, hemlock, balsam fir, and white spruce. The lighter, sandy soils are forested at present with jack and red pine, white birch, quaking aspen, and pin cherry. The virgin forests contained heavy stands of red pine. Large areas of the sandy soils in northern Wisconsin have been logged and severely burned and are at present covered by little more than sweet fern (*Myrica asplenifolia*), scrub oak (*Quercus ellipsoidalis*), and young stands of jack pine. They are frequently referred to as the pine barrens, sand barrens, or barrens. Agriculture is almost impossible in such areas.

The virgin forests of northcentral Wisconsin contained some of the most valuable timber in the state, and because they represented such a fine example of the lake forest, a study of its history was undertaken.

The region in which the present study was conducted is central Vilas County in Wisconsin. The fossils in three bogs are reported from this investigation. These bogs are located in kettles upon the pitted outwash plains of Wisconsin substage 4, and near lakes after which each is named.

THE FOSSILS

The peat material studied was collected by means of a Davis peat sampler. In the laboratory, about 50 grams of dry peat were pulverized and boiled in about 200 cc. of water until it became a humic mass. Then a few centimeters of concentrated sodium hydroxide solution was added to the material, which was thoroughly stirred. This treament is usually sufficient to free the fossils and make them suitable for study. The material was then screened through a one millimeter mesh and diluted with water. The diluted solution was then centrifuged and washed several times. Some material was stained with saffranin for 12 hours and again washed and centrifuged. Material for permanent reference was mounted in glycerine jelly, but the counts were made from temporary slides. The photographs were made from stained glycerine and glycerine jelly mounts. The identification and counting of the fossil pollen was done with a compound binocular microscope using 15× oculars and 10 mm. and 3mm. objectives. The slides were controlled with a mechanical stage, and usually two hundred fossils were counted for the analysis. The photomicrographs were made with a Zeiss Ikon camera supplemented with a detachable Eastman Kodachrome adapter. The film used was 35 mm. Panatomic-X; it was developed in D-11 and D-8 developer. The magnification used in the photographing varied according to the size and structure of the microfossils. The compound microscope used is a monocular, and combinations were made with oculars of 5×, 10×, and 20× magnification, and 10 mm. and 3 mm. objectives.

At present the illustrative material of pollen and spores is very scanty and it is necessary for each worker in paleoecology to collect and prepare for himself a collection of the most common spores and pollen. Regardless of the abundance of illustrations and descriptions of spores and pollen, it will always be necessary for each worker to have at his disposal such a collection for study and frequent comparison. It is now becoming apparent that pollen of the same species varies not only within the same sporange, but also there appear to be differences in the pollen of the same species in various portions of their geographic ranges. However, the value of further illustrations cannot be overlooked, since they may serve to clear up problems of identification, and also may be a real help to the innovate. With this in mind, the authors are presenting the following photomicrographs and the accompanying notes of the most common fossils found in the Vilas County bogs. Numerous abnormal grains appear in peat deposits and illustrations of them are worth recording, since these forms may be confusing to the beginner, and, too, they are of morphological interest.

Sphagnum sp (Plate I, Figs. 1, 2). Triangular to round when seen in proximal or distal view; diameter 25-29 microns; wall thin, unornamented; trilete mark on proximal surface.

This is an important fossil since it is indicative of local ecological conditions.

Lycopodium lucidulum (Plate I, Fig. 5). Triangular, sides concave in proximal or distal view; diameter 25-30 microns; wall uniformly papillate (1.2 mu.) on distal surface, papillae on proximal surface finer or absent; trilete mark on proximal surface.

The occurrence of *L. lucidulum* in peat is rather uncommon. The senior author, when monographing the genus (1934), noted that the proximal surface of this species and *L. selago* were unornamented. This appears to be the usual condition of the spores when they are subjected to the drastic KOH treatment used in the preparation of the material described in that paper. The spores found in the Vilas County peat were not smooth on the proximal surface.

Lycopodium annotinum (Plate I, Figs. 8, 9). Triangular to round in proximal or distal view; diameter 28-33 microns; proximal surface smooth, distal surface somewhat wavy reticulate, reticulum extending to the equator and ending as plainly visible projections. The number of projections upon the equator is approximately twenty, fewer than any other species of American lycopod. This species and its varieties are frequent inhabitants of peat bogs.

Lycopodium clavatum (Plate I, Figs. 10, 11). Triangular to round in proximal or distal view; diameter 28-35 microns; proximal and distal surfaces polygonally reticulate, 35 or more projections are present on the equator, reticulum upon the proximal surface extends three-fourths or higher into the angles of the trilete mark.

The spores of this species are differentiated from *L. complanatum* by the greater number of projections on the equator and the higher extent of the reticulum into the angles of the trilete mark. In the latter species the projections are usually about 30, and the reticulum enters very slightly into the angles of the trilete mark.

Lycopodium clavatum and its varieties are frequent inhabitants of peat bogs, and their spores are common fossils in some peat deposits.

Lycopodium inundatum (Plate I, Figs. 6, 7). Triangular to round in proximal or distal view; diameter 43-48 microns; proximal surface papillate, especially in the angles of the trilete mark, distal surface wavy reticulate.

Lycopodium inundatum appears as an abundant fossil in the lower levels of the Winchester Bog (Wilson and Webster, 1942). This species is interesting because McLaughlin (1932) has pointed out that it is at present associated with many species of Coastal Plain plants that appear to have migrated inland during the stages of Glacial Great Lakes. The occurrence of the fossils in Vilas County substantiates the early appearance of the species.

Thelypteris sp. (Plate I, Fig. 3). Bean-shaped in lateral view; length 37-45 microns; thickness 24-34 microns; wall smooth, monolete mark on proximal surface.

Fern spores are abundant in peat and need further study as fossils. The spore illustrated appears to be *Thelypteris palustris*, but definite identification with this species is withheld, for other spores of the same genus appear to lose their perisphoral structures when subjected to boiling. This results in a spore the type of which is illustrated.

Osmunda sp. (Plate I, Fig. 4). Spherical; diameter 36-39 microns; wall densely and irregularly covered with blunt projections, 1-3 microns long; trilete mark extends to equator.

The spores of *Osmunda* should prove interesting to the taxonomist, for they appear to have specific characters. *Osmunda* spores are frequently observed in the peat.

Picea mariana (Plate I, Figs. 12, 13). Winged grains; greatest dimension of tube cell 55-65 microns; bladders somewhat half-moon-shaped when seen in distal (ventral) view of the grain (Fig. 13); in transverse view (Fig. 12) the bladders join the tube cell at a nearly straight angle; a marginal crest appears to be absent.

The photomicrographs show typical examples of this species, but there are transitional forms that make separation of it from *P. glauca, Pinus resinosa,* and *P. Strobus* very difficult. The pollen of conifers need a critical study and comparison since there is considerable overlapping of the characters used to distinguish them.

Picea glauca (Plate I, Figs. 15, 16). Similar to *P. mariana,* but larger (tube cell 65-75 microns in greatest dimension), and the bladders are frequently more angular when seen in distal (ventral) view (Fig. 16).

This species has undoubtedly been mistaken for *Abies* by many workers in peat fossils. *P. glauca* is very abundant in the basal levels of nearly every peat bog in the Middle West.

Abies balsamea (Plate I, Figs. 17, 18). Largest winged pollen in the Middle West; tube cell 72-81 microns in greatest dimension; bladders bulbous, joining the tube cell at a sharp angle near the dorsal (proximal) roots, round or nearly so in distal view (Fig. 18); tube cell also frequently round in this view.

Wodehouse (1935) states that a faint triradiate streak is sometimes present on the dorsal (proximal) side of the grain, but it has never been seen in fossil material by the authors. This may be due to corrosion of the exine, since the trilete mark is at best a very indefinite feature of the tube cell.

Abies does not occur as abundantly in middlewestern peat as was previously supposed by many authors.

Tsuga canadensis (Plate I, Fig. 14). Wingless, doubly convexed to round in optical section; diameter 60-80 microns; coarse exine texture.

A very abundant pollen in some middlewestern peats. Sears (1930) has pointed out the danger of mistaking pteridophyte spores for pollen of *Tsuga*. He further points out that the former may be distinguished by the presence of triradiate prismatic faces on the proximal side. The fern spore most closely resembling *Tsuga* is *Osmunda,* and in this genus the trilete mark is not always apparent, even in fresh material. With some practice it is possible to separate *Osmunda* and *Tsuga* by exine structure. The exine of *Osmunda* is generally less reticulate and is more spinose. Another adjunct in determining the presence of *Osmunda* in peat is the occurrence of the wool-like trichomes. These have characteristic thickenings that give the appearance of joints. They preserve well as fossils and are easily recognized.

Pinus Banksiana (Plate II, Figs. 19, 20, 21). Smallest winged pollen in the Middle West; tube cell 41-48 microns in greatest dimension; marginal crest frequently well defined; bladders nearly round when seen in distal view.

Explanation of Plates I-II

Fig. 1, 2. *Sphagnum*, sp.

Fig. 3. *Thelypteris* sp.

Fig. 4. *Osmunda sp.*

Fig. 5. *Lycopodium lucidulum*

Fig. 6, 7. *Lycopodium inundatum*

Fig. 8, 9. *Lycopodium annotinum*

Fig. 10, 11. *Lycopodium clavatum*

Fig. 12, 13. *Picea mariana*

Fig. 14. *Tsuga canadensis*

Fig. 15, 16. *Picea glauca*

Fig. 17, 18. *Abies balsamea*

Fig. 19, 20, 21. *Pinus Banksiana*

Fig. 22, 23, 24, 25, 26. *Pinus Strobus* or *P. resinosa*

Fig. 27, 28. *Alnus* sp.

Fig. 29, 30, 31, 32. *Betula* sp.

Fig. 33, 34, 35. *Quercus* sp.

Fig. 36. *Corylus* sp.

Fig. 37, 38. *Ulmus americana*

Fig. 39, 40, 41. *Tilia americana*

Fig. 42, 43. *Juglans cinerea*

Fig. 44. *Carya cordiformis*

PLATE I

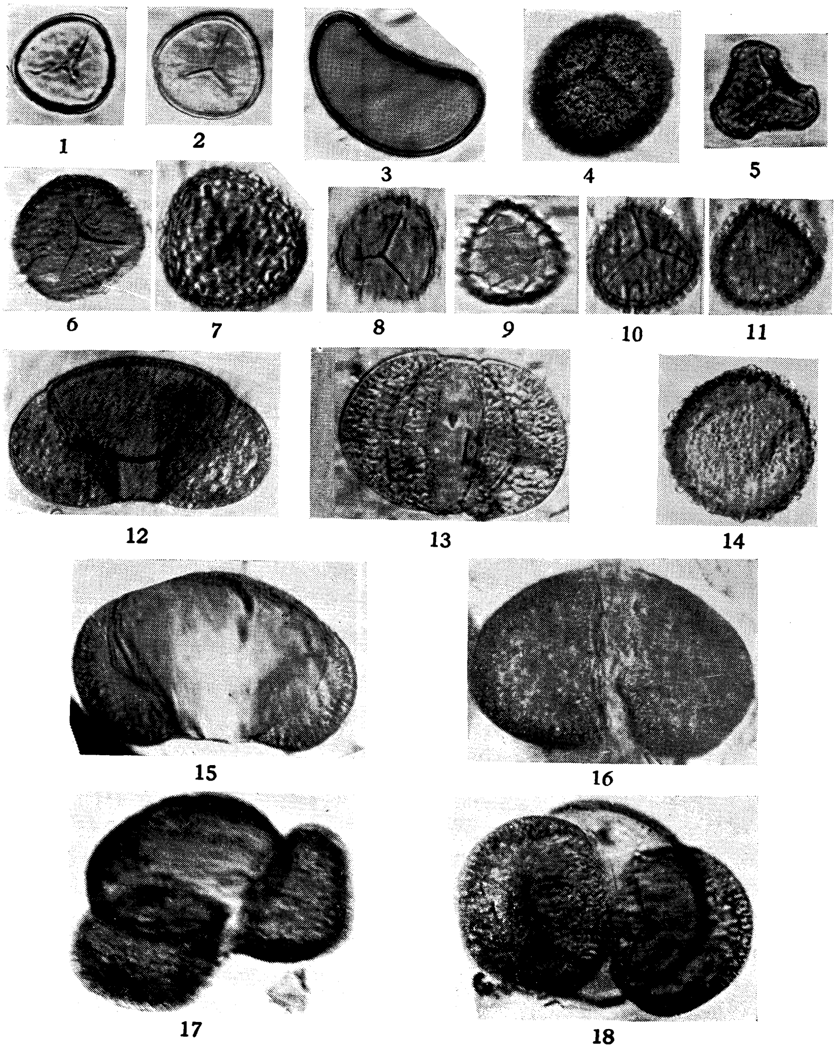
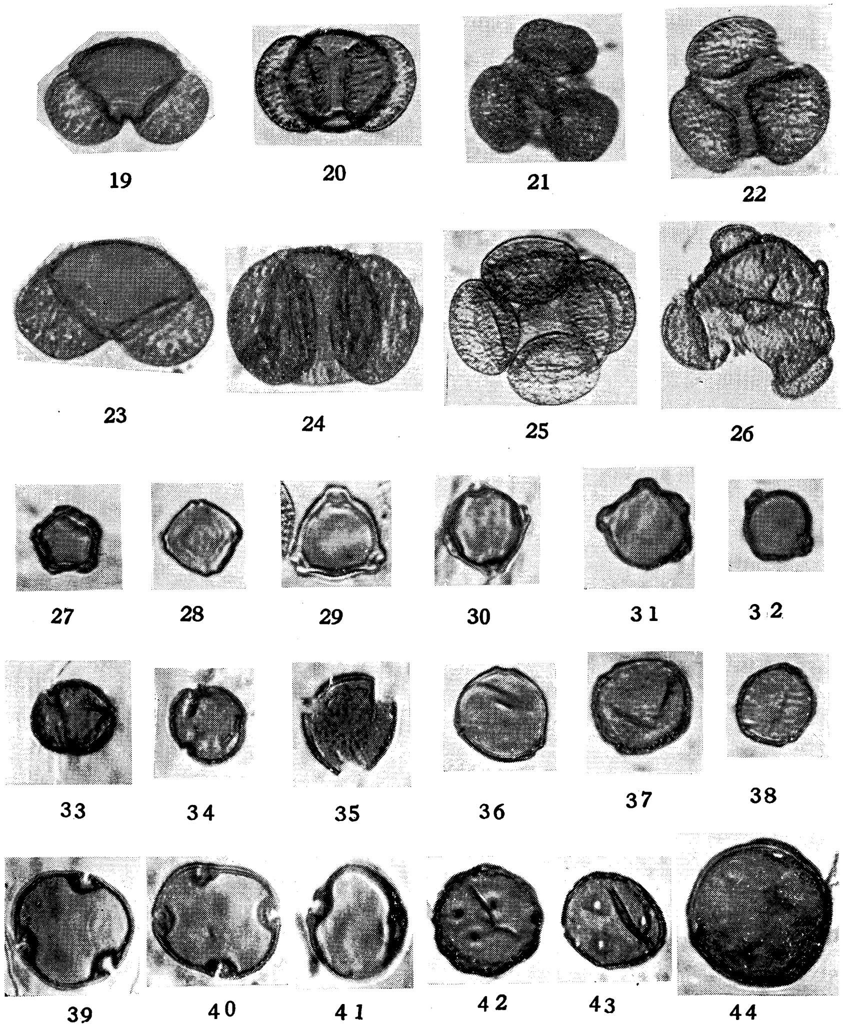


PLATE II


19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44

Cain (1940) has shown by size-frequency determinations that *P. Banksiana* may be distinguished from other pines of the east by its smaller size. Figure 21 is a photomicrograph of an abnormal grain with three, possibly four bladders.

Pinus Strobus or *P. resinosa* (Plate II, Figs. 22, 23, 24, 25, 26). The distinction of these two species as fossils is very doubtful, for even in fresh material, no constant character appears to be present. In fresh material of *P. Strobus* the reticulation of the bladders is fairly uniform, while that of *P. resinosa* appears to be finer near the edges when the grains are viewed on the distal side. However, this method of distinction is not a satisfactory one. Both species of pollen are about the same size, the tube cell measurements being 55-67 microns in longest dimension. Figures 22, 25, and 26 are abnormal grains.

Alnus sp. (Plate II, Figs. 27, 28). Diameter 18-27 microns; pores, narrowly elongate, generally four or five in number; subexineous thickenings usually extend from pore to pore along the equator. Not all fossil specimens examined have had these thickenings present. The specimens illustrated are either *A. crispa* or *A. incana*.

Betula sp. (Plate II, Figs. 29, 30, 31, 32). Diameter 20-31 microns, generally about 26 microns; usually three elliptical pores; two- and four-pored forms have been observed (Figs. 30, 31, 32); exine at pore expanded, appearing as broad knobs when viewed in optical section.

Several species of *Betula* pollen are present in the Vilas County peat, but these cannot be differentiated with certainty.

Corylus sp. (Plate II, Fig. 36). Diameter 22-26 microns; three circular or elliptical pores; exine at pores club-shaped when viewed in optical section.

Quercus sp. (Plate II, Figs. 33, 34, 35). Diameter 25-37 microns; spheroidal or flattened; three-furrowed; exine granular or warty, no regular pattern. When flattened, the grains frequently split along the furrows and appear in fossil form as illustrated in Figure 35.

Ulmus americana (Plate II, Figs. 37, 38). Diameter 28-38 microns; oblately flattened; usually four or five elliptical pores; subexineous reticulation.

Ulmus is one of the important trees of the swamp forest in northern Wisconsin and has an extensive fossil history in the peats.

Tilia americana (Plate II, Figs. 39, 40, 41). Diameter 25-37 microns; oblately flattened; usually three elliptical pores that are deeply sunken, and have marked subexineous thickenings which are seen in optical section; exine uniformly pitted.

Two- and four-pored grains have been observed in the peat, but these are rare.

Juglans cinerea (Plate II, Figs. 42, 43). Diameter 32-35 microns; spheroidal; 9 to 12 circular pores restricted to one hemisphere; subexineous thickening around pores; exine smooth.

This species and *Carya cordiformis* are considered more fully below in the discussion.

Carya cordiformis (Plate II, Fig. 44). Diameter about 40 microns; spheroidal or oblately flattened; pores usually three, elliptical to circular, and generally in one hemisphere; exine somewhat granular.

SPRUCE LAKE BOG

This peat deposit is an extensive bog covering several thousand acres. The location where borings were made is the NW ¼ of the SW ¼, Section 7, Township 41 N., Range 5 E. Near the center of this deposit is a bog lake known as Spruce Lake, and from this the bog takes its name. The deposit is relatively shallow as one would expect in a bog of such large size. At the location where samples were collected, the contact of peat with sandy clay was found nine feet below the surface. Samples were collected from one-foot intervals. The surface of the bog is covered with a dense growth of heaths and a few small, black spruces. The heaths are species of *Vaccinium, Chamaedaphne, Gaylussacia, Ledum, Kalmia,* and *Andromeda.*

The forests around the bog are of recent second growth and consist of red, white, and jack pine, balsam fir, white spruce, white birch, aspen, soft maple, and scrub oaks.

Figure 1 shows graphically the abundance and succession of the microfossils in the Spruce Lake Bog, and Table I gives further details. From these microfossil studies there is evidence that the pine forests were preceded by a more northern type of forest composed largely of white spruce. This early gave way to the pine forest, as is indicated by the increase in pine pollen about two-thirds of the distance from the top of the deposit. Near the middle levels there is a suggestion that basswood and ash were more abundant than they are today. Birch pollen is more important in the top level than below. Some of the birch

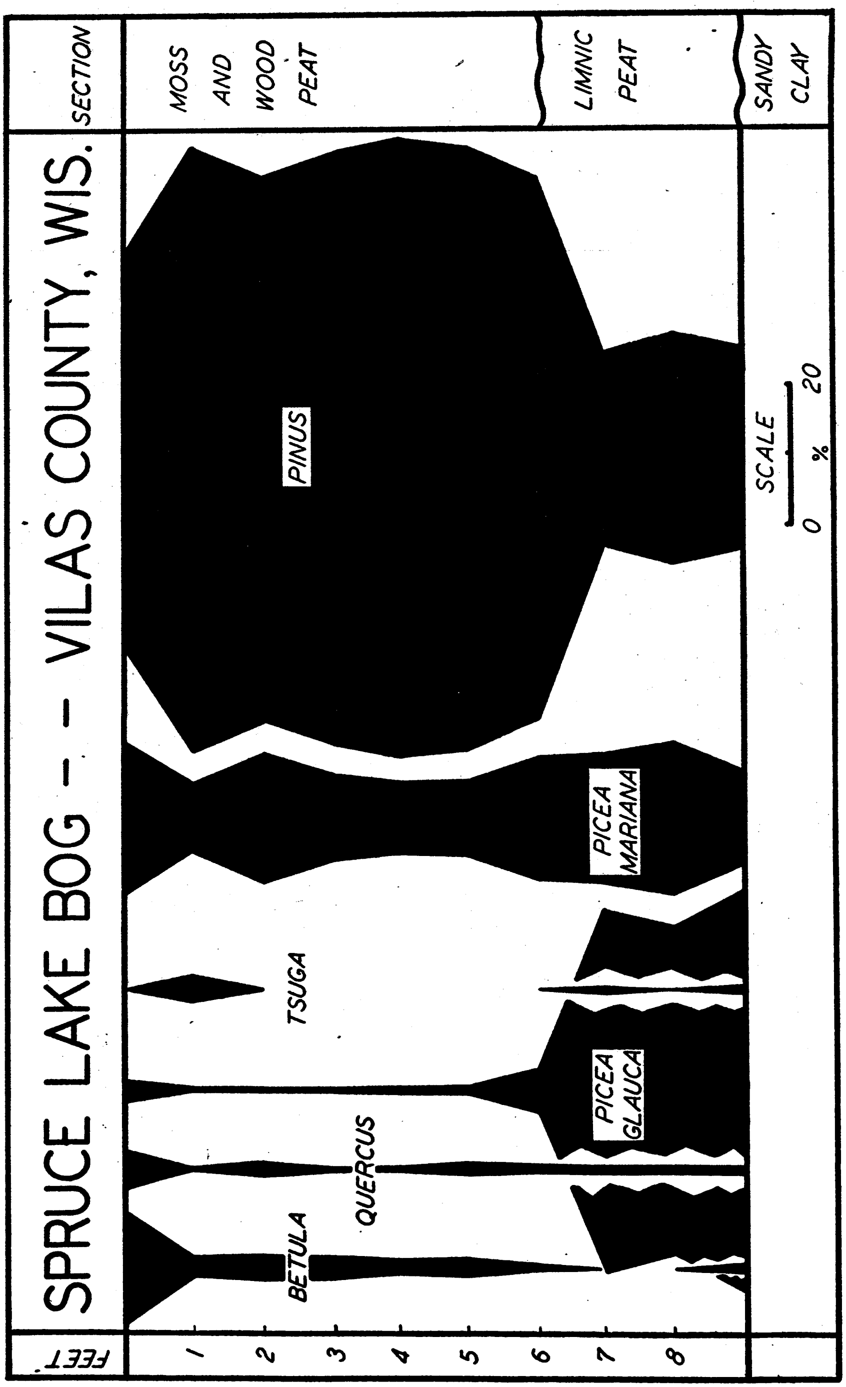


Fig. 1. Diagram showing the distribution and succession of microfossils in in the Spruce Lake Bog.

fossils undoubtedly are of bog species, and therefore this pollen does not give a true picture of the forest composition. The occurrence of hemlock at the bottom and near the top of the bog is of interest, since this species of tree has not been seen in the immediate vicinity today. Such occurrence supports other evidence that this species has had a wider distribution in the past than at present. Black spruce pollen usually occurs abundantly in two levels of the spectrum, and these are separated by levels where it is scarce. An explanation of this occurrence may be that the black spruce was early an upland tree along with the white spruce. When most of the latter migrated northward, some of the black spruce probably remained near the edge of the lake in which peat was accumulating, and attained greater importance when subaerial peat was formed and a bog such as the present one came into existence. The return of white spruce fossils to the spectrum may be suggestive of climatic change and reverse to cooler conditions. Such has been suggested by Cooper (1942).

TABLE I.

Percentages of fossil pollen in the Spruce Lake Bog, Vilas County, Wisconsin.

Species	Depth in Feet									
	9	8	7	6	5	4	3	2	1	0
ABIES BALSAMEA		1.0	3.0	.5	.5	1.0	.5	.5	.25	
PICEA GLAUCA	56.0	45.0	50.0	6.0	1.0	1.0	.5	.5	.5	3.0
PICEA MARIANA	13.0	21.0	18.0	17.0	10.5	10.0	12.0	18.0	9.5	21.0
PINUS BANKSIANA	16.0	19.0	8.0	46.0	27.5	20.0	22.0	14.0	20.75	8.0
PINUS RESINOSA & PINUS STROBUS	12.0	13.0	19.0	29.0	56.0	65.5	60.5	61.5	62.5	48.0
TSUGA CANADENSIS	1.0		1.0					3.5		
BETULA	1.0			.5	2.5	2.0	3.0	3.5	2.75	15.0
QUERCUS	1.0	1.0	1.0	1.0	1.5	.5	.5	2.0	.25	5.0
FRAXINUS							.5			
TILIA AMERICANA					.5		.5			

SILVER LAKE BOG

Silver Lake Bog is located in the SE ¼ of the SW ¼ of Section 24, Township 41 N., Range 6 E. It is about one-quarter of a mile

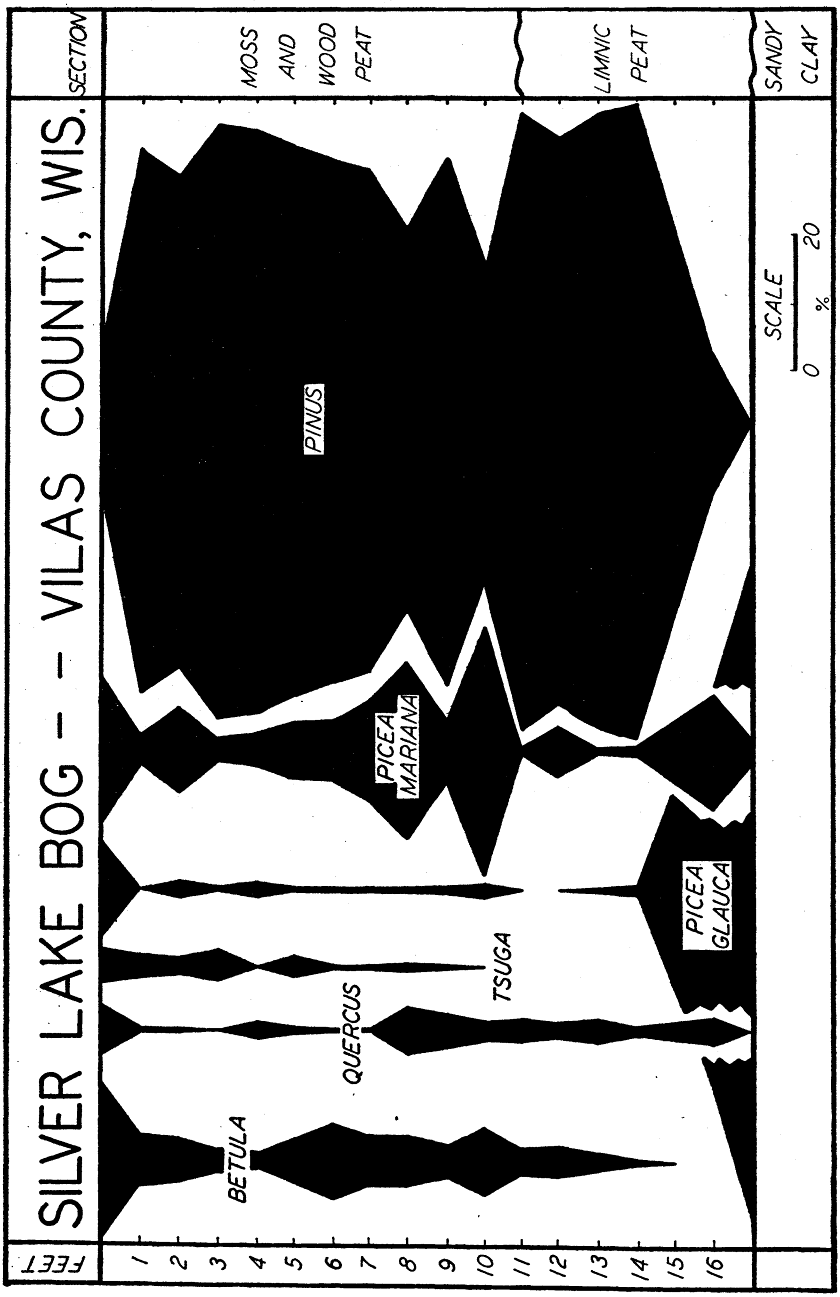


Fig. 2. Diagram showing the distribution and succession of microfossils in the Silver Lake Bog.

east of Silver Lake and approximately the same distance south of Trout Lake. The bog is about three acres in area and located in a rather deep kettle hole near the edge of an outwash plain. Thwaites (1929) maps the area immediately to the south as part of the Muskellunge Moraine.

The forest surrounding the bog is second growth with a predominant element of white birch and aspen. In addition, white and red pine, balsam fir, white spruce, red oak, and soft maple occur. A few small black spruces grow upon the bog and the remaining cover is that of heaths and other characteristic bog plants.

The depth of the peat is seventeen feet to the contact with sandy clay. Samples were collected at one foot intervals, except from the fifteenth foot level where a water pocket was encountered, and no peat was recovered.

Table 2 and Figure 2 illustrate the abundance and succession of the fossil pollen in the Silver Lake Bog. The same general succession of the forest species is indicated as is suggested in the Spruce Lake Bog. Hemlock again appears in the peat but is not present in the immediate vicinity of the bog today. The surface sample, however, shows hemlock to be present. Two possibilities exist; the sample taken from the surface may have extended deep enough to include peat that was formed before lumbering began, or, hemlock pollen is being deposited upon the bog from a small stand that is nearly three miles away. Hickory pollen occurs in the eight foot and one foot levels, and butternut in the one foot level. These are not living in the region today. The nearest hickory is found about 65 miles southward, and butternut about 60 miles westward.

White Sand Lake Bog

The location of White Sand Lake Bog is the NW ¼ of the SE ¼ in Section 28, Township 42 N., Range 7 E. It is approximately one acre in area and seven feet deep near its center. Sandy clay underlies the deposit.

The cover of the bog is *Chamaedaphne* and a few small, black spruces. The upland is typical jack pine barrens, as is much of the area of outwash plain in that region. In addition to having been logged, the region has been severely burned. There is evidence in the stumpage that the immediate vicinity did support a heavy cover of red pine. Many of the stumps are two and three feet in diameter.

TABLE II.

Percentages of fossil pollen in the Silver Lake Bog, Vilas County, Wisconsin.

Species	Depth in Feet																	
	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ABIES BALSAMEA				1.0				.5	1.0	.5	1.0	1.5	.5	1.0	.5	3.0	4.5	
PICEA GLAUCA	96.0	59.0		1.5	0.5			2.0	1.0	.5	.5	.5	.5	2.0	.5	2.5		14.0
PICEA MARIANA	4.0	17.0		1.5	1.0	7.5	1.5	36.5	9.0	26.0	15.0	9.0	8.5	5.0	3.5	12.5	4.5	21.0
PINUS BANKSIANA		13.0		58.0	34.5	14.5	40.5	6.0	12.5	4.5	9.0	7.0	14.5	20.5	23.5	17.5	14.0	2.0
PINUS RESINOSA & PINUS STROBUS		7.0		35.0	55.5	69.5	50.5	40.5	66.0	51.0	65.0	69.5	66.0	65.0	63.5	54.5	64.0	25.0
TSUGA CANADENSIS									.5	1.0	.5	.5	3.0		4.5	2.5	3.5	5.0
BETULA				.5	2.5	4.5	4.0	10.0	5.0	7.5	7.5	11.0	6.0	2.5	3.5	6.5	7.5	23.0
QUERCUS		4.0		1.5	3.5	2.5	3.5	3.0	5.0	7.0	.5	.5	1.0	2.5		.5	.5	7.0
ULMUS AMERICANA					.5	.5				.5					.5			
ACER				1.0	2.0	1.0		.5		.5	1.0	.5		1.5		.5		3.0
JUGLANS CINEREA																	.5	
CARYA CORDIFORMIS																	.5	
TILIA AMERICANA								1.0									.5	

Table 3 and Figure 3 indicate the abundance and succession of the microfossils. It will be noted again that the fossil spectrum suggests that the earliest forest was spruce and that this gave way to pine. Again there appears to have been a period during which hemlock was more abundant than at present. Also, elm is present in the middle levels and not found on the surface. Birch and oak show a fairly strong percentage at the two foot level, and the latter is present through the entire section of the bog.

TABLE III.

Percentages of fossil pollen in the White Sand Lake Bog, Vilas County, Wisconsin.

Species	Depth in Feet								
	7	6.5	6	5	4	3	2	1	0
ABIES BALSAMEA	1.0								
PICEA GLAUCA	82.0	1.5			1.5	2.5	1.5		1.0
PICEA MARIANA	11.0	10.0	11.0	6.5	24.5	27.0	28.5	7.5	10.0
PINUS BANKSIANA		79.5	8.0	29.5	4.0	6.5	5.5	14.0	55.0
PINUS RESINOSA & PINUS STROBUS	3.0	7.5	74.5	60.0	64.0	61.0	46.5	70.0	18.0
TSUGA CANADENSIS			1.5		.5		.5	4.5	
BETULA		1.0	3.5	.5	3.0	1.5	13.0	3.5	11.0
QUERCUS	3.0	.5	1.5	2.0	2.0	1.5	4.0	.5	5.0
ULMUS AMERICANA				1.0			.5		
ACER				.5					
TILIA AMERICANA					.5				

DISCUSSION

The three bogs give a rather definite history for the development of the lake forest in northcentral Wisconsin. It appears to have early succeeded the boreal forest of white spruce and has remained the important formation of the region since. It has been pointed out above that near the middle levels in each bog there is evidence of an abundance of certain hardwoods, namely, oak, hickory, birch, basswood, ash, elm, and maple. This minor fluctuation in species of hardwood pollen is general throughout upper Wisconsin. There appears to be a direct correlation with a greater fluctuation of hardwood pollen in bogs of southern Wis-

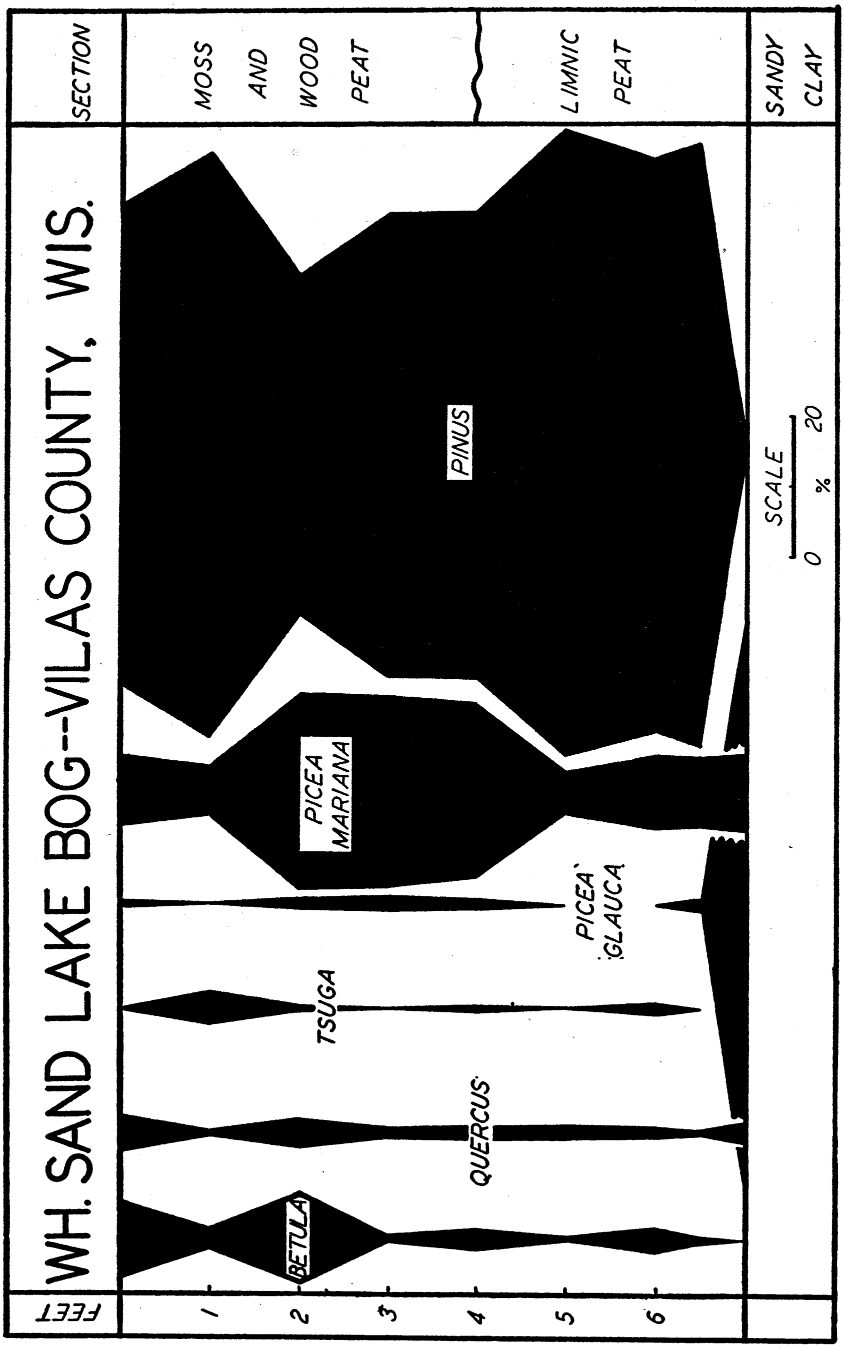


Fig. 3. Diagram showing the distribution and succession of microfossils in the Sand Lake Bog.

consin, Illinois, Indiana, and Ohio, but closer comparison must wait a critical examination of many more intermediately located bogs and a careful study of age relationships. The wide distribution of hardwood forest elements approximately in the center of a pine forest period is not a normal sequence of forest succession. This irregularity has been suggested as evidence of a climatic shift, and supports the climatic hypothesis of Von Post (1930). He suggests that there were three generalized phases: (1) increasing warmth, (2) maximum warmth, and (3) decreasing warmth. The strongest fossil pollen evidence for this hypothesis in northcentral Wisconsin is the occurrence of hickory pollen in the Silver Lake Bog, noted above, and the Winchester Bog located about twenty-five miles northwest (Wilson and Webster, 1942). Both of these localities are north of the present range of hickory in Wisconsin and suggest that during the so-called "xerothermic period", the oak-hickory forest of southern Wisconsin extended farther north than it does at present. A return to a cooler climate is suggested by the disappearance of hickory, the decrease in abundance of other hardwoods, and the increase of conifers such as white spruce and possibly hemlock.

Summary

1. Three bogs in Vilas County, Wisconsin, were investigated paleoecologically to determine the history of the lake forest present in that region.

2. Notes and photomicrographs of common and abnormal spores and pollen found in the deposits are included in the studies.

3. The fossils indicate that the lake forest was preceded by a boreal forest composed largely of white spruce. Near the middle of the pine forest period there is a small amount of hardwood fossil pollen including hickory and butternut, two species which no longer grow within the region.

4. The occurrence of hickory and other hardwood pollen is interpreted as evidence of a warmer period of climate in late postglacial time, supporting the Von Post hypothesis.

Literature Cited

Cain, Stanley A. 1940. The identification of species in fossil pollen of *Pinus* by size-frequency determinations. Amer. Jour. Bot. 27: 301-308.

Cooper, W. S. 1942. Vegetation of the Prince William Sound Region, Alaska; with a brief excursion into post-Pleistocene climatic history. Ecol. Mono. 12: 1-22.

McLaughlin, W. T. 1932. Atlantic Coastal Plain plants in the sand barrens of northwestern Wisconsin. Ecol. Mono. 2: 335-383.

Sears, P. B. 1930. Common fossil pollen of the Erie Basin. Bot. Gaz. 89: 95-106.

Thwaites, F. T. 1929. Glacial geology of part of Vilas County, Wisconsin. Trans. Wis. Acad. Sci., Arts & Let. 24: 109-125.

Von Post, L. 1930. Problems and working lines in the post-arctic history of Europe. Rept. Proc. 5th Intern. Bot. Cougr. Cambridge: 48-54.

Weaver, J. E. and F. E. Clements. 1929. Plant Ecology. McGraw-Hill Book Company, New York.

Wilson, L. R. 1934. The spores of the genus *Lycopodium* in the United States and Canada. Rhodora 36: 13-19.

. . . . . 1938. The postglacial history of vegetation in northwestern Wisconsin. Rhodora 40: 137-174.

. . . . . and R. M. Webster. 1942. Fossil evidence of wider post-Pleistocene range for hickory and butternut in Wisconsin. Rhodora 44: 409-414.

Wodehouse, R. P. 1935. Pollen Grains. McGraw-Hill Book Co., New York.

A PHOTOELECTRIC METHOD FOR DETERMINATION OF pH

JOHN RAE AND V. W. MELOCHE

An accurate and rapid photocolorimetric method for determining pH without the use of color standards for comparison is described in detail.

A calibration table is presented for rapid conversion of light transmission to pH. Correction data for temperature and salt concentration variations are also offered in easily useable form.

The present method is directly applicable to systems adapted to analysis by other colorimetric pH methods. In addition this method works well, with certain restrictions, in the case of solutions containing coloring materials. Suspended colloids in orange juice and in the soil-water mixtures used in soil reaction studies are held responsible for unreliable results in these cases because of adsorption of the indicator. The method was found to be well suited to acidity control work with nutrient solutions such as are used in hydroponics.

The method is readily adaptable to rapid multiple determinations and is exceedingly inexpensive. Only one standard solution is necessary and this is easily standardized and stable for at least one month.

INTRODUCTION

H. T. S. Britton (1) in his book entitled *Hydrogen Ions, Their Determination and Importance in Pure and Industrial Chemistry,* has emphasized the importance of hydrogen ion concentration. "Hydrogen ion concentrations have long been recognized as an essential factor in many biochemical processes, and it is undoubtedly on account of this recognition that considerable additions have been made in recent years to our knowledge of biochemical principles. In other branches of chemistry, hydrogen ion concentrations are only just beginning to be regarded as being of fundamental importance, and the use of the hydrogen electrode and the other associated methods are being increasingly applied, not only to measure very small changes in acidity and alkalinity, but as valuable indicators of the extents to which reactions have proceeded and as a means of controlling these reactions with an exactitude hitherto impossible." Today hydrogen ion considerations are most important to leather processing concerns, sugar manufacturers, pulp and paper manufacturing plants, brewing concerns, baking houses, sewage disposal plants, ceramics, and textile and dye industries.

Although the indicator colorimetric methods for the determination of hydrogen ion concentrations are being replaced by electrical methods making use of the standard half-elements, the hydrogen electrode, the quinhydrone electrode, oxygen and air electrodes, metal-metallic oxide electrodes, and the glass electrode systems, the colorimetric methods are still today widely used. These colorimetric methods often require the use of a series of buffer solutions of known pH for color comparisons. The preparation and use of these buffer solutions is time-consuming and as a rule, the solutions are subject to bacterial action and their usefulness in accurate pH work is limited to a period of a week or two.

The purpose of the present work was to develop an accurate and rapid method for determining hydrogen ion concentrations without the use of color standards for comparison. This was accomplished chiefly by the use of an improved type of photoelectric colorimeter, the careful choice of indicator and reagent concentrations, and the construction of a calibration table of universal applicability.

In principle the present method is based upon the work of Wallace R. Brode (2) who has described "the determination of hydrogen ion concentration by a spectrophotometric method and the absorption of certain indicators." According to the Brode method, a standard amount of indicator is added to the test solution and the hydrogen ion concentration is determined by comparing the height of its absorption band with those obtained with solutions of known hydrogen ion concentration. These measurements necessarily involved the use of a spectrophotometer. The present modification is more direct, accurate, and rapid and does not involve the use of a spectrophotometer. Moreover the technique of the operations involved is exceedingly simple so that even the unskilled operator should have no difficulty in using the method.

Brode has observed in the spectrophotometric study of certain dyes and indicators at various hydrogen ion concentrations, that the absorption band does not shift in wave length but merely changes in height, with changing pH. If, then, light of wave length corresponding to the region of maximum absorption of the indicator is used along with a suitable instrument for measuring light transmission, the observed transmission will be a measure of the hydrogen ion concentration. This is the principle upon which the present method is based.

Since the work was completed, a method based upon the same principle has been described (3). However, since that paper lacked certain details of operation and technique, it was considered necessary to publish the more detailed report.

Materials

Colorimeter. The Evelyn Photoelectric Colorimeter equipped with filter No. 540 was especially selected for this work. It was chosen for the high degree of standardization of its components permitting the interchange of calibration curves and constants from one colorimeter to any other colorimeter of the same make. Thus it has been possible to offer calibration data of universal applicability for the determination of pH. The necessity of constructing new calibration curves for each different colorimeter is thereby obviated, and with the calibration data offered here one can proceed at once with the actual determination without having to make up any standards for comparison.

Standard Methyl Red Reagent. 0.100 grams of methyl red were ground in an agate mortar with 3.7 ml. of 0.1 N NaOH and 3.7 ml. of distilled water. This mixture was made up to about one liter with distilled water and filtered into a one liter storage bottle. 380 ml. of this approximately 0.01 per cent water solution of neutralized methyl red were diluted to about 880 ml. in a one liter bottle. A one ml. aliquot of this diluted solution was added to 20 ml. of 0.1000 N HCl and the color density read on the colorimeter. Subsequent adjustments were then made on the original diluted indicator solution to bring the indicator concentration to a value which gave a corrected colorimeter reading of 36.7 at 25° C when one ml. of the indicator solution was added to 20 ml. of 0.1000 N HCl as above. (In making these adjustments it is convenient to know that 2.1 ml. of distilled water or 0.8 ml. of 0.01 per cent methyl red solution added to 900 ml. of the diluted methyl red will result in a difference of about 0.1 mm. in the colorimeter reading. The reading will be higher if water is added and lower if methyl red is added. It is also convenient to know that the temperature coefficient of this system is about +0.1 mm. (scale divisions) per degree rise in temperature. In these color density measurements the HCl solution and not water was used for the 100 setting of the galvanometer.

It has been found that this standard solution of methyl red can be kept unaltered for a period of at least one month.

Description of Method

pH Calibration Curve. Standard buffer solutions ranging from pH 4.00 to pH 7.00 in steps of 0.20 pH units were made up according to Clark and Lubs (4), using a potassium biphthalate-sodium hydroxide system from pH 4.00 to 6.00 and a mono-potassium phosphate-sodium hydroxide system for pH's above 6.00. One-ml. aliquots of the above described standard methyl red solution were pipetted into test tubes containing 10 ml. of buffer solution. The test tubes, of the specially selected 7″ x ⅞″ variety supplied with the Evelyn Colorimeter, were stoppered with No. 4 rubber stoppers. After thoroughly mixing the solution, their light transmissions were measured at 25° C. All transmission measurements were taken relative to the trans-

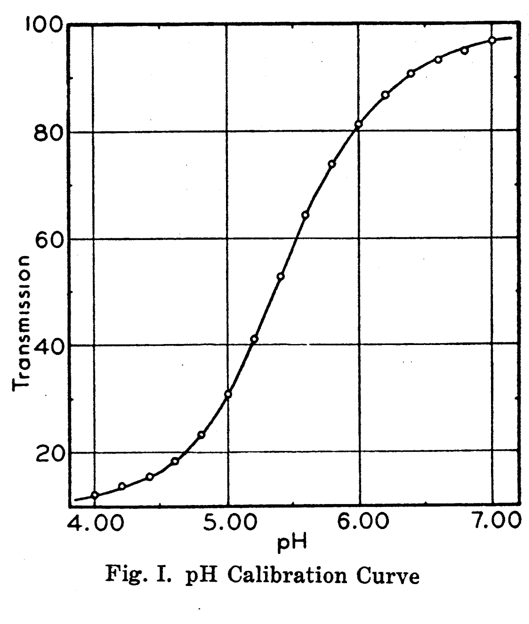


Fig. I. pH Calibration Curve

mission of the test solution before the addition of indicator and were read directly on the colorimeter. The colorimeter readings were plotted against pH as shown in Figure I.

This calibration curve was constructed on the basis of a commercial grade of methyl red purified by recrystallization from glacial acetic acid. However, points on the curve were checked with a methyl red solution made up from the unpurified product and were found to be identical with those obtained with the purified methyl red.

Procedure. To determine the pH of an unknown system, 10 ml. of the test solution were pipetted into a clean, dry colorimeter tube. One ml. of the standard methyl red indicator was added, and the transmission of the thoroughly mixed solution was read on the colorimeter, as indicated in the description of the construction of the standard curve. The test solution was set at 100 on the galvanometer scale before the addition of the indicator.

Calculation of Results. The direct conversion of colorimeter readings to pH can be accomplished by use of the standard curve shown in Figure I above. Actually, however, for greater ease in making more accurate conversions, Table I is used.

TABLE I. Colorimeter readings and corresponding pH*

G	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
10			3.94	4.10	4.23	4.34	4.42	4.49	4.56	4.62
20	4.67	4.71	4.75	4.79	4.82	4.85	4.87	4.90	4.93	4.95
30	4.98	5.00	5.02	5.04	5.06	5.08	5.10	5.12	5.14	5.16
40	5.18	5.19	5.21	5.23	5.25	5.26	5.28	5.30	5.32	5.33
50	5.35	5.37	5.38	5.40	5.42	5.44	5.45	5.47	5.49	5.50
60	5.52	5.54	5.56	5.58	5.60	5.62	5.64	5.66	5.68	5.70
70	5.72	5.74	5.76	5.78	5.80	5.83	5.86	5.88	5.91	5.94
80	5.97	6.00	6.03	6.06	6.09	6.13	6.17	6.21	6.26	6.31
90	6.37	6.44	6.52	6.61	6.71	6.82	6.94	7.07		

*At 25° C and salt concentration of 0.08 M.

This table was built by the use of Newton's interpolation formula from a difference table constructed from data obtained with the standard buffer series mentioned above.

For very accurate work it is sometimes necessary to correct the apparent pH for variations in temperature above or below 25° C. This temperature correction varies from –0.001 to –0.014 pH units per degree rise in temperature depending upon the pH of the solution as shown in Figure II.

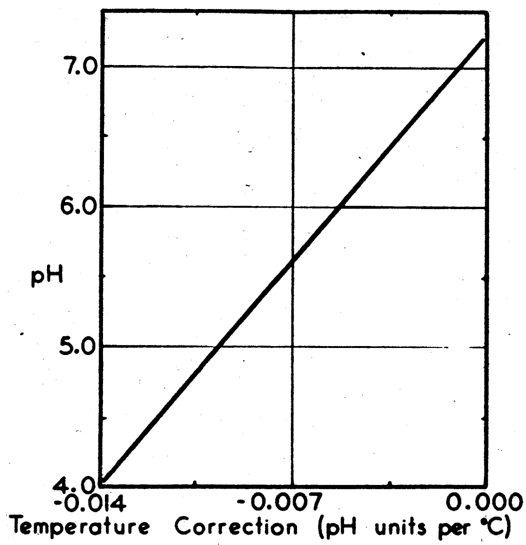


Fig. II. Temperature coefficient curve

In addition to the correction for temperature variations, it is often advisable to make a correction for variations in the salt content of the test solution. This correction amounts to approximately 0.01 pH units per 0.01 mole of electrolyte per liter of solution but will vary for different electrolytes as explained under "Experimental Results". Inasmuch as the calibration data in Table I were computed assuming a salt concentration of 0.08 M, this figure should be subtracted from the estimated salt concentration in the test solution. The difference, expressed in pH units, should be added to the uncorrected pH. In many cases the salt concentration of the particular solution being tested will be such that this correction will be unnecessary for the degree of accuracy required of the determination.

Application and Limitation of the Method. It is demonstrated below that the present proposed method for determining pH is well suited to the type of solution which lends itself to analysis by the ordinary colorimetric pH methods. More particularly, the present method has been applied successfully to "reaction" studies with nutrient solutions such as are used in hydroponics. In addition, it has been found that the method is also applicable, with certain restrictions, to colored and turbid solutions. (The presence of color or suspended material in the solution is taken care of automatically by setting the "blank" at 100 on the galvanometer scale before the addition of the indicator solution.)

This method cannot be used with a high degree of accuracy in the case of (1) solutions too highly colored to be set at 100 on the galvanometer scale, (2) solutions containing sufficient colloidally suspended material to adsorb appreciable quantities of indicator, or (3) solutions containing substances which will enter into chemical reaction with the indicator dye. These limitations are common to any colorimetric pH method.

As far as reproducibility of results is concerned it has been found that on portions of the same test solution hydrogen ion concentrations can be reproduced easily to within two hundredths of a pH unit in the optimum range of the indicator. However, there are other factors besides precision which enter in to effect the accuracy of the determination. The temperature effect has already been referred to and correction data have been offered. Another source of error is the effect of salt concentration as referred to above and discussed below under "Experimental Results".

An idea of the possible instrumental error involved can be had from Figure III which shows the effect of a 1 mm. galvanometer deviation upon the apparent pH.

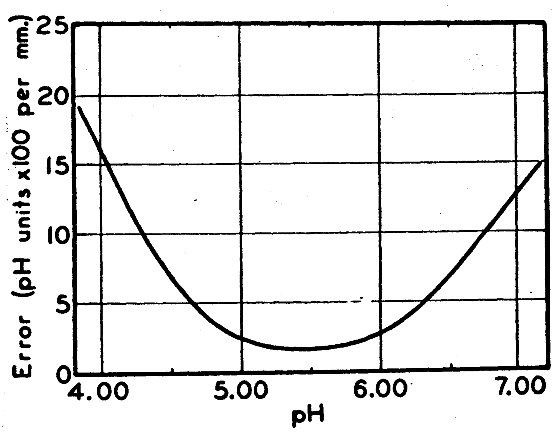


Fig. III. Instrumental error curve

Since it has been found that galvanometer readings are reproducible within 0.3 mm., the plotted pH coefficients can be divided by a factor of three for an estimate of the error caused by ordinary variations experienced in the operation of the colorimeter.

In connection with the general, direct applicability of the calibration data presented in Table I, it has been demonstrated (see "Experimental Results") that the mean error incurred by using the calibration data interchangeably with any Evelyn Colorimeter will not exceed 0.03 pH units in the pH range between 4.8 and 6.0. The maximum possible error (based on calculations from the Maxwell distribution) should not exceed 0.15 pH units. Where a high degree of accuracy is required it is recommended that several points on Table I be checked with buffer solutions as described above in the description of the method. If these checks are not satisfactory, correction data can be worked out to be used along with Table I.

Experimental Results

Spectral Characteristics of Indicator Solution. The spectral transmission of a buffer solution of pH 4.20 containing 1 ml. of a 0.00394 per cent solution of methyl red per 10 ml. of buffer solution was studied with the aid of both a Coleman Spectrophotometer and a Cenco Spectrophotelometer. The data obtained are plotted in Figure IV. Curves 1 and 2 represent data obtained with the Coleman and Cenco instruments respectively.

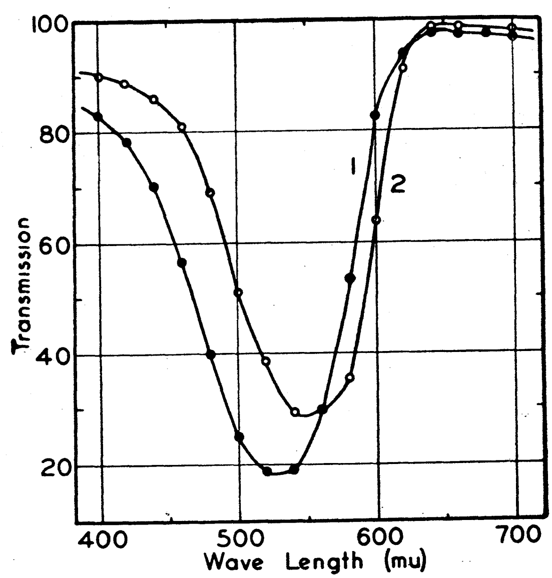


Fig. IV. Spectral transmission of methyl red at pH 4.20

As previously noted, Brode (2) has shown the absorption band for a number of indicator dyes including methyl red does not shift in wave length but simply changes in intensity with a change of hydrogen-ion concentration. In the light of this fact, the above data indicate that the optimum color filter to use exclusively in the present proposed method of determining hydrogen ion concentrations should transmit light of about 540 mμ in wave length. (It is obvious from Figure IV that there was a difference in wave length calibration of about 20mμ in the case of the two instruments used in the investigation.)

Determination of Optimum Color Filter and Indicator Concentration. In order to determine the best color filter to use for maximum sensitivity in measuring the light absorption of methyl red, varying amounts of a 0.01 per cent aqueous solution of methyl red were added to two series of colorimeter tubes, the first series containing 20 ml. aliquots of buffer solution at pH 3.00 and the second series containing 20 ml. aliquots of buffer solution at pH 6.00. (The buffer solutions were made according to Clark and Lubs (4).) The transmissions of these solutions were measured by use of the Evelyn Colorimeter equipped with filters No. 520, No. 540, and No. 540M successively. As a measure of colorimeter sensitivity over the range from pH 3.00 to 6.00, the transmissions of the solutions at pH 3.00 were subtracted from the transmissions of the solutions at pH 6.00 to which an equal amount of indicator had been added. These differential transmissions were then plotted against indicator concentrations as shown in Figure V.

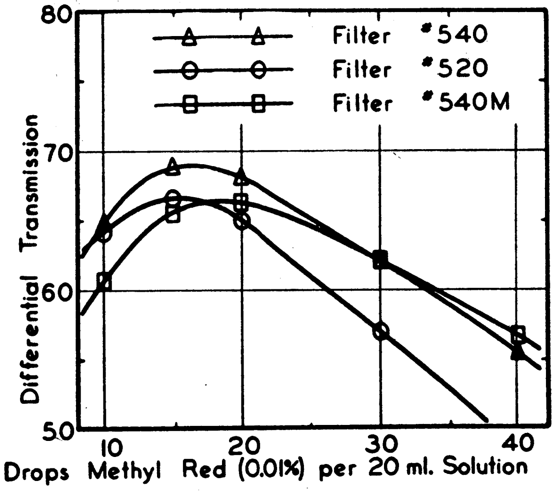


Fig. V. Filter-concentration curve

These data would indicate that for the pH range under consideration, the best color filter from the standpoint of sensitivity is filter No. 540. In addition, it is seen that the optimum indicator concentration should correspond to about 15.4 drops of 0.01 per cent aqueous methyl red. (The volume of 15.4 drops of indicator solution was determined as 0.788 ml. by determining the average weight per drop and then converting this weight into volume and multiplying by the number of drops.) It was tentatively concluded that 0.788 ml. of 0.01 per cent methyl red should be used for 20 ml. of test solution or 0.394 ml. should be used with 10 ml. of test solution. For convenience in adding the indicator solution it was diluted at this stage of the investigation to a concentration of 0.00394 per cent so that a 1 ml. aliquot could be added to 10 ml. of test solution in place of 0.394 ml. of the 0.01 per cent.

Theoretical and practical considerations indicated that the best indicator concentration for maximum sensitivity in one pH range as from pH 3.00 to 6.00 would not be the best concentration for maximum sensitivity in another pH range. Accordingly this point was tested. Varying amounts of the diluted indicator were added to three series of colorimeter tubes containing buffer solutions of pH 4.20, 5.20 and 6.00. Sensitivities, measured by differences in transmission as above, over the pH ranges considered, were recorded and plotted against the amount of indicator added as indicated in Figure VI.

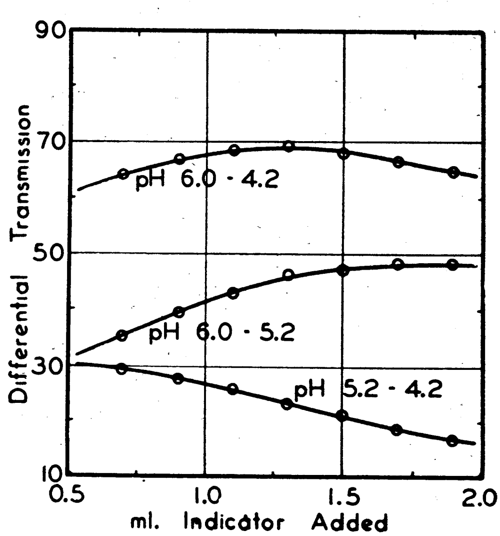


Fig. VI. Optimum indicator concentrations for various pH ranges

The data show clearly that optimum indicator concentrations vary with the pH range under consideration. It appears that for pH ranges covering similar differences in pH, the optimum indicator concentration for maximum sensitivity decreases with increasing acidity of the test solution. However, these data show that an indicator concentration of 1 ml. of 0.00394 per cent methyl red per 10 ml. of test solution is a good compromise.

Having thus determined the indicator concentration, it was important to be able to reproduce accurately the 0.00394 per cent solution of methyl red so that standard pH curves would remain valid and could be used unaltered in other laboratories. Because of the variability of the purity of the methyl red reagent, the standard indicator solution cannot be made up by direct weighing. Hence it was found convenient and entirely satisfactory to make up an approximate indicator solution and subsequently adjust it with distilled water to give a colorimeter reading of 36.7 (at 25° C.) when added to 0.1000 N hydrochloric acid in the proportion of 1 ml. of indicator to 20 ml. of test solution. This value of 36.7 was determined simply by adding 1 ml. of the 0.00394 per cent indicator solution to 20 ml. of 0.1000 N HCl contained in a colorimeter tube at 25° C. and reading the transmission on the colorimeter. The average transmission was 36.7 per cent. The detailed procedure for preparing the standard indicator solution has been described above under "Materials".

Temperature Effects. In connection with the construction of the pH calibration curve, Figure I, as well as with the practical application of the method to various systems, it was important to determine quantitatively the effect of temperature on the apparent pH of a system as estimated by light absorption according to the procedure described above. Accordingly, a 3 ml. aliquot of the standard indicator solution was added to each of a series of colorimeter tubes containing 30 ml. aliquots of buffer solutions ranging in pH from 4.00 to 7.00 in steps of 0.20 pH units. In addition, a study of the temperature-transmission coefficient of a 0.1000 N HCl solution containing 1 ml. of indicator per 20 ml. of acid was included in these studies. The light transmissions of this series of solutions were measured and recorded at different temperatures over a region from 15 to 43 degrees centigrade as shown in Figure VII.

For these investigations the temperature was controlled by the use of hot and cold water baths and measured by means of a thermometer protruding directly into the solution in the colorimeter tube fitted with a one-hole rubber stopper.

The data obtained indicate a straight-line relationship between temperature and transmission for the various buffer systems studied. It is seen that the slope of these lines falls off nearly to zero as either limit of the pH range of the indicator is approached.

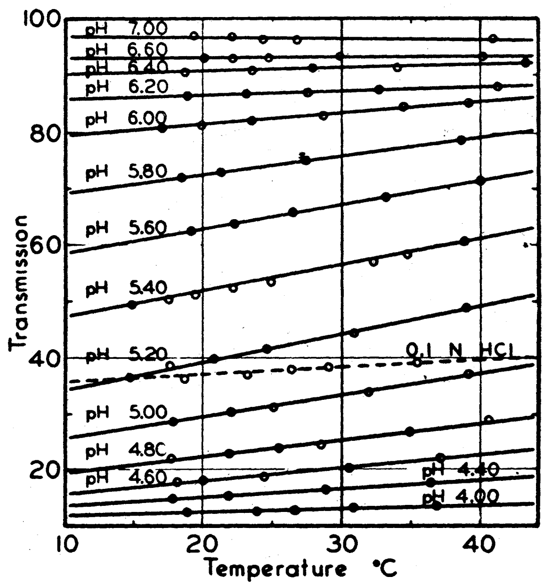


Fig. VII. Transmission-temperature coefficient curves

Light transmissions corresponding to a temperature of 25 degrees centigrade, found by graphic interpolation, were plotted against the pH of the buffer solutions to obtain the standard pH calibration curve (Figure I above). The slopes of the tangents drawn to this curve at various pH values determine the differential transmission per pH unit at the particular pH chosen. These coefficients were combined with the temperature-transmission coefficients in such a way as to give temperature-pH coefficients (see Figure II) which are necessary in determining pH for making corrections for deviations in temperature from 25° C.

Salt Effect. To determine the effect of salt concentration upon the light absorption of the methyl red indicator and thus upon the apparent pH as determined colorimetrically, a buffer of pH 5.40 was diluted with distilled water to give salt concentrations of 0.085, 0.043 and 0.015 M. The pH of these buffer solutions was determined by use of a Beckman pH meter and these values were assumed to be the correct ones. The values obtained colorimetrically by use of the pH calibration curve, constructed on the basis of an average salt concentration of 0.08 M, were then compared to those obtained with the Beckman pH meter. From the data obtained it appears that in the colorimetric method the effect of the salt concentration of the test solution is to give an apparent pH which varies approximately one-hundredth of a pH unit per one-hundredth of a mole of electrolyte per liter of solution as shown in Figure VIII.

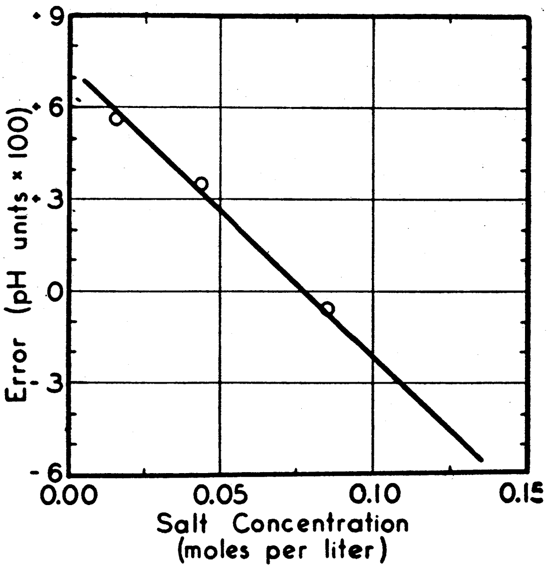


Fig. VIII. Salt effect

The effect of electrolyte concentration upon the apparent pH will vary somewhat for different electrolytes and the specific effect shown in Figure VIII is intended merely to indicate the order of magnitude of possible errors caused by changes in salt concentration.

It should be mentioned here that this salt effect is not caused by a change in light transmission of the test solution before the addition of the indicator. This point was checked by comparing the transmission of a 0.1 M buffer solution with that of distilled water. No appreciable difference was observed.

Check on pH of Buffer Solutions by Use of the Beckman pH Meter. As a check on the pH of the buffer solutions used during the present investigations and at the same time as a means of testing the validity of pH determinations by the Beckman pH meter employing a glass electrode, a series of buffer solutions ranging in pH from 4.00 to 6.00 in steps of 0.20 pH units was tested by use of the Beckman instrument. Table II shows that in no case did the determined pH differ from the accepted value for the particular buffer solution by more than 0.02 pH units. Furthermore, it is significant that the sum of the differences was zero.

TABLE II. Check on pH of buffer solutions

pH According to Clark and Lubs	pH Indicated by Beckman	Difference
4.00	3.98	−0.02
4.20	4.20	0.00
4.40	4.38	−0.02
4.60	4.61	+0.01
4.80	4.82	+0.02
5.00	5.01	+0.01
5.20	5.18	−0.02
5.40	5.40	0.00
5.60	5.62	+0.02
5.80	5.81	+0.01
6.00	5.99	−0.01
		Total 0.00

Colorimeter Comparison Studies. For the purpose of ascertaining the error involved in using the calibration data presented in Table I interchangeably with different Evelyn Colorimeters, transmissions of two different buffer systems of pH 6.00 and 4.80 with methyl red added were measured on eight different Evelyn Colorimeters fitted with filter No. 540. The results as summarized in Table III show an average deviation from the mean of 0.4 and 0.7 scale divisions for the buffer solutions of pH 6.00 and 4.80 respectively.

From these data and the fact that one mm. scale division corresponds to 0.03 pH units or less between pH 4.80 and 6.00, it was estimated that the mean error involved in using calibration data interchangeably from one Evelyn Colorimeter to any other of the same make will not exceed 0.03 pH units. The maximum error (based on the Maxwell distribution of errors) should not exceed 0.15 pH units.

TABLE III. Colorimeter comparison

Colorimeter	Per Cent Transmission		Deviation from Mean	
	pH 4.8	pH 6.0	pH 4.8	pH 6.0
#1	23.1	81.7	+0.5	+0.5
#2	22.2	80.9	−0.4	−0.3
#3	22.0	81.2	−0.6	0.0
#4	21.5	80.9	−1.1	−0.3
#5	22.2	80.8	−0.4	−0.4
#6	22.9	81.2	+0.3	0.0
#7	24.7	82.0	+2.1	+0.8
#8	22.4	81.0	−0.2	−0.2
Average	22.6	81.2	±0.7	±0.4

Effect of Coloring Matter in the Test Solution. In an attempt to determine the effectiveness of correcting for color or turbidity in the test solution by setting the solution at 100 on the colorimeter before the addition of indicator, separate portions of a buffer solution of pH 5.40 were given a considerable coloration with Bismark Brown, Methyl Red, Methyl Orange, and ordinary writing ink. The pH of these colored solutions was determined colorimetrically by the present method, the colorimeter being set at 100 with the colored test solution before the addition of the indicator. Table IV shows that, except for the case in which the solution was colored with methyl red itself, the described blank was effective in keeping the error due to coloration below 0.04 pH units.

TABLE IV. Effect of foreign color

Coloring Material	Estimated pH	Error
Bismark Brown	5.42	+0.02
Methyl Red	5.77	+0.37
Methyl Orange	5.43	+0.03
Ink	5.42	+0.02

Throughout these investigations on the effect of color it was observed that the apparent pH by the colorimetric method was invariably higher than that obtained by use of the Beckman pH meter. This was attributed to the fact that the above described blank does not take into account dilution of the color of the test solution by the indicator solution added. This, however, is a second order effect and can be neglected in rough work, especially when the solutions are not too deeply colored. To obtain a more correct blank one should dilute a separate 10 ml. aliquot of the test solution with one ml. of water and set this at 100 on the colorimeter.

In this connection it should be mentioned that some advantage might, in certain cases, be gained by using only 0.1 ml. of an indicator solution adjusted to 36.7 with 0.1 N HCl as above but using a 0.1 ml. aliquot of indicator, instead of a one ml. aliquot, with 20 ml. of HCl. Reducing the volume of indicator solution used would lessen the error in the convenient approximate blank described above and might be advantageous in the case of poorly buffered solutions. It would possess the disadvantage that it is difficult to measure out accurately 0.1 ml. and, further, the more concentrated methyl red solution appears to be less stable.

TABLE V. Acidity of nutrient solutions

Solution	Sample Number	Colorimetric pH	Beckman pH	Difference
PO	1	6.80		
	2	6.79		
		Avg. 6.80	6.41	+0.39
P27	3	6.08		
	4	6.12		
		Avg. 6.10	6.18	−0.08
KO	5	4.95		
	6	4.92		
		Avg. 4.94	5.06	−0.12
K81	7	4.94		
	8	4.94		
		Avg. 4.94	4.88	+0.06
N3	9	5.16		
	10	5.17		
		Avg. 5.16	5.12	+0.04
N243	11	5.29		
	12	5.28		
		Avg. 5.28	5.27	+0.01

Attempted Applications. At the outset it was thought that the present colorimetric pH method would be convenient for the determination of soil reaction. However, it was found that this was not the case. The principal source of interference seems to lie in the colloid fraction of the soil. In the first place this fraction often renders the ultimate test solution too dark to read on the colorimeter. In the second place appreciable amounts of indicator are absorbed by the colloidally suspended material. This phenomenon leads to results which are in some cases nearly 1 pH unit high.

The absorption of the indicator dye by colloidal particles was also found to interfere with the colorimetric determination of the pH of orange juice. The results in this case were observed to be 0.73 pH units higher by the colorimetric method than by the glass electrode determination.

Another attempted application of the present method was the pH control of nutrient solutions used in hydroponics. Six samples of different composition were collected from different feeder reservoirs and tested for hydrogen ion concentration both by the present colorimetric method and by the Beckman pH meter. The results of these analyses are summarized in Table V.

The designations PO, P27, KO, K81, N3, and N243 in the Table refer to aqueous solutions of the following salt concentrations:

PO	0.0090 M $Ca(NO_3)_2$ 0.0045 M $MgSO_4$ 0.0045 M KCl
P27	Same as PO plus sufficient NaH_2PO_4 to yield 27 ppm. of phosphorus.
KO	0.0090 M $Ca(NO_3)_2$ 0.0045 M $MgSO_4$ 0.0045 M NaH_2PO_4
K81	Same as KO plus sufficient K_2SO_4 to yield 81 ppm. of potassium.
N3	0.0090 M $CaCl_2$ 0.0045 M $MgSO_4$ 0.0045 M KH_2PO_4 plus sufficient $NaNO_3$ to yield 3 ppm. of nitrogen.
N243	Same as N3 but sufficient $NaNO_3$ to yield 243 ppm. of nitrogen.

To all of the above solutions the following elements were added in the quantities designated:

Fe	1 ppm.
Mn	0.5 ppm.
B	0.25 ppm.
Zn	0.5 ppm.
Cu	0.1 ppm.

The data in Table V would indicate that a mean error of about 0.06 pH units can be expected in the case of buffered nutrient solutions. (Note that PO is poorly buffered.)

Determination of the Equation of the pH Calibration Curve. It should be mentioned in passing that considerable time was devoted to a search for a simple equation which would fit the observed data and permit mathematical expression of the relationship between pH and transmission. The problem was attacked from both theoretical and empirical considerations. The theoretically derived equation,

$$pH = 5.00 + \log [\{1.017/(2 - \log G')\} - 1]$$

(in which G′ is the transmission of the test solution plus methyl red relative to that of the test solution before addition of the indicator) was found to fit the data to within 0.05 pH units everywhere in the pH range from 4.4 to 6.4. It was concluded, however, that this equation could not be used practically in the actual determination of pH because of its failure at the extremes of the pH range considered, its limited accuracy even in the optimum range of the indicator, and the labor involved in calculating pH from transmission. No better relationship was found.

Literature Cited

(1) Britton, H. T. S., *Hydrogen Ions, Their Determination and Importance in Pure and Industrial Chemistry,* (1929).

(2) Brode, Wallace R., J. Am. Chem. Soc., 46, 581 (1924).

(3) Hatfield, W. D., and Phillips, G. E., Ind. Eng. Chem., Anal. Ed., 13, 430 (1941).

(4) Kolthoff, I. M., *pH and Electrotitrations,* (1941), p. 34.

SAMUEL CHAPPUZEAU AND HIS "EUROPE VIVANTE," 1666-71

CASIMIR D. ZDANOWICZ

Samuel Chappuzeau is scarcely known today except by the historians of the French theatre, who never fail to quote his little book on "Le Théâtre François", published in 1674, which contains much useful information on the conditions of dramatic production in his day, to which he had contributed several mediocre works, both tragedies and comedies, one of which Molière's troupe had produced, and from several of which the great master of comedy drew little bits to fit into his own great works.

But this "adventurer in literature", as he has been called, deserves better of posterity because of some of his ideas and undertakings, the conception of which bear the mark of originality and boldness, even though he lacked that element of genius which has been described as the "infinite capacity for taking pains". Hè wrote too rapidly and too much, and distributed his energies over too wide a field.

A mere enumeration of his works fills one with amazement. Born in 1625, he began his literary career in 1649-50 with a novel, "Ladice," for which he has never received credit, since it was published anonymously. He followed the mode of the day so successfully that the work is frequently quoted in one of the recent histories of the French novel of the 17th century, but without name of author. Then he tried poetry, was for a time a preacher, at least one of whose sermons was published, and later wrote a treatise on "Christian Oratory"—"L'Orateur Chrétien", which may be read with profit even today. A translator of the "Colloquies" of Erasmus, he wove several parts of these into a little play, "Le Cercle des femmes," which antedated by three years the "Précieuses Ridicules" of Molière. The same year he brought out the first of his books on contemporary history, "Lyon dans son lustre", a description of Lyons, with its monuments and civic organizations, and the important people, celebrating the city in which he had lived for five years as a proof-reader. After other dramatic works, and two years as tutor of French to William of Orange, later King of England, he returned to Paris, and, while conducting a kind of boarding school, he wrote other plays. Removing to Geneva, he taught geography, and languages, and became a sort of prolific hack writer for the publisher Widerhold—producing an "Orbis Physicus" in Latin, a "Histoire des Joyaux," a book of French dialogues for his students (since he was dissatisfied with the available material), a series of French and Latin verses to accompany a re-edition of Bible illustrations, and several minor works. It was then that he conceived the plan of a history of contemporary Europe—which would give a picture of the geography, political and social conditions, and above all, the reigning families and great figures of each country. This was his "Europe Vivante."

He devoted parts of several years to travel in the different countries, collecting his information at first hand, received at court, and making acquaintances from whom he received notes and accounts which he incorporated in his book.

At this time also the appearance of the first volume of Moreri's "Dictionary" filled him with the ambition to compile a great encyclopedia. This fitted in well with his own fondness for geography and history, and throughout the remainder of his life he was absorbed with the collection of this material. He translated the work of the German Hoffmann, and Widerhold was to bring out a new "dictionary" when lawsuits with other publishers prevented. It seems that much of Chappuzeau's material was utilized in the later edition of Moreri.

In the meantime Chappuzeau found time to write from notes and dictation the account of the "Six Voyages" of Tavernier, whose travels and explorations to the Near and Far East made him the most renowned traveler of his day.

There are also attributed to Chappuzeau a translation of the "Dialogues" of Mathurin Cordier, also intended for school use, and the preparation of a German-French-Latin Lexicon, and perhaps a Latin-French grammar, though these were not signed and the publisher did not give credit to the compiler.

A poem entitled "Genève délivrée," a sort of epic on the successful defense of the city against the attack of the Duke of Savoy, published posthumously, about completes the list, though, during his later years, while serving as "Gouverneur des pages" of the Duke of Brunschwig-Lunebourg, he published a geographical work—"L'Idée du Monde," and is reported to have prepared each month for the Duke a compendium of the happenings of the Court, entitled "Le Mercure." As late as 1694 he issued a prospectus for a "Bibliothèque universelle, Dessin d'un nouveau Dictionnaire historique, géographique, chronologique, et philologique, etc." and extant letters show negotiations with publishers, and correspondence asking for special articles, almost to the time of his death in 1701. Unhappily this ambition was not to be realized and just before he died he lost his sight. Our regret that he was not permitted to complete his work is tempered by his own philosophical reflection—"But I shall be satisfied if I never draw from it any other advantage than to have worked at it for my own satisfaction, and to learn a thousand fine things which I should never have known without applying myself to this work."

"L'EUROPE VIVANTE"

This work consists of two volumes, to which two other volumes with separate titles are closely related. The complete title of the first part reads, in translation:

"Living Europe, or a New Political and Historical Account of All its States according to their actual Situation at the End of the Year 1666, Represented in divers Tableaux which disclose their Extent, Quality, Commerce, Strength, Revolutions, Religion, Government, Claims and Interests, followed by Portraits and Alliances of the Kings and Princes, in which are discussed the Condition of their Courts, the Genius of their Peoples, the Universities and celebrated Libraries, Academies of Eloquence, and Illustrious Persons in each Profession, with a Collection of the Most Memorable Things which have happened in Europe since the General Peace; Revolutions, Wonders, Wars, Crimes, Treaties of Peace, Great Projects, New Discoveries, Solemn Ceremonies, Deaths, Births and Illustrious Marriages." Published in 1666, this was republished in 1669, with the change of date to correspond—"According to the situation from the end of the year 1666 to the beginning of the year 1669," and, with a second part, entitled, "Protestant Germany, or a new account of a Journey made to the Courts of the Electors and Protestant Princes of the Empire during the months of April, May, June, July and August of the year 1669," and republished two years later, the title again brought up to date.

The table includes the following courts in the order in which the author had visited them:

Wurtemberg, Baden, the Palatinate, Hessia, Saxony, Anhalt, Brunschwig-Lunebourg, Brandenburg, Holstein and Mecklenberg, and, in his "Design of the Author," he enumerates the same objects of study as in the previous volume, promising, above all, to "display the splendor of the Electoral Houses and the Princes who follow them and to give their portraits along with those of their Families . . ." (pen portraits to be sure), 556 pages.

In 1673 was published an "Account of the Courts of Savoy and Bavaria," containing 203 pages for the first part—"On the Royal House of Savoy,"—and 178 pages on "The Present State of the Electoral House of the Court of Bavaria."

In 1667 had been published separately an "Exact Description of Hessia, drawn upon the spot from very good accounts."

These descriptive titles convey a very good idea of what Chappuzeau was attempting to do. He dedicates his first work to the "Sovereign Princes of Christendom," and claims that it has been conceived for their honor and glory, and, in other places the author makes clear his admiration and veneration for royalty, as divinely appointed.

In his introduction, Chappuzeau maintains the boldness of his project, though modestly admitting that he may have fallen short in its execution.

"I shall say then, in the first place, that I feel my own weakness, and that I do not pretend to the glory of the Great Authors; that I am not writing for the Learned, but for those who know less than I, and who have not measured on foot so many Provinces. Thus my work should be beneath censure and not deserve the criticism of the Learned.

"I shall say, in the second place, that I am giving here only the plan of a great Work which I am meditating, and in which I should not be sorry to be forestalled by someone else, since anyone else would acquit himself of it better than I. My purpose is doubtless ingenious enough, but perhaps not so successful in execution; I have hurried things too much, or I have not made them sufficiently clear, and I have tried to put the Iliad into a nutshell.

"I confess that I have not received all of the reports which I wished, or that I have not had the patience to wait for them. But, after all, I have not gone far from my subject, and I have purposed only to give Europe in brief and to condense in a few pages the different current accounts of its states. If I have not said all, I have touched on the most essential; or if I have only followed others, I am persuaded that one takes pleasure in reading different versions of the same work to see the different talents of the translators."

Again,

"I should have had sufficient material—(claims and interests of Princes) to fill a thick volume; but, besides the short amount of time which my affairs leave me, and the pressing demands of the printer, I have had to follow necessarily my own disposition, which avoids long drawn out labor, and which, by running too fast, cannot run very far."

Chappuzeau anticipates both the criticism and the praise which the modern reader might give him. It was a bold and original plan to give a complete sketch of contempororary Europe, and he tries to embrace it all. He had himself travelled extensively. He claims to have gone from one end of France to the other. In his youth he had accompanied a young Scotch lord to Edinborough, and spent several months in Scotland and England, returning twice to the latter country, "after it had been restored to its rightful lord"—(rather a striking sentence from a Protestant, and indicating the royalist convictions of the author). He lived twice in the Netherlands, the second time from 1656 to 1661, during the last two years of which he was preceptor to the Prince, as he lost no opportunity to remind his readers. In preparation for writing "L'Europe Vivante," he had revisited France and England, the Netherlands, and even the Scandinavian countries, or, at least Denmark. He was for twenty years a resident of Geneva, and travelled in northern Italy, and Germany. He writes of Spain and Portugal, Russia, "Muscovy", Poland, and Turkey, in addition to those countries which he had himself seen, but admits that his knowledge of them is more limited. His style is always personal and he likes to bring himself into the picture wherever possible. This is especially true of the volumes on Protestant Germany and on Savoy, in which he narrates his visits to these courts, the reception he received, and his conversations with princes and notable persons; but, along with these details, which have little interest to us today, he gives descriptions of places and people, and observations on the theatre, on manners and characteristics, which have their value, though we must often discount his enthusiasm, or his over-eulogistic remarks about various notables calculated to arouse their generosity toward the writer, for town councils as well as individuals made him gifts when he could point to his praise of them in his first volume, or promise to include it later.

He recounts himself how he started in 1669, "with all Europe in his saddle-bags," colporting his book, and never fails to mention the munificent presents he received. Bayle in his correspondence refers to someone who had just been "skimming the cream" off of the German princes—"à la Chappuzeau."

Although the "Journal des Sçavans" in 1667 criticized the first volume for showing a Protestant bias, Chappuzeau is remarkably liberal and tolerant, both in religion and politics. He says in the text of the first volume (page 124)—

"Do not expect to find here, nor in all the course of my work, that I take sides nor that I undertake to censure men who all believe themselves wise in the conduct of their affairs. I shall blame neither their Religion nor their Politics, nor their customs; because a writer who treats History ought, it seems to me, to be free of all self-interest. Far from giving insulting names to peoples who follow different religions, I do not undertake to touch their maxims, and I shall speak of each with honor."

He takes occasion to rebuke the French for a feeling of superiority and hopes that his book on the German courts will disabuse those who believe that all politeness and gallantry of the age are to be found between Calais and Marseilles.

His view about Germany is of especial interest for the present time—Vol. I, p. 339—

"It is difficult to give a very exact account of all these things, and it is a Labyrinth in which the most intelligent are lost. All these sovereigns, all these cities, all these Diets, have their special privileges, and their jurisdictions are so cut up and intertwined with each other that the Elector of Mayence goes as far as the gates of Heidelberg, and the Elector of Palatinate to the gates of Mayence. The same is true of several other princes of the Empire, and of several cities, and large volumes would not suffice to untangle so many things and give all the detail. I shall merely say that while Germany shall remain well united and all the members of this great body shall move in harmony, there is no power in the world capable of disturbing it and which will not hesitate more than once before making any attack on a liberty which forms all its felicity and all its glory. But, as in the great machines, there is often some piece which happens to fail, and which prevents all the rest from functioning, Germany is not always fully in accord with itself, and it gives the foreigner sometimes occasion to mingle too much with its affairs, which, for its tranquillity it ought to avoid as much as it can. This august republic should have a leader but it ought not really to have a master, and while it flees slavery from within it would be shameful to have the law laid down from without. Therein is its great and principal concern; and it is still advantageous for it that the *Sophie* is delaying the *Grand Seigneur* in Asia to turn aside the storm which sometimes falls on its frontiers, and to relieve it of a redoubtable enemy."

Professors of language, historians, geographers, and men of letters, writers of encyclopedias, all find a colleague in this little-known writer of the 17th century, whose unbounded admiration for the French Academy and for Academies in general would have won mention of the august assembly before me, were he to be re-incarnated and to be describing Wisconsin of today.

CHAPPUZEAU

(Partial Bibliography)

The best studies of Chappuzeau are: the dissertation of F. Meinel, "Samuel Chappuzeau, 1625-1701." Inaugural-Dissertation zur Erlangung du Doctorwürde, etc., Leipzig, 1908; the article of Lanson in *La Grande Encyclopédie*, and Eugene and E. M. Haag, "La France Protestante," Vols. III and VII, Paris, 1852.

(Principal Works)

1. "Ladice ou les Victoires du grand Tamerlan," Première Partie, 2 vols. Paris, Toussaint Quinet, 1650.
2. "Le Cercle des Femmes, Entretien Comique, Tiré des Dialogues d'Erasme, etc." Lyon, chez Michel Duhan, 1656.
3. "Lyon dans son Lustre," Lyon, 1656.
4. Two of Chappuzeau's comedies, "La Dame d'Intrigue ou le Riche Vilain" (1663) and "L'Académie des Femmes" (1661) have been published in Victor Fournel, "Les Contemporains de Molière," Vols. I and III, Paris, 1863-1875.
5. "Le Théâtre François, divisé en trois livres," etc., Lyon, 1674. (Edited by Georges Monval, Paris, 1876).
6. "L'Orateur Chrétien, ou Traité de l'excellence et de la pratique de la Chaire," Paris, 1676.
7. "Histoire des joyaux et des principales richesses de l'Orient et de l'Occident, etc." Geneva, 1665.
8. "Orbus Physicus, hoc est utriusque sphaerae synopsis, etc." Geneva, 1665. (in fol. 8 pp.)
9. "Les Six Voyages de Jean Baptiste Tavernier . . . qu'il a fait en Turquie, en Perse et aux Indes, pendant l'espace de quarante ans . . ." Paris, G. Clouzier, 1676.

10. "Entretiens familiers pour l'instruction de la noblesse étrangère . . ." 2nd edition, Geneva, 1671.
11. "Icones historicae Veteris et Novi Testamenti," Geneva, 1681.
12. "Les Entretiens familiers d'Erasme, divisez en cinq decades . . . Traduction nouvelle . . . " Geneva, 1669.
13. "L'Europe Vivante, ou Relation nouvelle historique et politique, de tous ses estats selon la face qu'ils ont sur la fin de la presente année 1666." Geneva, 1666.

    Reprinted with a second part "depuis la fin de l'année 1666 jusques au commencement de l'année 1669," 2 vols., quarto, Geneva, 1669.

    "Suite de l'Europe Vivante . . ." same title as preceding, with change of date: "jusques au commencement de l'année 1671," two books in one vol., quarto, Geneva, 1671.

    Another: "Suite de l'Europe Vivante contenant la Relation d'un voyage fait en Alemagne, etc.," Geneva, 1671.

    Reprinted as: "L'Alemagne, ou Relation nouvelle de toutes les cours del l'Empire, recueillie en deux voyages que l'auteur y a faits en 1669 et 1672—*Ière* partie reveuë . . . en cette seconde édition, Paris, C. Barbin 1673.

    "Relation de l'Etat présent de la maison royale et de la cour de Savoye, . . . Relation de l'Etat présent de la maison électoral et de la Cour de Bavière, par le sieur Chapuzeau," 2 parties en 1 vol. in -12, Paris, L. Billaine, 1673.

    "Description exacte de la Hesse, tirée sur les lieux de très bons memoires, . . ." [British Museum, (See Blanc (J). Le grand Atlas, etc. vol. 3, part 2, 1667, fol.]
14. "La Muse Enjouée, ou le théâtre comique du sieur Chapuzeau, . . ." Lyon, J. Girin et D. Rivière, undated, contains four plays in verse, of different dates and printings:

    "Le Partisan duppé" (same as *Le Riche impertinent* or *Le Riche mécontent*).

    "Le Riche vilain, ou La Dame d'intrigue."

    "Les Eaux de Pirmont."

    "Le Cercle des femmes" (same as *l'Académie des femmes*).
15. "Damon et Pythias, ou le Triomphe de l'amitié," tragi-comédie, Amsterdam, 1657.
16. "Armetzar, ou les Amis ennemis," tragi-comédie, Leyden, 1658.

MARGARET ASHMUN: WISCONSIN AUTHOR AND EDUCATOR

JULIA GRACE WALES

Americans are sometimes impressed with the matter-of-fact way that the Englishman—or any other European—knows and enjoys the literature not only of his own land but of his own locality, regarding it as a commodity to be kept in constant use. With our cosmopolitan tendency to look abroad for greatness, we have sometimes in the past been too modest about our product and failed to perceive that in its relation to our own scene it is not duplicated elsewhere. Among Wisconsin possessions which it would be a misfortune to lose is the work of Margaret Ashmun.

Margaret Eliza Ashmun was born in Rural, Waupaca County, Wisconsin. She was a graduate of Stevens Point State College. She took her Ph.B. at the University of Wisconsin in 1904, and her A.M. in 1908. She was the head of the English Department at Stout Institute, Menomonie, Wisconsin, 1904-06, and a member of the Department of English at the University of Wisconsin 1907-12. In 1912 she went to New York, and from that year on she gave the greater part of her time to writing. She kept up her home in Rural, spent some winters in Madison, and was several times abroad for considerable periods. In 1928 she adopted a little girl, whose death ten years later was a great shock and grief to her. Miss Ashmun died in 1940 at the age of 65.

Her literary work falls into several distinct categories. First, her educational work, which includes several books: *Prose Literature for Secondary Schools* (1910), "with some suggestions for correlation with composition", *Modern Prose and Poetry for Secondary Schools* (1914), the selections being accompanied by notes, study helps, and reading lists, *Modern Short Stories* (1924) including an introduction, biographies and bibliographies, and finally, in 1914, *The Study and Practice of Writing English,* of which last she was joint author with Mr. Gerard P. Lomer.

These books throw sidelights on her work in general, her interest in education and in the young, her critical theories, and her methods of writing.

In the second place we have the material published in magazines including articles, stories, and poetry. The most important of Miss Ashmun's short stories is "The Birthplace",[1] published in the *Atlantic Monthly* in 1911. It is a poignant little tale of loss and resignation, the scene, vividly realized, being a small town in Illinois and more particularly an old-fashioned garden, on a June afternoon and evening.

Miss Ashmun produced a considerable amount of verse, which was rather extensively published in the *New England Magazine*, the *Overland Monthly*, *Good Housekeeping*, the *Christian Science Monitor*, and other periodicals, but never collected in a volume. Miss Ashmun did not take her verse very seriously but thought of it as a minor part of her work.

Among the finest pieces are some sonnets published in the *New England Magazine*. One, "On an Old Russian Candlestick", paints the chiaroscuro of some "strange-set" board, where, long ago, the flame of the candle lighted "wine-wild faces" and was caught by studded swordhilts,

> " . . . till, coarse-carousing with her lord,
> Some jewelled woman flashed it back again."

And now

> "This bit of brass forlornly braves its doom—
> To waste with me the silent day's desire,
> To watch long nights of quietness and gloom,
> To share the lonely glimmer of my fire
> And cheer the hired bareness of my room."[2]

It may be that the greatest service of Margaret Ashmun to her generation is found in her books for children. That these have been appreciated is well enough seen from the worn copies in our public libraries. How many little folk in small chairs at small tables have pored over *No School Tomorrow* (1925), *School Keeps Today* (1926), *Brenda Stays at Home* (1926), *Mother's Away* (1927), *Susie Sugarbeet* (1930). The very titles are alluring. Who could resist *No School Tomorrow?*

One is impressed with all the inventiveness that went into these little books—the devising of ever-new play, that is at the same time grounded in the essential psychological appeal of all the old games of the world.

These are glorious places, seen in high lights and rich shadows: hayloft, woodshed, attic, a garden, an old mill, a flowing brook, the kitchen with its gay ragrugs, "and the bright dishes

---

[1] *Atlantic Monthly*, Vol. 107, No. 2 (February, 1911), pp. 233-241.

[2] *New England Magazine*, n.s. 35: 345. November, 1906.

in the glass cupboard and yellow gingham curtains at the windows, and Flora, the black and white cat, washing her paws in the square of sunshine on the floor." And there are happy companionships: kittens, birds, dolls, and a real playmate whose tastes complement one's own, whose love of doing real things keeps pace with one's more fanciful imaginings.

We see the Little Girl going through the garden with her orange in her hand, and entering the barn where "the sunshine streamed in across the plank floor, which was littered with dried grass and straw and was soft to your bare feet. Above, there was a high roof, where rays of light came through tiny cracks between the shingles, and made long dusty lines in the shadows."

"She wished she didn't remember things so vividly. Other people didn't seem to." These words occur in one of the novels for adult readers, with implications of sadness. But in the children's books this powerful recollection is a great storehouse of treasures. Vivid sense impressions, color, the warmth of the sun, the freshness of the wind, the ecstasy of running and jumping—these things are here as the child first senses them in that pre-school age before "shades of the prison house" have cut off the sharpness of their light. The books are designed to reinforce these impressions at the point where they might be lost—just when school begins to keep today and crowd them out with other needful furnishings of the mind. Wordsworth turned back to recollect these riches and make them the stuff of reflective verse. What Margaret Ashmun has done is to organize them for the child himself, while he is still a child, and so insure his permanent possession of them.

The writing of these little books was no time-serving task. The writer gave herself to the enjoyment of them. And so they are a boon not only to the child but to those grown-ups who read to children. They are interspersed with original verse of the school of Mother Goose.

There is plenty of incidental instruction, too: how to build a fire, how to make an outdoor fireplace, how to paper a wall. A recipe for pancakes becomes a narrative of high adventure breathlessly pursued by two small girls allowed to do real cooking on a rainy day.

Margaret Ashmun's work is probably known in her native state most extensively through her books for teen-age girls—the

Isabel Carleton series of five volumes (1916-19). These perform the same function as Miss Alcott's books did and still do.

That Miss Ashmun was consciously going on with Miss Alcott's mission, though quite in her own individual way, is borne out by a sonnet "On a Portrait of Miss Alcott," published in the *New England Magazine,* in which Miss Ashmun describes how in her childhood she had thought of Miss Alcott as a marvelous figure, a sort of princess "on whom a kindly fate forever smiled." The latter part of the sonnet goes on to say,

> "Now where I, musing, stand
> Her portrait hangs. This unassuming guise
> Shows, not a princess, haughty to command,
> But one most humble, human, sorrow-wise,
> Who seems to live and reach me forth her hand—
> A woman simple, sweet, with tired eyes."[3]

Of the four novels for adult readers the most notable are *The Lake,* published in 1924, and *Pa: Head of the Family,* published in 1927.

The English edition of *The Lake* came out under a slightly different title *The Lonely Lake.* The book was, I think, Miss Ashmun's own favorite of her writings.*

It is a bleak novel, at times as bleak as *Ethan Frome,* but it is a point of contrast with the New England novel that the bleakness is alleviated much as in Hardy by a warm homeliness of detail that accords well with the opulent and richly colored Wisconsin landscape.

> "They turned in along the edge of the marsh, where twisted gentians stood up stiffly, and iris pods were dry and slitting. On a harder knoll a hickory tree showed its dark fruit. The squirrel instinct of the boy would hardly let him pass."[4]

The treatment of setting is profoundly integrated with characterization, affording not only frame and background but at once realistic detail of the action and poetic symbols of the essence of the theme.

> "Bert set out, with the heavy basket on his arm. He was warmly dressed, in his reefer and muffler and mittens, but the cold cut avidly through his clothes. The wind was keen and slashing. He tramped along the narrow wood road, looking up at the tops of the trees against the pale, hard sky. He thought of the time, not so very long ago, when he and Uncle Alec were out in the woods, and there was a warm golden colour

---

[3] *New England Magazine* 37:78. September, 1907.

[4] *The Lake,* New York, 1924, p. 101.

* Part of my comment on this book, repeated with permission, was published in the *Capital Times,* Madison, Sunday, March 15, 1936, under the title "A Story of Central Wisconsin."

over everything. How different it was now! How long the winter was! It had hardly more than begun. The snow would lie on the ground till March or April. Even in the latter days of April, it would not be melted in the dark places under the hemlocks, or on northward knoll-sides in the woods."[5]

The natural scene and persons alike are always beheld with the seeing eye—even the rhubarb "flaunting huge crumpled leaves on rose-colored stocks",[6] the Hunt's cottage "unintentionally pretty."[7]

> "He walked as if getting over the ground were a process of nature, involuntary and unnoticed like breathing."[8]
> "Averil Faraday was a quiet woman, who would have been thought beautiful in a different environment. The country people did not like her black hair, which she wore braided and wound about her head, coronetwise; nor her deep-set eyes, which seemed to them too knowing; nor her white skin, which kept its smoothness in the heat of summer and the cold of winter."[9]

Properties are used with skill and reappear in the story at intervals with tragic effect, the flashlight "sickly yellow in the sun",[10] the lad's silver watch, the screen door thrice left wide open, the kitchen table, after the devastating domestic storm has spent its fury, "placidly covered with its checked blue cloth."[11]

The people are made real to us through their very inarticulateness, which contributes both to their power of outward control and to the danger from submerged emotions once they find a vent: Alexander and Willard able to work together all day and many days with tragic jealousy and uncertainty between them; Libbie and Averil thinking of their individual troubles.

> "Each was tempted to tell her secrets to the other, but each refrained. Each was sorry for the other, but dared not make mention of her reasons, lest she appear prying or bold."[12]

A high point of characterization is in the portrayal of the Hunt family—"Caddie", whose firm, capable, young hands must disentangle the knots of other people's lives; Mrs. Hunt (called "poor Libbie Hunt" because of the behaviour of an elusive husband), who with her quiet common sense and ethical hold on life, enduring without a martyr spirit, refuses tragedy for her-

[5] *The Lake*, p. 140-141.
[6] *Ibid.*, p. 70.
[7] *Ibid.*, p. 19.
[8] *Ibid.*, p. 100.
[9] *Ibid.*, p. 3.
[10] *Ibid.*, p. 13.
[11] *Ibid.*, p. 16.
[12] *Ibid.*, p. 63.

self and alleviates it in others. "The whole interior of the Hunt family is delightfully presented,"[13] wrote a reviewer in the *London Times Literary Supplement*, "and the incident of the vagabond husband's brief return to live upon her [his wife] is extremely telling."

Power of characterization is seen not only in the strong drawing of the main characters but in vivid picturing of minor ones. The scene is never over-crowded. Only those appear who have an essential part to play; yet they suffice to suggest the community life three-dimensionally.

The tragic central story is set firmly in a larger stream of experience. The passion of youth is spent before the story opens; yet the action never lacks intensity. It begins at once and moves swiftly. The dark aftermath is given fully and logically; yet it is not the end. Even in the bitter struggle with disillusionment which the younger generation have to suffer and the expiation they have to make, we are not allowed the sense of despair and finality; rather we are taken up into an onward movement toward renewal of life. Unflinching realism is combined with sanity.

The book is not without its weaknesses—notably the rather flat surface presentation of Mr. Sutton, the well-meaning young minister, and the element of conventionality and improbability in the treatment of Daddy Gleason and his part in the denouement. Mr. J. B. Priestley mentioned some weaknesses in his review of the book in the London *Mercury*, but nevertheless commented on "the power,[14] the curious reality and conviction of her more dramatic scenes that are so extraordinarily good." He goes on to say, "She has imagined these incidents with intensity, and though she never raises her voice and never departs from her detached sane manner of narration, she dominates our imagination with them."

The style has many excellencies—gravity and grace, ease and reticence, thrift and high finish, and in its best passages, an unobtrusive exactness in choice of word, carrying within its simplicity a symbolism that seems at once fortuitous and accurate:

> "His voice sounded far away, indistinct, and unavailing."
>
> "She merely wanted to rest there on the surface of the lake, in the precarious safety of the boat."[15]
>
> "The harvest came, as harvests will come, after the patient sus-

[13] *The Times Literary Supplement*, Thursday, Dec. 18, 1924, p. 868.

[14] London *Mercury*, Vol. 11, No. 63 (January, 1925), p. 319-20.

[15] *The Lake*, p. 41.

pense, after the sprouting and ripening of the plant, whose seed is in itself."[16]

In stressing the local interest of *The Lake,* we must not forget that it has a universal interest too. When it appeared, it was received with enthusiasm both at home and abroad. The *New York Times* commended it for being "psychological without being clinical," and pronounced its plot one "over which Hardy must have rejoiced." Dorothy Foster Gilman, writing in the Boston *Transcript,* described it as "an exceptionally interesting novel, well written, artistically conceived, with an emotional significance both fervent and exalted. . . . The narrative unwinds with deliberation and power . . . Miss Ashmun has shown herself the possessor of remarkable talent, coupled with a deep sense of the grandeur and significance of our human drama." The *Nation* (New York) described the book as "a lowering, sombre tale of hidden love hovering between tragedy and release; carried on a tide of intense and passionate writing which is strikingly appropriate to the theme."[17] The Cardiff *Mail* said of the author, "She has a strength and dignity and a sense of architecture which are given to few writers." The Glasgow *Herald* did not hesitate to say, "The texture of this fine transatlantic novel suggests some of the qualities of the best Russian fiction." Similar comments have already been quoted from the London *Mercury* and the *Literary Supplement* of the London *Times.*

Pa: Head of the Family (Macmillan, 1927) though of less depth and power than *The Lake,* is in some ways more skillfully executed. Its values are in its intensely clear-cut setting, its sharp characterizations, and the hard clarity of the style, not a word wasted, with no ornament, no affectation, no idealization, with nothing but an ever-present ironic humor to mitigate the harsh reality. The story goes through to its logical ending. The unethical conduct of some of its persons gets no comment. If the reader has help in keeping his sense of human values, it is through the presence of Emma Doty. Yet Emma herself is not idealized. She is a sensible, right-feeling woman, kind, just-minded, patient in a humorous way, disciplined in herself through taking the circumstances of her own life in good part. In the words and thoughts given her, however, there is nothing imported from any larger range of awareness than her own.

"Pa" himself is a masterpiece of characterization.

---

[16] *Ibid.,* p. 50.

[17] The *Nation,* Vol. 120, No. 3107 (January 21, 1925), p. 74.

"The old man sat down clumsily, letting his cane fall with a clatter. He noted with rancour that his cup of weak tea was already cooling at his place. He felt like pushing it off the table. He loved hot, strong tea, with plenty of sugar at the bottom of the cup."

If the book has a "heroine" it must be Mattie. She it is who goes through desperate adventures and makes haven at last in the secure ever-after of matrimony. Her misfortunes are not sentimentalized for the reader. Her spinal curvature and withered arm are never presented as a claim for a kindly judgment. Mattie stands on her own, in venom and egotism more than the equal of the others.

The action of the story never flags and never leaves its track. Mattie prepares with great zest for her wedding and is deserted by the bridegroom at the last moment—Pa, who hates his granddaughter, Mattie, having secretly encouraged the young man to get away while there is time. All the reactions of everybody to these events are mirrored with the utmost precision and hold our interest by their sheer clarity, like objects sharply seen in a painting of a Dutch interior.

When a new Prince Charming appears, in the person of Arne, the Swede, hired man of the Doty's, we are no more worried about his fate than about Petruchio's. True, Mattie will never be tamed, but Arne's good nature and shrewd materialism will be a match for her. He knows what he is doing, and feels compensated by the dowry wrested from the obstinate Pa by a trick which it does not even occur to Arne to be ashamed of.

The humor of the treament is not found in comment or any pointing up of absurdity. It is in the steady, ironic eye of the author, who sees everything, but without malice.

It remains to speak of Miss Ashmun's scholarly biography of Anne Seward, a contemporary of Dr. Johnson. *The Singing Swan* was published in 1931 by the Oxford Press, and must have represented a great deal of very delightful research in England.

This book seems to me to be the high point of Margaret Ashmun's literary achievement. The style is as far as possible from being naive; yet it remains simple and unaffected. The book is scholarly and at the same time human. Over every page plays the light of delicate irony that at times reminds one of Jane Austen. Every absurdity in the human situations dealt with is relentlessly seen in the light of that irony—and yet not mercilessly, for in the very justice of every judgment there is an ever-present human kindness and understanding rare with such penetrating humor. Though the narrative keeps the pace of a biography based on exact research, the skill of the practiced narrator is felt in the way she now anticipates and now withholds the story. In this book, more than anywhere else, it seems to me, is revealed in its maturity the personality of Margaret Ashmun, which those of us who knew her found so delightful—good sense, ironic humor, moderation, human understanding, resolute justness of mind, and a taste for simplicity.

AN EIGHTEENTH CENTURY DICTATORSHIP

BERENICE COOPER

Superior State Teachers College

Among the writers of France during the eighteenth century, the Abbé Prévost has received scant attention for any contribution to the intellectual life of this period. Although Bayle, Montesquieu, Diderot, Voltaire, and Beaumarchais have been generously accorded a place in the history of the development of ideas of tolerance and human freedom, the Abbé Prévost is known chiefly for his sentimental romance of passionate love, *Manon Lescaut.* The rest of his fiction is too often dismissed as long-winded melodrama of interest only to the aspiring Ph. D. in desperate need of an unexplored field.

Such an estimate of the good Abbé is unfair to an author who is a keen student and satirist of the manners and of the intellectual problems of his period. His analysis of the human problems lying beneath the veneer of events so surely penetrates to aspects of universal significance that the modern reader finds himself saying, "How true that is today! How true it has always been for thinking human beings!"

Of no work is this more characteristic than of *Le Philosophe Anglais,* a novel written and published over a period of eight or ten years, a work which represents questions, observations, and conclusions with regard to education, government, philosophy and religion in relation to the needs of the human mind and heart.

The external events in this eight-volume work are the stuff from which typical eighteenth century novels of adventure are made: shipwrecks, tales of the American wilderness, political and love intrigues, revenge, and persecution. In spite of the superficialities of such melodrama, the fundamental conflict in the novel is between ideas and feelings. The English philosopher-hero, Mr. Cleveland, natural son of Oliver Cromwell, is indeed very busy escaping the malignant vengeance of his father, seeking to advance the cause of Charles II in the American Colonies, winning and losing and rewinning the woman he loves, and narrowly missing death by the sword of his jealous rival. The essence of the plot, however, is not the struggle against a cruel fate; the unifying theme is the search of Cleveland for peace of mind, for a philosophy of life which can reconcile apparent inconsistencies in the facts of experience and endue the soul with strength to bear grief.

Cleveland's search for a philosophy of life includes experiments in many personal relationships—family, romantic love, friendship; in social institutions—education, government, church; in a philosophy which shall so harmonize all these phases of human life as to satisfy both the intellectual and the emotional needs of man.

The narrative of the successive stages in Cleveland's development offers satirical passages widely varying from subtle implications to obvious statements and from sly ambiguity to keen thrust.

Early in the hero's experiences occurs the adventure in the Carolinas with the American Indian tribe, the Abaquis. So subtle is the satire of the foundation principles of absolutism in these episodes that it provoked no such contemporary resentment as was produced by the account of Cleveland's teaching the savages a natural religion.[1] To the modern reader, however, Cleveland's methods of establishing and maintaining absolute power and the causes of the fall of his dictatorship are almost prophetically parallel with the ideas being discussed today in newspapers, in magazines and over the radio.

This eighteenth century experiment in dictatorship appears upon a superficial examination to be beneficent in purpose, an attempt to create a Utopian state among a tribe of American Indians; but under a closer scrutiny of the principles and methods employed, the aims of Cleveland's government seem less noble.

The opportunity to initiate this experiment is forced upon Cleveland because the tribe into whose hands he falls while wandering in the Carolinas develop such a devotion for him that they will not consider allowing him to continue on his travels.[2] From this affectionate internment Cleveland wishes to escape in order to search for his father-in-law and in order to carry out his mission as an agent in America for the cause of Charles II.[3]

Shrewdly he decides that by becoming the ruler of the tribe he can manage his escape, win the Abaquis as loyal subjects of

[1] *Bibliotheque Belgique*, Oct., 1731, pp. 419-50.
[2] *Le Philosophe Anglais*, (Utrecht: Neaulme, 1736) III, iv, III-18.
[3] *Ibid.*, pp. 125-26.

Charles II[4], and in addition do the noble work of civilizing this savage people, raising them from their crude customs and introducing an organization lacking in their primitive society[5].

When the project of governing the Abaquis is adequately motivated and justified in Cleveland's mind, he does not proceed by any crudely obvious method to seize absolute power. He determines to be urgently invited to become a ruler and through his devoted Indian servant is able so to manipulate public opinion that the desired invitation is given by the tribe. Upon hearing the request of the Abaquis, he feigns great reluctance to grant it and, as he expects, this response serves only to increase the ardor of the savages' request that he becomes their ruler. Finally, he accepts upon the sole condition that his power be made absolute.[6]

As soon as he has been granted absolute power, Cleveland puts into operation three measures for securing himself against rebellion: appeal to fear in order to instill obedience, diplomatic handling of strong men, and rigid military discipline.

The first step in this program is to find an oath which the savages will respect because its violation will bring certain and terrible punishment. He learns that the Abaquis are sun-worshippers and that in their legends there are many tales of direful punishments which follow violation of an oath sworn in the name of the sun. This use of a superstitious religion which he does not respect, he defends on the ground that he thus uses their simplicity for their ultimate welfare, since by this means he will be able to civilize them; later, he says, he will teach them a better religion. Before administering the oath of allegiance, he deliberately plays upon their fears by reminding them of the horrible punishments which always follow the breaking of such a solemn oath.[7]

Another means by which Cleveland attempts to secure his absolute power is by a judicious selection of ministers. Iglou, an older man, superior to the other Abaquis in intelligence and sincerely devoted to Cleveland, is selected as a kind of prime minister. Moou, a potential dangerous youth, impulsive, not easily disciplined, apt to stir up trouble, is flattered by an appointment as a

---

[4] *Ibid.*
[5] *Ibid.*, p. 128.
[6] *Ibid.*, pp. 128-29.
[7] *Ibid.*, pp. 128-29.

sort of personal aide to Cleveland, a method not entirely outmoded.[8]

As has been said, this dictatorship is represented as beneficient. Cleveland has many reforms in mind in order to raise the savages from their ignorance and superstitution, but he is enough of an eighteenth century primitivist to wish to preserve the noble features of the savage. He decides to make no change in the natural simplicity of their food and dress (or lack of dress), but to civilize them by introducing changes in family life: private instead of community dwellings and greater respect for age. At present he permits them to continue their sun-worship, since a futile attempt to present a deistical religion convinces him that their minds are not amenable to reason. He hopes, however, to teach them some day a natural religion of a higher type than sun-worship.[9]

As an institution of propaganda for the reforms which his government initiates, Cleveland creates an advisory council. Each council-member represents a district in which he supervises and checks on the daily life of the people. To be sure, Cleveland is unlike modern dictators in some respects, for there are women on the council. They must be over fifty, however, for like modern dictators, he considers that up to that age their main function in the state is that of childbearing.[10]

And this eighteenth century dictator has his youth movement, too. Because he fears the young men in the tribe may resent some of his reforms, Cleveland institutes compulsory military service to keep them employed. Appealing to their fears of a neighboring tribe, the Rouintons, he promises his subjects protection from their most dangerous enemies and regiments them into a project of digging about the camp a trench, filled with water and crossed by drawbridges. At the same time he institutes a military organization with stiff drill and discipline.[11]

Unfortunately, the youth movement fails to direct Moou's dangerous energy so that he serves the cause of the dictator, for the young savage can not adapt himself to the regimented life and to taking orders from a superior officer.

When Moou leads a rebellion against the rigid militarism, Cleveland orders the rebels killed by a bomb and a rifle shot; the

[8] *Ibid.*, pp. 129-39.
[9] *Ibid.*, pp. 180-181.
[10] *Ibid.*, pp. 163-164.
[11] *Ibid.*, pp. 165-169.

incident completely terrorizes the savages, who are ignorant of the use of gun-powder. Here comes the opportunity which Cleveland has awaited to teach the savages a better religion. One of the most remarkably inconsistent features of the story is his use of superstitious fears to convert the Abaquis to religious doctrines which he designates as the religion of nature, based on reason.[12]

After having terrorized them by killing Moou and his confederates, Cleveland addresses to the trembling Abaquis an impressive speech pointing out the evidence that the power of his god is greater than that of the sun, that his god sends down terrible punshments for disobedience but rewards obedience and will protect them from their enemies. The savages ask two questions before capitulating. Where is this god? Why can we not see him as we see the sun? When Cleveland answers that God is seen in the rain, the thunder, in all forces of nature, "the eyes of the savages are immediately opened to the truth." Cleveland ascribes this victory to one of three causes: the truth of his answer, the quality of his voice, or the infinite goodness of God.[13]

Although Cleveland meets successfully the first attack upon his absolute power and, by threat of a punishment like that of Moou, achieves even greater power over the untutored mind, security soon proves to be only a temporary state. Again in the military system lies the source of the trouble.

Some youth of the Rouinton tribe tangle with some of the Abaquis in a dispute over killing game. The Abaquis are impatient to exercise their newly acquired skill in arts of warfare. Although Cleveland hates war, the Abaquis are insistent, and he concludes that it may be well to permit them to vanquish these enemies. Furthermore, he speculates, it might be possible after conquering the Rouintons to unite the two tribes into a friendly nation. Having thus rationalized his motives in acceding to the demands of the Abaquis, Cleveland makes all necessary preparation for attacking the enemy.[14]

The army marches in orderly and well disciplined fashion toward the territory of the Rouintons. Even though it would be easy to take the enemy by surprise and cut them to pieces, Cleveland offers them an opportunity for peaceful negotiation. To avoid being insulted, the envoys of peace are to give out first the

---

[12] *Ibid.*, pp. 199-203.
[13] *Ibid.*, pp. 199-203.
[14] *Ibid.*, pp. 207-210.

information that they are supported by fifteen hundred troops. The Rouintons boast only eight hundred.[15]

Cleveland orders his general to behave severely and haughtily in stating terms. "My sense of security," he says, "was based on the ignorance of those with whom I treated and upon my superior forces." The demands, described as "candid and humane," require that the Rouintons burn all their arms, submit to Cleveland's authority, and found a settlement in the valley of the Abaquis.[16]

The Rouintons do not behave as Cleveland anticipates. They choose to flee away under cover of the night rather than to submit. They burn their villages and retreat only to return later to wreck a horrible vengeance. Cleveland's army weakened by a sudden epidemic that sweeps the camps, is easily defeated, and the captives find that the Rouintons are a cannibal tribe.[17]

Such is the tale of Cleveland's government. Its power has rested upon fear of punishment, shrewd manipulation of dangerous men, and regimentation. The first threat to absolutism, the revolt of a dangerous leader, was successfully met by further appeal to fear, but brought a very temporary security even with religion as an ally.

Is this eighteenth century tale a satire of all absolutism?

Le Philosophe Anglais is packed with incidents and stories within the story which offer satirical comment upon the eighteenth century theory and practice in government, politics, education, and religion. Unifying a novel, which upon superficial consideration appears to be a rambling collection of episodes in the life of the hero and his acquaintances, is the theme of the insufficiency of reason to solve the problem of satisfactory living and of the supremacy of strong emotions over human reason. This episode of the attempted dictatorial government of the Abaquis satirizes the instability of a government founded upon fear, upon the prostitution of religion to the theory of absolutism, and upon militarism.

This narrative, probably composed in 1731 when Voltaire as well as Prévost found greater toleration in England than in France, may conceivably be motivated by Prévost's observations of the weakness of absolutism as he considered contemporary politics and government.

---

[15] *Ibid.*, p. 211.
[16] *Ibid.*, pp. 211-212.
[17] *Ibid.*, pp. 215-216.

THE VOGUE OF MACAULAY IN AMERICA

HARRY HAYDEN CLARK*

Much interest has been aroused in this crucial time in the traditions for which England and America have stood, and in the history of the inter-relations and of the divergence of those traditions. One good index to such history is the record of the vogue and influence in one country of representative authors of the other country. Thus Professor Harold Blodgett's *Walt Whitman in England* (1934) offers a fascinating history of the way in which British opinion of the more extreme forms of American democracy in politics and poetry have fluctuated in different periods. And Dr. Robert Rodney's study of British reactions to Mark Twain and such anti-feudalistic books as *The Connecticut Yankee in King Arthur's Court* should be even more revealing as a record of changing British opinion and literary taste. On the other hand, much able work as been done on American reactions to representative British authors such as Byron and Scott, but much of it has had to deal with matters which are exclusively literary. In the present study I propose to deal with a figure who is more broadly representative not only of literary taste but of political, religious, and ethical ideas as well—with Thomas Babington Macaulay. As literary critic, as Whig statesman, as a protagonist of the practical and the scientific, as a historian of the Puritanism which entered so largely into the founding of America, he represents a large segment of the circumference of British traditions in the nineteenth century. And the year by year reaction of Americans ought to provide an interesting barometer to many phases of the history of American opinion of what our British allies stood for during the last century and to help us to understand the ideals of the two countries more intelligently.

If Byron and Scott[1] in the first half of the nineteenth century were the first English writers to take the American reading public by storm, their triumphant acceptance appears very small

* The writer gratefully acknowledges that this work was supported in part by a grant from the Research Fund of the University of Wisconsin.

[1] W. E. Leonard, *Byron and Byronism in America* (1905). G. H. Orians is about to publish a full-length study of Scott's vogue in America.

indeed beside the epic-reception accorded to Macaulay after 1840. The sales' records of his books read like a modern fairy tale. Edward Everett told Macaulay that only the Bible and one or two common school books had had such sale in the United States as his *History.*[2] In 1849, shortly after its appearance in America, Harpers wrote that there would soon be six American editions; 60,000 copies had already been disposed of and the demand was expected to rise to 200,000 within three months. "No work, of any kind, has ever so completely taken our whole country by storm."[3] So great was the Macaulay legend that at the end of the century, Charles Francis Adams could say: at least twenty "American publishing houses have brought out complete editions of Macaulay, both his *Miscellanies* and the *History of England.*" And though many of these were very expensive, "they seem uniformly to have met with a ready demand."[4] Macaulay himself was not only "greatly pleased," but somewhat puzzled by the American popularity of his works, especially the *History* which he admitted was "quite insular in spirit." "I do not understand," he wrote Everett, "how it should be acceptable to the body of a people who have no king, no lords, no established church, no tories, nay, I might say, no whigs, in the English sense of the word."[5]

One feels that Macaulay's perplexity was entirely justified. Why should a five-volume history covering only the years from 1688 to 1702 find such favor with Americans? Why should Macaulay's critical essays gain more favor, even before the appearance of the *History,* than many other and better critics? The answer is found in the numerous critical articles and reviews which were called forth with each new edition and biography. American opinion, however, was by no means unanimous, and a study of Macaulay criticism not only reveals the actual influence of the man himself but throws into relief the changing temper of American literature and criticism, even to the extent of bringing out some minor critical trends hitherto unrecognized.

---

[2] Quoted by A. H. Guernsey, *Galaxy,* XXII, 806 (Dec., 1876).

[3] G. E. Trevelyan, *Life and Letters of Lord Macaulay,* II, 509, (1931).

The American historian W. H. Prescott wrote Mrs. Milman in 1855 of Macaulay's "tens of thousands" of readers in America. "There is no man who speaks to such an audience as Macaulay. It is certainly a great responsibility." George Ticknor's *Life of W. H. Prescott* (Philadelphia, 1875), p. 289.

[4] "The Sifted Grain and the Grain Sifters," *American Historical Review,* VI, 228 (Jan., 1901).

[5] Quoted by Guernsey, *op. cit.,* p. 806.

The reputation of Macaulay in America can be studied in three fairly well-defined periods: 1840 to 1860—a period in which Macaulay is quite generally, though by no means unanimously, accepted; 1860 to 1900—a period in which his genius is challenged, mainly by the new scientific historians; and 1900 to 1940—a period of more detached critical evaluation resulting in an upward turn of his reputation.

I. 1840 TO 1860

The journals of the conservative Puritan sects were the first in America to notice Macaulay. This was the time of the transcendental heresy, and the conservatives were in quest of a champion such as the transcendentalists had in Carlyle. The reviewer[1] of the *Critical and Miscellaneous Essays* for the *Princeton Review* in 1840 felt that in Macaulay the great defender of common sense religion had been found. "Strong common sense . . . marks every paragraph: there is no puling, there is no cant, there is no transcendentalism."[2] Moreover, the "serene dignity" and "tragic pathos" of Macaulay's essay on Milton indicate that the "fame of the Puritans" may be trusted in Macaulay's hands.[3] The *Christian Review*[4] in discussing the same work asserts the same contentions. Macaulay has the "impress of an elegant and well-balanced mind" and "deals but slightly in the subtleties of metaphysics"; he has no "enigmatical sayings, no newfangled philosophy" like Carlyle whom he "far surpasses." Besides, he is a "master critic" as the essay on Milton shows, and at the same time he possesses one of the "very best specimens of pure and finished English."[5]

On the other hand, Edgar Allan Poe[6] as a great spokesman of romanticism and a disciple of the transcendental Coleridge, charges Macaulay with shallowness—the typical charge brought by the romantic against the man of common sense. Macaulay, he says, is "a terse, forcible, and logical writer," but it is wrong to regard him as "a comprehensive and profound thinker." His "exceeding closeness of logic" misleads him to "concentrate force upon minutiae, at the expense of a subject as a whole." Poe therefore became the first to raise a charge that was to be made again and again, particularly by romantic writers.

E. P. Whipple, who first gained literary recognition through

[1] James W. Alexander, "Critical and Miscellaneous Essays," *Biblical Repertory and Princeton Review*, XII, 431-451, (July, 1840). This was the official organ of the Presbyterians at the Princeton Theological Seminary.

[2] *Ibid.*, p. 445.

[3] *Ibid.*, pp. 434-5.

[4] V. 450-472, (Sept., 1840).

[5] *Ibid.*, pp. 451-4.

[6] Reprinted in *Edgar Allan Poe: Representative Selections* (ed. by M. Alterton and H. Craig, 1935) pp. 318-321. In another and peculiarly typical passage Poe asserts, "The style and general conduct of Macaulay's critical papers could scarcely be improved," and that two of our best critics, E. P. Whipple and W. A. Jones are his imitators. Then he proceeds to "analyze" Macaulay's style to show how in practice, not theory, it could be improved. See "E. P. Whipple and other Critics," *Literary Criticism*, Sterling edition, 405-15.

his essay on Macaulay in 1843[7], came under the literary influence of the Englishman himself and Macaulay's style is clearly "reflected in much of the earlier work of his American admirer."[8] Whipple's essay itself shows a deep admiration for Macaulay's "range over the field of literature and science, and the boldness of his generalizations."[9] As a critic, Macaulay shows "depth of feeling," "a fine sense of the beautiful" and "a comprehensive and penetrating judgment," though his "critical severity" is regrettable.[10] Moreover, Macaulay pays "eloquent tribute" to "the Puritans."[11] He has faults, but these are all due to one source—his great "vigor." "Byron displays hardly more intensity."[12] Whipple's uncritical acceptance of Macaulay is typical of a great many American essays. It took minds of considerable critical insight to find faults in Macaulay's brilliant glitter.

In the same year, 1843, the *Lays of Ancient Rome* were published and were enthusiastically reviewed by the *Southern Literary Messenger*.[13] Macaulay "infused new life and vigor into the old legends" and "initiated the close and easy simplicity of the ballad style" better than could be expected in this artificial age. The *Lays* convey more "true historical information" and "genuine classical taste than many other works of more ponderous form and of graver pretensions." The *Lays* themselves did a great deal to popularize Macaulay in America. Their appearance here fortunately coincided with the revival of the ballad form by our most popular poets, Longfellow and Whittier, and as a result, they were widely read.

But in *The Pioneer*,[14] vehicle for the young Lowell's fiery idealism, Macaulay's work met with a far different reception. Lowell, who liked to sparkle himself, praised the *Lays* as "brilliant, but never profound, witty, but not humorous, full of sparkling antitheses." Macaulay "is a kind of prose Pope," with philosophizing and talent but with "no great ideas, no true philosophy." Above all, "he is not a genius." His Whig politics seem to Lowell an ignoble, selfish compromise. His sympathies are merely "fashionable," expressed "to be admired by everybody

[7] *Boston Miscellany* (Feb. 1843). Reprinted in *Essays and Reviews*, I, (1848), pp. 9-30.

[8] George S. Hellman, *C H A L*, III, 125-6. He says that Whipple's book, *Essays and Reviews*, is closely related to "the Macaulay school of essayists."

[9] *Essays and Reviews*, p. 15.

[10] *Ibid.*, pp. 17, 20.

[11] *Ibid.*, p. 24.

[12] *Ibid.*, p. 28.

[13] IV, 76-81 (July, 1843).

[14] I, 2 (Jan., 1843), 93-4.

today, and then to retire upon such precarious pittance of immortality as is furnished by the charitable corner of a country newspaper."

Before returning to the attack on the poet himself, Lowell turns aside to drub "Christopher North" (who had persecuted both Keats and Tennyson) for North's "vulgarity and intrepid egotism." This sally against a "self-constituted dictator in Parnassus" is made relevant by citations of North's compliments to Macaulay. Then Lowell comes to the philosophic heart of his objections to the *Lays*. Their spirit is "a mistaken one. The chivalry which it tends to excite, is anti-spiritual, and therefore, (except insofar as it is picturesque,) anti-poetic." In short:

> That poetry which awakens the gentle and deeper feelings of our original nature, not that which rouses those fierce and quarrelsome principles which have been implanted in us by long ages of barbarism, is the best. Whatever spurs the soul to overcome hatred with love, and violence with meekness, to struggle against and overcome inward enemies, makes a man more truly manly, than all that fosters in him that physical courage, which only makes him the better animal. The patriotism of Horatius might have been ideal two thousand years ago, but, however slowly, a nobler and higher ideal is surely rising, and men are learning that there is a moral and spiritual patriotism as far above that bodily patriotism of the Romans, as beauty is above deformity.

The best Lowell can find to say for "Macaulay" at this time is that his "book displays a fine classical taste, and the possession of an excitable temperament, and a good ear for metre, rather than poetical power." It exhibits "the highest range and accomplishment of a man of talent." The net effect is to damn by both precept and faint praise.

Hawthorne seems to have had a genuine admiration for Macaulay. Mrs. Hawthorne wrote in 1844, "My husband has been reading aloud to me. . . . Macaulay's 'Miscellanies'." He is "very acute, a good hater, a sensible admirer, and one of the best simile-makers." His style is clear and his humor pleasant, but "we do not always agree with his dicta."[15] Later, Hawthorne became deeply interested in the ancient history of Italy, and before leaving England caused his children "to learn by heart Macaulay's 'Lays of Ancient Rome'."[16]

Not a little of the early reception of Macaulay was due to the influence of his father, the great abolitionist. As leader of the Freetown colony in Africa, Zachary Macaulay was well known in

---

[15] II. Hawthorne, Nathaniel, *Hawthorne and His Wife* (1895), I, 275.
[16] *Ibid.*, II, p. 172.

America, and this popularity obtained quick recognition for the work of his son, particularly in New England. This was the case with Edward Everett[17] first a friend of the father, and later an intimate friend and ardent admirer of the son. In 1844, while ambassador to England, he wrote that Macaulay is "the ablest writer of the day and one of the most extraordinary men. His conversation is as remarkable as his writing, pouring out in a full tide, upon every subject that comes up, as if he had read everything that was written, and remembered everything he had read." [18] The two men occasionally corresponded. In 1849 Macaulay wrote Everett, hoping that he would soon return to England: "For I am sure that you can do more than any other man living to promote good feeling between New England and Old England, and we are both, I am confident, equally convinced that the concord of the two great branches of the English race, is of highest importance to the happiness of both."[19] Macaulay had a very high opinion of Everett's capacity, and urged that he "undertake to give us a history of the United States, such as might become classical."[20]

Another early channel for the transmission of Macaulay's influence to America was the historian George Bancroft who served as ambassador to England, 1846 to 1849. He wrote to John Appleton in 1847 that he saw Macaulay "very often" and "each day that I see him makes me more and more admire the wonderful extent and precision of his knowledge. His memory is as great as his industry; and politics or theology, the ancient or the modern, the literature of all cultivated nations in all ages, are equally present to him."[21] Later the same year he wrote to the American historian, Prescott, that of all the contemporary historians in England, "Macaulay is the most extraordinary of them all. He rises in my esteem . . . every time I see him; for his foibles show themselves at once; his greatness by degrees. He has the most nearly universal knowledge of any man I ever met; . . . I think him what is so rare, greater than his book." Bancroft then proceeds to notice Macaulay's one defect; he has "good intentions as an inquirer" but "he fastens upon a subject or a character with a tenacity and vehemence which sometimes leads

[17] Everett visited Zachary Macaulay in London in 1815 and 1818. See P. R. Frothingham, *Edward Everett: Orator and Statesman* (1925), pp. 38, 49-50.

[18] *Ibid.*, p. 245.

[19] *Ibid.*, p. 302.

[20] *Ibid.*, pp. 308-9.

[21] *Life and Letters of George Bancroft* (ed. by M. A. DeWolfe Howe, 1908), II, p. 11.

him to judgments which a more tranquil mind would qualify."[22] Thus Bancroft even before the appearance of the *History* diagnosed the historian's chief defect as a lack of impartiality. Yet Bancroft's admiration and almost daily association with Macaulay at the time when he was completing his *History of England* suggests he may have exerted considerable influence on Bancroft's *History,* the last seven volumes of which appeared after this time.

The actual appearance of Macaulay's *History of England* in America in 1849, had very unexpected results. The popularity of Macaulay's earlier work, particularly in New England, would seem to presage a very warm reception for the brilliant *History.* But such is not the case—at least among the reviewers. The reason is that Macaulay said some very unpleasant things about the Puritans and Noncomformists in volume one of the *History,* and most of the American reviewers were Puritan. G. E. Ellis, reviewing the work in the *Christian Examiner*[23] (the journal of the Harvard theology faculty) is favorable in general and notes that our "newspapers are all copying [the] narrative." But he goes on to say that he must take two exceptions to Macaulay's account. The reader must take a more comprehensive view of Puritanism before accepting such a judgment as Macaulay's. And he must not accept too readily Macaulay's analysis of the character of William Penn. Though the other reviewers often repeated this criticism, they were not always so candid. J. Williams in the *Church Review*[24] attacked Macaulay as "very brilliant" but "very unscrupulous." He has forced the narrative to subserve the "paltry purposes of party: the never-failing characteristic of a narrow-minded and superficial historian." He has entirely misunderstood the political side of Anglicanism and the status of the Church of England as the *Via Media.* Politics is his vocation, but philosophizing on "the high truths of religion" and estimating the "characters of the good and the wise" are "beyond his depth." *Brownson's Quarterly* takes a similar stand. The Puritans with all their "faults, sour looks, and cant, are, under a human point of view, always to be preferred to the swearing, toast-drinking, and licentious Cavaliers."[25] G. P. Fisher in *Knickerbocker Magazine*[26] is more disturbed, but takes the same

[22] *Ibid.,* II, 16-17.
[23] XLVI, 253 ff. (1849).
[24] II, 2 ff. (1849).
[25] VI. 275 (1849).
[26] "Macaulay and the Puritans," XXXIII, 508 ff. (June, 1849).

point of view. Macaulay is not successful in describing Cromwell; "it requires a thorough Puritan to comprehend the Prince of Puritanism." The aristocratic *North American Review*[27] avoids the issue with a short notice in which the orthographic changes in the Harper edition are attacked but the *History* is snubbed by making no comment on it.

Whittier of course came to bat for the Quakers.[28] Macaulay's "sparkling rhetoric is not the safest medium of truth to the simple-minded inquirer." The "intelligent and well-informed reader" is continually compelled "to reverse the decisions of the author, and deliver some unfortunate personage, sect, or class from the pillory of his rhetoric."[29] And while giving praise to the great "third chapter," Whittier proceeds to defend the character of William Penn. Macaulay has labored through "many pages of disingenuous innuendoes and distortion of facts to transform the saint of history into a pliant courtier."[30] He goes further and defends the character of James II, and attacks Macaulay for relying on Burnett.[31]

And in the September 16, 1847, *National Era* Whittier made the hue and cry raised by his Scotch constituents' disciplining of Macaulay for flouting their Dissenter interests the occasion of an article entitled "The Rejection of Macaulay at Edinburgh." He listed the sins against democratic representation committed by Macaulay which justified his defeat at the polls, replied with mingled irony and preaching to the sneers and invective levelled by English journals at the rugged Scots who had rejected the Great Man, and called his countrymen to witness that in a time of rising democracy notice was being served upon any "popular genius whose ambition may lead [him] to block up the pathway of Reform with the tropes and figures of rhetoric" that neither Englishmen nor Americans would tolerate such waywardness longer.

Theodore Parker, as editor of the *Massachusetts Quarterly*,[32] spoke out for the Transcendentalists in a long essay. Parker asserts that in general Macaulay's impartiality "is very con-

---

27 LXVIII, 511 ff. (1849).

28 "England under James II," *Prose Works*, II, 348-367.

29 *Ibid.*, p. 348.

30 *Ibid.*, p. 355.

31 *Ibid.*, pp. 363-7.

32 II, 326 ff. (1849). Reprinted in the Centenary Edition in the volume entitled *The American Scholar*, pp. 323-63.

spicuous," but if he errs in any direction, it is "that he may not have done full justice to the religious or political principles of the Independents."[33] In Macaulay's comparison of the England of 1685 with Victorian England, Parker thinks that "the former is somewhat overcharged, and the latter . . . a little flattering."[34] Parker essentially agrees with Macaulay's picture of the 17th century, but thinks that in Victorian times the concentration of land in a few hands is "a melancholy, disastrous change in the social system of England"[35] and that the educational system of New England is not due to English precedents, "but to the piety and wisdom of our Puritan ancestors."[36]

The favorable reviews of the *History* are limited to three. L. Bacon in the *New Englander*[37] replies to the attack of the *Church Review*. He defends Macaulay's analysis of the rôle of the Anglican Church in the 17th century, and says that the *History* is "finding its way everywhere. It will be read by all our reading population."[38] The *History* was also praised by the conservative aristocratic *Southern Quarterly Review*[39] because the reviewer believed that the children of the South should be imbued "with the high, bold, manly morality of *Old* England, (not *New* England, or *modern* England) . . ."[40] The soundest critical review of the *History* was a favorable one appearing in the scholarly *Democratic Review*.[41] The reviewer considers the *History's* lack of profundity "one of its decided charms," for where the philosopher's duty is analysis, that of the historian is "to narrate."[42] And suggestibility therefore is the most important quality a history can have. Macaulay also discovered a "neglected branch of history" in "character-writing"[43] and had besides a "spontaneous style" free from "artificial rules,"—essentially the style of the

---

[33] *The American Scholar*, p. 325.

[34] *Ibid.*, p. 327.

[35] *Ibid.*, p. 351.

[36] *Ibid.*, p. 359. When Parker came to discuss Prescott's histories, however, he found comparison with Macaulay a good means of attack. Wishing social and literary, rather than merely political, history, Parker pointed out in Macaulay the "spirit of humanity," the criterion of histories by which he condemned Prescott. *Mass. Quart. Rev.*, II, 215-48; 437-70.

[37] "Macaulay and the Anglo-Catholics," VII, 288ff. (May, 1849). See also Frederic Howes' "Macaulay's *History of England*," *Mass. Quart. Rev.*, June, 1849, pp. 326-55.

[38] "We are glad and thankful that in our country, everybody that wants this book can have it—the rich at two dollars . . . and others at almost any price . . . down to twenty-five cents."

[39] XV, 374 ff. (1849).

[40] *Ibid.*, p. 407.

[41] XXIV, 205 ff. (March, 1849).

[42] *Ibid.*, p. 209.

[43] *Ibid.*, p. 213.

cultivated 19th-century Englishman, "self-possessed, healthy, with reason on the alert, and comfort all around."[44]

In the same year, H. H. Hudson, the romantic Shakespearean critic, reviewed a new edition of the essays for *The American Review*.[45] He violently attacked Macaulay who, he says, shows a "practical atheism of human virtue" in failing to appreciate the "likeability" of character in Dr. Johnson. He is plagued by an "itching fondness for saying smart things." He has a wrong-headednesss which makes him cherish his opinions "above his sense and above the ideals of love, God, and justice." His "understanding of ecclesiastic and religious questions" is sophomoric and his *History* is inferior to Lord Mahon's. Hudson's review carries on the romantic attack on Macaulay begun by Poe; like Poe, Hudson was a disciple of Coleridge, the Transcendentalist.

In 1850 the *Princeton Review*[46] (the conservative Presbyterian journal) reviewed the *History* and reversed its enthusiastic reception of Macaulay ten years before. He should have avoided the history of the Commonwealth, for he shows a grave lack of "deep and earnest religious convictions."[47] His ignorance of the Puritans' doctrines makes him do them "great injustice," and thus with all his "rare gifts" Macaulay is not "a philosopher or a reasoner."[48] In the same years, an anonymous reviewer made a violent attack in the *Democratic Review*[49] on the *Lays of Ancient Rome* which had come out in a new edition. The reviewer evidently has a strong romantic bias. He accuses Macaulay of trying "to hide a lack of imagination under the garb of pleasing simplicity," and contrasts him with Keats' magic handling of old legends. The *Lays* are full of "puerilities" and "gross plagiarism" and Macaulay had better go back to "writing prejudiced history, and one-sided reviews!"

Macaulay's speeches were reviewed in the scholarly *Christian Examiner*[50] of Harvard by C. C. Smith in 1853. Like Whipple, Smith explains Macaulay's partisanship as the "vehemence with which he espouses any cause" rather than the "uniform advocacy of the measures" of a party.[51] He is one of the great practical

[44] *Ibid.*, pp. 214-15.
[45] IX, 499 ff. (May, 1849).
[46] *Biblical Repertory and Princeton Review*, XXII, 101 ff. (Jan., 1850).
[47] *Ibid.*, p. 104.
[48] *Ibid.*, pp. 108, 120.
[49] XXVI, 209-219. (March, 1850).
[50] LIV, 285-307 (March, 1853)
[51] *Ibid.*, p. 290.

statesmen and "regards the security of property as the chief object for which governments are instituted" and as a result he has "always opposed universal suffrage." Nevertheless in education his views "are broad, liberal, and statesmanlike."[52] This well-balanced review was followed later by a vigorous but uncritical attack on Macaulay in the *New York Quarterly*.[53] Macaulay "is in no respect qualified" for history. His great feature is partiality; he was "the mere instrument of the Whigs" and the malicious slanderer of Stuarts as well as Puritans. His "present courtly habits" prevent him from correctly "depicting the glorious character of Cromwell."[54] His essays are "vigorous and brilliant" but he is "not an original or creative writer."[55]

J. C. Moffat's essay in the *Princeton Review*[56] in 1856 manifests a new spirit in the attitude of the puritanical church journals toward Macaulay. The attitude of American Puritans as a whole underwent an interesting evolution. At first Macaulay was enthusiastically received as a friend of Puritanism and as a Whig reformer and protector in modern England of the political liberties which the Puritans felt they had won in the Revolution. The appearance of the *History* destroyed this illusion and for several years the Puritans were very bitter. By 1856, however, the church journals lost their bitterness and began to take a view of Macaulay which, if not entirely favorable, at least approached a fairly accurate critical understanding. This new spirit was first expressed by C. C. Smith in the *Christian Examiner* in 1853 when he noticed that though Macaulay's views on education were "broad, liberal, and statesmanlike," he was not a dyed-in-the-wool liberal and "always opposed universal suffrage" in order to protect property.[57] Moffat carries on this better understanding, and introduces an entirely new element. "The ultimate object," he says, "of national progress is perfect equality of rights" and "the existence of England is the longest . . . practical commentary upon the law of that progress."[58] And the very essence of English history—the dualism between absolute monarchy and "parliamentary business"—has been recorded by Macaulay in "an

---

[52] *Ibid.*, pp. 293-4.
[53] "Macaulay's England," III, 499-521, (Jan., 1855).
[54] *Ibid.* p. 507.
[55] *Ibid.*, pp. 515-16.
[56] XXVIII, 286 ff. (April, 1856).
[57] C. C. Smith, *op. cit.*, p. 294.
[58] Moffat, *op. cit.*, p. 287.

animating style."[59] Moffat is a thorough democrat almost to the extent of being class-conscious, and though he feels that Macaulay "failed to do justice to [the religious] motive of Englishmen" in securing greater political and social equality, yet he has "a heart that beats in unison with the great natural impulses of his countrymen."[60] He has written a "great historical epic"[61] of the struggle of his country to secure free government and his *History* can teach America "a lesson of ever-during value" as to the cost of regaining free government should we ever "permit it to elude our grasp."[62] Thus Macaulay was being read, even by one who disagreed with him, for his embodiment of the democratic spirit. And this, combined with his belief in material progress and common-sense intellectualism, all imbibed by a reading public running into millions, must have constituted a considerable force for the rise of realism in America.

The new spirit of the Puritan journals is perhaps best shown by L. E. Smith in the *Christian Review* for 1856.[63] Smith is quite objective and reveals some of the conditions which resulted in so much praise and blame for the *History*. He says that there is a marked contrast "between the popular judgment and that of professional critics," and that the whole-hearted popular admiration for Macaulay is the more sound. Part of Macaulay's popularity seems to have been due to his inheritance of the novel-reading public of Scott, particularly in New England where novels were considered immoral but history was not. Smith quotes a disgruntled critic who tried to predict what history would be in "the ascendant when 'the mob of novel-readers' shall have deserted Mr. Macaulay for some new favorite." Smith makes a very striking analysis of the cause of the opposition to the *History*. He says it is difficult to write an impartial history of 17th-century England because it "involves the history of a struggle between principles that, in one form or another, are still living and in conflict on either side of the Atlantic,—between parties in politics and religion whose successors and representatives now struggle on a wider and still widening field." In such a case the historian can no more gain favor with the "partisans on both sides than one man can serve two masters." Hence the

---

[59] *Ibid.*, p. 288.
[60] *Ibid.*, p. 290.
[61] *Ibid.*, p. 300.
[62] *Ibid.*, pp. 308-9.
[63] XXI, 356 ff. (July, 1856).

attainment of a cordial reception under these conditions is indeed "proof of transcendent merit." Yet Macaulay's "credibility" is not "very seriously" damaged; "at least in this country, where he probably has more readers than in his own." This marks the end of the Puritan controversy over Macaulay and if we may judge from favorableness of the last reviews, Macaulay was henceforth as readily accepted by the American Puritans as in the days of his first appearance.

In *English Traits* (1856) Emerson delivered the strongest romantic and transcendental attack, centering his criticism on Macaulay's materialism.[64] Macaulay, he says, "explicitly teaches that *good* means good to eat, good to wear, material commodity; that the glory of modern philosophy is its direction on 'fruit'; to yield economical inventions; and that its merit is to avoid ideas and avoid morals." Furthermore he believed the distinctive merit of Bacon over Plato to be in "disentangling the intellect from theories of the all-Fair and all-Good" in order to obtain "solid advantage," meaning always that "sensual benefit is the only good." And thus after a thousand years the civility and religion of England "ends in denying morals and reducing the intellect to a sauce-pan." Peter Bayne's essay[65] two years later was written in the same vein and was widely circulated in New England. Bayne takes Plato to represent "the highest order of mind," and Bacon with his aversion for "scaling the Infinite" to represent minds of the second order. Macaulay belongs to the latter class. He "rests satisfied in the fabric of human knowledge as it is,"[66] and entirely ignores the Christian doctrine that there is a "spiritual influence from on high upon the human mind."[67] Hence he goes astray because of "this fatal defect." He limits the theory of government to a "purely temporal end, the protection of the persons and property of men." Bayne says he can hardly "imagine a government, whose aims were of no more exalted a character" and that true government "must be progressive in a nobler sense

[64] Pp. 247-8. See also pp. 262, 292. Upon meeting him while in England, Emerson had written home: "Macaulay is the king of diners-out. I do not know when I have seen such wonderful vivacity. He has the strength of ten men; immense memory, fun, fire, learning, politics, manners, and pride,—talks all the time in a steady torrent. You would say, he was the best type of England." Yet Emerson relayed with sympathetic gusto the verdict "that this most fashionable orator, scholar, statesman, gentleman, is, in some companies of highest fashion, voted a bore." *Letters of Ralph Waldo Emerson*, ed. by Rusk, 1939, IV, 42-3. See also I, 306; II, 22, 41, 62; V, 29, 172; VI, 6, 19, 20.

[65] "T. B. Macaulay," *Essays in Biography and Criticism*, Second Series (Boston, 1858), pp. 52-85.

[66] *Ibid.*, p. 58.

[67] *Ibid.*, p. 63.

than this theory admits."[68] This marks the end of the romantic and transcendental opposition to Macaulay. After the Civil War the new literary forces of realism dominated America and stronger forces of anti-Macaulay criticism arose from a very different source.

One avenue for the transmission of Macaulay's influence to America, as we have seen in the case of Everett and Bancroft, was the direct contact of prominent Americans with Macaulay in England. In 1856 George Ticknor, then perhaps the outstanding American scholar, met and formed an intimate friendship with Macaulay.[69] He was astonished at the "resources" of Macaulay's great memory, which, he says, is "all but fabulous."[70] Macaulay also had a high opinion of Ticknor's work and once recommended the *History of Spanish Literature* to the Queen as one of the best books of the age.[71]

The new literary journal, *Putnam's Monthly Magazine*,[72] contained a journalistic essay highly appreciative of Macaulay in 1856. The reviewer believed that Macaulay owed much of his success to the *Edinburgh Review* because of its use of the historical essay in his early training period. As to Macaulay himself, the writer thought him to be a greater political philosopher than Hume, but a less permanent addition to literature because of his barn-storming eloquence.

William Alfred Jones, whose debts to Macaulay we have already seen discussed by Poe,[73] was in the van of his admirers. His list[74] of Macaulay's excellences is only just short of rhapsodic. He is "probably, the most brilliant writer of English now living," a successful politician as well as "splendid writer." His "reviews are the very Iliad and Odyssey of criticism—models of that kind of writing. Abler men and deeper scholars have written review articles without that mastery of the art." Even Hazlitt was not so good a reviewer, though of course a better critic. Macaulay is "that rare union of critic and miscellaneous writer—a critical essayist." Jones' partiality to his style makes him seek a romantic image to describe it: "It is like love at first sight, you may

[68] *Ibid.*, pp. 70, 71.

[69] For accounts of his visits with Macaulay, see *Life, Letters, and Journals of George Ticknor* (1876), II, 361, 362, 366, 367, 369, 373.

[70] *Ibid.*, II, 325.

[71] *Ibid.*, II, 220 n.

[72] VII, 255 ff. (March, 1856). The essay is probably by Parke Godwin who was editor at this time.

[73] See Poe's essay "E. P. Whipple and Other Critics."

[74] *Characters and Criticisms*, 1857, 164-5.

always know his hand." Since Macaulay is "always partizan," however, he would have been at his greatest as a political pamphleteer. Finally, there are the historical essays where "portrait painting and finished declamation have been carried to perfection . . . in which we find, besides, a treasury of fine and ingenious thoughts, richly illustrated and admirably employed."

Of all American magazines the *Southern Literary Messenger* seems to have been most sympathetic to Macaulay. Though one or two unfavorable essays were published, it contained a far greater number of favorable notices than any other magazine. Besides his own merit, Macaulay's anti-Puritan reputation and his prominence as an English man of affairs undoubtedly contributed to this preference. The period just before the Civil War was especially fruitful. The first article of this series was a comparison, entitled "Prescott and Macaulay," made in 1856.[75] The writer claimed that the only similarity of the two men was their "laborious research." On the other hand, where Prescott was "calm, unimpassioned and judicial," Macaulay is much "less frigid" and hence is "always on one or the other side of every great question that arises." Macaulay's partisanship however is not a defect, but "lends a coloring to his history" which is "absolutely necessary for . . . perception." For that reason Macaulay is not less "to be relied on that Prescott." The writer believes, however, that Prescott is superior to Macaulay in style. Where Prescott is "free from mannerisms" and "rarely brilliant," Macaulay shows "pictorial effects" and a "love of antithetical forms of expression" but with an "extravagance" seldom equalled anywhere. "The eternal epigram becomes at last pointless" and betrays him "into exaggeration—if not misstatement." In 1859 a controversy appeared in the magazine over Macaulay's criticism of Bacon. William S. Grayson attacked Macaulay's view in the September number.[76] He says he admires Macaulay's estimate of Bacon the man, but that his review of Baconian philosophy must be accepted with "many grains of allowance." He raises the old charge of Macaulay's lack of depth. He "is eminently an historian, and just as eminently not a philosopher . . . His genius revels in the world of men, and not in the world of mind." He "signally failed in comprehending the hypothesis on which Bacon's fame reposes." W. S. McCabe came to Macaulay's defense

[75] XXII, 144 ff. (Feb., 1856).

[76] "Bacon's Philosophy, and Macaulay's Criticism of It," *Southern Literary Messenger*, XXIX, 177-183 (Sept., 1859).

in the November number.[77] He says that Grayson did not fully quote "Macaulay's opinion of the Baconian philosophy" and thus failed to give his "opinion of the great importance and true benefit of the Baconian philosophy."[78] At this time also a controversy was raging over Macaulay's treatment of Marlborough, and the *Messenger* has two articles on the subject. The controversy arose over an article in *Blackwood's*[79] attacking Macaulay's portrait as "inaccurate and false." In October, 1859,[80] a writer answered the *Blackwood's* charges, claiming that it is impossible to be an impartial historian where religion and politics are concerned. All we can do is "to judge leniently of men." A writer in the January, 1860, number[81] replied, attacking Macaulay's portrait, and defending the *Blackwood's* article with a technical discussion of the evidence.

There are other articles in the immediately following numbers of the *Messenger*, but they belong by the nature of their content in the next period of Macaulay's reputation in America. As we shall see there was a fairly distinct break in American criticism of Macaulay after 1860. Before the Civil War he was received as essentially a materialist at the height of our romantic transcendentalism. After the War literary tastes had changed and from 1860 to 1900 the problem becomes Macaulay's reception in the period when American literature was devoted to realism.

---

[77] "Bacon's Philosophy and Macaulay's Criticism of It," *Southern Literary Messenger*, XXIX, 382-386 (Nov., 1859).

[78] *Ibid.*, p. 382.

[79] LXXXV, June, 1859, pp. 661-76.

[80] "Lord Macaulay and Marlborough," *Southern Literary Messenger*, XXIX, 241 ff. (Oct., 1859).

[81] "Macaulay and Marlborough," *Southern Literary Messenger*, XXX, 1-10 (Jan., 1860).

II. 1860 TO 1900

In the first period the most serious opposition to Macaulay in America came from such romantic and transcendental critics as Poe, Hudson, Theodore Parker, Whittier, and Emerson. Such opposition was entirely natural; the intellectualism, materialism, and optimistic Victorianism of the Macaulay temper provided little attraction for the romantic spirit of the 1840's and 1850's. But romanticism was a receding force with Whitman and Howells, and hence opposition from this source, even though coming from some of the greatest spirits of American literature, could not check the rising tide of Macaulay-popularity. For Macaulay's popularity in America rose with, if it did not indeed help along, the rise of American realism. And it was only when Macaulay's genius began to be questioned by men of his own stripe, by certain forces within the realistic movement itself, that his reputation began to suffer. These were not the declining but the rising and dominating forces of their time, and thus had ample power to injure seriously the Macaulay juggernaut. This receding movement was aided by the death of Macaulay himself in 1859 at the very time when the movement was getting under way, but as a matter of fact, it had already been written in the stars.

The new attitude did not escape the sharp eyes of H. T. Tuckerman when he wrote his essay on Macaulay in 1860.[1] The "gifted few," he says, are beginning to look somewhat askance on Macaulay. It is beginning to be felt "that he is too dazzling to be trusted, too interesting to be solid, too attractive to be true." This position, says Tuckerman, is maintained by a new class of men who "deny the possibility of uniting substantial and profound historical research and speculation—with a style and method that shall win English workmen to listen with delight."[2] This "new class of men" was of course the new scientific school[3] of ultra-realistic historians who were destined to furnish the chief opposition to Macaulay for the next forty years. Thus we see that where Macaulay was too material-minded in a romantic age, now he is not realistic enough for the scientific

[1] *Southern Literary Messenger*, XXX, 241-250 (April, 1860).

[2] *Ibid.*, p. 241.

[3] The most influential of this school was of course Leopold von Ranke, who held the chair of History at Berlin from 1825 to 1871. See C. K. Adams, "Recent Historical Work [since 1860] in the Colleges and Europe and America," *Papers*, Amer. Hist. Assn. (Jan. 1890), pp. 39-65; and E. G. Bourne, "Leopold Von Ranke," *Annual Rept.*, Amer. Hist. Assn. (1896) pp. 65-82.

historians. Tuckerman says that Macaulay also alienated "the clerical instinct" when he attacked certain episcopal and dissenting ministers for lack of humility and truthfulness. Still others attacked Macaulay for being a Whig advocate. But the most serious charge against him is "his disloyalty to fact."[4] "All these factors taken together," he says, "contributed to the decline of Macaulay's prosperity at this time." Tuckerman himself, however, is essentially a Macaulay man. He thinks the "number of actual errors of judgment or of statement is remarkably small in proportion to the extent of the subject."[5] Macaulay himself best exemplifies the "British practical and thorough, positive and intelligent spirit." There is no indistinctness—"all is bold, clear, full, direct, effective—neither French rhetoric and sentiment nor German mysticism and diffuseness—but Saxon vigor, lucidity, freedom and abundance." He made his country's institutions and her illustrious characters "known in Europe as they were never known before."[6] And whatever was thought, said, or acted in the British Isles "Macaulay knew and announced in a memorable style."[7] There is a critical fairness in Tuckerman's attitude toward Macaulay that was seldom met with before the end of the century.

It was in 1860 also that a crucial event occurred which had considerable significance for Macaulay, in America. Again the journal involved was the *Southern Literary Messenger* which published the articles in its March and August issues. It had long been thought strange, says the writer of the March article,[8] that Macaulay expressed no opinion of America, a land where his *History*, was "read and admired by a vastly greater number of persons . . . than on his own side of the Atlantic." He adds, however, that this deficiency is now supplied by Macaulay's letter to H. S. Randall,[9] the American biographer of Jefferson. The letter

[4] *Ibid.*, p. 242.

[5] *Ibid.*, p. 243.

[6] *Ibid.*, p. 245.

[7] *Ibid.*, p. 246.

[8] "Macaulay's Opinion of the United States Government," *Southern Literary Messenger*, XXX, 225-228 (March 1860).

[9] Randall's *Life of Thomas Jefferson* (New York, 1858), 3 vols., still ranks as the "official" biography of Jefferson. The letter from Macaulay resulted from Randall's presentation of his biography and other books on American history to the historian. Randall may have been inspired by political motives to publish the letters so soon after Macaulay's death. The fact that they were published in a southern magazine strengthens this conclusion. The letters actually are a strong indictment of the democratic ideal as it was held by a large part of the North, above all by the abolitionists. On the other hand, they would seem in general to support southern notions of government by an aristocracy.

which he reprints was written in 1857 and outlines Macaulay's views on the future of democracy in the United States. Macaulay begins by saying that he has "not a high opinion of Mr. Jefferson" nor of democracy itself. He says that he has never believed "that the supreme authority in a state ought to be entrusted to the majority of citizens told by the head . . . I have long been convinced that institutions purely democratic must, sooner or later, destroy liberty or civilization, or both." The extreme form of Jeffersonian democracy being established in the United States, says Macaulay, would have very dire results in a thickly-populated land like England. "Either the poor would plunder the rich, and civilization would perish, or order and prosperity would be saved by a strong military government, and liberty would perish." Macaulay, however, saw no immediate danger; Jeffersonian politics, he thought, could continue to exist without causing a fatal calamity as long as large areas of fertile land[10] remained unoccupied. But he foresaw a very black future when the free land was gone and repeated economic crises shook a crowded nation to its foundations. And on the basis of this thought he concluded with his famous prediction, of the fall of American democracy in the twentieth century.

> It is quite plain that your government will never be able to restrain a distressed and discontented majority. For with you the majority is the government, and has the rich, who are always a minority, absolutely at its mercy . . . There will be, I fear, spoliation. The spoliation will increase the distress. The distress will produce fresh spoliation. There is nothing to stop you. Your Constitution is all sail and no anchor. . . . when a society has entered on this downward progress, either civilization or liberty must perish. Either some Caesar or Napoleon will seize the reins of government with a strong hand, or your republic will be as fearfully plundered . . . in the twentieth century as the Roman Empire was in the fifth . . .

The letter raised a great storm of protest, and some said it did not represent Macaulay's true opinion of America, and others that he changed his opinion later. Randall himself denied these explanations in the August issue of the *Messenger*,[11] and pub-

[10] It seems odd that neither Randall nor Macaulay nor the early commentators on this letter knew that Jefferson himself had expressed much the same doctrine: "I think our governments will remain virtuous . . . as long as they are chiefly agricultural; and this will be as long as there shall be vacant lands in any part of America. When they (the people) get piled upon one another in large cities, as in Europe, they will become corrupt as in Europe." (*Writings of Jefferson*, ed. Ford, IV, 479-80, Dec. 20, 1787.)

[11] H. S. Randall, "American Institutions. Lord Macaulay's Letter to the Biographer of Jefferson," *Southern Literary Messenger*, XXX, 133-135 (August, 1860).

lished parts of other letters[12] from Macaulay re-affirming the opinions in the published letter. In a later letter[13] written only a year before his death Macaulay went even further than in the letter published. He emphatically denied that American progress and prosperity were in any way the consequences of our peculiar democratic institutions, but the result of "causes which operated in America long before your Declaration of Independence, and which are still operating in many parts of the British Empire." And he cites the case of Australia which has made as great progress within the Empire as the United States has without.

The effect of the letters eventually was to alienate from Macaulay another large class within the realistic movement—the believers in American democracy and progress. The Civil War, however, seems to have deferred such a consequence for a time. In this same year, 1860, George Fitzhugh, a well-known Virginia apologist for slave labor, delivered a violent attack in the strong pro-South *De Bow's Review*[14] on Milton and Macaulay. Fitzhugh evidently sees in the two men twin symbols of the free labor system of the North. Both share the "ultra-liberal doctrines of the Puritans, Independents and Infidels, and of the vulgar despotism of Cromwell." To say that "liberty is a good is absurdly false." Fitzhugh regards Macaulay as a menace to Southern aristocracy. He merely "proposes to combine the landed and moneyed interests, and form a government of the middle classes," but for the great "laboring class, he has no care." And the false friends of liberty, "like Macaulay, may rue the day when they stripped the poor of their only natural friends . . . a king with the power and the will to protect them, a feudal nobility" and "a church richly endowed."[15] Fitzhugh discredits the predictions in Macaulay's letter of the impermanence of American institutions, especially in the South. "There is no free suffrage at the South, for only the whites vote, and negroes constitute the larger portion of the common laboring class." Until lately, Fitzhugh goes on to say, it seemed likely that in the North "Macaulay's predictions would prove true. We now believe that strikes and trade-unions will anticipate free suffrage in the work of destruction and anarchy."[16] Thus we see how the strained

---

[12] In all, Macaulay wrote four letters to Randall, the dates of which are Jan. 18, 1857, May 23, 1857, Oct. 9, 1858, and Jan. 8, 1859. The letter first published in the *Messenger* was the second.

[13] Oct. 9, 1858.

[14] "Milton and Macaulay," *De Bow's Review*, XXVIII, 667 ff. (June, 1860).

[15] *Ibid.*, pp. 670-1. (Compare R. C. Beatty's southern agrarian view in 1938.)

[16] *Ibid.*, p. 672.

sympathies of the Civil War had an adverse effect on Macaulay's reputation in the South. It was but natural that the son of an eminent abolitionist and the advocate of the Reform Bill of 1832 should find little favor in the South in 1860.

In the North, on the other hand, Macaulay was received with more enthusiasm than ever, particularly by the abolitionists who were greatly pleased by his essay attacking slavery. Sumner met Macaulay in London shortly before his death and was greatly impressed. "His conversation was as full and interesting as ever. Nothing seemed too great or too small for his memory. I think that I was more than ever struck by him."[17] Sumner wrote an introduction[18] to Macaulay's early essay on slavery when it was published by Horace Greeley in the *New York Tribune,* March 3, 1860. Sumner charged that the essay had been deliberately omitted from American editions of the *Essays* because it favored abolition. The essay itself dealt with British slavery in the West Indies, but Sumner claims that Macaulay's analysis foreshadows the whole slavery movement in the United States. It is very striking "to find how exact the parallel becomes."[19] He even predicted the "threats of disunion, coming from slave-drivers."[20] Sumner concludes with a very high estimate of Macaulay. He is "the first writer of the English language in our day, and one of the first in all times."[21] W. H. Seward also met Macaulay in London in 1859 just before his death,[22] and his son wrote that Macaulay was among his father's favorite essayists.[23]

The chief American magazine, the conservative *North American Review,* waited until 1861 before devoting a long essay to Macaulay, but that year published C. C. Smith's highly favorable defense, "Lord Macaulay as an Historian."[24] Smith begins with an analysis of Macaulay's "lofty conception" of the qualifications of an historian. These, he says, are four in number: the union of "reason and imagination"; "ability to portray the characters of individual actors"; "copiousness of information"; and "the homely virtue of honesty."[25] To the first three Macaulay gave

[17] Ed. L. Pierce, *Memoirs and Letters of Charles Sumner* (1878), III, 589.
[18] The introduction entitled, "Macaulay on Slavery," is reprinted in Sumner's *Works,* IV, 417-423.
[19] *Ibid.,* p. 418.
[20] *Ibid.,* p. 419.
[21] *Ibid.,* p. 421.
[22] Frederick Bancroft, *Life of W. H. Seward,* (1900), II, 75.
[23] *Ibid.,* II, 72, n. 2.
[24] XCIII, 418-456 (Oct., 1861).
[25] *Ibid.,* pp. 420-1.

"far greater importance than any of his predecessors."[26] And thus, of this "ideal standard of historic excellence," Macaulay "furnishes the best illustration," while the "signal triumph" of the *History* itself abundantly shows "the soundness of the theory." Everywhere readers have pronounced it "not less interesting than the last new work of Thackeray or Dickens."[27] But though the "unflagging interest of the narrative" is chiefly responsible for its popularity, its soundness in other respects must not be overlooked. Smith, however, like Tuckerman, notes that charges are beginning to be "preferred in respectable quarters" at this time that Macaulay is no better than a "brilliant partisan." "These charges . . . relate to the accuracy of his knowledge, to his impartiality, and to his honesty."[28] But unlike Tuckerman, Smith was not acute enough to understand the seriousness of the charges being brought against Macaulay from "respectable quarters." Instead he goes into an elaborate defense of Macaulay's accuracy of facts. The charges against Macaulay, he says,[29] may be reduced to seven alleged inaccuracies of fact: he misunderstood and misrepresented the character of Cranmer and the Established Church; drew a false picture of the social position of the rural clergy under Charles II; libelled the Scotch Covenanters; caricatured the Highlanders of Scotland and heaped unmerited obloquy on their leaders; indulged in unfounded strictures on the Duke of Marlborough; concealed defects in the character of William; and committed a gross blunder in regard to the character of William Penn. The list helps in a specific way to explain the many attacks on the *History* from the clerical journals; a great many sects came in for some kind of censure from Macaulay. Smith, however, upholds Macaulay in every case, and concludes that none of the charges "will bear the test of a critical examination";[30] even in the case of Penn, he says, that "there is as yet no reason to doubt that it presents a correct portrait."[31] Smith ends with a comparison of Macaulay and the "most eminent" historians of modern times, and concludes that "in a certain rare combination of qualities of the first importance to an historian he is superior to them all."[32] Smith's essay is the

[26] *Ibid.*, p. 422.
[27] *Ibid.*, p. 428.
[28] *Ibid.*, p. 432.
[29] *Ibid.*, p. 432 ff.
[30] *Ibid.*, p. 453.
[31] *Ibid.*, p. 440.
[32] *Ibid.*, p. 456.

high-water mark in American criticism favorable to Macaulay. Never again was he to be given such unqualified praise from so high a source. And had Smith been more discerning, he might have seen that the winds had already changed.

The Civil War had now begun in earnest, and there is little to record in the way of Macaulay criticism for the remainder of this decade. Lowell, however, expressed his opinion of Macaulay in 1864, and thereafter to the end of his life gave occasional opinions of Macaulay. Lowell's first reference appeared in the essay, "The Rebellion," where he discusses history and historians.[33] Lowell exalted poetry over history—it "is not to be depended upon in any absolute sense"; nevertheless he preferred "historical romance" to the mechanical "impartial historian." Several types of "historical romance," he says, are written. Carlyle represents one type—the choice of a heroic figure around which events and characters group themselves. In the second type "a period is selected, where the facts, by coloring and arrangement, may be made to support the views of a party, and history becomes a political pamphlet indefinitely prolonged . . . Macaulay is preeminent in this kind, and woe to the party or the man that comes between him and his epigrammatic necessity."[34] Lowell, however, goes on to say that a third type of "romantic history" is the new scientific history of Froude, Buckle, and Taine, and that this method by which facts are made subservient to an *a priori* theory is even less reliable than Macaulay's partiality.[35] Three years later, in 1867, he praised Macaulay's use of his sources. "In what gutters has not Macaulay raked for the brilliant bits with which he has put together his admirable mosaic picture of England under the Stuarts?"[36] In 1876 he attacked Morley's paper on Macaulay as "altogether too *a priori* and Teutonically obtuse," but he said that Stephen's essay did "more justice than the rest to the essential manliness and Britishism of his character."[37] Much later, in 1890, Lowell again referred to Macaulay's partiality; it is his "wont when dealing with men whom he dislikes" to blacken their character. Lowell, however, was not wholly antagonized by Macaulay's partiality. His position is that all history is partial in one way or

[33] *Writings of James Russell Lowell* (Riverside Edition, 1890), V, pp. 120-132.
[34] *Ibid.*, Elmwood Edition, VI, 153.
[35] *Ibid.*, Riverside Edition, V, 123-4.
[36] *Ibid.*, II, 284.
[37] "Letter to Miss Norton," *Letters of James Russell Lowell* (ed. by C. E. Norton), II, 170.

another. At the same time he believed the literary values of history to be quite as important as the historical values. And therefore, though he recognized deficiencies in Macaulay's partiality and rhetoric, Lowell came to quite a high estimate of his worth as a writer of history. This view, however, was not typical of Macaulay criticism at this time, and the immediate future criticism of Macaulay was more than at any other time determined by special biases. But Lowell was a good critic, and his balanced view foreshadows that which would be taken in the new century.

Sidney Lanier, who as a representative of the Old South had no cause to value Macaulay's politics, chose to combat him chiefly for personally antipathetic literary opinions. In his early novel, *Tiger Lilies* (1867), Lanier wrote with a fine poetic scorn and some logic: "And so who can believe this humbug of Macaulay, that the advance of the imagination is inverse to the advance of reason, and that as science flourishes poetry must decline? . . . But how long a time intervened between Humboldt and Goethe; how long between Agassiz and Tennyson."[38]

In the 1870's American criticism of Macaulay regained its former volume. In 1872, M. A. Munson attacked Macaulay as an historian in the *Lakeside Monthly*.[39] He says he cannot agree with Macaulay's principle of forming history on "little incidents" and "the imagination." Such a method is "inaccurate and partial." Besides, Macaulay was a Whig protagonist and "uses history only to illustrate principles and to grace literature." His "keen and well-feathered antithesis" most often lodges "in the very heart of murdered truth." He views history merely as the "raw materials" out of which to create his portraits. Munson ends his essay with a minute defense of Penn against Macaulay's charges. In general Munson may be classed with those who believed that Macaulay was deficient in objective historical truth.

John Bascom's *Philosophy of English Literature*, 1874, simply lists Macaulay (p. 268) among a number of men who have contributed to progress in historiography. The year following G. H. Calvert repeated with emphasis Lowell's early disparagement of Macaulay as a man of talent, not genius.[40] And in 1876 Noah

[38] Quoted by Starke, *Lanier*, p. 97. This same year (1867) Youmans reprinted an attack on the study of classical languages from the "Essay on the Athenian Orators" in his *The Culture Demanded by Modern Life*. (pp. 451-2).

[39] "A Few Chapters from Macaulay," *Lakeside Monthly*, VIII, 140 ff. (1872).

[40] *Essays Aesthetical*, 1875, p. 100.

Porter attacked Macaulay for writing "quasi-historical novels" like an "impassioned advocate . . , a retained attorney."[41]

In 1876 the English historian, E. A. Freeman, wrote on Macaulay for the *International Review*.[42] His very appreciative essay emphasizes the fact that "Macaulay is a model of style" and could be used as a model. He has nothing to say of Macaulay as historian, but notes his immense reading of Greek and Latin writers of which so "very little came." Among all his essays, "there is not one directly devoted to any Greek or Roman subjects."[43] Freeman concludes by noticing Macaulay's "eighteenth century contempt for mediaeval times." In the same year, Henry Adams, the American historian, then editor of the *North American Review*, wrote that he was going to ask "F. T. Palgrave for a notice of Macaulay" and "if he won't [write it], I will do it myself."[44] The essay was never written. Later Adams wrote to his assistant editor, H. C. Lodge, concerning Macaulay: "I advise you to read Gardiner's books. They are not written like Macaulay's but they are fairer."[45] And here again is the perennial charge of historical inaccuracy rising up at this time to challenge Macaulay's reputation.

In 1876 also the appearance of George Otto Trevelyan's great *Life and Letters of Lord Macaulay* brought forth many reviews. The foremost of these was that by Professor A. V. Dicey, the English correspondent of Godkin's *Nation*,[46] who followed C. C. Smith in defending Macaulay against the critical historians. Dicey thinks that the verdict of time will rectify that of Macaulay's present readers and will "pronounce him the greatest historical narrator who has written in English." The first condition of his success is a "capacity for living in the past." The immediate sources of his success as a narrator, however, are an "extraordinary gift of memory," a style which is "completely the natural expression of his mode of thought," and "rarest and noblest" of all an intellect of "matchless lucidity." Dicey admits however, that Macaulay lacked the power of psychological analysis. This "comparative deficiency in analytical power affected both his reputation among his contemporaries and the character

---

[41] *Books and Reading* . . . pp. 162, 182. He did, however, defend Macaulay's politics as contributing to the progress of England. See p. 200.

[42] "Macaulay," *International Review*, III, 689 ff. (1876).

[43] *Ibid.*, 694.

[44] *Letters of Henry Adams* (1858-1891), ed. by W. C. Ford, 1930, p. 286.

[45] *Ibid.*, p. 295.

[46] *Nation*, XXII, 337-338 (May 25, 1876).

of his . . . work." On the other hand, the prevailing literary taste of the time has a "passion for analysis of character." With such a fashion "Macaulay's whole tone of mind was thoroughly out of sympathy," and consequently this lack of harmony greatly "diminishes Macaulay's influence at the present moment" over "opinion in England and America." Dicey believes that it was Froude's "partisan pamphlets," published under the name of histories, which distorted contemporary opinion. Macaulay, however, was a narrator rather than a critical historian. This does not mean that he was "credulous" or lacked capacity for weighing evidence. He may occasionally have been biased by prejudice, but his weighing of evidence was "far more sound than that of the various minute critics who, on the strength of special study of particular questions, have from time to time assailed his general conclusions grounded on immense general knowledge of his subject." Macaulay intended to do no more than narrate facts, for he considered that to be the job of the historian. And it augurs well for the future of Macaulay's reputation that while the "value of the theories must almost inevitably pass away, the value of the facts remains."

A. H. Guernsey, the former editor of *Harper's*, wrote his review of Trevelyan's *Life* for *Galaxy*[47] in the form of a highly favorable summary of Macaulay's life, but says nothing of the historian in a critical way. The *Life* was also reviewed in *Harper's New Monthly Magazine*,[48] but again the interest was mainly biographical, though the reviewer was favorable to Macaulay. The notice in the *Methodist Quarterly Review*[49] by Rev. Abel Stevens, however, was more critical, though not very incisive. He pays high tribute to Macaulay and proposes to trace in his writings and memoirs "the conditions of his vigorous and manifold intellectual life."[50] Macaulay built on a sound natural base—the ideal of "the *mens sana in corpore sana*." He acquired his transcendent style by " 'persistent diligence.' " His essays are all founded on "minute accuracy of research."[51] And his great memory gave him such "extraordinary versatility" that he knew more theology than most clergymen.[52] The crux of Rev. Stevens' admiration, however, seems to have been Macaulay's favorable treatment of

---

[47] "Macaulay," *Galaxy*, XXII, 793-809, (Dec. 1876).

[48] "Lord Macaulay and His Friends," LIII, 85 ff., 238 ff. (June, 1876) by R. H. Stoddard.

[49] "Lord Macaulay," XXXVII, 197-224 (April, 1877).

[50] *Ibid.*, p. 200.

[51] *Ibid.*, p. 204.

[52] *Ibid.*, p. 208-9.

Wesley. Methodists everywhere have been "partial to him for his estimate of their founder." But Stevens also sanctions Macaulay's Whig partiality in the *History*. He "justly" represents the doctrines of Whig politics as the "fundamental ideas of modern civilization and progress." And therefore his *History* "is, and for indefinite time will be, an oriflamme in front of the onward march of the Anglo-Saxon race."[53]

In 1877 *Harper's*, which seems to have been consistently interested in the popular or sensational aspects of Macaulay's character, published without comment the complete text of the famous letters to Randall.[54] This was the first time that the letters had *all* been published *together*.[55] Two years later, 1879, *Harper's*[56] also published D. D. Lloyd's pleasant biographical essay, "The 'Tom' Side of Macaulay."

Prior to the Lloyd essay in *Harper's*, two new journals were heard from on Macaulay. M. J. Griffin, an eminent Catholic leader, attacked Macaulay in the *Canadian Monthly* for not being a true liberal. His liberalism "was in truth whiggism of the Queen Anne period." He was not interested in "the masses"; he was not "genial" nor "popular," and he disliked public speaking. Moreover, he hated Lord Brougham, the "great Liberal champion." And Griffin concludes that if he "lived today, he would be a conservative." Griffin's attitude[57] undoubtedly grew out of the publication of the Randall letters by *Harper's* the previous year. The specific nature of Macaulay's liberalism was greatly clarified by the opinions on American democracy expressed in the letters. The effect of the letters was to alienate a large part of the followers of liberalism and democracy, and Griffin first gives expression to an attitude that was henceforth to become quite common. In the same year the *American Journal of Education*[58] praised Macaulay as an advocate of a "liberal system of public instruction" and as supporting a strong, judicious civil service system by competitive examinations. The article ends on a note quite incon-

[53] *Ibid.*, p. 215.

[54] "Lord Macaulay on American Institutions," *Harper's Magazine*, LIV, 460-462 (Feb., 1877).

[55] For a complete history of these remarkable letters, see Charles M. Adams, "Macaulay on America, Once More," *Bulletin of the New York Public Library*, XL, 437-439 (May, 1936).

[56] LVIII, 605 ff. (1879).

[57] Part of Griffin's attitude may have been due to his pro-Irish sympathies. *Griffin's Journal*, published in Philadelphia from 1873 to 1900, was under the leadership of the Irish Catholic Benevolent Union. See F. L. Mott, *A History of American Magazines*, 1865-1885, (1938), p. 261.

[58] *"Thomas Babington Macaulay,"* XXVIII, 449 ff. (1878).

sistent with the first part of the essay by quoting extracts from Macaulay's illiberal letters to Randall expressing his disbelief in Jeffersonian democracy.

An interesting sidelight on the Randall letters has recently been uncovered.[59] Sometime after their publication by *Harper's* in 1877, and probably during the presidential campaign of 1880, Macaulay's strictures on American democracy were brought to the attention of Garfield, who attempted to answer them. He defended America against Macaulay's prediction, and said that England herself had taken dangerous steps in the same direction since the prediction was made. Garfield thought the prediction itself was deficient because British writers, like Macaulay, born into an aristocracy, cannot emancipate themselves from the idea "that mankind are born into permanent classes." The possibility of such a class-conflict as Macaulay envisioned, says Garfield, will materialize only where classes are fixed. And he concludes that in depicting the dangers of universal suffrage, Macaulay leaves "wholly out of the account the great counterbalancing force of universal education."[60] Thus we have the spectacle of an American, not especially notable for his liberalism, condemning Macaulay as aristocratic and conservative. Macaulay's reputation therefore has come a long way from the early days where he was looked upon as a great Whig reformer, sympathetic to 17th-century Puritan levellers. One of the most important contributions of the criticism of this period was the clarification of the basic nature of Macaulay's political and social theory.

William Mathews, pedestrian but voluminous critic, echoed the voice of the times in 1879 by terming Macaulay's "so-called History" an "ingenious and masterly piece of special pleading," in the disparagement of James II and glorification of his successor.[61] Aside from his decided impartiality, Macaulay's great fault lay in the inability of his brilliant impassivity to rise "to the height of the great argument of Puritanism."[62] Mathews feels compelled to admit "Macaulay's champagne-like exhiliration of style, his sparkling antithesis, epigram, and point,"[63] his unsurpassed "power of lucid, swift, brilliant statement."[64] But his

[59] Charles H. Betts, "Macaulay's Criticism of Democracy and Garfield's Reply." *Open Court*, XXXII, 273-279 (May, 1918).

[60] Betts, *op. cit.*, 277.

[61] *Hours With Men and Books*, 174.

[62] *Ibid.*, 181-3.

[63] *Literary Style, and other Essays*, 1881, 124.

[64] *Ibid.*, 23-4.

professorial judgment is that Macaulay is possessed by the "very demon of mannerism, and his tricks of style are . . . transparent"; his style is "obtrusive by its brilliancy": therefore, "Macaulay's style is necessarily second-rate."[65]

The opposition to Macaulay was brought to a climax by the appearance of J. C. Morison's *Macaulay* in 1882. The reviewer in the Boston *Literary World*[66] stated its significance by saying that it first gave "full popular expression to the opinions of dissenters from what we may reasonably call the great Macaulay cult." Morison's list of the "direct and indirect causes which prevented Macaulay from attaining a permanent place among the foremost of English prose writers" was as follows: a natural cast of mind repugnant to all philosophical thought; a lack of passion and genuine affection for humanity; a want of intellectual curiosity; a want of ethical depth; an incapacity for psychological analysis and therefore a lack of ideality and suggestiveness; and the destruction of " 'the tender bloom of his mind' " by an early experience in politics. Morison's chief objections against the *History* were: a want of generalized and synthetic views; excessive diffuseness; and deficient historical spirit. The American reviewer of Morison's book, however, is favorable to Macaulay and says that Macaulay's ability to hold his own in spite of so formidable arraignment, "argues the existence of magnificent qualities."

Henry Adams praised Morison's attack quite highly in his letters. In 1882 he wrote to Henry Cabot Lodge that America needed more impersonality in her books. "On the whole the English still do better work than we. Morison's *Macaulay* is an instance."[67] He expressed further interest in the book when he asked C. M. Gaskell in 1883 to find out for him "who is a man named Morison, who has written a very clever sketch of Macaulay? So good a piece of criticism ought to come from some one who is known."[68] Professor Dicey, the English correspondent of the American *Nation* again came to Macaulay's defense.[69] Dicey is, by all odds, Macaulay's most clear-headed defender in this period. He saw clearly the basic issue at stake between Macaulay and the critical historians, and he defends Macaulay on the only grounds

[65] *Ibid.*, 23-4.
[66] XIV, 38-9 (Feb. 10, 1883)
[67] *Letters, op. cit.*, 344.
[68] *Ibid.*, p. 346.
[69] Review of Morison's *Macaulay, Nation*, XXXVI, 174-5, 195-6, (Feb. 22, March 1, 1883).

where that is possible. Macaulay, he asserted over and over again, was "above all things a narrator: his object was to tell the tale of the past," and he "will certainly be quite misunderstood if you confuse the object of a narrator with the aims of an historical critic." Morison has not always remembered this, though he appreciated the literary character, public spirit, and manliness of Macaulay. And if these qualities, says Dicey, fail to arouse sympathy in the present generation, "the question may arise whether the defect lies in the man who possesses these qualities, or in the generation which is imbued with a passion for sympathy and self-analysis."

The remark shows the extent to which Macaulay's reputation had suffered as a result of the new trends of thought, and suggests that already he is regarded as a representative of Victorian prudery.[70] In the second half of his review Dicey discusses the two basic problems raised by Morison on which Macaulay must finally be judged. First, did Macaulay succeed in carrying out his own idea of the task of the historian? Morison said not, but Dicey says he misunderstood Macaulay's position of narrator. Second, what was the worth of Macaulay's conception of history? This is the basic question in which Macaulay's reputation will be determined. The present reaction against Macaulay, says Dicey, is due to the rise of two schools of history radically different from Macaulay's own. One is that of Carlyle and his school who writes history as a "branch of ethics." Dicey believes, however, that no one "who really cares for the progress of knowledge [can] doubt that Macaulay's treatment of history is . . . far more sound and healthy than the mode in which it is treated by Carlyle."[71] The other group are those who trace in history the evolution of ideas and principles. This group think that Macaulay does not deserve to be called an historian because he held no such theory. From this position Dicey says he would "distinctly demur." Macaulay is a narrator, and theories of history change with each age, but narrated facts remain permanent. Anyway, there is room in the field of history "for both types." At present, however, there is "some real danger lest the importance of narration should be underrated" and as long as such a tendency exists men will continue to underrate "one of the best, if not *the* best, of all historical story-tellers."[72]

[70] *Ibid.*, p. 175.
[71] *Ibid.*, p. 195.
[72] *Ibid.*, p. 196.

Dicey's labor of rehabilitation of the position of Macaulay was abetted by Charles F. Thwing, who defended Macaulay especially for his readability. Since 1849, wrote Thwing (in 1883), many histories have "been as interesting as a romance. To the great Whig historian is due in a large degree the honor of creating the change. It was Macaulay's design, as he expresses it, to write a history which, for at least two weeks, should supplant the latest novel on a young lady's table, and he succeeded . . . The chief reason of the wonderful success was that the work was written in a glowing, attractive, picturesque style." This sort of statement was much more important in the resuscitation of Macaulay's reputation at its point of lowest vitality than mere assertions such as that made by Thwing that Macaulay's treatment of James II and William and Mary "is the work first to be consulted" by a student of that period.[73]

In the years following Morison's *Macaulay*, John Fiske, the most outstanding American spokesman for evolution, frequently spoke out against Macaulay's conception of history. In his *Excursions of an Evolutionist* (1883) he spoke of Macaulay as being entirely outmoded. "The interval in knowledge which separates a Freeman in 1880 from a Macaulay in 1850 is as great as the interval which separated Dalton and Davy from the believers in phlogiston."[74] Many years later, in *A Century of Science* (1899), he again spoke of the "remarkable advance in fairness and breadth of view which historical studies have made within the last fifty years," and he again illustrates the change by contrasting "the spirit in which the seventeenth century is treated by Masson and Gardiner" as compared to Macaulay.[75] In his *Essays* written about this time he says that he also considers Gardiner's work on the 17th century to have superseded "all others."[76] Fiske's opinion may be taken as the extreme view of critical historians toward Macaulay in the last two decades of the 19th century. Fiske himself is now considered "unscientific" by modern historians.

In 1886, in an essay on John Morley, Melville B. Anderson continued the attack, this time on Macaulay's style. According

[73] *The Reading of Books*, 1883, 29-30, 33.

[74] *Excursions of an Evolutionist*, Boston, p. 194.

[75] *Ibid.*, p. 156.

[76] "Old and New Ways of Treating History," *Essays Historical and Literary* (1902), Vol. II, p. 9. Fiske may have been prejudiced against Macaulay because of the latter's unsympathetic treatment of William Penn, for Fiske idealized Penn and the Quakers as those who realized "the Christian ideal more perfectly than any other sect of Christians."

to Anderson, Morley's "style has few of those fascinating qualities that made Macaulay the bread and meat of young minds in the last generation,—until they tired of his antithetic trick and began to learn that truth has infinite shades and iridescences not to be portrayed by the crude purples and blacks of Macaulay's palette. To thoughtful and sincere minds that have reached this stage of cultivation, no better corrective to the narrow and confident assertiveness of Macaulay could well be found" than Morley.[76a]

From a wholly different and somewhat sentimental point of view, the aristocratic Miss Agnes Repplier attacked Macaulay in 1888 in her volume of essays, *Books and Men*. Her principal charges were that Macaulay was one of those "men whose unusual powers of discernment were too often dimmed by their prejudices";[77] and that he had an unfortunate blindness for the gay, colorful, and joyous aspects of life. The second view is particularly exploited throughout the concluding essay, "The Cavalier." Here every effort is made to discredit Macaulay for inaccuracy and dull Puritanism, and Walter Bagehot is skillfully played off against him. Miss Repplier's thesis is well summed up in her saying: "the Cavalier looked straight into the sunshine with clear, joyous eyes, and troubled himself not at all with the disheartening problems of humanity. How could a mind like Macaulay's, logical, disciplined, and gravely intolerant, sympathize for a moment with this utterly irresponsible buoyancy! How was he, of all men, to understand this careless zest for the old feast of life, this unreasoning loyalty to an indifferent sovereign, this passionate devotion to a church and easy disregard of her precepts, this magnificent wanton courage, this gay prodigality of enjoyment! It was his loss, no less than ours, that, in turning over the pages of the past, he should miss half of their beauty and their pathos . . ."[78]

Two notable defenses of Macaulay came in the decade after 1889. Professor Henry E. Shepherd gave high praise to Macaulay as a writer of history in the new scholarly journal, *Modern Language Notes*.[79] He says Macaulay was especially fitted to write

---

76a *The Dial*, VII, 101-2 (Sept., 1886).

77 *Books and Men*, p. 145. H. T. Griswold's essay on Macaulay in her *Home Life of Great Authors* (Chicago, 1887; pp. 177-187), in contrast, is rhapsodic in its appreciation of Macaulay as a joyous person and a "wonderful conversationalist."

78 *Ibid.*, p. 207. See also Miss Repplier's *Essays in Idleness*, 1893, pp. 196-8, where she defends Horace Walpole against Macaulay's attack.

79 "Lord Macaulay as an Historian," *Modern Language Notes*, IV, 73-76, (1889).

the history of the 17th century. Many elements of the period had a strong personal appeal for him: "the diversity of strongly defined character, the ample scope for the exercise of delineative faculty, the unfolding of that political consciousness which was so eminently developed in our historian." Shepherd denies the "charge of inaccuracy and of unfair delineation of character."[80] His narrative may have been overwrought, but "among all the masters of historic art, none has been animated by greater purity of spirit, by a more thorough absence of tampering with authorities, by more intense and exacting scrutiny of original sources." "The quickening power of his work is the purest attestation of its excellence." For, as a matter of fact, and here Shepherd takes issue with the critical historians, the shaping spirit of the imagination is as essential to the "historian as it is to the poet or the scientist." It is this power which enables Macaulay to "re-create and restore a 'day that is dead'."[81] Shepherd concludes with the prediction that "the calmer scrutiny of a distant generation will discern in Macaulay's finished and breathing pictures, some deeper semblance of truth than shadowy counterfeits and mythical delineations."[82] The prediction is full of meaning, for it points directly to what was soon to happen.

The other defense of Macaulay at this time, 1899, was H. D. Sedgwick's essay, "The Vitality of Macaulay," in the *Atlantic Monthly*.[83] The principal reason for Macaulay's popularity is the fact that he had "much of the permanent English in him." His speeches on the Reform Bill "are characteristic of the English mind. He instinctively employs only English arguments; he disclaims any symmetrical theory, he courts property, he shouts warning of instant danger." All of which, of course, does not account for his equally great American popularity. Sedgwick next comments on the causes of Macaulay's popularity have more relevancy to America. "Common sense is the great English characteristic; Macaulay was filled with it," and "cared not for philos-

[80] *Ibid.*, p. 74.

[81] *Ibid.*, p. 75.

[82] *Ibid.*, p. 76. The power of style which figures in Shepherd's praise found periodic appreciators such as T. W. Hunt who found the difference in manner between the essays of Arnold and those of Lamb and Macaulay "marked in favor of the latter, and the difference is one between restricted and general circulation." "Matthew Arnold as an English Writer," *New Princeton Review*, VI, New York, 1888, p. 368. D. G. Mitchell was representative of the prevailing wing of critical doctrine, however, in saying that Macaulay "was apt to let his exuberant and cumulative rhetoric carry him up to a climacteric which the ladder of his facts would scantily reach." See his *Works*, Edgewood ed., XII, 111.

[83] LXXXIV, 163-174 (August, 1899).

ophy. The history of England is the great romance of the modern world,"[84] but before Macaulay her historians had not done justice to the part played by the Whig middle class with its "achievements of utility and progress." Macaulay arose to "show the real value of the work of the middle classes."[85] And the *History* suits neither the Tories, the religious, nor the artistic, but it suits instead "the majority of Englishmen, by its virile directness, its honest clearness, and its bold definiteness." Sedgwick now turns to more fundamental issues. He defends Macaulay against the charges of being narrow and prejudiced, of understanding only what the "liberals of his generation understood," and of seeing the outward but not the inward aspects of life. History is always written by the adherents of some sect, and Macaulay merely wrote "the Whig, or rather . . . the English idea of history."[86] Froude, Morley, and Sir Leslie Stephens themselves are each "limited by some special creed of their own." Macaulay, however, "is so steeped in information that, although he may be wrong as to a particular fact, he is justified in his conclusion." Thus we have the peculiar situation in which critical analysis instead of being used by Macaulay's opponents to attack his lack of depth, is now being used by his friends to justify his biases; since critical analysis of late years[87] had shown that the most scientific method of approach could not entirely eradicate the special view of the historian, and that therefore *all* historians were more or less prejudiced, Sedgwick concludes with high praise for Macaulay's essays. He is the greatest rhetorician in English literature and is comparable to "a Cicero, a Bossuet."[88] He presents everything "in brilliant images." There is nothing in his work "which the world did not possess before; but most of the world was not aware of those possessions until Macaulay gathered them together."[89]

W. J. Ashley's review of a book called *Social Life in England from the Restoration to the Revolution, 1660-1690*, by a certain William C. Sydney, for the *Nation*[90] in 1893 reveals in a very

---

[84] *Ibid*, pp. 164, 165.
[85] *Ibid.*, p. 167.
[86] *Ibid.*, p. 172.
[87] See, for example, Charles A. Beard's address as President of the American Historical Association entitled "Written History as an Act of Faith," *American Historical Review*, XXXIX, 219-231 (Jan., 1934). Also Arnold J. Toynbee's "The Relativity of Historical Thought," in *A Study of History*, London, 1934, Vol. I, pp. 1-16.
[88] Sedgwich, *op. cit.*, p. 173.
[89] *Ibid.*, p. 174.
[90] "Macaulay and Water," LVI, 16-17 (Jan. 5, 1893).

trenchant way the ebb-tide of Macaulay's popularity in America in the last decades of the century. Ashley quotes parallel passages to show that Sydney had compiled his book by merely paraphrasing the *History* and at times even using Macaulay's exact words for a paragraph or two. Such a stunt is now possible, says Ashley, because the "general public no longer reads its Macaulay."

Frederic Harrison, the English positivist, wrote on Macaulay for the American *Forum*[91] in 1894. Macaulay, he says, is popular with the public but not with the critics. The modern "scientific" school calls his *History* "a splendid failure." His optimism and robust health forms a contrast for "poor, despondent, morbid and cynical" Carlyle. The public, however, likes a manly, downright optimist" but "the moody and prophetic pessimist" appeals merely to the critics. The arguments he sets forth for his point of view are neither philosophy nor history, but nevertheless are full of a "certain rich literary seed." Harrison, however, dislikes Macaulay's stylistic tricks which he thinks lead to a "habit of false emphasis." And Harrison comes to the standard judgment of the critical realist of this time in regard to Macaulay. "He stands between philosophic historians and the public very much as journals and periodicals stand between the masses and great libraries." He brings the mature work of scholars to the "man in the street," but compared to Gibbon's work his *History* is mere "glorified journalism."

In 1895 came Howell's appreciative estimate of his own early reception of Macaulay.[92] There was much in Macaulay to strike responsive chords in Howells, and he records how he read "every one" of Macaulay's essays. "It was like a long debauch, from which I emerged with regret that it should ever end." Howells says he liked him better than Carlyle after exhausting the *Essays*. "I read his history of England, and I could measurably console myself with that." He goes on to tell how he discussed the *Essays* with the machinist, the organ-builder, and the printer, until an "intense fascination" and "personal devotion" had overtaken him. "Of course I reformed my prose style . . . and began to write in the manner of Macaulay, in short, quick sentences, and with the prevalent use of brief Anglo-Saxon words. . . . As for his notions

[91] "Macaulay's Place in Literature," XVIII, 80 ff. (1894).

[92] *My Literary Passions* (1895), New York, 1895, pp. 114-118. However, W. H. Hudson (*Studies in Interpretation*, New York, 1896, pp. 193-4) spoke of Macaulay as one "in whom the shallow self-complacency of the time found a ready and vigorous spokesman." Hudson refers to his essay on Southey and "the concluding paragraphs of the famous third chapter of his *History*."

of literature, I simply accepted them with the feeling that any question of them would have been little better than blasphemy." Later, he says, his taste, for Macaulay "waned rapidly." (It will be remembered that Howells became a Socialist.) "His worst fault was only to have stopped short of the finest truth in art, in morals, in politics." He had a "bright and clear intelligence" and "I do not think yet that he swayed me in any very wrong way."

The last notice of Macaulay in the nineteenth century is fatefully enough the reappearance of his prophetic letters to Randall on the fate of American democracy in the twentieth century. The Panic of 1893 and the consequent economic and social ills had recalled the letters to mind, as was to be the case in later economic crises, and they were reprinted without comment in *Gunton's Magazine* in 1896. The truth of the prophecies and their further effect on his reputation, however, are matters affecting Macaulay's reputation in the twentieth century, to which we now turn.

III. 1900 TO 1940

After 1900 criticism of Macaulay gradually entered its mature stage. There is little of the blind devotion and prejudiced hostility of the period from 1840 to 1860, nor much of the dogmatic criticism of the period from 1860 to 1900. And as biases die out, criticism mellows. The new spirit was undoubtedly aided also by the rise of investigative scholarship in American universities and the establishment of scholarly journals. At any rate the new age is characterized by quiet investigation and more accurate evaluation. In the period just past the *History* alone had pretty well dominated American criticism of Macaulay. This will no longer be true. The strength and weakness of the *History* had been pretty well analyzed by 1900. The new age is a period of special studies of many aspects of Macaulay's varied career, overlooked in the earlier dominance of the *History*. New emphasis is to be given to his criticism, his poetry, his style, and his real literary values. There is much less unity in the criticism of the period. No trend of thought, like that of a new school of history, unifies the criticism of this period. It is one of independent study by isolated men. In general the most important feature of the new age is a slow improvement of Macaulay's reputation in America.

The new age, however, was not to come at once. The old criticism lived on into the first years of the new century. The Knickerbocker edition of Macaulay's works appeared in 1900 and was reviewed in *Current Literature*[1] in 1901. The reviewer testifies to the "renewed appetite" for Macaulay, and adds that much "nonsense" has been written lately criticizing Macaulay by men who could better spend their time "in studying the secrets of his eloquence."

Edward Eggleston's *Beginners of a Nation* (1896) and *The Transit of Civilization* (1901), the only volumes he completed in a projected comprehensive history of American life, were significant signs of the growing retreat from military "drum and trumpet" history toward social history concerned with the full circumference of the everyday life of the masses. And it is therefore interesting to notice that in Eggleston's influential Presidential Address entitled "The New History," before the American Historical Association in 1900, he should have praised

[1] XXX, 54-55 (Jan., 1901).

Macaulay and acknowledged his indebtedness to him. He begins by excusing the fact that his style, while "brilliant and balanced," was "too antithetical," by reminding us that "he wrote in the first half of the nineteenth century." Macaulay's history, he says, "begins with taxes and revenues; the customs and revenue lists of the princes are much elaborated and are not very interesting. But by degrees he draws near to manners and he draws near to London. The picture of old London, turned over and over in his mind in those long walks Macaulay is said to have made through every street of the metropolis, is a wonderful piece of history. It is worth the whole history beside. And nobody ever dreamed before that such a subject was in the province of history." Like other histories, Macaulay's has gone, he says, through a cycle of disapprobation, but he concludes that the greatest of nineteenth century historians is Macaulay.[2]

In the same year Charles Francis Adams renewed the attack of the modern historians on Macaulay.[3] Adams is ready to recognize Macaulay's greatness as an historian on one side only. He came "nearer than any other English writer of the century to the great historical stature; but he failed to attain it." Of the three essential attributes of an historian, he had only one—"vast erudition" with a "phenomenal memory." His judgment was defective by being "partisan" and the "wealth of his imagination and the exuberance of his rhetoric were fatal to his sense of form." "He was incomparably the greatest of historical *raconteurs,* but the fascination of the story overcame his sense of proportion, and he was buried under his own riches." His work is "unquestionably history," but the pigments he used are "indisputably Whig." His method was instinctively correct but he labored under two fatal disadvantages: "like Gibbon, he was born and wrote before the discoveries of Darwin had given its whole great unity to history"; and he did not subordinate his plan to "both his imagination and his rhetoric." Thus Adams re-stated three of the four most commonly expressed charges against Macaulay as historian: his partisanship, his lack of a philosophy of history, and his lack of a style suited to historical truth. The fourth charge—a lack of critical analysis of motives —was amply treated by his previous critics. One of the most interesting phases

[2] *Annual Report of the American Historical Association for the Year 1900,* Vol. I, pp. 44-45.

[3] "The Sifted Grain and the Grain Sifters," *American Historical Review,* VI, 218-220, 227, 228 n. (Jan., 1901). The whole essay, a sifting of historians, was delivered as a lecture at the founding of the Wisconsin Historical Society Library, Oct. 18, 1900.

of Macaulay criticism in the new century is the later historians' opinion of the charges preferred against Macaulay by the 19th-century historians. Thus in 1900 Sydney G. Fisher, reviewing John Fiske's *Dutch and Quaker Colonies,* attacked the style and manner of earlier American historians as "horrible." "If I were a professor of English literature I should give my pupils a course in these writers just to show them what turgidity, bombast, insincerity, and all the weaknesses and faults of style are in actual practice." He ranks Macaulay with Gibbon as having "dignity and real dignity." "Read Macaulay's essay on the writing of history, and see what he thinks should be the mental equipment and training of a man who sets forth to write history with a light hand. Even Mr. Fiske, good as he is, is not up to Macaulay's standard."[4] In 1902 John Burroughs[5] cited Macaulay among those who "have studied and elaborate styles, but in each the matter is paramount and the mind finds something solid to rest upon." Mark Twain in a political speech in 1901 compared the politicians of Tammany Hall to Warren Hastings, saying: "The most of us know no Hastings but Macaulay's, and there is good reason for that. When we try to read the impeachment charge against him we find that we cannot endure the pain of the details. They burn, they blister, they wrench the heart, they drive us out of ourselves . . ."[6] The power of style which had made him feel the emotional and political effectiveness of the parallel is as patent as the high praise from a powerful writer who had no hesitation about roasting the sacred dead if he felt they deserved it.

In 1902 Professor A. V. Dicey appeared with another of his periodical defenses of Macaulay in the American *Nation.*[7] He attributes Macaulay's decline to the fact that his genius was "antipathetic" to the men "who guided the educated opinion of

---

[4] *Book Buyer,* XX, 146-48 (March, 1900). On the other hand, Fiske is praised in the *Nation* (LXXVI, 17, Jan. 1, 1903) because his writings "introduced into American historical writing a feature of which Macaulay first revealed the secret—that of reconstituting the past by actually introducing us to the daily life of the period—a feature lacking in some of the best volumes of even so recent a writer as Parkman." Another reviewer of Fiske (*Athenaeum,* No. 3940, 560-61, May 2, 1903), concludes that he holds "a place in the new school of historical writers akin to that which the two latter [Prescott and Motley] held in the age of Hallam and Macaulay."

[5] John Burroughs, *Literary Values* (in *Works,* Riverby Edition, X), 73. On p. 106 Burroughs says "The critic must escape from the local and accidental. We would have Macaulay cease to be a Whig . . ." He thought that his "highest excellence as a poet is his eloquence" (p. 182). See also pp. 70, 71, 73, 87, 145.

[6] See A. B. Paine, *Mark Twain, a Biography,* 1912.

[7] "Macaulay and His Critics," *Nation,* LXXIV, 388-389 (May 18, 1902). The article is a review of two books on Macaulay by Sir Richard C. Jebb and H. D. Macgregor.

England" in the latter half of the 19th century. He was really more like the 18th century in character, yet his "onslaught on the *a priori* . . . method of the Benthamites . . . breaks with the intellectual tradition of the eighteenth century, and anticipates the historical view of political science." His belief that democratic life was "due to the rise of Christianity" is also quite foreign to the ideas of Gibbon and Hume. He expresses the "spirit of 1832" in his optimism, belief in material progress, and manly vigor, but he is not part of the intellectual reaction to 19th century thought represented by Carlyle, Froude, Newman, and Matthew Arnold. His view of history as primarily "narrative" was also opposed by the "scientific" historians. But their charge that he made no "discoveries" of truth is meaningless. Macaulay is a man of genius and no amount of criticism can injure him.

The first essay typical of Macaulay criticism in the 20th century is T. E. Blakely's study of "Macaulay's English" in *Harper's*.[8] All critics agree, he says, that in Macaulay's works "the English language has been written more clearly and correctly than in any great literary composition of the nineteenth century." Macaulay's clearness, correctness, and delicacy comes from two sources: his careful study of "the great classical writers" and his "study of the genius and grammatical structure of the English language."[9] Macaulay carefully revised all his work. Even after the *History* had been completely successful, he went over the whole work in 1855 and made thousands of changes, nine-tenths of which were in grammar and rhetoric. Blakely claims that "no English writer of the last century displays such scrupulous observance of the rules of grammar and rhetoric, such careful selection of words, and such regard for euphony and clearness."[10] And from this he concludes that those who strive to write should observe that the most popular writer of the 19th century was one who paid most attention to grammar and the classics.[11]

H. D. Sedgwick's second essay on Macaulay came out in 1903.[12] Sedgwick believed that Macaulay's "enormous fund of information" was an injury rather than an aid "by coddling, as it were, the stunted side of his imagination,"—a view that has become quite generally accepted. Sedgwick is also among the

[8] CV, 529-533 (1902).
[9] *Ibid.*, p. 529.
[10] *Ibid.*, p. 530.
[11] *Ibid.*, p. 533.
[12] "Macaulay," *Essays on Great Writers* (1903), pp. 141-197.

first to stress emotional deficiency in Macaulay's life—another view that was to be generally accepted. He never had "the education of a great private personal emotion. He never was in love; he never comprehended the meaning of religion."[13] "All his life Macaulay was convinced that truth is as clear as day," and he had "the highest aims and the noblest aspirations that are compatible with complete mental subjection to the practical . . . mechanical parts of life." Sedgwick quotes Froude as saying that Macaulay embodied his age. He did have the rosy vision of many men regarding the "growth of population and the increase of wealth." Sedgwick also gives a new emphasis to Macaulay's *Essays*. They form "part of the strength of English literature," and fill the need in English for the rhetorical type of essay. His poetry, like his prose, is written for the "strong, healthy, typical Englishman." Sedgwick's essay is important for several new elements which will receive more emphasis in later criticism.

Professor Dicey wrote his last defense of Macaulay for the *Nation* in 1903.[14] Dicey emphasizes the change which has taken place in the world since Macaulay wrote. He belongs "in spirit to a different and a more robust and manly age than ours." Dicey admits that Macaulay "lacked the quality of scientific disinterestedness," but his "partisanship was nothing but the weak side of a splendid historical imagination." Macaulay was psychologically blind to certain things; he could not comprehend historical characters "in whom religious sentiment was blended . . . with a certain amount of moral obliquity." As an historian Macaulay was "picturesque" rather than "scientific," but in "power of narration" he "stands a head and shoulders above all modern English writers." Macaulay's reputation has suffered because the modern view sees history less as literature and more as scientific research to "discover" facts. Dicey, however, claims that this is ultimately "a narrow and one-sided creed." This prediction was soon borne out by the historians themselves. Only a year later, G. Smith, President of the American Historical Association, in his essay on "The Treatment of History"[15] called Macaulay "the most brilliant of historians."

The year 1906 saw the private printing of *The Education of Henry Adams* which treated Macaulay according to the customary Adams' procedure of criticism by snatching back more

[13] *Ibid.*, p. 158.
[14] "Macaulay as an Essayist," LXXVII, 529-530 (Dec. 31, 1903).
[15] *American Historical Review*, X (April, 1905), 511-20.

with the excoriating right hand than the laudatory left had given. "Adams had the greatest admiration for Macaulay," he wrote of the great fellow-historian whose acquaintance he had made in London, "but he felt that anyone who should even distantly imitate Macaulay would perish in self-contempt. One might as well imitate Shakespeare. Yet evidently something was wrong here, for the poet and the historian ought to have different methods, and Macaulay's method ought to be imitable if it were sound; yet the method was more doubtful than the style. He was a dramatist; and painter; a poet, like Carlyle. This was the English mind, method, genius, or whatever one might call it; but one never could quite admit that the method which ended in Froude and Kinglake could be sound for America where passion and poetry were eccentricities . . . perhaps the English method was right, and art fragmentary by essence. History, like everything else, might be a field of scraps . . ."[16]

In 1907 the *Contemporary Review*[16a] published an article on the marginalia which Macaulay had penciled into insignificant books. This was the type of work that needed to be done before Macaulay could be evaluated as a critic. The article is not exhaustive, however, and the subject was to be much more thoroughly investigated later by Chislett and Williams, as we shall soon see.

William Cleaver Wilkinson the next year (1908) set himself up as "the true critic" in opposition to Matthew Arnold and proclaimed that:

> The verse of Macaulay in his Lays is of course not poetry in any high sense, and that critic misses the mark who appraises it and condemns it as if it pretended to be such. The Lays are simply an incomparably spirited embodiment of the primitive Roman genius and character as Livy conceived and represented [them] . . . No true lover of literature, with taste and comprehension broad enough to constitute the qualified critic, can fail to feel the manly stir and rally that Macaulay has put into his lines. There is base metal in them only to the reader who falsely judges . . .[17]

In his essay of 1908, "Two Types of Humanitarians: Bacon and Rousseau," the humanist, Irving Babbitt, took eager advantage of Macaulay's weakness for "glittering antitheses" to make a major point. Macaulay had poised Bacon's glorious idea of

---

[16] *The Education of Henry Adams*, Popular edition, 221.

[16a] "Among Macaulay's Books," LXXXXII, Supplement, pp. 9-11, (Dec., 1907).

[17] *Some New Literary Valuations*, p. 136.

progress against his personal meanness. "But for one who is seeking the truth and not rhetorical effect," Babbitt snapped, "the significance of Bacon's moral breakdown lies in the very fact that it had the same origins as his idea of progress. He was led to neglect the human law through a too subservient pursuit of the natural law . . ."[18] In addition to castigating this "strange psychological anomaly,"[19] he slashed once more at Macaulay for a "shallow infatuation with material progress."[20]

The golden anniversary of Macaulay's death was celebrated by two essays in 1909. The *Bookman*[21] contained a personality-sketch in which the writer concluded that Macaulay was a dangerous writer for an "untrained or immature mind" and that, though the *History* was declining, it would never die. William Roscoe Thayer's brilliant essay "Macaulay Fifty Years After," appeared a few weeks later in the *North American Review*.[22] The essay is an accurate, impartial account of Macaulay's reception in the last fifty years. "Optimism, clear doctrines which chimed with the prevailing ideas of liberty and progress, vivacity, a genius for the pictorial, a level head and a wholesome heart"—these, says Thayer, were the qualities which contributed to Macaulay's early popularity. He furnished "definite, cogent, aggressive opinions" for those "who could quote, but not form them." And what he said brought to the oppressed population of the world "the redemptive virtues of Freedom and Constitutionalism and Nationality."[23] Yet all this would not have sufficed without "his amazing style"—for his "great service was to clarify, once for all, the language of affairs."[24] According to Mayer, a great turn against Macaulay took place after 1860: "Realism, based on Science and guided by the theory of Evolution," sought to make everything human "as transparent as a chemist's reaction"; "infallible law would be traceable even in matters of taste"; "literary criticism would become an exact science and history merely the study of applied social dynamics." In such a world Macaulay seemed "not only unprofitable, but a stumbling-block."[25] His freedom, optimism, and progress seemed out of

[18] *Literature and the American College*, pp. 38-9.

[19] *Ibid.*, p. 49.

[20] *Ibid.*, p. 40.

[21] E. Fuller, "Macaulay: Then and Now," XXX, 38-40 (Sept. 1909).

[22] CXC, 737-752 (Dec., 1909).

[23] *Ibid.*, p. 737.

[24] *Ibid.*, p. 738.

[25] *Ibid.*, p. 739. For general orientation consult W. M. Payne, "American Literary Criticism and the Doctrine of Evolution," *International Monthly*, II, 26-46, 127-153 (1900);

tune with the "hideous inequalities" of industrialism; his chief interest was politics, but the new interests were economics and sociology; his ideal of freedom seemed strange when the position of the privileged classes was confirmed by the doctrine of the survival of the fittest; and his practical science was much in advertence with the science of evolution striving for the key to the universe. Literary taste had also changed. "Objectivity was now the ideal," and Matthew Arnold said Macaulay's "chief sin was his subjectivity."[26] The current of English prose was shifting "to the colloquial on one hand and to preciosity on the other." And to both groups Macaulay's style seemed "unnatural."[27] The fiercest war, however, raged over the nature of history. Here also objectivity was in the ascendant and a great quarrel arose between the "scientific" and "literary" historians. Followers of Ranke fifty years ago tried to "avoid interpretation as a deadly sin." Hence resulted the unpopularity of Macaulay "who was so frankly an interpreter."[28] The scientists debased historical composition to mere research and out of Germany came the notion of publishing doctor's theses. Thayer believes that it is because "Macaulay can serve as a corrective of some of these developments that a return to him may be recommended."[29] He represents the past "not as dead, but living." He "attains the highest truth by dwelling in the heart and not on the surface."[30] If any adverse criticism is to be made, it is that his *History* "seems too *prepared*." The evidence is so skillfully selected and so lucidly presented that we miss the element of chance or mystery in human affairs. Thayer says he does not exaggerate the contrast between Macaulay's well-defined body of opinions and "the Pragmatist confusion in which we are weltering to-day."[31] He is the last English writer in whom "tradition can be seen unblurred." His writings "are the most Roman of all modern productions."[32] With Thayer's important essay Macaulay's reputation may be said to be definitely on the upward path again.

In 1909 the popular historian James F. Rhodes thought that John Richard Green, whom he greatly admired and who was

---

J. P. Hoskins, "Biological Analogy in Literary Criticism," *Modern Philology*, April and July, 1909, p. 407-434; and James M. Baldwin, *Darwin and the Humanities* (1909).

[26] *Ibid.*, p. 740.

[27] *Ibid.*, p. 741.

[28] *Ibid.*, p. 744.

[29] *Ibid.*, p. 745.

[30] *Ibid.*, p. 746.

[31] *Ibid.*, p. 751.

[32] *Ibid.*, p. 752.

very widely read in America, was still surpassed in popularity here by Macaulay. As shapers of the opinions of the reading public Macaulay is ranked with Carlyle and Gibbon.[32a]

Nevertheless in 1909, C. H. Rominger attacked Macaulay's essay on Milton in *Education.*[33] He claims Macaulay had no taste for Milton's delicacy, but a good deal for his bombast. His essay shows little feeling or soul. "It is the calm, reflective criticism of a matter-of-fact mind." Macaulay gives a great amount of space to the "almost irrelevant consideration of English politics" and comparatively little to Milton's poems. In Rominger's essay American criticism spreads out to include Macaulay the critic and before the period is ended an attempt will be made to estimate his critical importance.

In 1910 Professor A. B. Hart, the popular Harvard historian, made a new evaluation of the essential qualifications of the true historian in his essay, "Imagination in History."[34] This new emphasis on imagination marks a new era for Macaulay as a historian. Hart thinks him "the most striking example of the imaginative historian." He has "been in and out of fashion several times: the scientific historians find him unreal; the dull writers think him meretricious, but one thing is certain"; you can get history from anyone, "but in reading Macaulay you get Macaulay. He puts into every page his own experience of life; he moves forward and backward; everywhere he finds comparisons, allusions, parallels, categories."[35] "The arousing style, the prodigality of knowledge, the real interest in, acquaintance with, and love for, historical characters . . . combine to put Macaulay in the front rank of the world's historians. He is great because of his dramatic power; his people are all taking a part in a mighty movement; one after another speaks his lines, telling us why he is on stage, or by indirection making us aware of his assignment."[36] Thus did Hart set forth the terms on which the new century was to come to a newer and higher and more accurate estimate of Macaulay's *History.*

[32a] Rhodes, *Historical Essays,* 1909, "Green."

[33] "Macaulay's Essay on Milton," XXX, 36-39 (Sept., 1909). D. J. Snider, the St. Louis Hegelian, is enthusiastic but a little patronizing in his description of the way in which Macaulay's Milton essay thrilled him as a college boy. The style and manner are recalled as full of rush and gusto. The volume of essays is, then, "one of the best educational books for boys between sixteen and twenty, or for men—of the same degree of ripeness." But it can give no "lasting satisfaction" to maturity. See Snider's *A Writer of Books,* 1910, 118-9.

[34] *American Historical Review,* XV, 227-251 (Jan., 1910).

[35] *Ibid.,* p. 247.

[36] *Ibid.,* p. 248. For Hart's criteria see also his article on "The American School of Historians," *International Monthly,* II, 294-322 (Sept., 1900).

The *Lays of Ancient Rome* were edited in 1912 by Professor Arthur Beatty who wrote an appreciative scholarly introduction.[37] He discusses the ballad revival and the relation of the *Lays* to previous ballad forms, and finds that they "have the force and vigorous simplicity of Scott, with the directness of the ballad, combined with the free stanza-form of Coleridge." The *Lays* themselves he regards "as a successful attempt to transform some part of Roman legend back again into the lost ballad-poetry of the ancient city."[38] He traces the source of the ballads to Niebuhr's *History of Rome* and says they thus "are the result of the profound scholarship of Niebuhr and the brilliant, rhetorical genius of Macaulay."[39] He defends the *Lays* against the attack of Matthew Arnold, and concludes that in them there is "an abundance of good matter for the nurture of the spirit and of the imagination, which cannot fail to develop in youth the love for the best in life and literature."[40] Beatty's essay shows the tendency of 20th century American criticism to develop all sides of Macaulay's work and to investigate and understand before it judges.

In 1913 Theodore Roosevelt continued the theme begun by Hart three years before and emphasized the need for literary qualities in the writing of history. In his essay, "History as Literature,"[41] he, like Hart, pays high tribute to Macaulay. Macaulay "the historian is read by countless thousands to whom otherwise history would be a sealed book," because his works "are material additions to the great sum of English literature." They have filled the great need "for vivid and powerful presentation of scientific matter in literary form."[42] Such a verdict must have had great influence because Roosevelt was not only President of the United States but President of the American Historical Society, before which this address was made.

The regeneration of Macaulay's reputation as a historian was continued in W. C. Abbott's reviews[43] of Firth's Illustrated Edition of the *History* which appeared volume by volume in 1914 and 1915. Since its appearance sixty-five years ago, says Abbott,

[37] *Lays of Ancient Rome* (Scribner English Classics, 1912) pp. viii-xxi.

[38] *Ibid.*, p. xv.

[39] *Ibid.*, p. xvii.

[40] *Ibid.*, p. xx.

[41] *American Historical Review*, XVIII, 473-489 (April, 1913).

[42] *Ibid.*, p. 474.

[43] Abbott's reviews appeared in the *American Historical Review* as each volume of the new edition appeared: XIX, 612 (April, 1914), 149 (Oct., 1913) ; XX, 431 (Jan., 1915), 662 (April, 1915) ; XXI, 145-6 (Oct., 1915).

Macaulay's *History* "has been, if not the most admired, almost certainly the most widely read historical work in the English language." And Macaulay, he says, is one of the "two most eminent of English historians."[44] Abbott testifies to Macaulay's "marvellously intimate acquaintance with the almost innumerable individuals whose actions and characters he chronicles."[45] He says the two most "current criticisms" of Macaulay are that he was "insular and political to a degree which limits greatly the value and general appeal of his work." Abbott defends Macaulay against these charges. When compared to Ranke and Klopp (the two most prominent continental writers in the same field), "the infinitely greater catholicity of interest and the scarcely less breadth of view of the English historian" is evident at once. Abbott thinks that the appearance of Firth's monumental edition portends "a revival of Macaulay from the relative obscurity and discredit into which the past generation of critics and scholars has driven his work." Such a revival seems more likely now "than at any time in the past thirty years."[46]

In 1915 appeared W. Chislett's special study, "Macaulay's Classical Reading."[47] He found Macaulay's classical reading to be "prodigious."[48] He read the classics throughout his life and "arrived at an appreciation of Greek and Latin writers that was vital, sound, and his own."[49] He was not interested in the "metaphysics and politics" of Plato and he "disliked Socrates," comparing them unfavorably with Bacon. But he had high praise for Demosthenes, thought Thucydides " 'the greatest historian that ever lived'."[50] and appreciated and understood Cicero as few "scholars of his day understood" him.[51] Macaulay's familiarity with the classics enabled him to deal "critically with the scholarship of men and movements of which he wrote"; made him learned without appearing to be so; and brought into the *History* the influence of Thucydides and Demosthenes who "stand always before him as the ideal orator and the ideal historian."[52] Chislett's essay indicates that American criticism of Macaulay has reached its maturity—a period of very specialized studies devoted to certain neglected phases of his personality and work.

The advent of the World War at this point disrupted all criticism and for five years there is a lapse in the expression of American opinion on Macaulay. When it was resumed again,

[44] *Ibid.*, XIV, 612.
[45] *Ibid.*, XX, 149.
[46] *Ibid.*, XXI, 146.
[47] *Classical Journal*, XI, 142-150 (1915).
[48] *Ibid.*, p. 149.
[49] *Ibid.*, p. 142.
[50] *Ibid.*, p. 145.
[51] *Ibid.*, p. 148.
[52] *Ibid.*, p. 150.

very characteristically it was Macaulay's letter to Randall containing his famous prediction regarding democracy in 20th-century America that first attracted attention. And thus the popularity of the letter in the chaotic days following the Civil War was re-enacted on a much larger scale after the World War. Macaulay's prediction had really been made in reference to the 20th century, and to many in the troublous post-War period the evil day of Macaulay's prediction seemed to have come. For forty years no mention had been made of the letter in American criticism of Macaulay, and the World War generation was undoubtedly unaware of its existence. It was probably brought inadvertently into public notice again when Charles H. Betts reprinted it in the *Open Court*[53] in 1918 and published with it President Garfield's refutation, without comment of his own. But other writers were quick to see the importance of the letter for their time, and for the next twenty years men were forever bringing it to light. In 1920 A. R. Dearborn reprinted the letter in the *Sewanee Review*[54] for the purpose, he says, of awakening the public conscience to "the importance of giving timely consideration to impending dangers now indicated by things too obvious to be ignored." This situation has come about by "the failure of civilization to prevent the destruction of all that has made for progress, by the warring nations of Europe."[55] "The changes in class conditions that have taken place in England since 1914, have swept from beneath his [Macaulay's] feet the ground upon which he stood in 1857." In America, organized labor, capitalizing on the nation's war necessities, has insisted on concessions, and "has left the country in a state of socialistic paternalism of which its founders never dreamed."[56] And Dearborn concludes that in the midst of our glorious triumph in the World War, we would do "well to put on the garments of humility that go with true greatness and view with soberness Lord Macaulay's suggestion—'That your Huns and Vandals will have been engendered within your own country by your own institutions'."[56a]

C. D. Hazen in his Introduction to the Modern Students Library edition of the *Historical Essays*[56b] tried to explain in 1921

[53] "Macaulay's Criticism of Democracy and Garfield's Reply," XXXII, 273-279 (May, 1918). The article has been discussed above for the year 1880.

[54] "Macaulay Up to Date," XXVIII, 66-74 (1920).

[55] *Ibid.*, p. 70.

[56] *Ibid.*, p. 73.

[56a] *Ibid.*, p. 74.

[56b] *Historical Essays by Lord Macaulay* (1921), pp. v-xvii.

the causes of Macaulay's American popularity. Hazen believes there can be no doubt of his "universal popularity" and "the permanency of his influence," and he believes it was chiefly gained through "the magic of style." But besides, Macaulay was a self-made man and thus satisfied "all the supposed requirements of our democratic and popular morality."[57] Hazen analyzes in detail the art of the new historical essay of Macaulay and finds that in many ways it is akin to the novel; it is therefore an aid to the memory and the quick reader alike.[58] His "supreme merits as a writer of history" are many: he places himself in the center of time and place by vivid detail; imparts to others his living visualizations; possesses a dramatic sense of subordination and arrangement of scene; conveys a sense of breadth by comparison, contrast and illustration; and conveys a sense of the pictorial through great portraits and panoramas. His animation and certainty are the qualities of youth. He was a crusader for "Whig liberty" but as an advocate he was "fair."[59] "His essays . . . make an incomparable manual and *vade mecum* for a busy, uneducated man."

In 1924 another essay appeared on Macaulay as a critic—this time from the pen of Stanley Williams.[60] One of the basic characteristics of modern evaluation of Macaulay is the emphasis on him as a critic. Not since the early days of the essays had this side of Macaulay attracted much attention. Williams, however, proposes to analyze Macaulay's informal criticism in his letters, marginal notes, and scraps of paper. A curious aspect of Macaulay's reading "was undiscriminating taste." He read the worst with the best. Williams says Macaulay was "well-equipped for criticism."[61] He had a wide knowledge of the classics. The nature of his interest, however, shows the bent of

---

[57] *Ibid.*, p. vi.

[58] *Ibid.*, p. x. In 1921, in his essay, "What is a Puritan?" (*Atlantic Monthly*, CXXVIII, 342-56), S. P. Sherman wrote: "When, a hundred years ago, Macaulay wrote his famous passage on the Puritans in the essay on Milton, he tried to do them justice; and he did brush aside the traditional charge of hypocrisy with the contempt which it deserves. But in place of the picture of the oily hypocrite, he set up another picture equally questionable. He painted the Puritan as a kind of religious superman of incredible fortitude and determination . . ." This "caricature . . . violently exaggerates certain harsh traits of individual Puritans under persecution and at war; it suppresses all the mild and attractive traits . . . It gives an historically false impression, because it conveys the idea that Puritans were exceptionally harsh and intolerant *as compared with other men in their own times.*"

[59] *Ibid.*, p. xv.

[60] "Macaulay's Reading and Literary Criticism," *Philological Quarterly*, III, 119-131 (1924).

[61] *Ibid.*, p. 124.

his mind and his weakness as a critic. "His interest is first in the historians." "There is the same interest in externals found in his formal criticisms." He probably did not understand the idealistic philosophy of Socrates and Plato. As a result, very slight influence was "exerted by the deepest thought of the ancients upon his writings."[62] He read widely in French, Spanish, Italian and German literature—but his mind was never penetrated with the ideas of a single writer. "Incidents, anecdotes, pageantry" were what interested him.

In 1925 under the title "What Did Macaulay Say About America?" the *Bulletin of the New York Public Library*[63] published without comment Macaulay's four letters to Randall on America. But America was rapidly recovering from the War in the middle of the '20s, and people saw that they were mistaken in believing that the evil day which Macaulay had predicted had arrived.

In 1929 the journalistic John Macy wrote on Macaulay under the title "Macaulay: Historian to the People."[64] Strangely enough Macy does not attack him as a stuffy Victorian. Macaulay was too masculine and strong in common sense and humor for that. In spite of some intellectual defects "he never did anything wrong, anything mean, ungenerous, anything with the faintest streak of dishonesty."[65] Macy tries to interpret Macaulay on the Freudian basis. "He was a man of suppressed feeling and thwarted ambition," and his attacks on characters were "the outlet for his emotions."[66] Macy thinks Macaulay's imaginative power was never realized in the right direction. He was "by instinct dramatist and novelist with a touch of the poet."[67] As a critic Macaulay has no value. His reading was a gluttony, "a defect rather than a merit." "I recall not even a single sentence of literary criticism in Macaulay which has the slightest value."[68] He had a natural "inability to search the heart of man." It was his "ineptitude as literary critic and his obtuseness to pure thought that caused the swift reaction against him among the literary men of the next generation who were concerned with critical, literary and philosophic ideas and cared little for his

[62] *Ibid.*, p. 125.
[63] XXIX, 459-481 (July, 1925).
[64] *Bookman*, LXX, 76-87 (Sept., 1929).
[65] *Ibid.*, p. 76.
[66] *Ibid.*, p. 79.
[67] *Ibid.*, p. 80.
[68] *Ibid.*, p. 81.

politics and public services."[69] In straight historical narrative he "is unrivalled"; "there is poetry of a pictorial and dramatic kind," but there is "no philosophy in any real meaning of the word." But Macy defends Macaulay's *History*. It was "not a cheap condescension." He "hit the center of the target with unerring aim. His success, granted his purpose and limitations, is absolute, perfect."[70] He is comparable to Dickens in his "immediate appeal to the senses of common people." Yet he wrote not mere fiction nor Whig prejudice. "His chief failing is his inability to think deeply, to search character and . . . to make really profound generalizations."[71] Macy ends with high praise for Macaulay's style. The external rhetorical deficiencies have always been stressed, but the "real qualities" of his "brilliant, virile prose" have been neglected.

In the same year discriminating Professor W. C. Abbott made the final defense of Macaulay as historian.[72] Unless all signs fail, he contends, "the so-called 'picturesque school' of historical writing is coming back." Abbott believes that Macaulay, with Gibbon, "occupies a place in the first rank of world historians."[73] Three bodies of detractors have arisen against Macaulay's *History*. Those who combed his books for small errors of fact. Those who objected to the spirit of his work and its sweeping generalizations. Those who resented his treatment of their heroes. The first must be admitted; the last dismissed; the second is controversial. Abbott defends the truthfulness of Macaulay's *History*. The charges against him arise from his "positiveness, his assertiveness, his vituperative phraseology, rather than his evidence." He "made few statements without evidence to back them." His *History* remains, after two generations of minute critical scrutiny, "astonishingly true."[74] The real crux of Macaulay's reputation is the change of temper which came over England at the end of the century. This change had three consequences. Macaulay wrote in the "full tide of Victorian success," while an "era of doubt" came over England about 1900. Reading habits have changed so that no one has time to read such a work as Macaulay's *History*. Most important of all, history itself has changed her garments and language and character—it foreswore

[69] *Ibid.*, p. 82.
[70] *Ibid.*, p. 85.
[71] *Ibid.*, p. 86.
[72] "Macaulay and the New History," *Yale Review*, XVIII, 539-557 (1929).
[73] *Ibid.*, p. 540.
[74] *Ibid.*, p. 552.

the world for the cloistered seminar and "dull science."[75] There is now a reaction against the dull scientific histories—a reaction against the reaction. As a result, "Macaulay is undoubtedly coming back."[76]

The hectic days following the Great Depression in the early 1930's again brought Macaulay's now famous letter on American democracy to the foreground of men's consciousness just as it had always done in troubled times before. Now certainly the evil day of Macaulay's prediction had come. In the *Review of Reviews*[77] for 1934 Roger Shaw published the letter and applied its prediction to New Deal economy. Shaw correctly states Macaulay's political beliefs: he "was a firm believer in the British ruling class, liberal but in no sense democractic, and he was a strong supporter of nineteenth-century vested interests and the institution of private property." Shaw says that "Macaulay's predictions as to the saturation point of the great American West and an American depression are telling examples of this noted historian's foresight." He wonders also if New Deal policies to aid the forgotten one-third are "not all cumulative proofs of Macaulay's prophetic powers?" And he concludes that "Macaulay proves himself a firm believer in laissez-faire and in natural economic laws of supply and demand, combined with civil liberties; and he clearly dislikes radical reform along the lines of any planned economy—as in present-day Russia, Italy, or America."

N. Ellenbogen replied to Shaw's article in the next issue.[78] Shaw's praise of Macaulay as a prophet is amusing. Macaulay's letter to Randall "was written nine years after the Communist Manifesto in which Marx and Engels also predicted crises, the end of democracy, the way of demogogues, etc." Hence it remains to be seen whether Marx and Macaulay were not "both right in implying that preventing starvation is impossible while we have the institution of private property."

The letter was reprinted again the following year in the *American Mercury* under the caption, a "Timely Letter from Lord Macaulay."[79] In 1936 Charles M. Adams gave the history of the famous letters to Randall in the *Bulletin of the New York Public*

[75] *Ibid.*, p. 554.

[76] *Ibid.*, p. 557.

[77] "Macaulay as a New Deal Prophet: with the Text of a Letter to H. S. Randall, 1857," XC, 38-39 (July, 1934).

[78] "Marx vs. Macaulay: Reply to Macaulay as a New Deal Prophet," *Review of Reviews*, XC, 4 (Oct., 1934).

[79] XXXV, 378-379 (1935).

Library.[80] There is one notable difference between the modern acceptance of Macaulay's criticism and that of the 19th century. At the time of its appearance in 1860 and for twenty years thereafter Macaulay was roundly condemned as a traitor to democracy and faithless to America. Its reappearance in the 20th century caused no such reaction. All hands, conservatives and radicals alike, seem to agree that there is a measure of truth in Macaulay's prophecy.

In contrast to these bids for popular attention, Godfrey Davies'[81] investigation into Macaulay's handling of materials for the history of the British Constitution is designed principally for the scholarly eye. Defects in Macaulay's historiography are his lack of knowledge about the periods prior to the seventeenth century, his failure to appreciate or analyze thoroughly the qualities of sixteenth and seventeenth century religious conflicts. He fails to see the power of the divine right theory in its own day, and some of his sources are generally suspect. His strengths, however, are an excellent account of the growth of political parties, and especially general "comprehensiveness."

The most recent book-length treatment of our "hero" is Richard Croom Beatty's *Lord Macaulay, Victorian Liberal* (Norman, Oklahoma, 1938). This attempts to "present objectively" Macaulay's philosophy of government as it "revealed itself in action." Although Dr. Beatty calls his *History* "the most magnificent and ambitious prose fragment in our literature," and admits that "his volumes became, as he hoped they would, as popular as the latest popular novel," the portrait of the "Victorian Liberal" is deeply critical. For Dr. Beatty hails from Vanderbilt, the home of the modern Southern Agrarians, and he not only dislikes Macaulay's faith in industrialism as the basis of progress but he believes that "the debacle of 1914-1918" was "one of the fairly early fruits of his philosophy." He was blind to the possibility of "periodic unemployment, specialization, the loss of freedom and initiative on the part of the laborer," blind to the possibility of the capitalists' using education so as to make the masses their slaves, blind to property's power of controlling public opinion. A liberal in sponsoring the Reform Bill of 1832, he became "static" in his thinking after that, putting his faith in "the sacred institution of property" and fearing universal suffrage. Constantly pre-

[80] "Macaulay on America, Once More," XL, 437-439 (May, 1936).

[81] "The Treatment of Constitutional History in Macaulay's *History of England*," *Huntington Liberary Quarterly*, II, 179-204.

occupied with material things, he was the foe of "spiritual reformers" like Carlyle and Ruskin—indeed the foe of all idealisms. "He saw men almost always from the outside . . . Their motives he did not inquire about . . . The subtleties of behavior, being attributes of spirit, eluded his clumsy hammer and tong probings." Yet he was "the most fascinating story-teller who ever wrote in the historical guise." (Pp. xv, 296, 307, xiii, 232, 231, 270-272.)

The reviews of this book mark the end of a century of American criticism of Macaulay. Lloyd Eshleman[82] calls Macaulay a "genuine liberal," the greatest liberal historian of England." He was always "steadfast in principle" and "took to heart Middleton's advice 'to live strictly and think freely; to practice what is moral and to believe what is rational'." Professor Geoffrey Brunn, in *New York Herald Tribune Books*,[83] says Beatty presents Macaulay as "the symbol and the spokesman of middle-class England in the second quarter of the nineteenth century." Yet he "transcends such a convenient classification. It is Macaulay the rhetorician, with his brilliance and his bias, his appalling literacy, his deficient emotional capacity, his outward complacency and inner disquietude, that dominates the book." Macaulay's tragedy was that he had "no vital and transforming human contacts, no electrifying emotional experience." In the *History* he said "what middle class England wanted to believe."

William S. Knickerbocker[84] finds in Beatty's book evidence that Macaulay, though on the other side of the fence as the representative of the "prosperous and powerful *bourgeoisie*," was a man as "completely 'class-conscious' "[85] as Karl Marx himself. Hence his brilliant sayings take on life and proper meaning only as they are interpreted in the light of the common sentiment of his day. Understanding Macaulay depends even upon a study of "his family and 'nurtural' inheritance."[86] Judged in these terms, Beatty's work is picturesque and buoyant, but not thorough-going enough or strenuous enough in its examination of terms or critical detachment in dealing with Macaulay himself. John Morley's study, undertaken in reply to Matthew Arnold's attack on Macaulay, remains, according to Knickerbocker, the most satisfac-

[82] *New York Times Book Review*, p. 2 (Jan. 1, 1939). In contrast to Beatty's view see J. W. Cunliffe, *Leaders of the Victorian Revolution* (New York, 1934), pp. 35-71.

[83] Jan. 15, 1939, p. 3.

[84] "Suet with No Plums," *Sewanee Review*, XLVII, 242-52.

[85] *Ibid.*, p. 248.

[86] *Ibid.*, p. 246.

tory, though not completely acceptable, treatment. However, Dr. Godfrey Davies of the Huntington Library finds Beatty's book better on Macaulay as a Victorian Liberal (he prefers the word Whig) than on Macaulay as the historian of the Revolution of 1688. According to Davies, Beatty's treatment of backgrounds is "distinctly amateurish in spots," and his "remarks on the *History of England* are rather conventional and trite."[87] Thus Macaulay continues to inspire sharply different opinions; and his vogue, favorable or unfavorable, endures as a vital part of our British heritage.

[87] *American Historical Review*, XLV, 386 (Jan., 1940). For Canadian views, see John Harris' *A Review of Macaulay's Teaching on the Relationship of Theology to Government* (Montreal, 1874), which argues against his disparagement of theology and attacks his lack of idealism; and D. Monroe's "Macaulay—The Last of the Whigs," *Dalhousie Review*, XIX, 428-437 (Jan., 1940), which briefly reviews his part in the drama of Victorian politics.

PROCEEDINGS OF THE ACADEMY

SEVENTY-FIRST ANNUAL MEETING

The seventy-first annual meeting of the Wisconsin Academy of Sciences, Arts and Letters was held jointly with the meeting of the Wisconsin Museums Conference and the Wisconsin Folklore Society at the Milwaukee Public Museum on Friday and Saturday, April 4 and 5, 1941. A total of more than 200 persons registered for the sessions, which were held on Friday afternoon and Saturday morning. Two separate sections were held each day, an Academy section and a Museum-Folklore section. The customary annual banquet was not held, and in its place the members and guests of the organizations were entertained at a reception, smoker, and tea on Friday evening, immediately following the annual lecture. The staff of the Milwaukee Public Museum acted as hosts.

The following program of papers and lectures was presented.

ACADEMY SECTION

Friday afternoon

Marvel Ings, University of Wisconsin. War at Home (Strategic Minerals); Rufus M. Bagg, Lawrence College, The Pebble Mill at Sister Bay; Ernest F. Bean, Wisconsin Geological Survey, Progress of Mapping in Wisconsin; Ralph N. Buckstaff, Oshkosh Public Museum, New Wisconsin Meteorite; Lincoln R. Thiesmeyer and Ralph E. Digman, Lawrence College, Wind-cut Stones in Kansan Drift of Wisconsin; Paul W. Icke, University of Illinois, Some Aspects of Recreational Land Use in the Northern Lakes Region of Wisconsin; Ole N. deWeerdt, Beloit College, An Operational Analysis of the Nature of Intelligence and its Measurement; Charlotte R. Partridge, Layton Art Gallery, The Layton Art Gallery.

MUSEUM-FOLKLORE SECTION

Friday afternoon

Albert Schnabel, Milwaukee, The Development of the Milwaukee Historical Museum; Wesley Shepard, Racine, Selling the Racine County Historical Museum to the Public; Chester Holway, Milwaukee, Will Americans Visit Their Own Museums?; Norbert W. Roeder, Kenosha, A Museum Is Born; Mrs. R. C. Buchanan, Green Bay, The Roi-Porlier-Tank House Museum; Mrs. Francis T. Blesch, Green Bay, The Old Fort Howard Buildings; Mrs. Rachel Grignon Twells, Green Bay, The Captain John Cotton House Museum; Mrs. John F. Conant, DePere, Art Exhibits at Green Bay; Alonzo W. Pond, Blue Mounds, The Cave of the Mounds—a Subterranean Museum; Henry L. Ward, Green Bay, How the Neville Museum Serves Green Bay; Walter E. Scott, Madison, Obtaining Natural History Specimens; Dorothy M. Brown, Madison, The Opportunity for Folklore Research in Wisconsin.

Annual Academy Lecture

The annual Academy lecture was delivered by Dr. Ira Edwards, Director of the Milwaukee Public Museum, in the Museum Lecture Hall on Friday evening April 4 at 8 p. m. The subject was *The General Geology of the Milwaukee Region.* Immediately following the lecture the members and guests adjourned to the Museum Trustees Room for the reception, smoker, and tea. The various members of the staff of the Museum and their wives served as hosts and hostesses.

Academy Section

Saturday morning

Fr. R. H. Reiss, Marquette University (Introduced by W. N. Steil), Interruption of Nerve Net in *Pelmatohydra oligactis;* W. N. Steil, Marquette University, Some Studies of Ferns; Robert Esser, Marquette University (Introduced by W. N. Steil), Preliminary Report on Incomplete Nuclear and Cell Divisions in the Apogamous fern *Cyrtomium falcatum var. compactum;* Lowell E. Noland, University of Wisconsin, Techniques for Growing Freshwater Snails Under Controlled Conditions in the Laboratory; Jack LaMalfa, University of Wisconsin (Introduced by L. E. Noland), Preliminary Studies on the Effects of Diet on Growth of *Lymnaea stagnalis lillianae;* J. E. Potzger, Butler University, and W. A. Van Engel, University of Wisconsin, Studies of the Large Aquatic Vegetation of Weber Lake, Vilas County, Wisconsin; William A. Hiestand, Purdue University, The Effects of Neurophil Drugs on the Starfish, *Asterias;* Willard A. Van Engel, University of Wisconsin (Introduced by Chancey Juday), The Food of the Black Crappie, *Pomoxis nigromaculatus*, in Wisconsin waters; Arthur H. Moeck, Milwaukee Entomological Society, The Honeybee; Banner Bill Morgan, University of Wisconsin (Introduced by Chancey Juday), The Physalopterinae (Nematoda) of North American Vertabrates; Max Shackelford, University of Wisconsin (Introduced by Leon J. Cole), Mutations in Mink; Robert E. Duncan, University of Wisconsin (Introduced by Charles E. Allen), Somatic Chromosome Numbers in the Cultivated Cypripediums; Lewis B. Nelson, University of Wisconsin, The Nature of Two Associated Wisconsin Soils as Influenced by Post-Glacial Erosion, Topography, and Substratum; Julia Grace Wales, University of Wisconsin, Warp and Woof in *Hamlet*: A Note of the Relating of Study of Source to Study of Structure.

Museum-Folklore Section

Saturday morning

Ralph N. Buckstaff, Oshkosh, A Toothed Stone Spade; George L. Pasco, Ripon, Indian Scrapers; Gerald C. Stowe, Superior, The Douglas County Historical Museum; Marvel Ings, Madison, Museum Storytelling for Children; Marion E. Martin, Hartford, The Erin Cache of Flint Disks; Nile C. Behncke, Oshkosh, The Benefit of Special Museum Art Exhibits; Leland A. Coon, Madison, The Wisconsin Folk Music Recording Project; Edith B. Heidner, West Bend, The Local History Museum of the West Bend High School; Henry L. Ward, Green Bay, Valediction of a Life of Museum Effort; Joseph Rohr, Madison, The State Visual Aids Projects; Harold R. McCall, Manitowoc, Historical Building Museums of Wisconsin; Walter Bubbert, Milwaukee, Indian Myths and Legends About Iron; Joseph Lucius, Solon Springs, The Blue Springs, Indian Shrine; H. Holmes Ellis, Columbus, Ohio, Caches of Flint Disks in Wisconsin.

ACADEMY PAPERS PRESENTED BY TITLE

Berenice Cooper, State Teachers College, Superior, The Abbé Prévost's Interpretation of the English Philosopher; Charles G. Wilber, Johns Hopkins University, The Contractile Vacuoles of *Pelomyxa carolinensis;* Clarence A. Brown, University of Wisconsin, Wordsworth's Theory of the Imagination; J. T. Curtis, University of Wisconsin, Natural Reproduction in the Genus *Cypripedium;* Chancey Juday, University of Wisconsin, The Summer Biomass of an Inland Lake.

REPORT ON THE ANNUAL BUSINESS MEETING AND CHANGE IN THE CONSTITUTION

The annual business meeting was held at 4 p. m. Friday, April 4, 1941 in the Museum Trustees Room. A change was voted in Article IV of the Constitution, as follows.

Article IX of the Constitution, regarding changes, reads as follows: "Amendments to this Constitution may be made at any annual meeting by a vote of three-fourths of all members present; PROVIDED, that the amendment has been proposed by five members, and that notice has been sent to all the members at least one month before the meeting." Proposal to change the terms of the officers of the Academy from three years to one year was received from the five following members: Charles E. Allen, Ernest F. Bean, Norman C. Fassett, Edward M. Gilbert, and Lowell E. Noland. This proposal was mailed to the entire membership on February 23, 1941, and acted upon at the business meeting. Article IV now reads "The officers of the Academy shall be a president, a vice-president for each of the three departments, sciences, arts and letters, a secretary, a librarian, a treasurer, and a custodian. These officers . . . shall hold office for one year."

The Academy officers, elected in 1939 for a three-year term carry through to the 1942 meeting, and the one-year term takes effect in the spring of 1942. Consequently no new officers were elected.

TREASURER'S REPORT

April 4, 1941

RECEIPTS

Carried forward in Treasury, April 1, 1940	$1,533.95
Receipts from dues, April 2, 1940—April 3, 1941	513.44
Grant from A. A. A. S. May 24, 1940	100.00
Sale of publications	181.50
Interest on investments	95.25
Total receipts	$2,424.14

DISBURSEMENTS

Safety box, paid April 2, 1940	$ 3.30
Safety box, paid April 2, 1941	3.33
Printing 1940 programs	7.00
Deposit for printing Vol. XXXII of Transactions	920.00
Reprint deposit for Vol. XXXII of Transactions	403.00
1940 grant-in-aid for research to Harry H. Clark	100.00
Printing call for Milwaukee meeting and proposed change in Constitution	7.25
Stamps	35.00
Secretary allowance	200.00
	$1,678.88

BALANCE, April 4, 1941, $745.26.

The Secretary-Treasurer appeared before Governor Heil and the Finance Committee of the Wisconsin Legislature asking for restoration of the fund to aid the Academy in publication of the Transactions. This was voted upon favorably by the Wisconsin Legislature. $1000. was granted, which was immediately cut 5% in common with all state appropriations, so $950. was granted the Academy. The State Emergency Board eventually cut the appropriation 25%, and the Academy received a credit of $712.50 from the state for aid in publication of Volume XXXII. This money was credited toward publication of the volume, in addition to the sum of money listed above. The sum does not appear in the receipt list, because it is not sent to the Academy, but an order is drawn upon it through the State Printing Board.

LOYAL DURAND, JR.
Secretary-Treasurer.

PROCEEDINGS OF THE ACADEMY

SEVENTY-SECOND ANNUAL MEETING

The seventy-second annual meeting of the Academy was held in Science Hall at the University of Wisconsin on Friday and Saturday, April 17 and 18, 1942. Three other organizations participated jointly in the meeting,—the Wisconsin Archeological Society, Wisconsin Museums Conference, and the Wisconsin Folklore Society. The Academy section met in Science Hall, while other sections held meetings in both Science Hall and the State Historical Society Building. Two hundred and fifty persons attended the various meetings, and 88 were in attendance at the annual banquet in the Wisconsin Memorial Union Building. The annual business meeting and election of officers was held on Friday afternoon. The following program of papers was presented.

ACADEMY SECTION

Friday morning

George Urdang, American Institute of Pharmacy (Introduced by Arthur H. Uhl), In Commemoration of the Bi-Centennial of the Birth of Carl Wilhelm Scheele; Julia Grace Wales, University of Wisconsin, Margaret Ashmun: Wisconsin Novelist and Educator; Chancey Juday, University of Wisconsin, The Summer Standing Crop of Plants and Animals in Four Wisconsin Lakes; L. R. Wilson and R. M. Webster, Coe College (Introduced by Chancey Juday), Fossil Evidence of Wider Post-Pleistocene Range for Hickory and Butternut in Wisconsin; Lemuel A. Fraser, University of Wisconsin (Introduced by Lowell E. Noland), Observations on the Fresh-Water Clam, *Sphaerium;* Thomas H. Flanigon, University of Wisconsin (Introduced by Chancey Juday), Limnological Survey of Six Lakes in Vilas County, Wisconsin, with respect to a Fish Management Program; Lemuel A. Fraser and Charles W. Lines, University of Wisconsin (Introduced by Chancey Juday), Observations on *Corethra* Larvae in Lake Mendota; J. E. Potzger, Butler University, Flowering Plants and Ferns of Vilas County, Wisconsin (By title); J. E. Potzger and C. O. Keller, Butler University, A. Pollen Study of Four Bogs Along the Southern Border of Vilas County, Wisconsin (By title); Ralph Hile, University of Michigan, Mathematical Relationship Between the Length and Age of the Rock Bass, *Ambloplites ripestris* (Rafinesque) (By title); Melbourne R. Carriker, University of Wisconsin (Introduced by Lowell E. Noland), On the Structure and Function of the Proboscis in the Common Oyster Drill, *Urosalpinx cinerea* Say; Louis W. Holm, University of Wisconsin (Introduced by Lowell E. Noland), Reproduction of *Lymnaea stagnalis.*

MUSEUM-ARCHEOLOGICAL SECTION

Friday morning

Marvel Ings, Madison, The University Geological Museum in Public Service; J. Stanley Dietz, Madison, The Grand Army Museum; Edna Mc-

Chesney Bullard, Madison, The Story of Eden Glen; Charles G. Schoewe, Milwaukee, Did the Indian Practice Conservation?; Albert O. Barton, Madison, Early Galena Letters; Albert Schnabel, Milwaukee, Obtaining Museum Accessions; W. C. English, Wyocena, The Teaching of History; Walter Bubbert, Milwaukee, Community Nature Museum; Lorraine C. Brown, Beloit, A Cache of Stone Netweights; Sylvester Jerry, Racine, The Program of the Charles A. Wustum Museum of Fine Arts; Charles E. Brown, Madison, Large Native Copper Axes.

ACADEMY SECTION

Friday afternoon

Mary Jo Read, Milwaukee State Teachers College, The Population of the Driftless Hill Land During the Pioneer Period; Ira Edwards, Milwaukee Public Museum, Glacial Studies in the Vicinity of Waukesha, Wisconsin; Leon J. Cole and R. M. Shackelford, University of Wisconsin, New Color Phases in Foxes; J. F. Groves, Ripon College, Organizing a Teaching Museum; Clarence H. Pratt and George H. Conant, Ripon, A New Station for *Habenaria leucophaea* in Green Lake County; John Limbach, Ripon (Introduced by George H. Conant), Staining Celloidin Sections of Woody Tissues on the Slide; John Limbach, Ripon (Introduced by George H. Conant), Sodium Hypochlorite in Chromosome-Nucleolus Staining; John T. Curtis, University of Wisconsin, Natural Germination of Some Wisconsin Orchids; John Catenhusen, University of Wisconsin (Introduced by Aldo Leopold), Birds of the Arboretum—Summary of a Paper by H. G. Anderson, T. M. Sperry, and W. S. Feeney; Lynn L. Gee, Wisconsin Conservation Department, and W. B. Sarles, University of Wisconsin, The Disinfection of Trout Eggs Contaminated with *Bact. salmonicida;* Charles G. Wilber, Johns Hopkins University, The Digestion of Fat in *Pelomyxa carolinensis* (By title); Berenice Cooper, Superior State Teachers College, The Religious Convictions of the Abbé Prévost (By title).

FOLKLORE-MUSEUM SECTION

Friday afternoon

Hans D. Gabler, Watertown, The Octagon House; Zida C. Ivey, Fort Atkinson, The Dwight Foster Historical Museum; Neita O. Friend, Hartland, Indian Uses of Native Plants; Dorothy M. Brown, Madison, The National Folk Festival; Nancy Oestreich, Milwaukee, The Indian and the Butterfly; Bernadine C. Ratzlaff, Edgerton, Wisconsin Pictorial Folklore Maps; Mrs. Willis Tyler, Lake Mills, Old Aztalan; George Urdang, Madison, The Serpent in Medicine; Dorothy Kundert, Monroe, This Our Heritage; Rev. Luther E. Stonecipher, Sturgeon Bay, Door County's Interesting Experiment; Ruth Potter, Lake Mills, An Aztalan Adventurer; Ella S. Colbo, Racine, Heg Memorial Park and Museum.

ACADEMY SECTION

Saturday morning

Paul W. Boutwell, Douglas Bannermann, Donald Anderson, and Paul Gibson, Beloit College, Some Factors Affecting the Formation of Aliphatic

Nitriles; Robert McIlrath and Paul W. Boutwell, Beloit College, The Use of Crystal Structure as a Teaching Aid in the Organic Laboratory; John Rae and V. W. Meloche, University of Wisconsin, A Photoelectric Method for Determination of pH; J. G. Kané, University of Wisconsin (Introduced by H. A. Schuette), The Indian Fat and Oil Industry; John B. Field, University of Wisconsin, Biochemical Studies of Fish Blood; Edward A. Birge, University of Wisconsin, The Relations Between Water and Transmitted Sunlight; Arthur D. Hasler and Roland K. Meyer, University of Wisconsin, The Respiratory Response of Goldfish to Carp Pituitary Before and After Castration; Hanspeter Thomsen, University of Wisconsin (Introduced by Arthur D. Hasler), Analysis of Game Fish Catch in Lake Geneva, August 1941; Merlin Nelson and Arthur D. Hasler, University of Wisconsin, Notes on the Life History of the Northern Mimic Shiner (*Notropis v. volucellus*); Merlin Nelson and Arthur D. Hasler, University of Wisconsin, A Report of the Gill Net Fishing in Lake Geneva for the Summer of 1941; Jay D. Andrews and Arthur D. Hasler, University of Wisconsin, The Fish Food Productivity of the Aquatic Plants of University Bay, Lake Mendota; Eleanor Reichel and Lowell E. Noland, University of Wisconsin, Life Cycle of a Pulmonate Snail, *Lymnaea stagnalis*, Completed Without Access to the Air; Charles M. Vaughn, University of Wisconsin (Introduced by Lowell E. Noland), The Effects of Temperature on the Hatching Time of the Snail, *Lymnaea stagnalis;* Vivian A. Mathews, University of Wisconsin (Introduced by Lowell E. Noland), The History and Developmental History of the Ovotestis of *Lymnaea stagnalis;* Wayland J. Hayes, Jr., University of Wisconsin (Introduced by Lowell E. Noland), A Survey of the *Rhabdocoela* of Dane and Vilas Counties.

Museum-Folklore Section

Saturday morning

Alonzo W. Pond, Blue Mounds, Growth of a Tradition; Helene Stratman-Thomas, Madison, Wisconsin Folks and Their Songs; Gladys J. Haney, Sparta, Paul Bunyan Research; Marie H. Pauly, Madison, Beliefs and Customs Concerning the Prehistoric Stones of France; Edith B. Heidner, West Bend, West Bend High School Museum; Vivian G. Dube, Superior, How Our Museum Serves the Public; Eloise Gerry, Madison, The Forest Products Museum, A Branch of the Forestry Museum Development; H. J. Rahmlow, Madison, The Wisconsin Horticultural Society and its Work; C. H. Bachhuber, Milwaukee, Early French Charcoal Burners of Dodge County.

Academy Business Meeting

The annual business meeting was held in Science Hall on Friday afternoon, April 17, 1942.

The Nominating Committee, Leon J. Cole, Chairman, presented the following slate of officers for the ensuing Academy year. The slate was elected for one year only, pursuant to the change in the Constitution made at Milwaukee in April, 1941.

President: A. W. Schorger, Madison.

Vice-President:

In Science—W. N. Steil, Marquette University.

In Arts—Ralph N. Buckstaff, Oshkosh.
In Letters—Berenice Cooper, Superior State Teachers College.
Secretary-Treasurer: Loyal Durand Jr., University of Wisconsin.
Librarian: Gilbert H. Doane, University of Wisconsin.
Curator: Charles E. Brown, State Historical Museum.

TREASURER'S REPORT

April 17, 1942

RECEIPTS

Cash on hand, April 4, 1941	$ 745.26
Receipts from dues, April 5, 1941 to April 17, 1942	448.00
Sale of publications	204.67
Sale of reprints from Vol. XXXII to authors	193.95
Collection from author for publication	11.22
Interest on investments	90.00
Grant from A. A. A. S. April 17, 1941	100.00
	$1,793.10

DISBURSEMENTS

Printing programs for Milwaukee meeting	$ 16.50
Printing of envelopes, November 1941	15.50
Printing of billheads, February 1942	11.00
Expressing reprints to authors	5.00
Stamps	15.00
Safety box, paid April 2, 1942	3.60
Secretary allowance	200.00
Grant-in-aid of research to James F. Groves, 1941	100.00
	$ 366.60

Cash on hand, April 17, 1942, $1,426.50.

LOYAL DURAND, JR.
Secretary-Treasurer.

"The Auditing Committee has examined the accounts of the Treasurer and the contents of the safety deposit box belonging to the Academy and has found them in order and as reported."

(signed) IRA EDWARDS.
(signed) V. C. FINCH.

ANNUAL DINNER AND LECTURE

The annual Academy dinner was held on Friday evening, April 17, in the Wisconsin Memorial Union. Two addresses were made. President Paul W. Boutwell of Beloit College presented his presidential talk, the subject of which was "Chemistry and Preparedness 25 Years Ago and Now." Professor Leon J. Cole of the University of Wisconsin gave an illustrated talk on "Alaska."

THE CONSTITUTION OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

(October 31, 1942)

ARTICLE I—NAME AND LOCATION

This association shall be known as the Wisconsin Academy of Sciences, Arts and Letters, and shall be located at the city of Madison.

ARTICLE II—OBJECT

The object of the Academy shall be the promotion of sciences, arts and letters in the state of Wisconsin. Among the special objects shall be the publication of the results of investigation and the formation of a library.

ARTICLE III—MEMBERSHIP

The Academy shall include four classes of members, viz.: life members, honorary members, corresponding members and active members, to be elected by ballot.

1. Life members shall be elected on account of special services rendered the Academy. Life membership may also be obtained by the payment of one hundred dollars and election by the Academy. Life members shall be allowed to vote and to hold office.
2. Honorary members shall be elected by the Academy and shall be men who have rendered conspicuous services to science, arts or letters.
3. Corresponding members shall be elected from those who have been active members of the Academy, but who have removed from the state. By special vote of the Academy men of attainments in science or letters may be elected corresponding members. They shall have no vote in the meetings of the Academy.
4. Active members shall be elected by the Academy or by the council, and shall enter upon membership on payment of the first annual dues.

ARTICLE IV—OFFICERS

The officers of the Academy shall be a president, a vice-president for each of the three departments, sciences, arts and letters, a secretary, a librarian, a treasurer, and a custodian. These officers shall be chosen by ballot, on recommendation of the committee on nomination of officers, by the Academy at an annual meeting and shall hold office for one year. Their duties shall be those usually performed by officers thus named in scientific societies. It shall be one of the duties of the president to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

ARTICLE V—COUNCIL

The council of the Academy shall be entrusted with the management of its affairs during the intervals between regular meetings, and shall consist of the president, the three vice-presidents, the secretary, the treasurer, the librarian, and the past presidents who retain their residence in Wisconsin. Three members of the council shall constitute a quorum for the transaction of business, provided the secretary and one of the presiding officers be included in the number.

Article VI—Committees

The standing committees of the Academy shall be a committee on publication, a library committee, and a committee on nomination of members. These committees shall be elected at the annual meeting of the Academy in the same manner as the other officers of the Academy, and shall hold office for the same term.

1. The committee on publication shall consist of the president and secretary and a third member elected by the Academy. They shall determine the matter which shall be printed in the publications of the Academy. They may at their discretion refer papers of a doubtful character to specialists for their opinion as to scientific value and relevancy.
2. The library committee shall consist of five members, of which the librarian shall be *ex officio* chairman, and of which a majority shall not be from the same city.
3. The committee on nomination of members shall consist of five members, one of whom shall be the secretary of the Academy.

Article VII—Meetings

The annual meeting of the Academy shall be held at such time and place as the council may designate. Summer field meetings shall be held at such times and places as the Academy or the council may decide. Special meetings may be called by the council.

Article VIII—Publications

The regular publication of the Academy shall be known as its Transactions, and shall include suitable papers, a record of its proceedings, and any other matter pertaining to the Academy. This shall be printed by the state as provided in the statutes of Wisconsin.

Article IX—Amendments

Amendments to this constitution may be made at any annual meeting by a vote of three-fourths of all members present; *provided,* that the amendment has been proposed by five members, and that notice has been sent to all the members at least one month before the meeting.

BY-LAWS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

1. The annual dues shall be two dollars for each active member, to be charged to his account on the first day of January of each year. Five dollars, paid in advance, shall constitute full payment for three years' annual dues.
2. The annual dues shall be remitted for the secretary-treasurer and librarian during their term of office.
3. As soon as possible after January first of each year the secretary-treasurer shall send to members statements of dues payable, and in case of non-payment shall, within the succeeding four months, send a second and, if necessary, a third notice.

4. The secretary-treasurer shall strike from the list of members the names of those who are one year or more in arrears in the payment of their dues, and shall notify such members of this action offering at the same time to reinstate them upon receipt of the dues in arrears plus the dues for the current year.

5. Each member of the Academy shall receive the current issue of the Transactions provided that his dues are paid. Any member in arrears at the time the Transactions are published shall receive his copy as soon as his dues are paid.

6. The fee received from life members shall be set apart as a permanent endowment fund to be invested exclusively in securities which are legal as investments for Wisconsin trust companies or savings banks. The income alone from such fund may be used for the general purposes of the Academy.

7. The secretary-treasurer shall receive annually an allowance of two hundred dollars for services.

8. The secretary-treasurer shall be charged with the special duty of editing and overseeing the publication of the Transactions. In the performance of this duty he shall be advised by the committee on publication.

9. The Transactions shall contain in each volume: (a) a list of the officers of the Academy (b) the minutes of the annual meeting and (c) such papers as are accepted under the provisions of Section 10 of these By-Laws and no others.

10. Papers to be published in the Transactions must be approved as to content and form by the committee on publication. They must represent genuine original contributions to the knowledge of the subject discussed. Preference shall be given to papers of special interest to the state of Wisconsin and to papers presented at a regular meeting of the Academy. The privilege of publishing in the Transactions shall be reserved for the members of the Academy.

11. The Constitution and By-Laws and the names and addresses of the members of the Academy shall be published every third year in the Transactions. The Constitution and By-Laws shall also be available in reprint form from the secretary-treasurer at any time.

12. Amendments to these By-Laws may be made at any annual meeting by vote of three-fourths of all the members present.