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## The Physiographic Ecology of a Wisconsin Drift Lake

Lois A. Catlin  
*Iowa State College*

Ada Hayden  
*Iowa State College*

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THE PHYSIOGRAPHIC ECOLOGY OF A WISCONSIN  
DRIFT LAKE

LOIS A. CATLIN AND ADA HAYDEN

INTRODUCTION

In Iowa, practically all of the swamp land and many of the smaller lakes with which the early pioneers were familiar have been drained and there agricultural crops are grown. Whether the greatest economic benefit may be derived from appropriating for agricultural purposes such a small proportion of the land as lake beds represent, or by conserving and developing their natural resources is a subject for consideration. With one exception (that of Wall Lake in Wright County), Little Wall Lake is the only lake of any size within an area with radius of at least fifty miles, and in view of its natural resources, it might well be preserved.

Some territory in this vicinity once occupied by Mud Lake was drained for tillage but this region in a wet season does not produce satisfactory crops and considerable of the area appears to be reverting to primeval state. For a long time Little Wall Lake has been frequented by sportsmen, because of the presence of water fowls and fish, such as carp and bullheads. While there has been considerable speculation about the desirability of draining Little Wall Lake, in view of the fact that nearby projects of lake drainage have not proved notably successful, this plan appears to have been abandoned, for arrangements have been recently completed by which this lake and some adjacent territory have become a unit of the State Park System of Iowa. (36)

LOCATION

Little Wall Lake is situated three miles south of Jewell, Hamilton County, Iowa, in sections 9, 10, 15 and 16 of township 86 north, range 34 west. It comprises an area of 230 acres and encloses by the meander 273 acres, or is approximately half a mile wide and a mile or more long. It is oblong in shape, yet much wider across the center and greater part than at either end. It is comparatively shallow, being only five to six feet in its deepest part.

The lake is in a saucer-like depression nearly surrounded by low sloping hills. In several places along the shores, "walls" have been built up by action of the ice, hence the early settlers named it "Wall Lake." No stream or large ditch empties into this body of water and one wonders why there is a lake. Rainfall is the chief source of water supply, although undoubtedly a part of its water filters through the gravel of the surrounding region. This latter, however, cannot be a relatively large amount because, (1) the whole lake is practically surrounded by hills which would limit the area to be drained, and (2) the natural slope of the land is toward the southeast; hence the greater part of the seepage and drainage water would necessarily come from the west and east. It is also

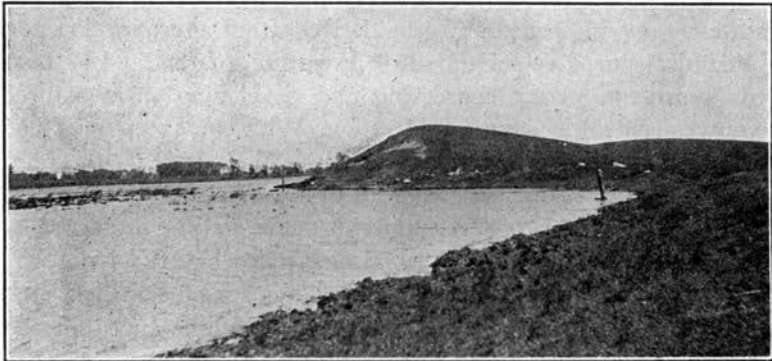


Fig. 1. Highest point in morainal wall.

thought that small springs or a gradual infiltration of water from the gravels beneath the lake aid in the water supply.

The natural outlet is at the southeast and where the bank is low. This would lead southeastward through a somewhat marshy region and finally enter the Skunk river after covering a distance of nearly two miles. However, it had been proposed to drain the lake by means of a ditch located at the north end. This would lead directly to a branch of the Skunk river and would cover a distance of a little more than a mile. It would probably be necessary to dig this ditch to considerable depth in order to overcome the slight natural "divide" at that place if it had been found more desirable to drain the lake than to improve it.

#### HISTORY AND CLIMATIC FACTORS

The records relating to this region are very inadequate. Toward the southeast of Little Wall Lake are seen many evidences of

material changes which have been brought about by the cultivation of the land. It is (33) probable that the lake was at one time considerably greater in extent and constituted one of a chain of lakes, with much of the surrounding country as swamp. Since the advent of the white man, practically all of the swamps have been drained and in their place now are pastures and fields of corn.

Hamilton County, in which the lake is situated, was formerly known as Risley County. In 1853 this name was changed to

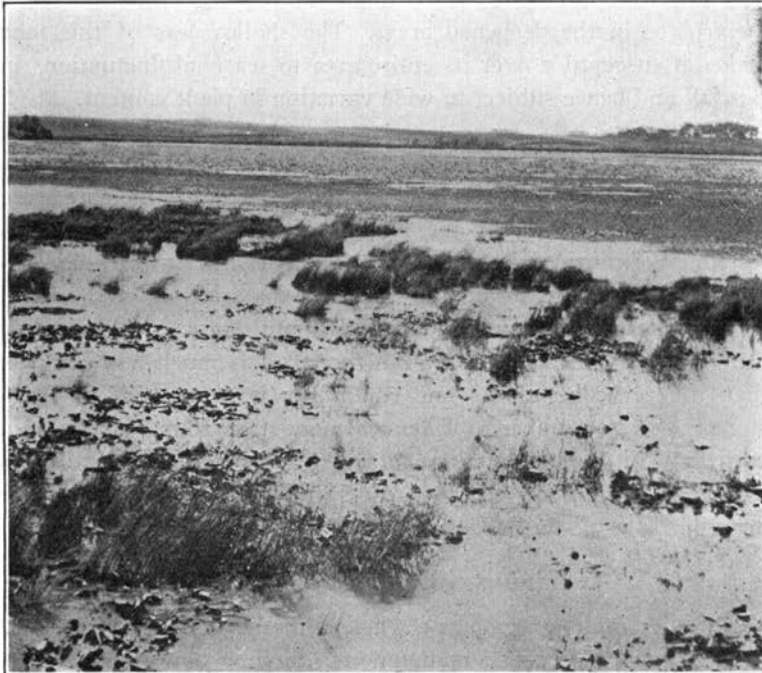


Fig. 2. Morainal wall along eastern shore.

Webster and in 1875 the county was reorganized and the name again changed to the one it now bears, namely, Hamilton, in honor of Alexander Hamilton. The United States Census Report (28) states that Risley County had a total population of 122 in 1852 with an increase in 15 years (1867) to 3,151, at which time it was known as Hamilton County. The years 1894 and 1901 are designated as having been very dry and warm due to the scant rainfall and high temperature (30). During those years the entire lake bed was reduced to a marsh upon which cattle pastured. MacBride (33) states that it is "simply a great marsh filled from side to side with aquatic plants. The margins are dark with sedges. In

the middle the cat-tail lifts its blades undisturbed." The State Highway Commission (32) in their report state that "a large part of its surface is grown up to rushes . . . and on the east side considerable natural timber is found."

Since that time there have been several years during which the amount of precipitation was above normal (11). This probably has been the chief factor which caused the cat-tails and rushes to disappear, since they are confined to shallow water, so that now only a few remain along the margin and other vegetation has taken their place in the deepened areas. The shallowness of this lake makes it susceptible over its entire area to seasonal fluctuations in rainfall and hence subject to wide variation in plant content.

#### GEOLOGY

The lake lies in the drift area of Iowa. Parts of the state were traversed successively by the Nebraskan, Illinoisan, Iowa, Kansan and Wisconsin drift sheets (25). This last drift is readily distinguished by the great amount of coarse materials as sand, gravel and boulders it contains and by the moraines (33). Relatively little erosion has taken place even though it is much less compact than the preceding drifts and contains a large amount of limestone. A great number of lakes and ponds are found in this area with few or none occurring outside of it. It is interesting to note (25) that nearly all the streams of Iowa originate within, or near this lobe of the Wisconsin.

#### PHYSIOGRAPHY AND SOILS

The surrounding region as a whole, although comparatively level prairie, cannot be called monotonous. Sloping almost imperceptibly to the southeast at the rate of about a foot a mile, it affords many contrasts in topography for prominent hills and valleys as well as minor inequalities and variations of surface are to be found. These contrasts were brought about chiefly by glacial action, although much of the minor variation was greatly influenced by erosion. The hills to the north and east of the lake constitute a part of a series of morainic hills which run north into Wright county and northeast to Rose Grove township. These are considered as being merely great piles of debris left by the glaciers, which, in its downward trend was checked by the warmer climate and eventually disappeared leaving its burdens where it had dropped them.

"Lakes seem nearly always to be found with this type of hills

(33), indicating that the lakes were formed by the same stern sculptor which shaped the hills." There are nine or ten lakes, varying in size, which are marshalled in a chain formation in company with the series of morainic hills. Most of these lakes are now drained, and of those which remain, none have a depth of over five or six feet, and are usually characterized as marshy due to the abundant vegetation.

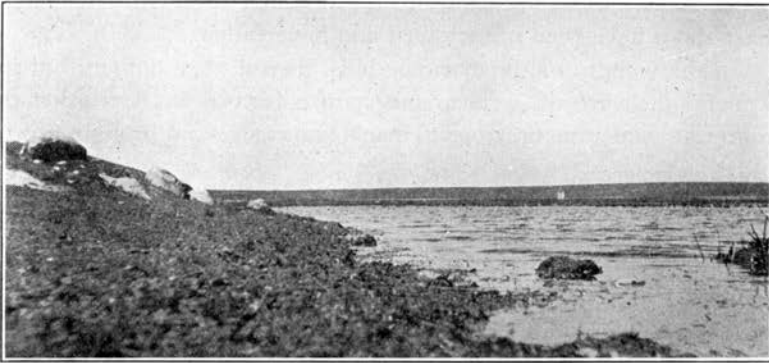


Fig. 3. Morainal wall along eastern shore.

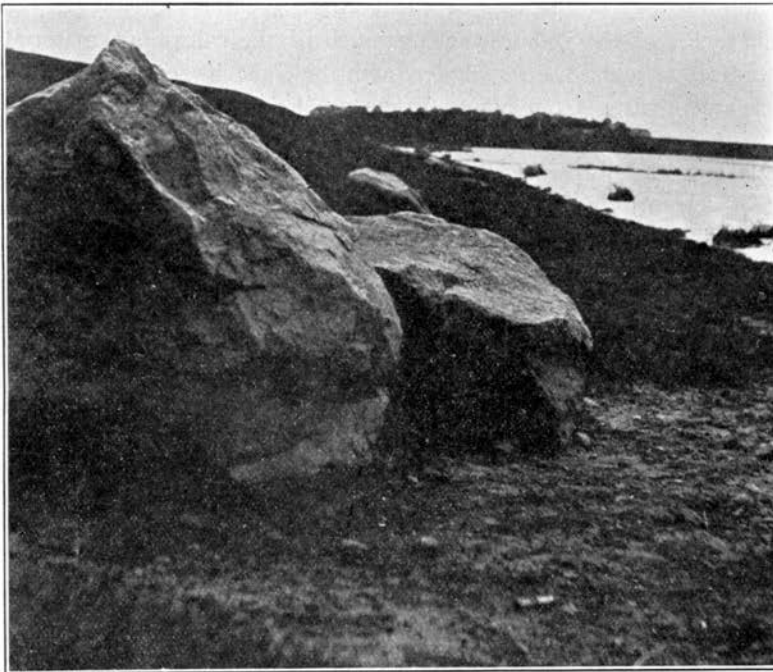


Fig. 4. Granitic boulders along morainal wall of the lake.

In the winter, the formation of ice causes the water to expand to an extent sufficient to push the soil back several inches on the shore. This, with the grinding of the ice when it breaks up in the spring, causes considerable erosion of the banks. The soil is loosened and undermined until blocks of grass-covered soil and even large trees fall into the water. The action of the ice is most evident along the west and north shores where the soil is composed chiefly of sandy loam or silt, although several trees on the east shore have been undermined and have fallen.

In the vicinity of the morainic hills, the soils are lighter; but in general they are of a calcareous nature formed by deposition in water at some time previous to man's knowledge and brought down by the glacier.

Along the south and east shores many boulders and pebbles are strewn along the bank and nearly covered with soil (Fig. 3). These are particularly prominent along the southeast shore at the foot of a long morainal hill where, sloping into the water, may be found all sizes of rocks from the largest boulder to a fine gravel (Fig. 4). This may be due to the fact that there the surface deposit by the glacier is deep and the rocks have not become disintegrated by the process of weathering. Weathering changes the character of the soil by causing much of the calcareous material to disappear and the remainder, with the constant accumulation of organic matter from plants forms the loams which still contain many boulders and pebbles. (45).

Along the northeast shore are a number of trees which arrange themselves into two groups. One group, consisting of black ash, cottonwood (Fig. 5) and willow inhabit the low ground (Fig. 6), and the other group, consisting of haws, hackberry, oak, hickory, wild apple, and wild cherry maintain their existence on comparatively high ground. There are also a few scattered willows on the west shore.

In the northern part of the lake bottom is found silt and probably peat, while considerable sand and gravel is found in the eastern and southern parts, and the western part is composed chiefly of sandy loam with one or two small areas of silt.

#### MORPHOLOGY OF WATER PLANTS

Probably the primeval forms of vegetation were aquatic (1). Present-day aquatics are frequently regarded as descendants of terrestrial plants which have reverted somewhat to the aquatic habits of their remote ancestors. This view may be maintained

because, "aquatic Angiosperms cannot trace their ancestry in an unbroken aquatic line from some far away algal progenitor," and "that their floral organs, in most cases, belong to a decidedly terrestrial type."

Hutchinson (29) states that "in the constant struggle for existence, many races of plants have, in all probability, been entirely exterminated. Some, such as aquatic flowering plants, have escaped destruction by taking to the water. The oldest representatives of these: *Elodea*, *Lemna* and *Ceratophyllum*, have changed much in



Fig. 5. *Populus deltoides* (Cottonwood)



their internal structure; whilst others with a shorter aquatic record have as yet been little modified internally, if at all."

In water plants with floating or emersed leaves the length of the stems and length of petiole may vary considerably, depending upon the depth of the water. These elongated water stems and petioles are usually very slender, and extend only to the water line. In higher plants the conductive tissue is more highly specialized than that found in submersed hydrophytes (16) such as *Elodea* and *Ceratophyllum* in which the leaf bundles are often so small as to easily escape detection.



Fig. 6. Willow, ash, elm, cottonwood bordering the shallow northeastern margin.

Many of the aquatics which are rooted in the soil reproduce by means of rhizomes which easily penetrate the oozy soil of the lake bottom, thus migrating rapidly. Cowles (16) states that "the remarkable capacity of water plants for vegetative reproduction is due chiefly to the ready detachability of aquatic stems, whose fragments float to a more or less distant locality where a new growth center is established."

Some water plants protect themselves during unfavorable conditions by means of winter buds which may easily become detached. These are compact growths at the end of the shoot formed by the stem ceasing to elongate and the leaves being closely imbricated.

Many aquatic spermatophytes show much variation in leaf structure; the submerged leaves are finely divided and ribbon-like, while the floating or aerial leaves are relatively simple. These submerged leaves, according to Arber (2) are "characterized anatom-

ically by the lack of stomates and by the presence of chlorophyll in the epidermis; therefore, they are well suited for the absorption of carbon dioxide in the dissolved form in which it presents itself to water plants." Many of these plants in their development pass through several stages from the juvenile to the higher form of leaf with stalk and blade (22).

Cowles (16) states that the outer walls of nearly all water plants are composed of cellulose, and "with constant water contact and freedom from transpiration conditions are suitable for water absorption by chlorophyll-bearing organs. In water plants, leaf absorption generally is much greater in amount than is root absorption." Gager (21) maintains that many floating plants are able to absorb their nutrient salts directly from the surrounding water by means of root hairs. Cowles (16) contends that true water roots are hairless and lacking in vascular development.

Except in plants which are completely submerged (as some *Potamogetons*, *Vallisneria* and *Elodea* (54)) pollination through the agency of water is very rare.(16).

Wind is the most important agent in pollination as the pollen of those plants which are not completely submerged is very light and is easily carried by this means.

#### ECOLOGY OF WATER PLANTS

The ecological factors of a lake in which freshwater aquatic plants are found are determined largely by the depth and temperature of the water and the soils of the banks and lake bottom, and are influenced by the atmospheric precipitation, movements of the water and the season or temperature of the climate. The vertical distribution is determined almost entirely by increase or decrease of light intensity which is dependent upon the turbidity and depth of the water (51). The temperature of the water varies with the depth but shows less fluctuation than does the temperature of the air because water is a poor conductor of heat.

Temperature readings of Little Wall Lake were made at different times, the results averaged, and tabulated as follows:

TEMPERATURE CHART

	AUG. 14, 1922	SEPT. 27, 1922	OCT. 28, 1922
1 ft.	29°	27°	26°
2 ft.	28°	26.50°	24°
3 ft.	26°	25°	23°
3½ ft.	25°	23°	22°
4 ft.	23°	21°	20°
4½ ft.	22°	20°	19°
5 ft.	21°	19°	18°

The atmospheric pressure, the relative humidity and the temperature of the air were practically the same when the data was procured.

The substratum has considerable influence upon the distribution of water plants, not only by means of chemical substances contained in it at the bottom (13, 37), but considerable nutritive material is found in solution (38, 5). The vegetation differs also with the physical nature of the substratum whether it be hard and stony, soft and muddy, or sandy.

For a comparatively shallow inland lake such as Little Wall Lake, atmospheric precipitation has much to do with the character of the plants to be found in it. An increase of rainfall which increases the depth of the water so that in seasons of excessive precipitation, the zonation may be entirely changed. Plants which attain their maximum development in comparatively shallow water may be driven back and those which grow best in deep water may take their place with the reverse conditions during a season or two of scant rainfall and considerable evaporation the plants inhabiting deep water do not survive while the zone of those which grow best in shallow water advances considerably but always in proportion to the depth of the water. During high wind and subsequent wave action, many of the more fragile plants and those which normally float are carried back and forth across the lake according to the direction from which the wind comes.

Due to the shallowness of the lake, it freezes over the entire surface and probably most of its depth. The character of most aquatic plants is changed during the winter in order that they may rest. Many algae go into a resting or dormant stage whereby a single cell may carry the plant over winter, some higher plants form winter buds, while others retain life only in their rootstocks..

#### CLASSIFICATION

Aquatic plants may be classified ecologically from the standpoint of the depth of the water.

1. Helophytes — Marsh or bog plants (semi-aquatic).

a. Reed-swamp formation (49) — composed chiefly of tall, monocotyledonous perennial herbaceous plants growing in water-saturated soil or in water of only a few inches in depth. Among the various plants to be found in this association are: *Calamagrostis canadensis*, *Juncus tenuis*, *Gerardia tenuifolia*, *G. aspera*, *Scirpus atrovirens*, *S. fluviatilis*, *S. validus*, *S. robustus*, *Carex vulpinoidea*, *C. aristata*, *Cyperus esculentus*, *C. ferax*, *C. rivularia*,

*Acorus calamus*, *Sparganium lucidum*, *S. eurycarpum*, *Spartina Michauxiana*, *Alisma Plantago-aquatica*, *Scutellaria laterifolia*, *S. versicolor*, *Lycopus uniflorus*, *Mentha canadensis*, *M. arvensis* var. *canadensis*, *M. piperita*, *Sagittaria latifolia*, *S. lanceolata*, *S. heterophylla*, *Typha latifolia*, *Iris versicolor*, *Steironema ciliatum*, *Sium*

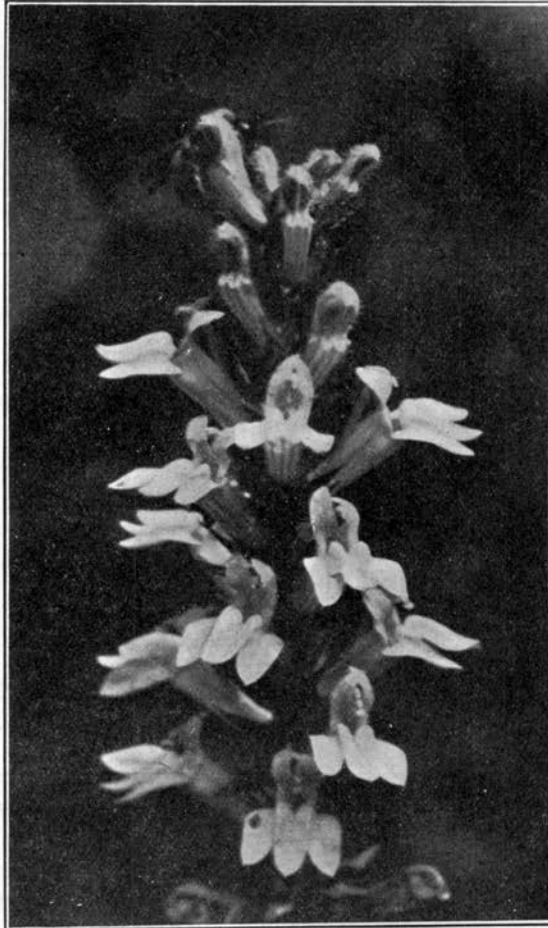


Fig. 7. *Lobelia siphilitica* (Blue lobelia).

*cicutaeifolium*, *Polygonum hydropiperoides*, *Polygonum amphibium*, *Lobelia spicata* var. *hirtella*, *Lobelia siphilitica*, *Eupatorium purpureum* var. *maculatum*, *Cicuta maculata*, *Asclepias incarnata*, *Eleocharis* sp., *Bidens Beckii*.

## 2. Hydrophytes (43).

This group comprises all true aquatics, or those whose existence



Fig. 8. *Iris versicolor* (Blue flag).



Fig. 9. *Nymphaea advena* (Yellow pond lily).

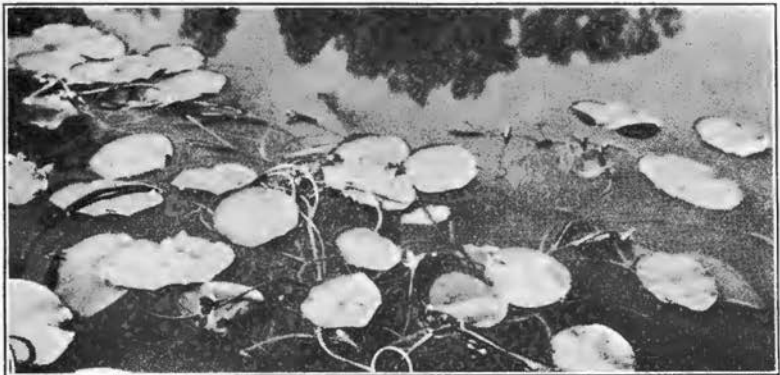


Fig. 10. *Brasenia Schreberi* (Water shield).

is maintained entirely under water (55), and all partly aquatics, or those which remain in the water but require some soil and air.

a. Spermatophytes.

(1) *Nymphaea* type. — This type includes plants rooted to the ground, yet with portions in the air. Among these are *Nymphaea advena*, *Castalia tuberosa*, *Brazenia Schreberi*, *Ranunculus delphinifolius*, *Zizania aquatica*, *Potamogeton* sp.

(2) *Ceratophyllum* type. — This includes plants either somewhat rooted in the soil, or free floating with long shoots. Among these are *Ceratophyllum demersum*, *Najas flexilis*, *Utricularia vulgaris* var. *Americana*, *Myriophyllum spicatum*, *Potamogeton* sp.

(3) *Elodea* type — including plants which are free floating with short shoots. This group may be subdivided into (1) those which are entirely submerged, as *Lemna trisulca*, (2) those of

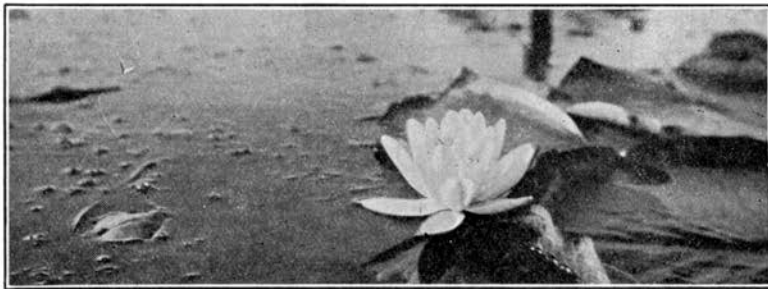


Fig. 11. *Castalia tuberosa* (White water lily)

which the greater part is submerged, as *Elodea canadensis* and *Vallisneria spiralis*, and (3) those of which the greater part remains floating on the surface, as *Lemna minor*, *Spirodela polyrhiza* and *Wolffia punctata*. The latter shift with the wind and may sometimes be found in the center or at various sides of the lake.

b. Thallophytes.

No group of lower plants was studied other than the Algae, and that somewhat briefly.

1. Limnoplankton (49) or fresh-water Plankton.

(a) Free floating — chiefly algae such as the *Diatoms*, *Chlamydomonas*, *Scenedesmus*, *Hydrodictyon* and *Pediastrum*.

(b) Potamoplankton — algae associated with aquatic spermatophytes.

(1) Those occurring in floating masses, such as *Ulothrix*, *Stichococcus*, *Mougeotia*, *Zygnema*, *Spirogyra*, *Cladophora* and *Oedogonium*.

(2) Those which are epiphytic in character occurring on stems or leaves of higher plants such as *Coleochaete*, *Characium* and *Oedogonium*.

(c) Heloplankton — algae which appear associated with marsh plants on wet soil or in shallow, muddy water such as *Vaucheria*, *Nostoc*, *Oscillatoria*, *Rivularia* and *Merismopedia*.

ALTERNATION AND ZONATION

Hydrophytic association of a lake show a structural arrange-

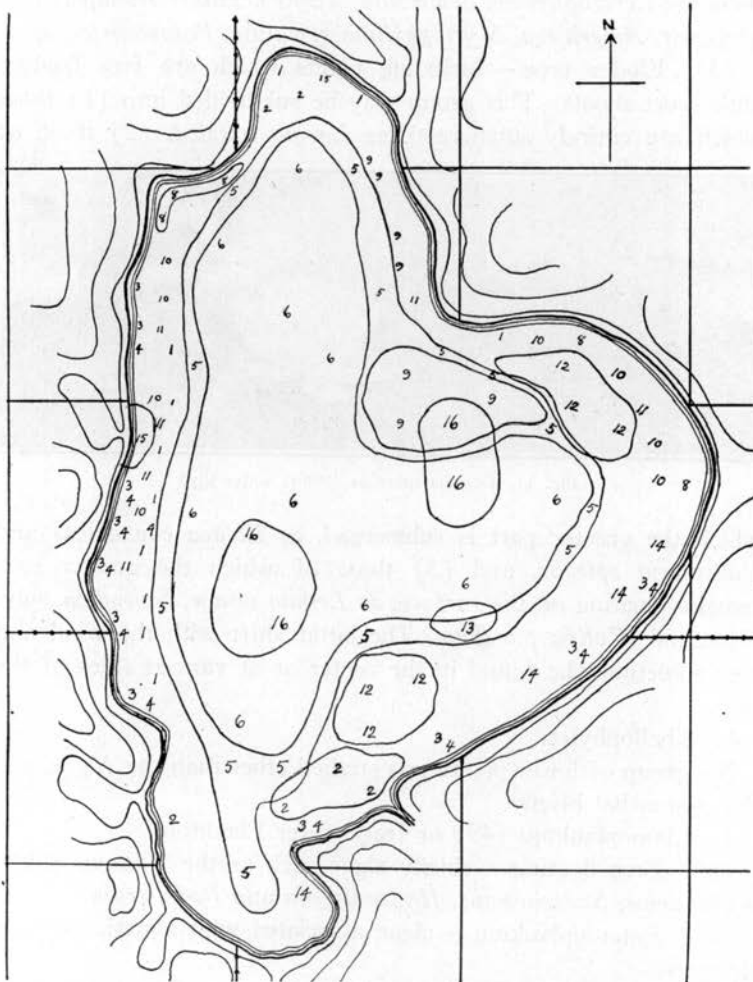


Fig. 12. Map of aquatic plant associations of Little Wall Lake.  
1. Elodea. 2. Scirpus validus. 3. Lemna. 4. Wolffia. 5. Nymphaea. 6. Castalia.  
7. Scirpus fluviatilis. 8. Sagittaria. 9. Myriophyllum. 10. Ceratophyllum. 11. Utricularia. 12. Zizania. 13. Ranunculus. 14. Potamogeton. 15. Typha. 16. Brasenia.

ment, relating to the depth of water and constituting three zones, namely, central, intermediate and marginal (8), the central zone being that in the deepest portion. In Little Wall Lake, the *Castalia* is predominant in the central zone with some *Myriophyllum* and *Ranunculus*. *Nymphaea*, *Ceratophyllum*, *Utricularia* and *Elodea* form the intermediate zone, while the marginal zone consists of *Zizania*, *Scirpus*, *Potamogeton*, *Sagittaria*, *Wolffia* and *Lemna*. These zones have no distinct line of demarkation because of the overlapping of plants from one zone by another.

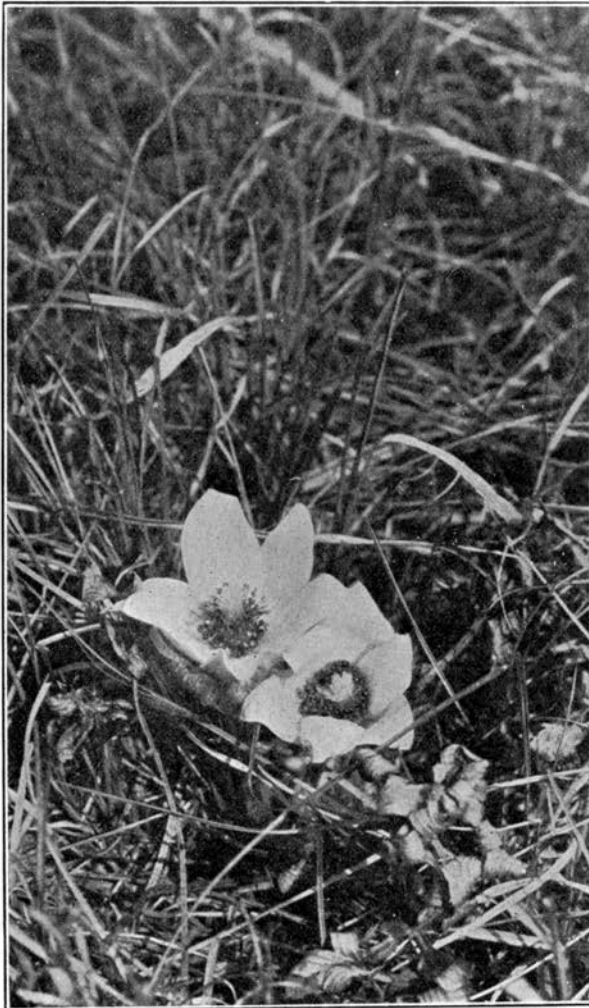


Fig. 13. *Anemone patens* var. *Wolfgangiana* (Pasque flower) growing on the northeast slope of the high wall.



Erosion is the most important factor which tends to fill the lake, however, dust blown from nearby fields and the deposit of dead vegetation or organic matter tends to build up the bottom. Then, during some unusually dry seasons marsh plants grow farther in and by drying, add their contribution to the vegetable matter. Thus, natural forces, with man's efforts at drainage and consequent lowering of the water table tend to make a lake more shallow. It is then reduced to a marsh and finally to dry ground excepting during periods of heavy rainfall when a few ponds are formed which eventually disappear and the whole lake area emerges as dry territory.

The process of transition requires many years, but conditions previously stated indicate that Little Wall Lake, like many others,

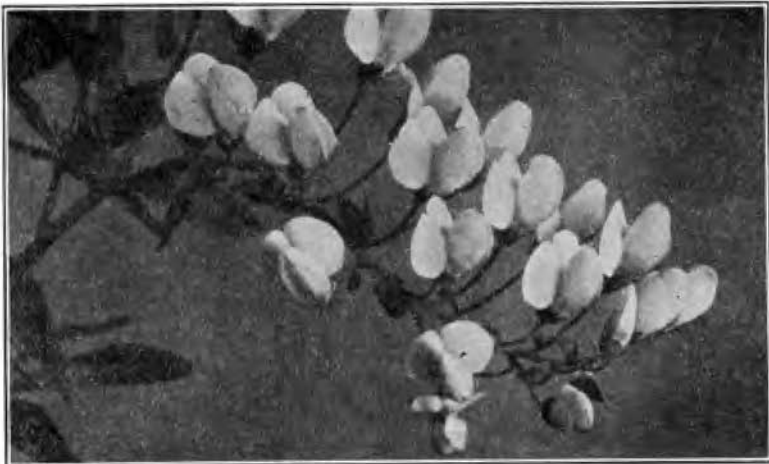


Fig. 14. *Baptisia bracteata* (False indigo) growing on the bluff or wall on the eastern shore.

is now in the transitional stage, and unless some means of prevention are employed, the whole lake probably will, in the process of time, disappear by transition to prairie type, if natural processes are not interrupted.

#### VESTIGIAL REMAINS OF THE PRAIRIE

On the somewhat elevated knolls and hills and by the roadsides surrounding the lake, may be seen remnants of the prairie whose plants have been nearly eliminated by pasturage and cultivation. Here such plants as *Andropogon nutans*, *A. furcatus*, *Sorghastrum nutans*, *Anemone patens* var. *Wolfgangiana*, *A. canadensis*, *Viola pedatifida*, *Lithospermum angustifolium*, *L. canescans*, *Bapti-*

*sia bracteata*, *Solidago rigida*, and *S. canadensis*, may be seen. Remnants of both upland and lowland types of prairie are present. Since the area immediately adjoining the lake will, because of its inclusion within the state park, be henceforth free from disturbance by cultivation, it is probable that the prairie may in some degree re-establish itself. Many of the Helophyte group which are mentioned in this discussion are found in lowland prairie formations in Iowa and exist here as transitional types in association with dominant grasses. The hydrophytic associations of this lake appear to show gradual transitory stages which pass progressively from submerged, free-floating, through hydrophytic-rooting to marsh, then to lowland prairie and to upland prairie associations. In dry seasons when the water is low the land plants advance toward and encroach upon the margins of the lake, when the water again deepens in the lake, the zones of water plants expand. Thus the lake margin presents a critical border of competition between land and water plants, governed by the fluctuation of the water supply.

TAXONOMY OF WATER PLANTS<sup>1</sup>

Tilden.....	<i>Cyanophyceae</i> .
Collins.....	<i>Chlorophyceae</i> .
Gray.....	7th edition — all other plants.

*Division Schizophyta.*

Class. Cyanophyceae.

Ord. Coccogoneae.

Fam. Chroococcaceae.

Merismopedium glaucum (Ehrenb.) Nägeli.

Ord. Hormogoneae.

Fam. Oscillatoriaceae.

Oscillatoria splendida Greville.

Oscillatoria limosa Agardh.

Oscillatoria anguina Bory.

Fam. Scytonemaceae.

Tolypothrix distorta (Hofman-Bang) Kuetzing.

Fam. Rivulariaceae.

Rivularia nitida Agardh.

*Division Euphyceae.*

Class. Chlorophyceae.

Ord. Conjugales.

Fam. Zygnemaceae.

Zygnema sp.<sup>2</sup><sup>1</sup> The nomenclature used was as follows:<sup>2</sup> Inadequate data was available to identify some of the species. Only a preliminary list of the algae is offered.

- Spirogyra sp.
- Fam. Mesocarpaceae.
- Mougeotia sp.
- Ord. Volvocales.
- Fam. Chlamydomonadaceae.
- Chlamydomonas sp.
- Ord. Protococcales.
- Fam. Protococcaceae.
- Characium ambiguum Hermann.
- Fam. Scenedesmaceae.
- Scenedesmus sp.
- Fam. Hydrodictyaceae.
- Hydrodictyon reticulatum L.
- Pediastrum sp.
- Ord. Ulothrichales.
- Fam. Ulothrichaceae.
- Ulothrix tenerrima Kützing.
- Stichococcus subtilis Kütz.
- Fam. Oedogoniaceae.
- Oedogonium sp.
- Fam. Coleochaetaceae.
- Coleochaete orbicularis Pringsh.
- Ord. Siphonocladiales.
- Fam. Cladophoraceae.
- Cladophora crispata (Roth) Kütz.
- Division Pteridophyta.*
- Fam. Equisetaceae.
- Equisetum arvense (L.) Tourn.
- Division Spermatophyta.*
- Class. Monocotyledoneae.
- Fam. Typhaceae.
- Typha latifolia L.
- Fam. Sparganiaceae.
- Sparganium eurycarpum Engelm.
- Sparganium lucidum Fernald and Eames.
- Fam. Najadaceae.
- Potamogeton natans L.
- Potamogeton pusillus L.
- Najas flexilis (Willd.) Rosth. & Schmidt.
- Fam. Alismaceae.
- Sagittaria latifolia Willd.
- Sagittaria heterophylla Pursh.

- Sagittaria latifolia* forma *obtusa* (Muhl.) Robinson.  
*Sagittaria latifolia* forma *gracilis* (Pursh.) Robinson.  
*Alisma* *Plantago-aquatica* L.
- Fam. Hydrocharitaceae.
- Elodea canadensis* Michx.  
*Vallisneria spiralis* L.
- Fam. Gramineae.
- Echinochloa crus-galli* (L.) Beauv.  
*Agrostis alba* L.  
*Calamagrostis canadensis* (Michx.) Beauv.  
*Spartina Michauxiana* Mitch.  
*Elymus canadensis* L.  
*Zizania aquatica* L.
- Fam. Cyperaceae.
- Cyperus rivularis* Kunth.  
*Cyperus ferax* Rich.  
*Eleocharis* sp.  
*Scirpus fluviatilis* (Tour.) Gray.  
*Scirpus atrovirens* Muhl.  
*Scirpus validus* Vahl.  
*Carex cristata* Schwein.  
*Carex vulpinoidea* Michx.
- Fam. Araceae.
- Acorus calamus* L.
- Fam. Lemnaceae.
- Spirodela polyrhiza* (L.) Schleid.  
*Lemna trisulca* L.  
*Lemna minor* L.  
*Wolffia punctata* Griseb.
- Fam. Juncaceae.
- Juncus tenuis* Willd.
- Fam. Iridaceae.
- Iris versicolor*.
- Class. Dicotyledoneae.
- Fam. Salicaceae.
- Salix longifolia* Muhl.  
*Populus deltoides* Marsh.  
*Salix cordata* Muhl.
- Fam. Juglandaceae.
- Carya ovata* (Mill.) K. Koch.
- Fam. Fagaceae.
- Quercus macrocarpa* Michx.

- Fam. Urticaceae.  
*Celtis occidentalis* L.
- Fam. Polygonaceae.  
*Rumex persicarioides* L.  
*Polygonum amphibium* L.  
*Polygonum hydropiperoides* Michx.  
*Polygonum Muhlenbergii* (Meisn.) Wats.  
*Polygonum pennsylvanicum* L.  
*Polygonum Persicaria* L.
- Fam. Ceratophyllaceae.  
*Ceratophyllum demersum* L.
- Fam. Nymphaeaceae.  
*Nymphaea advena* Ait.  
*Castalia tuberosa* (Paine) Green.  
*Brasenia Schreberi* Cmel.
- Fam. Ranunculaceae.  
*Ranunculus delphinifolius* Torr.
- Fam. Crassulaceae.  
*Sedum ternatum* Michx.
- Fam. Rosaceae.  
*Crataegus mollis* (T. & G.) Scheele.  
*Crataegus punctata* Jacq.  
*Pyrus iowensis* (Wood) Bailey.  
*Prunus serotina* Ehrh.
- Fam. Leguminosae.  
*Baptisia bracteata* (Muhl.) Ell.
- Fam. Balsaminaceae.  
*Impatiens pallida* Nutt.
- Fam. Haloragidaceae.  
*Myriophyllum spicatum* L.
- Fam. Umbelliferae.  
*Cicuta maculata* L.  
*Sium cicutaefolium* Schrank.
- Fam. Primulaceae.  
*Steironema ciliatum* (L.) Raf.
- Fam. Oleaceae.  
*Fraxinus nigra* Marsh.
- Fam. Verbenaceae.  
*Verbena hastata* L.  
*Lippia lanceolata* Michx.
- Fam. Labiatae.  
*Teucrium canadense* L.

- Scutellaria lateriflora* L.  
*Scutellaria versicolor* Nutt.  
*Monarda mollis* L.  
*Mentha Piperita* L.  
*Mentha arvensis* var. *canadensis* L.  
*Lycopus uniflorus* Michx.  
*Lycopus virginicus* L.  
 Fam. Scrophulariaceae.  
*Gerardia aspera* Dougl.  
*Gerardia tenuifolia* Vahl.  
 Fam. Lentibulariaceae.  
*Utricularia vulgaris* L. var. *Americana* Gray.  
 Fam. Lobeliaceae.  
*Lobelia siphilitica* L.  
*Lobelia spicata* Lam. var. *hirtella* Gray.  
 Fam. Compositae.  
*Eupatorium purpureum* L. var. *maculatum* L.  
*Bidens Beckii* Torr.

#### AQUATIC RESOURCES

Our lakes are not waste areas. They may be improved and devoted to aquaculture (19) just as readily as they may be drained and devoted to agriculture.

Fish might be profitably raised in an inland lake if certain fundamental features are observed as to their habits. Game fish as pickerel, black bass, etc., frequent deep and cool water in which to hide and rear their young. They avoid a muddy bottom but are associated with sand or gravel. The body of water should be fairly active, having a good source of supply and outlet rather than to remain somewhat stagnant. Other fish such as sunfish, bullheads and carp inhabit comparatively shallow inactive water with muddy bottom. It has been found advisable (21) in the preparation of ponds or lakes for fish culture to use a good loamy soil for the bottom such as is favorable for land plants. In order to raise fish it is necessary to know the kind and quantity of food they eat and whether the body of water under consideration either contains or can produce the required plant and animal foods. Many fishes are supported by very complex food chains which may be varied and are different for the different fishes. Scott (19) states that "a black bass may feed chiefly on minnows, the minnows feed on small crustacea, worms, and insect larvae, and these feed on still smaller animals, plants, and plant debris."

Little Wall Lake with its shallow water and its inadequate supply of water is at the present time best fitted to meet the requirements of raising carp and bullheads. However, these conditions might be modified so that the lake would produce other kinds of fish, but the inability to control the water supply might inhibit change.

Muskrats use quantities of the stems and leaves of rushes, cat-tails and waterlilies in the construction of their homes which are always found in comparatively shallow water. They eat such foods as the tender bulbs and shoots of the arrowhead (*Sagittaria latifolia*), rootstocks of pond lilies (*Nymphaea* and *Castalia*) and cat-tail tubers (*Typha latifolia*), and they are fond of any juicy

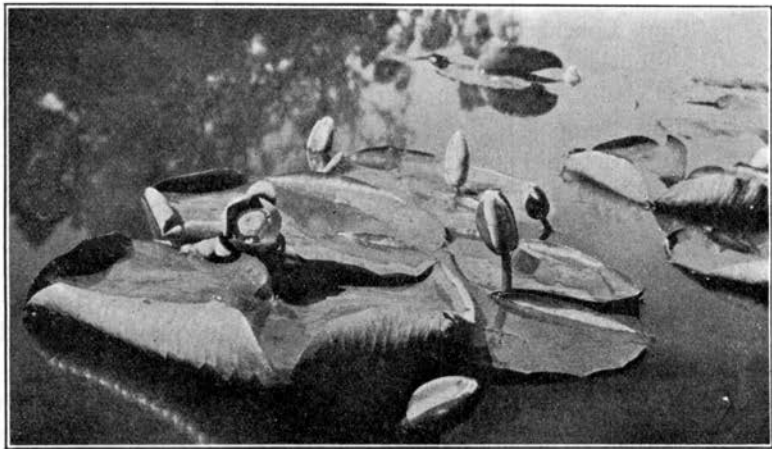


Fig. 15. Flower of *Nymphaea advena* (Yellow pond lily) and buds of *Castalia tuberosa* (White water lily).

aquatic stems or roots. Given an adequate food supply in Little Wall Lake, these animals might prove a valuable source of game.

Under favorable conditions game birds such as wild ducks may be successfully induced to remain in the vicinity of inland lakes. These conditions consist primarily of an adequate food supply and freedom from disturbance. They inhabit ponds, marshes, and shallow lakes which provide tall grasses, sedges and rushes in which to hide and rear their young. The food of wild ducks consists of wild rice (*Zizania aquatica*), wild celery (*Vallisneria spiralis*), duck potato (*Sagittaria latifolia*), pepper grass or water cress (*Nasturtium officinale*), American lotus (*Nelumbo lutea*), nut grass (*Cyperus esculentus*), blue duck millet (*Echinochloa crusgalli*), wild sage (*Potamogeton pectinatus*) and (*Potamogeton natans*).

As has been previously noted, many of these plants are found in this lake area. If this natural food supply is increased by planting, large numbers of wild ducks and geese will probably come to Little Wall Lake to feed and stay.

Klugh, (31) in a survey of the productivity of lakes based on personal observations as well as upon a summary derived from the review of a number of outstanding aquatic life studies, points out that it is highly desirable to search for an "*index character*" of the productivity of lakes. He thinks that undue emphasis has been placed in many papers to correlate productivity with the production of phytoplankton. Phytoplankton however are secondary



Fig. 16. A tern's nest among the rushes.

products, and the manner of their production must be explained in order to interpret the productivity of lakes.

In the literature reviewed, there are suggestions that rooted aquatics play an important part in the productivity of bodies of fresh water. Among those mentioned are *Elodea*, *Potamogeton*, *Vallisneria*, *Myriophyllum*, *Naias*, *Nymphaea*, *Castalia*, *Brasenia*, *Nymphoides*, *Sagittaria*, *Ranunculus*, *Bidens Beckii*, and *Polygonum amphibium*, which are recognized by (Pond 1905) as absorbers of salts, including nitrates, phosphates and potassium compounds. Upon decay of these plants, these salts are added to the water where they become available for the use of phytoplankton. These rooted aquatics add organic compounds to the water, which, in solution, it has been demonstrated by Klugh, Artari, Knorrich, and Snow, augment the growth of planktonic green algae. The



rooted aquatics on decay, contribute very materially to the organic detritus which not only favors the growth of more plants, but forms the food of many aquatic animals. These plants also provide places of attachment for immense numbers of algae, which form the food of many aquatic invertebrates.

## SUMMARY

1. Little Wall Lake is a type of lake found only in the Wisconsin drift area.

2. As in others of its type, this lake is in a transitional state; it is gradually becoming shallower by means of the accumulation of vegetation and the products of erosion.

3. Aquatic plants occur in zones corresponding somewhat to the depth of the water. The lake is surrounded by vestiges of prairie vegetation, the remains of the native cover. The plant associations of the lake manifest a progressive transition from the hydrophytic types including submerged, free-floating, floating-rooted, to marsh, lowland-prairie and upland-prairie types. Only a few trees occur along the northeast shore.

4. The luxuriant vegetation found here is now supporting a relatively small number though a considerable variety of the higher aquatic animals. These undeveloped resources, such as the production of fish, muskrats and wild ducks, if developed, might prove valuable.

5. This lake is rich in quantity of vegetation and number of species of the higher plants including rooting angiosperms. More determinations of the lower biotic forms must be made before correlations could be used in formulating an "*index character*" of productivity for this type of lake.

## ACKNOWLEDGEMENTS

To Dr. L. H. Pammel we owe our introduction to this lake. Through his leadership efforts to secure its preservation have materialized in its inclusion within the State Park System of Iowa. To Mr. R. I. Cratty we are indebted for the identification of the Cyperaceae and for conference regarding some of the aquatic angiosperms; to Prof. J. E. Guthrie for information regarding aquatic resources and to Charlotte M. King for critical comment.

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IOWA STATE COLLEGE,  
AMES, IOWA.

## MANGANESE IN IOWA CITY WATERS

EDWARD BARTOW AND W. T. BAILEY

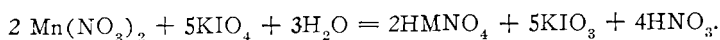
More than thirty years ago Proskauer reported the presence of manganese in many ground waters. For a long time afterward little attention was paid to the subject because it had not been proved that manganese imparted any bad qualities to water. But in 1906, the sudden appearance of iron and manganese in the Breslau water supply (1) in such quantities as to cause it to be abandoned, forced the recognition of the fact that iron and manganese produce like qualities in water. The first water in this country in which manganese occurred in sufficient quantity to cause trouble was from a well supplying a New England mill in 1898. The supply was abandoned. However water supplies containing manganese were regarded as uncommon in the United States previous to 1911, when the attention of the Illinois State Water Survey was called to a serious incrustation which had formed in the city water system of Mount Vernon, Illinois. (2) An analysis showed this to contain 4.4 to 8.8% and the original water to contain 0.6 ppm. manganese. Even at the present time manganese is seldom considered in the selection of a supply.

Manganese in a water supply is objectionable because it deposits a dark incrustation, which is sometimes so extensive as to cause complete stoppage in water pipes. The separation of the dioxide stains plumbing fixtures a dark color, and if a water containing manganese is used for laundry, it stains clothes yellow or brown. It is in these respects that waters containing manganese resemble those containing iron, but the deposits are darker, and more difficult to remove than those produced by waters containing iron.

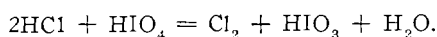
The present investigation was suggested by the finding of a deposit in the water pipes from University of Iowa well No. 2, which is located at the laundry. This deposit showed quantities of  $MnO_2$  as indicated by the evolution of chlorine from HCl. The purpose of the investigation was to determine, if possible, whether or not the manganese occurred in any definite strata, and whether or not it could be eliminated from wells by casing out manganese-bearing waters.

The quantitative methods for determining manganese when present in small quantities are based on the color of the permanganate ion, and are made by the oxidation of the manganous salts as they occur in the water. This was first suggested by W. Crum (3) but P. Pichard (4) was the first to work out the details

for a complete method. The fact that ammonium persulfate oxidizes manganous salts in the presence of silver nitrate was discovered by Marshall (5) about 1901, and was used as a quantitative method for the determination of manganese in iron and steel. In 1915, Corson and Bartow (6) made a comparative study of the quantitative determination of manganese by oxidation with lead peroxide, sodium bismuthate, and ammonium persulfate, and recommended that Standard Methods adopt the persulfate and bismuthate methods. These methods were adopted by Standard Methods and have been generally used. In 1917 H. H. Willard and L. H. Greathouse (7) made a study of the reactions between periodate and salts of manganese,



It was found that if sufficient acid were present, the permanganate ion was always formed, even when considerable amounts of manganese were present. The reliability of this reaction led to the adoption of it for the determination of manganese in iron and steel, and a comparison with the persulfate and bismuthate methods showed slightly better results in quantitative determinations. The chief advantage of the method is the ease with which small amounts of chloride may be removed from solutions containing chlorides by the oxidation of HCl by the periodate.



Since this eliminates the necessity for the removal of chloride by precipitation with silver nitrate and filtration, which is necessary for the persulfate method, and the repeated evaporations in the bismuthate method, we adopted this method for our work. A true permanganate color was always obtained which did not disappear on standing if sufficiently acidic and slight excess periodate were used.

Samples containing known amounts of manganese were prepared for us by W. L. Denman and results were obtained as follows:

TABLE I. MILLIGRAMS MANGANESE PER LITER

THEORETICAL CONTENT	DETERMINED	EXCESS OF DETERMINED OVER THEORETICAL CONTENT
0.40	0.385	- 0.015
0.40	0.390	- 0.010
0.11	0.120	+ 0.010
0.11	0.115	+ 0.005

A comparison with the sodium bismuthate method was also made, using actual samples of water containing manganese, with results as shown in Table II.

TABLE II. MILLIGRAMS MANGANESE PER LITER

PERIODATE	SODIUM BISMUTHATE
0.8	0.8
0.48	0.48
0.55	0.58
0.20	0.190

Method of analysis. 200 cc. of each sample was concentrated to about 10 cc.; after acidifying with 5 cc. concentrated HNO<sub>3</sub>, free from oxides of nitrogen. 5 cc. sirupy phosphoric acid, to prevent iron color interfering, and 5 cc. of concentrated nitric acid were added and the solution boiled a few minutes in an erlenmeyer flask. Then about 0.3 gram KIO<sub>4</sub> was added, and the solution boiled until the maximum color appeared, which usually required but a few minutes. The solution was then cooled, placed in a Nessler jar, diluted to 50 cc. and compared with tubes containing a known amount of permanganate which had been prepared by treating standard solution in the same way. The standard solution was prepared by titrating pure sodium oxalate with permanganate solution until a faint pink color remained, and was allowed to stand until this color disappeared, and was then oxidized with KIO<sub>4</sub> in the same way as the sample. This standard solution when so treated will retain its color two or three months if sufficiently acidic and a slight excess of periodate is used.

Samples from about fifty wells in Iowa City and the immediate vicinity were analyzed and practically all were found to contain small amounts of manganese.

TABLE III. WELLS ENTERING LIMESTONE

LOCATION	DEPTH	PARTS PER MILLION			
		MANGANESE (Mn)	IRON (Fe)	CHLORIDES	ALKALINITY
S. U. I. No. 1	200'	0.04	0.1	8	446
S. U. I. No. 2	150'	0.48	0.2	8	331
S. U. I. No. 3	400'	0.04	0.1	7	311
Jefferson Hotel	185'	0.15	0.2	10	330
Teeters'	180'	0.08	0.1	8	385

The three university wells, the well at the Englert Ice Plant, the one at the Jefferson Hotel, and the one at Dean Teeters' home are all drilled wells extending some depth into the underlying limestone, and located only a few blocks apart. Two of the S. U. I. wells show .04 ppm. manganese, the one at the Teeters' residence

.08 ppm., the Jefferson Hotel well and the Englert well 0.14 and 0.15 ppm., while the other university well shows 0.48 ppm., or more than three times as much manganese as the Englert well and twelve times as much as the other two University wells.

TABLE IV. WELLS IN GLACIAL DRIFT LOCATED IN EAST IOWA CITY

DEPTH	PARTS PER MILLION			
	MANGANESE (MN)	IRON (FE)	CHLORIDES	ALKALINITY
85'	0.13	6.0	10	245
62'	0.18	1.2	7	260
56'	0.15	2.4	9	220
60'	0.15	4.0	14	245
60'	0.25	1.4	4	250

The next five wells located on the lower Muscatine road are only about one hundred yards or so apart, and all are in the glacial drift. With one exception the manganese content is very nearly the same. This well contains 0.25 ppm., whereas the others contain .13 to .18 ppm. Since these waters come from the same source, the glacial drift, this would be an indication that manganous salts were present in greater quantities near this particular well. The fact that the iron content of these wells varies from 1.4 ppm. to 6.0 ppm. would also indicate that the distribution of metallic salts in the soil was not uniform.

Analyses of samples from dug wells from 28' to 45' showed no manganese. In such wells manganese, if present, would be subjected to oxidation and would be precipitated as manganese dioxide.

TABLE V. ALLUVIAL DRIFT AND RIVER

SOURCE	PARTS PER MILLION MANGANESE (MN)
Infiltration gallery	1.8
Low lift pump	1.6
Entrance to mains	0.8
River	0.2

The water supply of the city water company was next analyzed. This supply is taken partly from an infiltration gallery along the river, partly from ten flowing wells 150' deep, and the rest from the river. The infiltration gallery showed a content of 1.8 ppm. manganese, the river 0.2 ppm., but no sample could be secured from the wells.

The fact that wells located in the glacial drift contain a fairly large amount of manganese together with the extremely large amount found in the infiltration gallery would indicate that the

manganese occurs largely in glacial and alluvial drifts. H. P. Corson (6) found not more than 0.08 parts per million manganese in wells entering limestone in Illinois. The presence of fairly large amounts of manganese in such wells in Iowa City might be explained by the fact that the limestone is not solid, but contains many large crevices through which soil waters may be carried into wells.

Our results indicate that manganese may be concentrated in pockets, as is true of iron, and that it would be impossible to predict where a well might be located to secure a water free from manganese except perhaps in deep wells in rock. Inasmuch as five wells penetrating limestone to depths of from 180' to 400' show less than 0.1 ppm., it might be possible to prevent manganese-bearing waters from entering such a well by having a good junction of the casing to shut out the waters from the drift.

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