Spencer, David L
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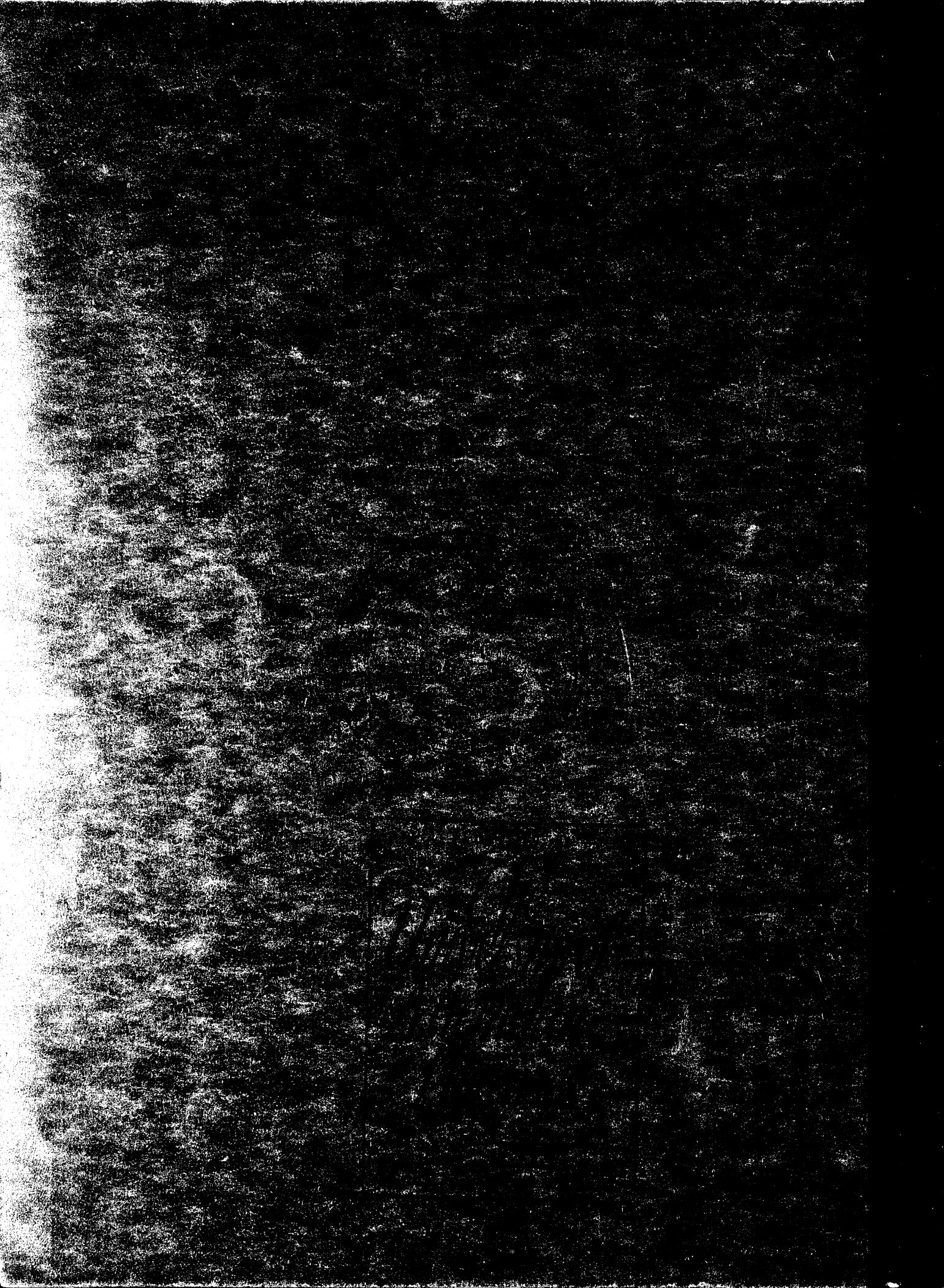

THE VALUE OF KETTLEHOLES TO WILDLIFE IN SOUTHERN MICHIGAN

David L. Spencer

"A dissertation submitted in
partial fulfillment of the requirements
for the degree of Master of Forestry
in the University of Michigan."

Ann Arbor, Michigan June 17, 1940

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ACKNOWLEDGEMENTS

Grateful acknowledgement is extended to Professor H. M. Wight under whose direction this study was undertaken. Thanks is given to Professor S. A. Graham and Professor E. C. O'Roke for many helpful suggestions and to various members of the Botany, Geology and Zoology Departments for guidance in the study of many phases of this problem.

CONTENTS

(Field maps in Copy # 1)

TABLES

FIGURES

The Value of Kettleholes to Wildlife in Southern Michigan

INTRODUCTION

In the intensively farmed lands of southern Michigan, suitable habitats for wildlife are scarce in many sections because much of the land is heavily cultivated. Small areas favorable for game are to be found along streams, fencerows, and in woodlots and marshes. Frequently these are heavily grazed or brushed out in the interests of clean farming. Notable among sanctuary areas for game in this farming country are small glacial depressions known as kettleholes. These are undrained, swampy areas often containing much brush and rank herbaceous growth. Because of the great expense entailed with making these areas suitable for any farming activity, they are often left untouched. The unspoiled nature of these habitats makes them admirably suited for wildlife of many kinds. Often they may be improved for wildlife at a low expenditure of money and labor in making slight changes in them such as; exclusion of grazing, planting of small food patches, and the introduction of various cover plants.

It is the purpose of this study to obtain general information on kettleholes rather than any specific data on any one phase of them. Emphasis will be laid on their

value to wildlife and from the knowledge gained in the investigation, an attempt will be made to recommend such improvements as will be consistent with good farming practices and which will benefit wildlife to the fullest possible extent.

This study will be concerned only with those small kettleholes that are important in farm management. Lakes and extensive swamp areas that may be of the same origin as kettles will not be studied, as this is another phase of wildlife management.

Although only 50 kettleholes were intensively mapped and studied, a great many more were observed to study the variations in them and to get a broad knowledge of all the kettlehole conditions in this region.

PHYSICAL CHARACTERISTICS

Geology

Although any undrained depression due to any cause might be considered a kettlehole, the type most frequently encountered are those that have been formed 25,000 to 50,000 years ago during the Pleistocene by glacial action. Kettles in southern Michigan were formed by the Labrador Ice sheet. The most common cause of these glacial kettleholes is the melting of ice blocks which have been separated from the glacier during its retreat and covered with morainic debris and outwash material. When these ice blocks happen to be in line of overloaded glacial drainage, they are covered to a greater or lesser degree by debris. They melt with extreme slowness because of the poor conduction of heat by the deposits. When the process of melting was prolonged until the drainage line was abandoned or the stream ceased depositing, melting brought about a settling of deposits and the formation of a depression. The condition of the surface level before and after melting of the ice block may be seen in Figure I.

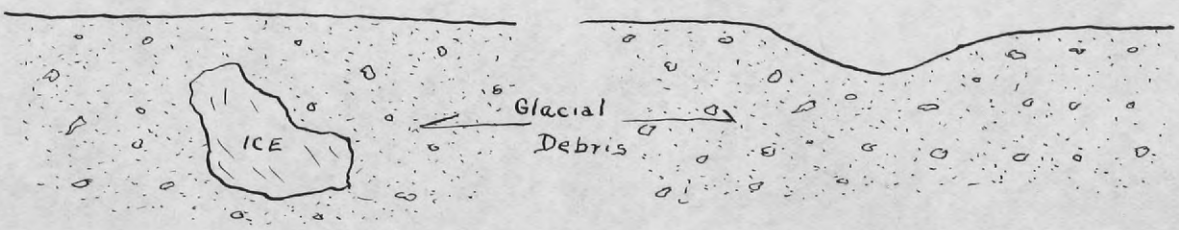


Figure I

This type of kettle may be formed on terminal morains, ground morains, or outwash plains. A similar type may be formed in old glacial lakes where icebergs were once buried under sediments carried into the lakes by streams.

Some kettles are formed in kame regions--hills of stratified glacial debris deposited along the margins of the ice sheet by glacial waters. These kames are commonly 50-150 feet in height. Deep depressions occurring between the hills give rise to a knob and kettle topography. The general effect is similar to that produced by dumping truckloads of gravel closely together. The kettles in these regions may occur in all situations from the low, poorly-drained ground between the hills to the tops of the highest eminences.

Figure 2

Kame Kettleholes

Other kettleholes may result from irregular deposition of glacial debris. These are merely depressions in the

surface of the drift and commonly develop on flat or slightly hilly morains.

Kettles are also formed in regions of existing glaciers as in Alaska. Larger kettleholes, often containing lakes of several hundred acres in extent, are known as pit lakes.

Formations which are sometimes similar to kettleholes in outward appearance are the sink holes formed in limestone regions. Subsurface water acts as a solvent on limestone, gypsum and salt bearing strata. A portion of the underlying limestone may be dissolved, resulting in a collapse of the surface material so that a depression is formed. These sink holes have underground drainage. They differ from kettleholes in that they have good underground drainage, no peat formation, and are basic, whereas kettleholes have poor drainage, peat formation and are usually acid.

Such depressions as quarries, ore, gravel and clay pits formed by man's activities may resemble kettleholes in appearance. They are usually not damp because of their position on morains and kames and the high permeability of underlying material.

It is then possible to make the following classification of kettleholes or kettlehole-like depressions based on the method of formation:

I True Kettleholes

A. Those formed by melting ice blocks and located on:

1. Terminal morains
2. Ground morains
3. Outwash plains
4. Old glacial lake bottoms

B. Those formed by uneq ual deposition of debris and outwash material:

1. Kame kettles
2. Flat and slightly hilly morain kettles

II Kettlehole-like Depressions

A. Sink holes

B. Man-made depressions

In washtenaw County, Michigan, the terminal morain kettle is the type most freq uently encduntered. Kame kettles and ground morain kettles were observed to a lesser degree, while few outwash plain kettles were found. No kettles were seen in the old glacial lake bottom in the southeast corner of the county. The kettles in morains resulting from unequal deposition of debris and those formed by melting ice blocks could not be distinguished by a superficial field examination. Gravel pits are common in this region.

The extent of glaciation in the United States is shown in Figure 3. Kettleholes may be found throughout this region.

Present Description

Size

Kettleholes in southern Michigan vary in size from

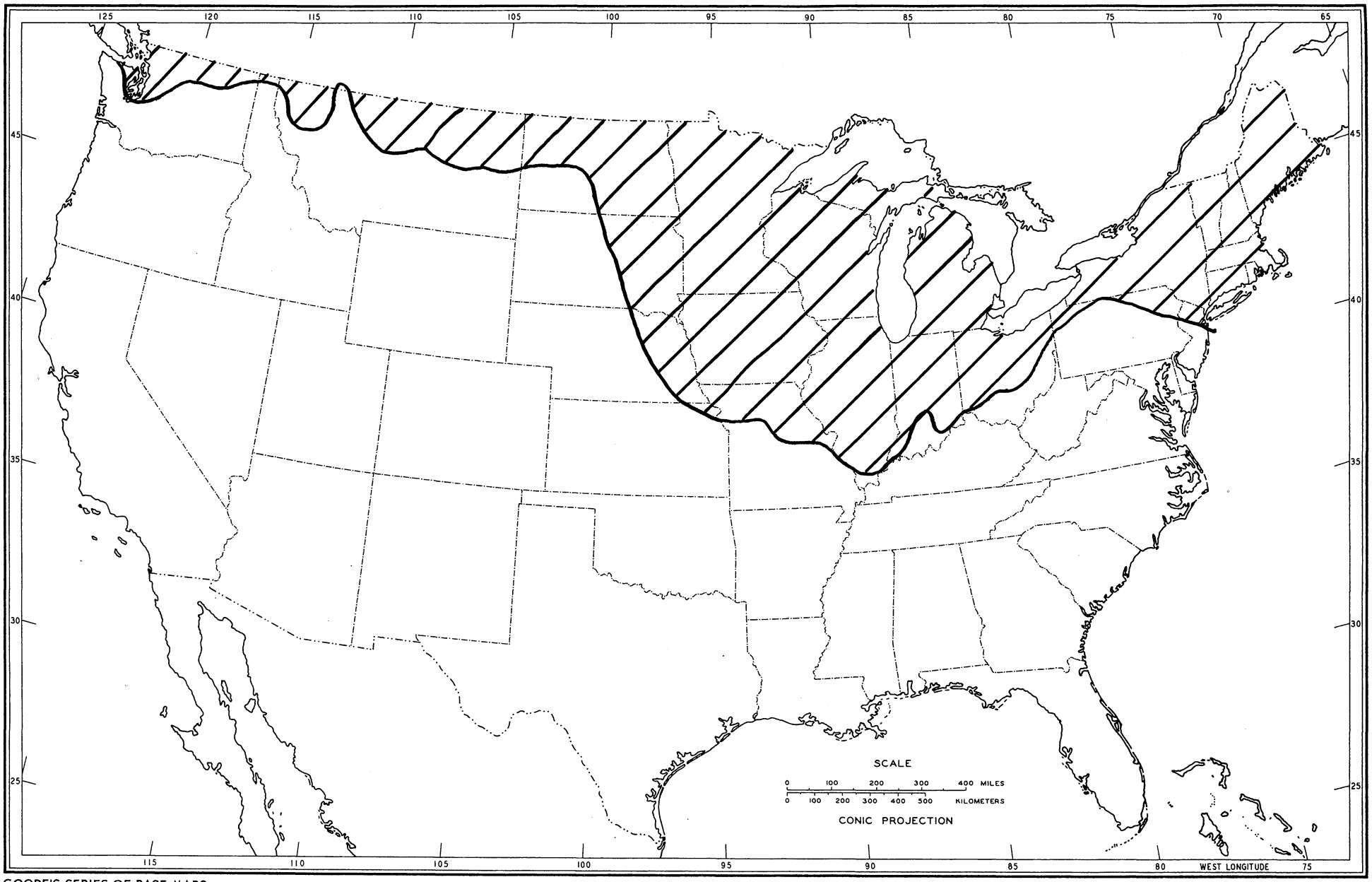


Fig. 3

Glaciated Region of U.S.

Coleman (1926)

less than one tenth of an acre to several hundred acres. The size most frequently encountered is less than one acre. The average size of 50 kettles selected at random in Washtenaw County is 1.53 acres. The following table shows the distribution of sizes of the 50 kettles measured:

Table 1

Size	No. of kettles
Below ½ acre	21
½--1 acre	9
1--2 acres	7
2--3 acres	7
3--5 acres	3
5--11 acres	3

Side Slope Percent

Side slope varies greatly in the individual kettle, particularly in the case of those situated on hillsides. Side slopes within an individual kettle may vary from 3% on one side to 30% on another. Fifty kettles having fairly uniform side slopes were measured with an Abney level and the average slope for each kettle computed. The number of kettles in each percent slope class is indicated in the following table:

Table 2

Slope %	No. of Kettles
Below 3 %	11
3--5 %	12
5--10 %	17
10--15 %	4
15--25 %	2
Abrupt drop	4

The greater number of kettles had slopes below 10 percent. The lowest slopes were on ground morains and outwash plains. The highest slopes were on terminal morains and in kames. No correlation of side slope with existing vegetation was observed. Previous usage, such as drainage, cultivation, and grazing probably has some effect on degree of side slope.

Depression Below Surrounding Land

The depression is a vertical measurement from the level of the surrounding land to the floor of the kettle. Fifty kettles that appeared to have a definite depression were measured. In many cases this was done by sighting to a point on a tree from the surrounding land surface. Later, the height from the point on the tree to the floor of the kettle was measured. In some cases where this was impossible, measurements were taken with an Abney level. The average depression for the 50 kettles was 9 feet. The

distribution of depression depths was as follows:

Table 3

Depression	No. of Kettles
Under 5 feet	14
5--10 feet	16
10--15 feet	13
15--20 feet	3
20--30 feet	4

The greatest depressions were encountered in terminal morains and kames.

Numbers of Kettles and Percent of Land Area:

Portions of 10 townships in Washtenaw County that had been cover mapped were studied as to the numbers of kettles. The following table shows the numbers in these townships:

Table 4

No. Sects. in Plot	No. Kettles	Average No. Kettles per Sect.
36	113	3.1
33	74	2.3
30	104	3.5
26	135	5.2
36	56	1.6
36	93	2.6
42	268	6.4
33	117	3.6
22	54	2.5
18	36	2.0

The average number of kettles per section was 3.3, and the average number to the township about 120. Assuming a figure of 1.53 acres as an average size for a kettle, the

portion of the total area in kettles is 0.8 percent. Figures 6 and 7 show the distribution of kettles in two townships in Washtenaw County.

Water Level

Permanence of water level in kettleholes varies with the position in regard to ground water table and the permeability of underlying soils. Many kettles are permanently filled with water. Others contain water for only a brief period in the spring, often when the ground is still frozen so that water will not drain out. All gradations between these occur. Those having permanent water are usually located at low elevations with regard to the surrounding land and at points below which the ground water table will not fall. The water table is the surface below which soils and rocks are saturated with water. The relation of the ground water table to hilly topography may be seen in Figure 5.

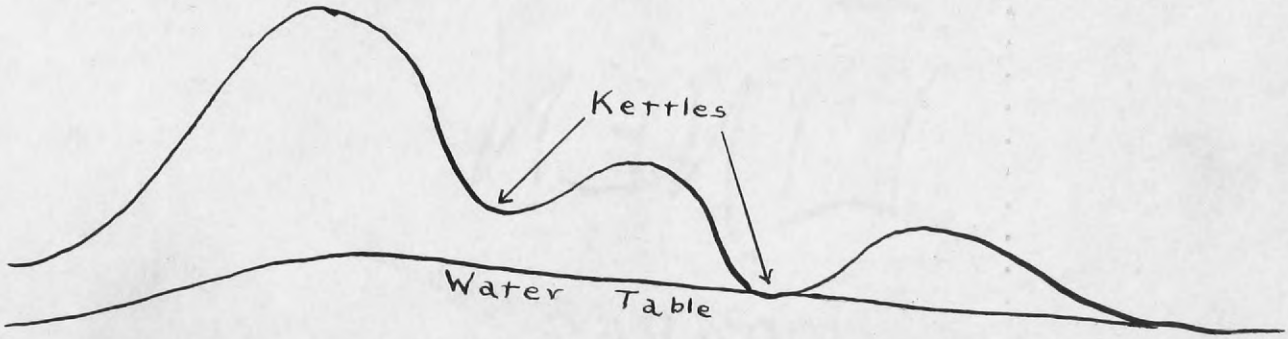


Figure 5

Ground Water Table

Webster Township

Northfield Township

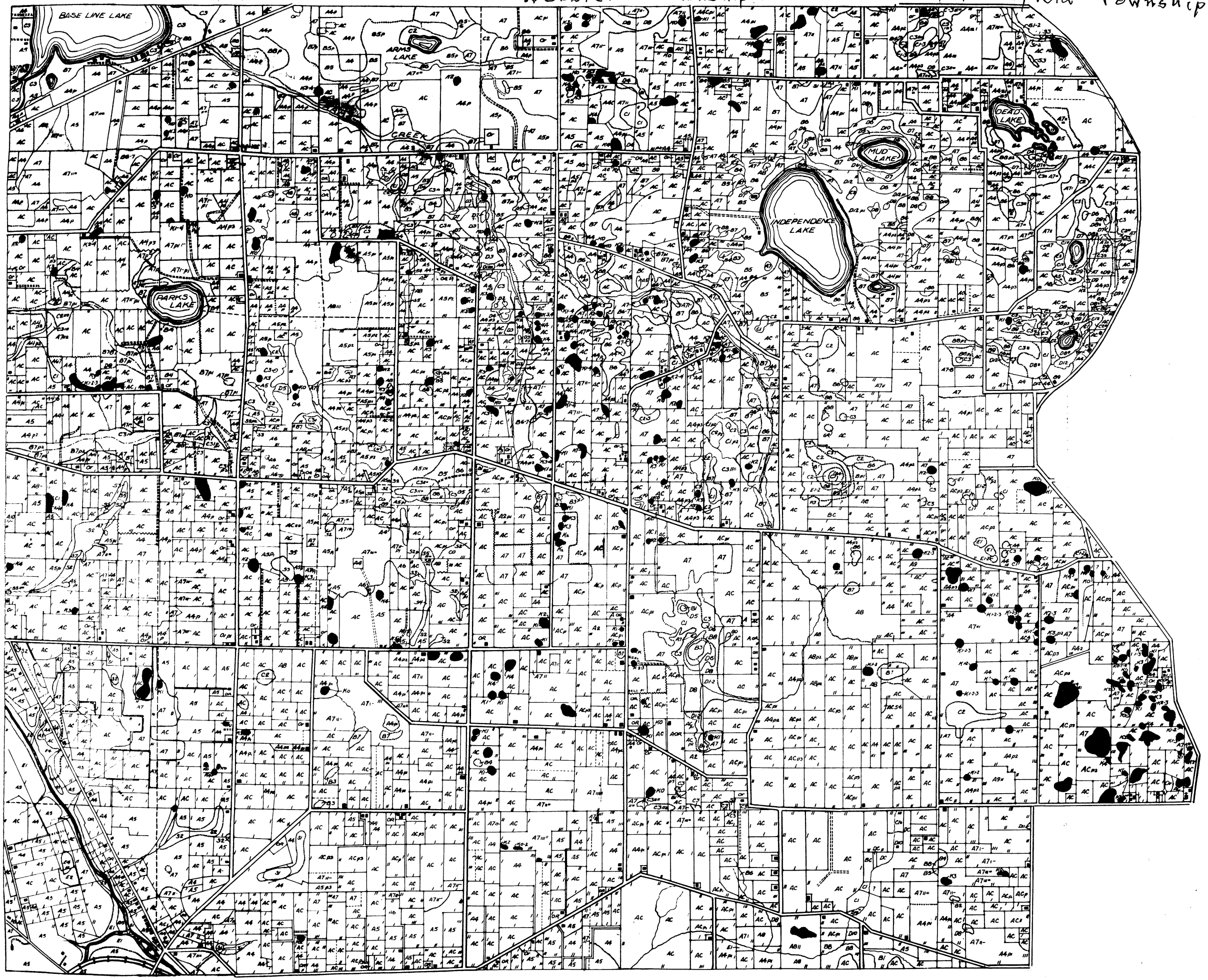
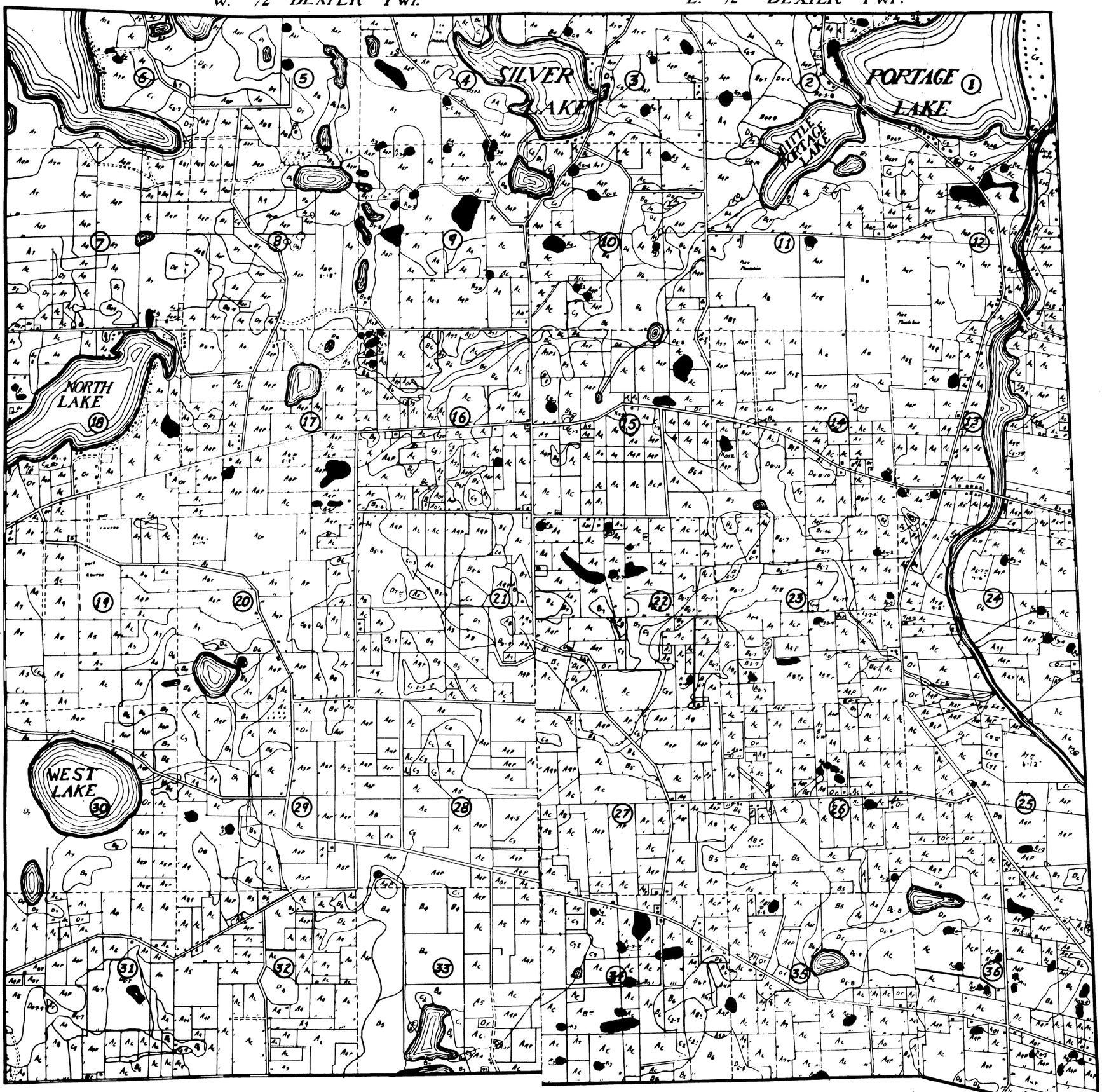


Fig. 6. ● — Kettle


W. ½ DEXTER TWP.
E. ½ DEXTER TWP.
SILVER LAKE
PORTAGE LAKE
LITTLE PORTAGE LAKE
NORTH LAKE
WEST LAKE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
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24
25
26
27
28
29
30
31
32
33
34
35
36

Fig. 7 ● — Kettle

The water table will be raised during periods of prolonged precipitation and lowers steadily during periods of dry weather. Ponds will be formed in kettles where the ground surface passes below the water table at these points. Water will then be found in kettles when precipitation causes the water table to rise above the kettle level. During dry periods the water table may sink below the surface of the kettle and the water will drain out. Borings disclosed the fact that in some kettles there was a layer of heavy clay below the organic deposits and above other mineral soil. These impervious subsurface layers would hinder the drainage and retain the water for a long period, even though the water table was below the surface. Other kettles were found to be underlain by sandy soils and would drain out rapidly.

Duration of water within the individual kettle from year to year varies with the amount of rainfall. Most of the kettles in this region are temporary ponds, filled with water for a few months in the spring.

Soil Formation

All kettleholes are underlain by drift, deposits of glacial origin. This drift is heterogenous material ranging

from fine clay and sand to large boulders. Most of these deposits were laid down during the retreat of the glacier and may have been deposited as stratified debris by glacial waters or as morains. The original soil found on ground morains was formed under the glacier during its melting and retreat. It is unstratified and usually of fine materials interspersed with pebbles and boulders. Terminal morains, formed where the terminus of a glacier remains in one position for a long time, are composed of unstratified coarser materials with more gravel. Outwash plains, formed by glacial streams spreading out over a wide area, are stratified and of fine material. Kettleholes are to be found in all these situations and with original soil of varying materials from fine clay to sand and gravel.

The present soil in kettleholes is usually organic, that is some stage of peat or muck. Some kettles, located on dry sandy situations, will have little or no peat formation because of the high rate of decomposition of plant materials. Others in damp situations have formed peat to a depth of several feet. Rate of peat formation depends on the scarcity of oxygen below the water level, acidity of ground water, and the occurrence of low temperatures. Peat, which consists of partially decomposed vegetable remains, owes its existence to the fact that the rate of decomposition of vegetable material varies greatly under various conditions. Perfectly dry vegetable matter will

remain unchanged indefinitely in dry air. Also, vegetable matter will keep for long periods entirely submerged in water. Decay is due to the growth of bacteria and fungi which use material in vegetable tissue for nourishment and growth. These bacteria and fungi require both air and moisture in order to grow. Too much water is detrimental to their growth, and without air they cannot survive. Kettleholes are in damp enough locations to provide for some decay. However, most of them contain too much water to provide entirely favorable conditions for decay organisms. Because of these unfavorable conditions, a slow and partial decomposition may take place, leaving the more resistant compounds of the vegetable matter unchanged. This is the condition encountered in many kettles. Some kettles that do not retain much moisture, permit decay to take place more completely, thereby forming little or no peat. Many contain muck, similar to peat but more thoroughly decomposed and containing considerable mineral matter.

Peat formation consists of two processes: (1) cremacausis and (2) putrefaction. Cremacausis, which occurs on the surface and promotes plant growth, is an oxidizing process. It is carried on in the presence of air by fungi and bacteria. The products are used as food materials for plant growth. Putrefaction, carried on below the surface, is essentially reduction. It is carried on in the absence of

air by anaerobic bacteria. The products of this process are of no value to plants as food.

The chemical composition of peat varies greatly, but in general consists of 50-60% carbon, 30-40% oxygen, 5-7% hydrogen, and 1-3% nitrogen. Other materials, known collectively as ash, include some metallic elements. Peat in its natural state is acidic because of the presence of organic acids. Humic acid is the main acid to be found in peat. Ulmic and ulmin acids are early products of decomposition, and crenic and apocrenic acids are further oxidization products. Other acids in peat are xylic, saccharic and glucinic. Basic waters from surrounding lands form a zone around the edges of kettles that results in basic soil and increases rate of decomposition of vegetable materials. In the case of very small kettles, this basic zone may extend across the entire kettle.

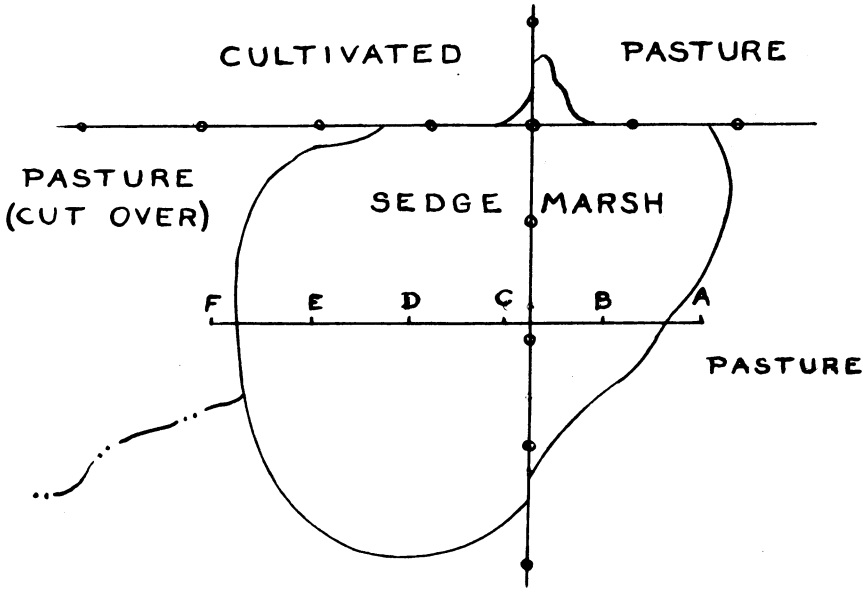
In order to study the formation of soil in kettles more completely, a sampler or sounder was constructed somewhat on the principle of the Davis Peat Sampler. With this sampler, pure samples could be brought up from any given depth in a peat deposit. This instrument proved to be entirely satisfactory and cores of peat or marl were brought up from depths to 35 feet. Profile studies were undertaken on two kettles, numbers 26 and 32. Borings were made at stations located at one chain intervals along a line extending across

the kettle. Samples of the soil were taken at each of these stations at the ground surface, 2 feet, 6 feet and at 4 feet intervals until mineral soil was reached or until the marl became too hard to allow the sampler to penetrate. Samples were labled and brought into the laboratory for examination. Figures 8 and 9 illustrate the results of the profile studies on number 26 and number 32 respectively.

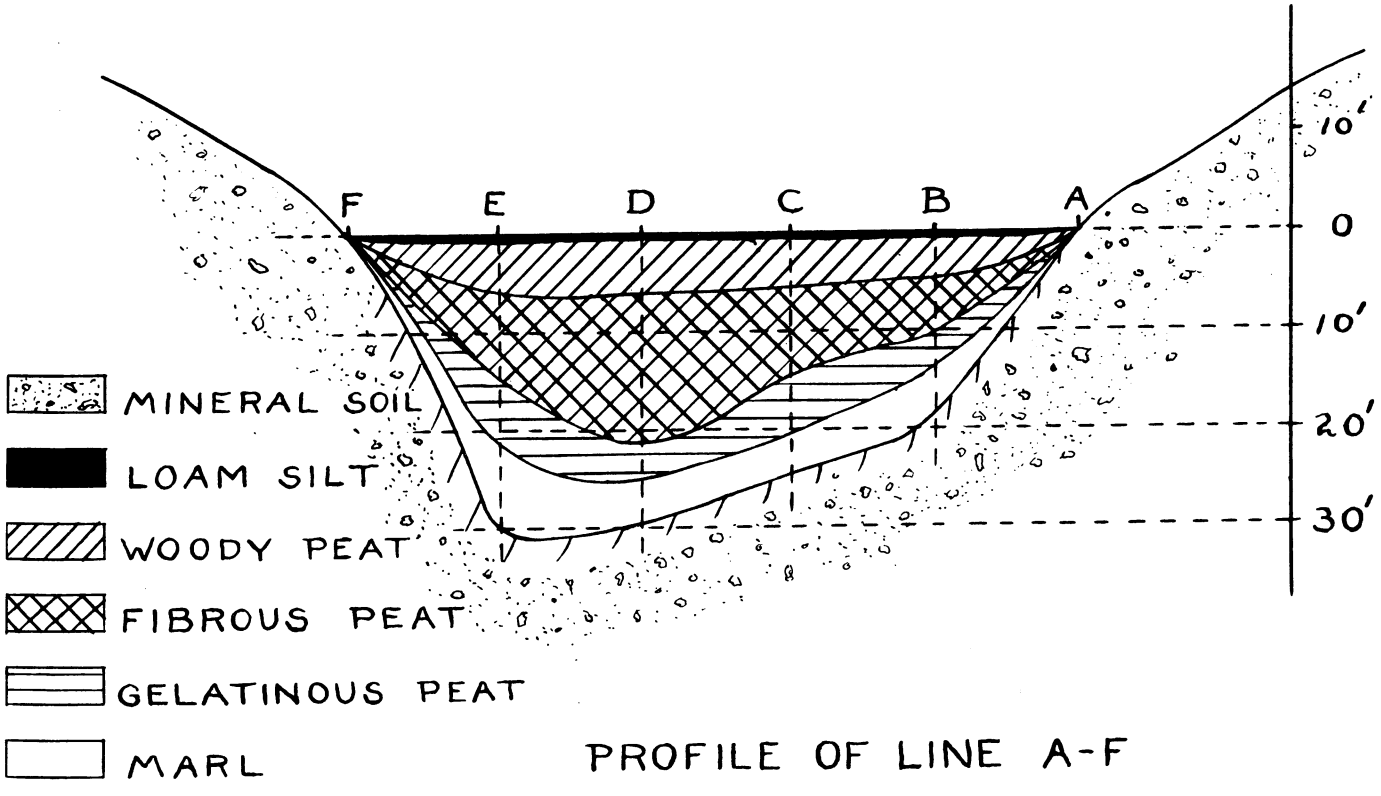
In the case of kettle number 26, six classes of soil are designated. Mineral soil consisted of the soil free from organic material that was found on land surrounding the kettle. Loam silt was mineral soil which had been washed on to the top surface of the kettle by drainage waters. Woody peat consisted of that peat which appeared to be derived from woody plants. It was probably deposited before the timber was cut from the surrounding land. Fibrous peat contained roots, fibers and parts of plant materials and was deposited by herbaceous plants such as sedges, reeds and mosses. Gelatinous peat was that peat in which no definite plant structures could be distinguished. It was laid down by small water plants such as algae and diatomes. Marl, a calcareous material, is derived from calcium and other mineral salts in glacial clays that are carried into the kettle in solution by streams and underground waters. Here various agencies cause these minerals to be redeposited in a calcium carbonate formation on the bottom of the kettle. Some of the causes for this precipitation of minerals are

FIG. 8

PROFILE STUDY OF KETTLE NUMBER 26

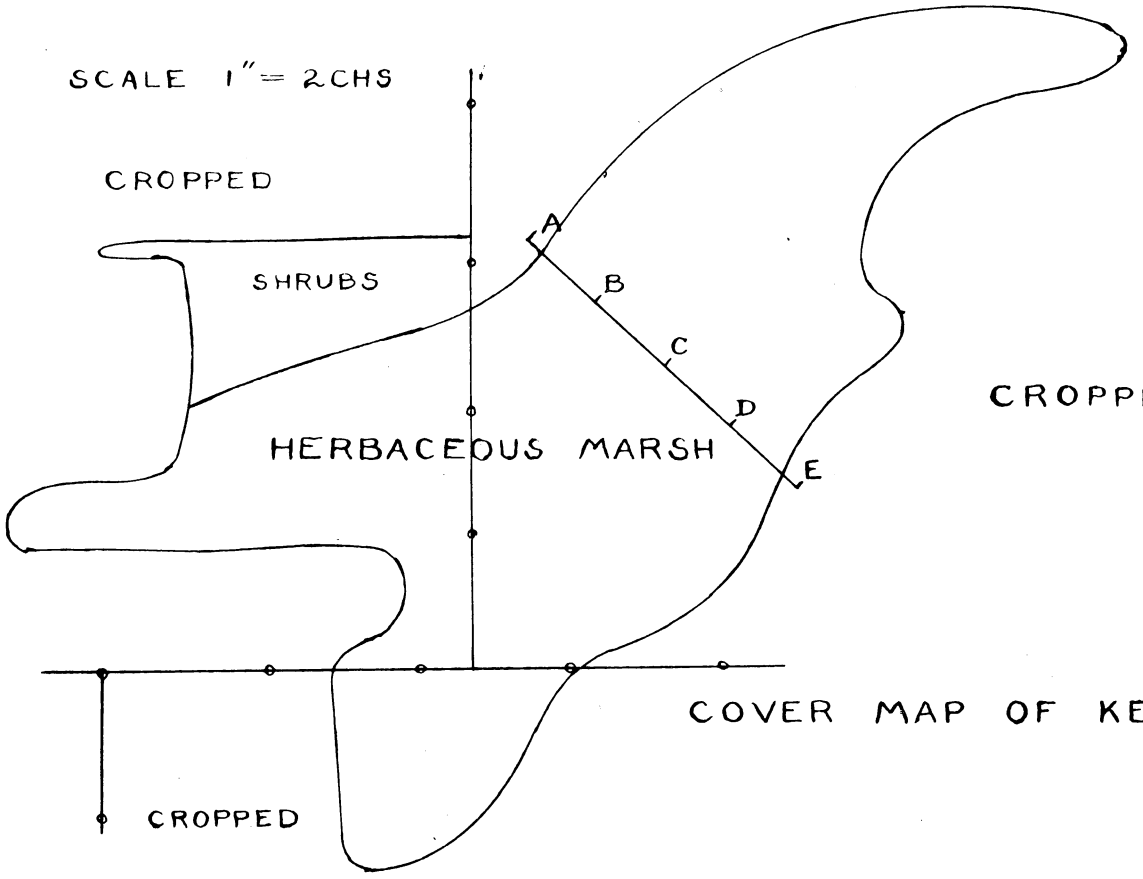


COVER TYPE MAP OF KETTLE

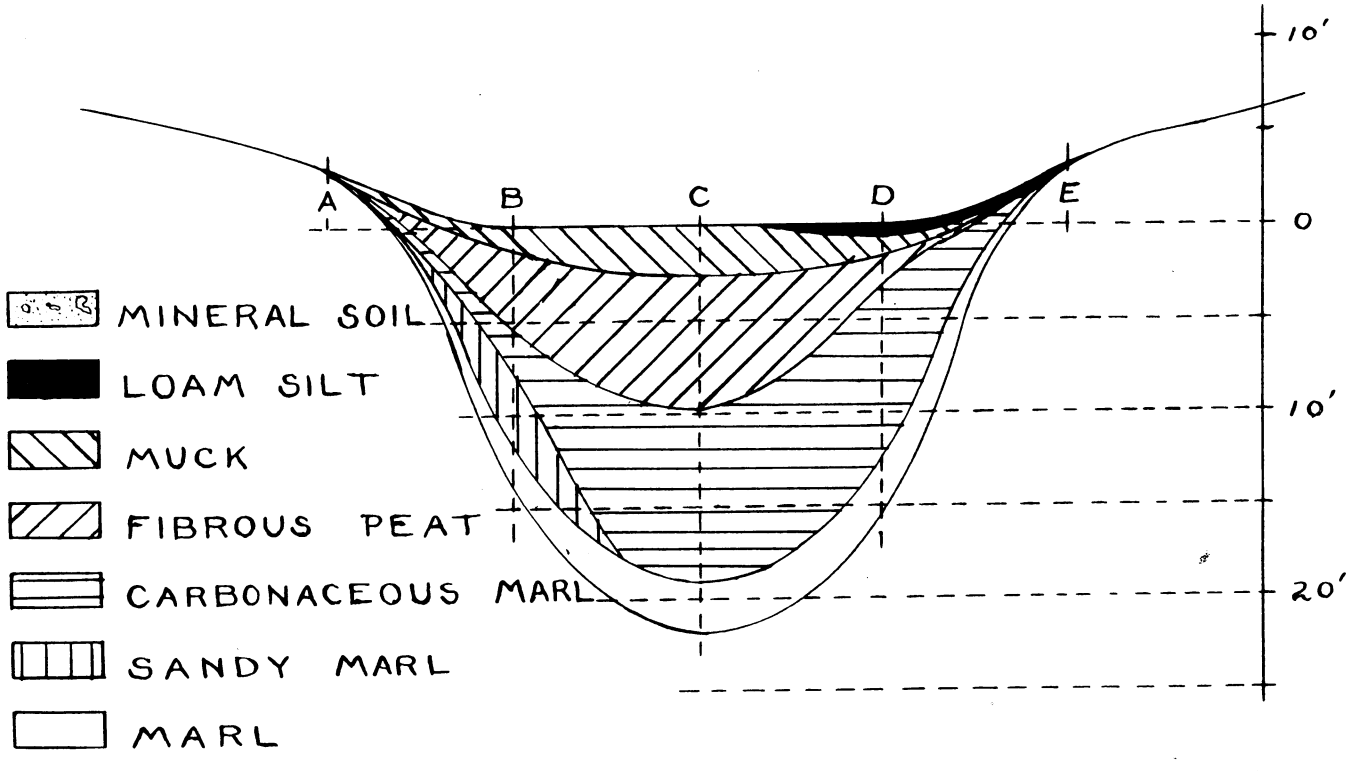


PROFILE OF LINE A-F

PROFILE STUDY OF KETTLE #32



COVER MAP OF KETTLE



PROFILE OF LINE A-E

FIG. 9

the variations in water temperature and the taking up of carbon dioxide from the water and the giving off of oxygen by various plants, namely Chara and Algae. Marl is deposited on the bottom, on these plants, and on various other materials in the water. This precipitated calcium carbonate gradually comes to rest on the bottom. In some cases the sampler would not penetrate the harder portions of the marl, but it is thought that these deposits were close to mineral soil. The nature of the samples indicated that this may have been at one time a bog lake.

Kettle number 32 exhibited similar formations as number 26, and in addition a material identified as carbonaceous marl, a marl containing considerable organic matter and shell remains. At station B, a layer in the marl at 8 feet was found to contain mainly sand, indicating that at some time in the past, outside waters had washed in a considerable amount of this material.

Borings were then made in 25 kettles selected at random to learn something of the depth and nature of the organic soil formation. Borings were taken in the approximate center of the kettles. Table 5 gives the results of this investigation

It will be seen from this table that no definite correlation exists between organic soil depth and area or existing type. In the three cases where kettles containing permanent ponds were sampled, a hard layer of soil, usually clay, was found at the surface with not much organic deposit. A few kettles were observed where mineral soil had silted in forming a hard layer of this material over a deposit of organic soil.

Table 5

Organic Soil Depth in Kettleholes

No.	Kettle Description: Type	Area	Organic Soil: Depth	Substratum
1	Sedge marsh	½ a.	1 foot overlain by 6" hard clay	clay
2	Buttonbush	2 a.	10 feet	sandy clay
3	Buttonbush permanent pond	2.5 a.	None	hard clay
4	buttonbush	1/20 a.	8 feet	hard clay
5	buttonbush	1.5 a.	10 feet	marl
6	sedge marsh	2 a.	6 feet	soft clay
7	buttonbush (perm. pond)	2 a.	0--1½ feet--hard loam 1½--4 feet + --hard woody peat	
8	buttonbush	1.3 a.	2 feet muck	boulder clay
9	sedge marsh	1/10 a.	6 feet	marl at 8 feet sandy below 8 feet
10	herbaceous	1/10 a.	None	0-1 foot-+ --hard loam
11	herbaceous	1 a.	5 feet	marl, sandy at 7½'
12	sedge marsh	½ a	None	0-6' loamy muck 6-7' clay
13	herbaceous	1/10 a.	None	0-1' + hard muck & loa
14	Herbaceous	½ a	6 feet muck	sandy clay
15	buttonbush	½ a.	8 feet	sandy boulder clay
16	leatherleaf	5 a.	26 feet	marl
17	buttonbush (perm. pond)	1 a.	None	hard clay
18	herbaceous	1.5 a.	5 feet	hard clay
19	cattail marsh	2 a.	5 feet	hard clay
20	sedge marsh	1.5 a.	24 feet	marl
21	herbaceous	3.5 a.	18 feet	marl
22	buttonbush	1 a.	8 feet	marl
23	sedge marsh	1.5 a.	12 feet	marl
24	buttonbush	1.a.	6 feet	sandy clay
25	herbaceous	½ a.	4 feet	sandy clay

BIOLOGICAL CHARACTERISTICS

Vegetation

Method of Study

In making a study of the vegetation, 50 kettle holes were mapped and described as to types within the kettle. Species found to occur in a kettle hole were listed on the map using a symbol derived from the scientific name of the plant. Definite vegetative types within the kettle were separated by type lines. Dominant vegetation within the type was designated by underlining the symbol on the map. Table 6 shows the vegetation encountered in kettle holes and the symbols used for each. Land surrounding the kettle-hole was mapped, using the method of cover mapping based on ecological succession that was developed by Wight (1934).

The scale used on the map varied with the size of the kettle and was indicated on the map. On the data sheet accompanying the map, the location of the kettle as to township, section and location within the section was noted. Areas were computed later with a planimeter. Approximate slope of the sides and depression from the surrounding land were taken. Other notes were taken on the vegetation, surrounding land and water if present. Observations were made of wildlife and wildlife signs at the time of mapping. The

Table 6

Plants Found in Kettleholes or Closely Associated with Them

Trees:

Symbol	Scientific Name	Common Name
Sal	Salix sp.	Willow
Ar	Acer rubrum	Red Maple
As	Acer saccharinum	Silver Maple
Fa	Fraxinus americana	White Ash
Fn	Fraxinus nigra	Black Ash
Fp	Fraxinus pennsylvanica	Green Ash
Pop	Populus sp.	Aspen & Cottonwoods
Ua	Ulmus americana	American Elm
Qb	Quercus bicolor	Swamp White Oak
Cc	Carpinus caroliniana	Blue Beech
Ov	Ostrya virginiana	Hop Hornbeam
Ll	Larix Laricina	Tamarack
Jv	Juniperus virginiana	Red Cedar
Pm	Picea mariana	Black Spruce
Pc	Picea canadensis	White Spruce
Jc	Juniperus communis	Common juniper

Shrubs

Cr	Crataegus sp.	Hawthorn
Py. c	Pyrus coronaria	Wild Crabapple
Spi.	Spirea Sp.	Spirea

Shrubs (Cont'd)

Symbol	Scientific Name	Common Name
Sc	Sanbaucus canadensis	Elderberry
Cs	Cornus stolonifera	Red Osier Dogwood
Cp	Cornus paniculatum	Gray Dogwood
Ros	Rosa sp.	Rose
Vit	Vitus sp. (vulpia)	Grape
Co	Cephalanthus occidentalis	Buttonbush
Rl	Ribes lacustre	Swamp Gooseberry
Iv	Illex verticillata	Michigan Holly
Am	Aronia melanocarpa	Choke Berry
Vc	Vaccinium coryombosum	High-bush Blueberry
Hv	Hamamelis virginiana	Witch Hazel
Pq	Psedera quin quefolia	Virginia Creeper
Ba	Benzoin aestivale	Spicebush
Rv	Rhus vernix	Poison Sumach
Rg	Rhus glabra	Smooth Sumach
Vl	Viburnum lentago	Nannyberry
Ch. c	Chamaedaphne calyculata	Leatherleaf

Herbaceous

Grasses:

Cal	Calamagrostis canadensis	Blue Joint
Ec	Echinochloa crusgalli	Wild Millet
Pa. c	Panicum capillare	Witchgrass

Grasses: (Cont'd)

Symbol	Scientific Name	Common Name
Set	Setaria glauca	Pigeon Grass
Eh	Eragrostis hypnoides	Eragrostis
Aa	Alopecaries	Foxtail

Rushes, Sedges, etc.:

Je	Juncus effusus	Common Rush
Jt	Juncus tenius	Pasture Rush
Elo	Eleocharis obtusa	Spike Rush
Elo a.	Eleocharis acicularis	Small Spike Rush
Car	Carex sp.	Sedge
Da	Dulichium arundinaceum	Sedge
Sc. c	Scirpus cyperinus	Wool Grass
Iri	Iris sp.	Iris
Tl	Typha latifolia	Cattail
Sd	Solanum dulcamara	Red-berried Nightshade
Bid	Bidens sp.	Spanish Needle
Sol	Solidago sp.	Goldenrod
Sol. s	Solidaga sijancea	Marsh Goldenrod
A Pa	Alisma Plantago-aquatica	Water Plantain
Pol	Polygonum sp.	Smartweed
Ast	Aster sp.	Aster
Vh	Verbena hastata	Blue vervain

Rushes, Sedges, etc. (Cont'd):

Symbol	Scientific Name	Common Name
Va	Verbena articifolia	Vervain
Pr	Potentella recta	Five-finger
Pv	Prunella vulgaris	Heal-all
Mf	Monarda festulosa	Wild Bergamot
Lc	Leonurus cardiaca	Motherwort
Pa	Polygonum arifolium	Tear Thumb
Gal	Galium sp.	Bedstraw
Ip	Impatiens pallida	Jewelweed
Tri	Trifolium sp.	Clover
Ca	Cirsium arvense	Canadian thistle
Xc	Cocklebur	Xanthium canadense
Epi	Epilobium sp.	Willow Herb
Rad	Radicula sp.	Water Cress
Fra	Fragaria sp.	Strawberry
Ran	Ranunculus sp.	Buttercup
Al	Arctium Lappa	Burdock
Dv	Decadon verticillatus	Swamp Loosestrife
Hv	Hippurus vulgaris	Mare's Tail
Pot	Potamogeton	Sago Pondweed
Lem	Lemna sp.	Duckweed
Vs	Valisneria spiralis	Wild Celery
Alg.		Algae
Na	Nymphaea advena	Yellow Pond Lily
Cas	Castalia odorata	Water Lily

location with reference to geological features was noted; that is ground morain, terminal morain, or outwash plain type. Figure 4 illustrates a sample map sheet as taken in the field.

Vegetable Types

Several more or less definite vegetative types of kettleholes were encountered. A possible classification based on existing vegetation is as follows:

Herbaceous

Sedge marsh
Cattail marsh

Mixed herbaceous

Dry mixed herbaceous
Grass
Open water

Shrub

Button bush
Spirea

Tree

Willow
Elm-red maple

Bog type

Much intergradation occurs between these types and two or more types may sometimes be encountered in an individual kettle, but in general they designate the main types to be found in Washtenaw County, Michigan. Of these twelve types the one most often noticed is the Buttonbush. Others frequently

Kettlehole Investigation

Date Mapped 10/8/39

No. 3 Twp. Lodi S. 10 Loc. NE 1/4
Pic. No. ___ Area: ___ Chs. X ___ Chs.
___ Acres. App. Slope of Sides 2%-E, 8-10% to N, S, & W.
App. Depression from Surrounding Land 4-5' to E, 10-12' to N, S, & W
Surrounding Land: Woods: E. Side - Hard Maple, Elm, Hop Hornbeam, W Ash, Red Maple, Oak, Hickory, E.R. Cedar
W - Hard Maple, Oak, Hickory

Vegetation: Dom. Button bush Prom. Mich. Holly Rose Num.
Ground Cover: Short Grasses, ferns, Ranunculus, Spike Rush
Trees: Mainly Red & Silver Maple, Some Willow, W. Ash & Elm. Island on E. side of Red Maple, Elm, Basswood, Ash
Other Veg. In Openings on edges - Grasses, Bidens, Jewelweed, Sedges, Wool Grass, Common Rush, Elderberry, Red-berried Nightshade, Spirea, Rubus, Ribes, Vaccinium
Water: Area — Depth —
Vegetation —

Wildlife: Observed 2 Rabbits, 2 Red Squirrel
4 Bluejay
Feces: Racoon, Weasel, Opossum, Rabbit, Mink
Dens: ~~Weasel~~, ~~Opossum~~ ? Mink, Red Squirrel
Tracks:
Brouse: Rabbit on Button bush.
Other Signs: Old muskrat workings
6 Songbird Nests
2 Downy Woodpecker, Ruby Crowned Kinglet
Weather Conditions:

Present Use: Very Slightly Grazed on edges

Notes: Ti Morain Type.
Spring ~~River~~ flooded.
Peat Depth 10-11', Underlain by marl

Scale - 1" = 2 chs
Area - 3.16 Acres

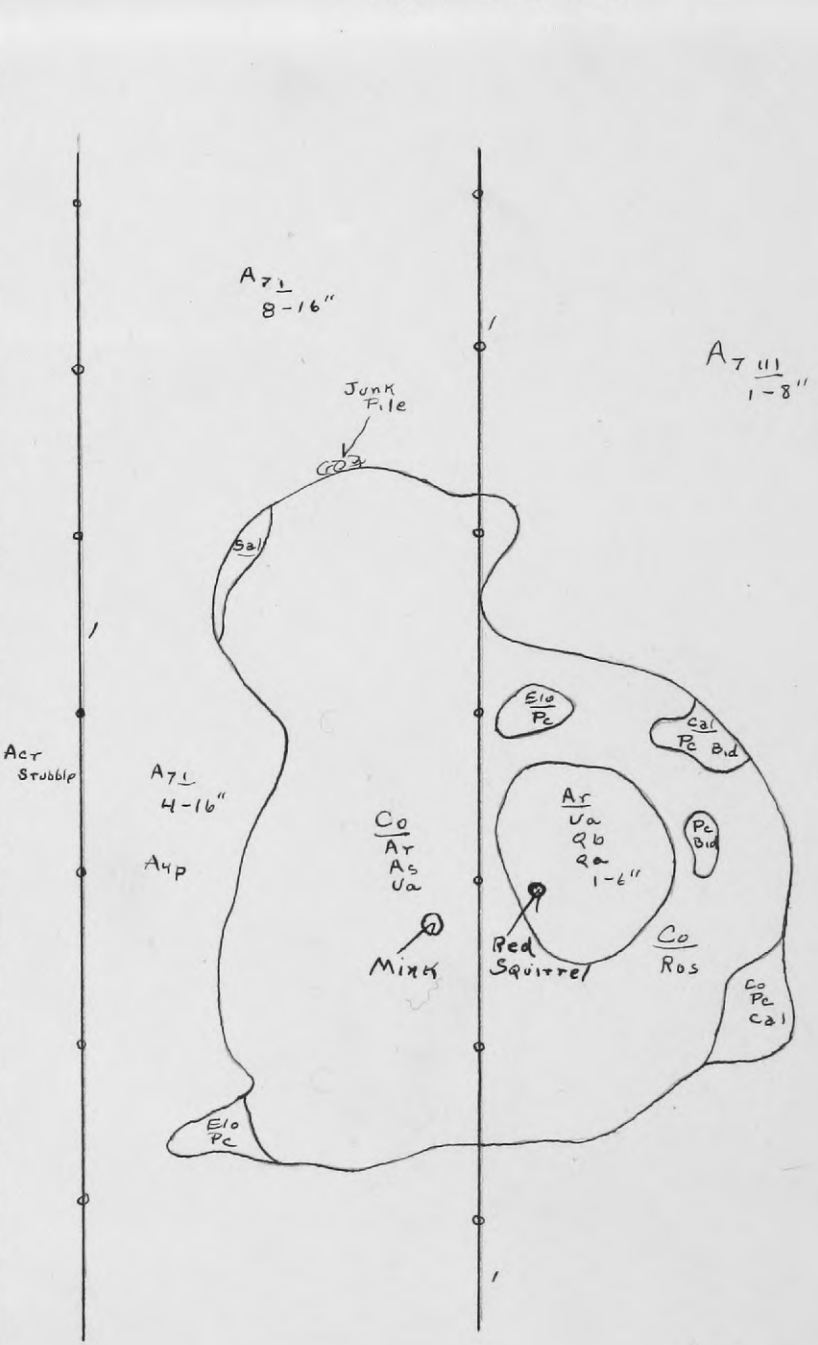


Fig. ~~5~~ 4

encountered are the mixed herbaceous marsh, sedge marsh and dry mixed herbaceous. Kettleholes having trees as the dominant vegetation are comparatively rare, as is the spirea type.

Sedge Marsh Type

This type of kettle is usually found in open fields although some have been observed in woods. It usually contains water for a few months in the spring and is in a moist condition over most of the year. Standing water will not be found in it throughout the year except in portions relatively free from vegetation.

The dominant vegetation is some species of sedge (Carex sp.) which frequently grows nearly pure and in very dense rank stands. Wool grass (Scirpus cyperinus) usually grows sparsely interposed with the sedge. Occasionally patches of spike rush (Elocharis obtusa) will be found on dryer portions. Variations occur with patches of cattail (Typha latifolia). Around the dryer borders, common rush (Juncus effusus), Spanish Needle (Bidens sp.) and blue vervain (Verbena hastata) are to be found. These species gradually merge with the dryer upland herbaceous species. Willows (Salix sp.), American elm (Ulmus americana), Red osier (Cornus stolonifera), spirea (Spirea sp.) and occasionally buttonbush (Cephalanthus occidentalis) sometimes occur in clumps around the edges.

Cattail Marsh Type:

This type of kettle is more damp than the edge marsh and frequently contains permanent water in some portions. They are usually found at lower elevations than the other types and commonly occur in the open rather than in woods.

The dominant vegetation is the common cattail. Stands of cattail occur nearly pure and very dense. Variations occur in mixtures with sedge, wool grass, water plantain (Alisma-Plantago-aquatica), and Blue joint grass (Calamagrostis canadensis). Species on the edges are similar to the sedge marsh. Smartweed (Polygonum sp.) often occur in open patches.

Mixed Herbaceous Marsh Type:

These kettles usually occur in the open and in moderately damp to wet situations. Dominant vegetation varies in different kettles and in different parts of an individual kettle. Some species observed to be dominant are sedge, water plantain, cattail, wool grass, blue-joint grass, common rush, and smartweed. Other plants commonly associated with these are spanish needle, spiked rush, marsh goldenrod, (Solidago sijancea), jewelweed, (Impatienspallida), watercress (Radicula sp.) and buttercups (Ranunculus sp.). They differ from the sedge and cattail marshes in the wide variety of species they contain: Red Osier, gray dogwood, (Cornus panicolatum), elderberry, (Sanbaucus canadensis) and spirea will occasionally be found in clumps around the edges.

Dry Mixed Herbaceous Type:

These kettles are found in dryer situations that the previous types. They range from those kettles that never contain water except when frozen to those containing water for a few months in the spring. They are usually located in the open and are the type most frequently farmed.

The type most commonly encountered contains Spanish needle dominant and in nearly pure stands. Water plantain and smartweed are to be found in the lowest portions. Variations occur with blue-joint grass, wool grass, and sedge dominant. Other species found sparsely in mixture throughout the kettle are: pigeon grass (Seraria glauca), wild millet (Echinochloa crusgalli), ragweed (Ambrosia sp.), common rush, spike rusg, marsh goldenrod, tear thumb (Polygonum arifolion), bedstraw (Galium sp.), cocklebur (Xanthium canadense), burdock (Arctium lappa), and sedge. Species occurring on the edges are blue vervain, ragweed, common rush, Canadian thistle (Cirsium arvense), wild bergamot, spirea, red osier, gray dogwood, buttonbush, and blackberry (Rubus sp.)

Grass Type:

Kettles containing grass as dominant vegetation are found in relatively dry situations, usually in cultivated land. The grass often grows dense and matted.

The dominant species is blue joint grass. Other

species found associated with blue joint grass are witch grass (Panicum capillare), wild millet, and Spanish needle. Portions of kettles will be found containing witch grass and buttercup in shadier situations. Scattered water plantain and marsh goldenrod will sometimes be found interspersed with the grass. Plants found on the edges are similar to those around the dry mixed herbaceous type.

Open Water Type:

The kettles containing permanent water are those with the lower surface below the ground water level. They are commonly in conjunction with cattail or shrub types. However, some in heavily grazed lands are practically devoid of marsh vegetation.

The type most frequently met with is that having a border of buttonbush around the edges. The water portion of these contained much decaying woody material and not and much water vegetation as is found in those ponds located in herbaceous marshes. Duckweed (Lemna sp.) and algae was the main aquatic vegetation. Buttercup was found growing in some of the shallower portions. Small spike rush (Eleocharis acicularis) was found growing in the mucky portions at the water's edge. This species is commonly found on the borders of those ponds heavily grazed and trampled by stock. Other open ponds are found in cattail and sedge marshes.

Other kettleholes containing lakes several acres in area develop through the swamp stage. Water vegetation in these is white and yellow water lily (Nymphaea sp.) sago pondweed (Potomogeton pectinat us) and mare's tail (Hippurus vulgaris). Swamp loosestrife (Decadon verticillatus) and bulrushes (Scirpus sp.) grow at the water's edge. Shrubs occur very close to the water's edge and are closely followed by elm and red maple. Other open ponds in cattail and sedge marsh type kettles do not contain much decaying woody vegetation. These are often quite shallow and contain much aquatic vegetation. Some of the species collected in these ponds are sago pondweed, mare's tail, duckweed, wild celery (Valisneria spiralis), and algae.

Buttonbush Type:

This kettlehole, a very common type in Southern Michigan, is found under various conditions from those containing portions of standing water to those in moderately dry situations. Although this type is often encountered in the open, it is the type most commonly found in woods.

The dominant vegetation is buttonbush, often growing so dense as to keep out most other species. Red-berried nightshade (Solanum dulcamara) associates with buttonbush even in dense stands. Scattered rose is also often found.

Other species found associated with buttonbush under

various conditions are: Michigan holly (Ilex verticillata), spirea, chokeberry (Aronia melanocarpa), high-bush (Vaccinium coryomposum), swamp gooseberry (Ribes lacusrre), nannyberry (Viburnum lentago), and leatherleaf (Chamaedaphne calyculata). Around the edges of these kettles may be found red osier dogwood, gray dogwood, grape, spirea, witch hazel (Hamamelis virginiana), virginia creeper (Psedera quinquifolia), spicebush (Benzoin aestivole), poison sumach (Rhus vernix) and smooth sumach (Rhus glabra), blackberry, American elm, red maple, willows, silver maple, aspen, and swamp white oak (Quercus bicolor).

Openings in these kettles may contain any of the herbaceous species found in kettleholes. Often they are covered by very short vegetation as buttercup and witch grass. Buttercup may be found growing under the shade of buttonbush when the canopy is not too dense.

Spirea Type:

This type is comparatively rare, and will be found in similar locations as the buttonbush type and in a dryer situation.

The dominant specie is spirea. In the kettleholes of this type studied, willow brush and rose in patches composed a large portion of the stand. Other species found associated with these are: red-berried nightshade, blackberry,

swamp gooseberry and nannyberry. Ground cover species are: sedge, Spanish needle, blue joint grass. Various other herbaceous kettlehole species will be found in smaller amounts. On the edges will be found red osier dogwood, gray dogwood, elderberry, blackberry, grape, smooth sumach, staghorn sumach, and hawthorne (Crataegus sp.).

Willow Type:

This type is sometimes found in deep depressions. It may be in either wet kettles or in those moderately dry. Willow kettles are commonly in conjunction with other types of kettles, either herbaceous or brushy. When they may be said to be dominant vegetation in a kettle, they usually have a ground cover of herbaceous vegetation. Willows have been observed growing in a deep kettle in a sandy location with no peat formation. Others grow in wet situations with much peat formation. Kettles of this type in dry soils have some of the following species associated with the willow: alder, elderberry, grape, raspberry, blackberry, buttonbush, red osier. Willow brush will sometimes be found in small dense patches.

Elm-Red Maple Type:

Although these trees are commonly found in many kettles, those in which they are the dominant type are not

numerous. They are usually small shallow depressions. Often they are located in woodlots. Some kettles of this type are small ones having a ring of elms and red maple around the edges with very little vegetation in the center. Others have trees throughout the kettle. Because of the dense shade formed by these trees, there is seldom much vegetation under them. Some of the shrub species such as buttonbush, Michigan holly, and red-berried nightshade may be associated with them. Silver maple, black oak, green ash, white ash, and blue beech are also encountered to a limited extent in these kettles.

Bog Type:

These kettles, usually large in size, develop through the typical bog series. These differ from the kettle hole succession in having characteristic plants not usually found in kettles. Some of these plants are sphagnum moss, cassandra, blueberry, huckleberry, aspen, tamarack, and black spruce. A detailed discussion of the vegetation of bogs will not be taken up here as such a subject is beyond the scope of this study

This type develops in deep depressions permanently filled with water where conditions are favorable for the formation of the floating mat. They range in size from a few acres to pit lakes of several hundred acres. Some have

progressed so far that the open water has been completely filled in. A bog kettle of about 10 acres of this stage of development is located in Pittsfield township, section 32. The smallest kettle of this type found in the study was one in section 15, Dexter township. It was about 5 acres total area and had a water area of 1-1/2 acres. It was located in a cultivated field. An attempt had been made to drain it, but this was unsuccessful. This bog had not progressed beyond the shrub stage. Kettle number 45, now composed mainly of leatherleaf and sphagnum moss is evidently of this type. Peat samples disclosed that it had never progressed beyond the shrub stage and that marl formation occurred at a depth of 28 feet.

Ecological Development of Vegetation.

Because of the many different situations where kettle-holes are formed, succession begins under a wide range of conditions in different kettles. These conditions may range from ponds permanently filled with water, through intermittent ponds to depressions in moderately dry locations. Succession is different under all these conditions, but all may pass through some similar stages during their development.

In southern Michigan many factors operate to interrupt or change the course of succession. These factors are so numerous in this region that few kettles will be found

where natural succession has not been altered by them to some extent. Some of these factors influencing succession in kettles are as follows:

Natural Causes

1. Prolonged periods of drought.
2. Prolonged periods of wetness.

Human Causes

1. Burning.
2. Cutting of vegetation.
3. Grazing.
4. Cropping activities adjacent to kettles.
5. Drainage.
6. Cultivation of kettle.

From the study of literature and observations in the field, it is possible to briefly describe the normal, unimpeded course of succession in kettles. Two types of origins will be considered; (1) permanent pond and (2) relatively dry depressions. It will be well to bear in mind that intermediate stages between these types occur that may differ from the succession as outlined here.

Permanent Pond Kettle:

These kettles may develop either through a marsh or a bog series. The bog series develops in a deep, steep-sided depression while the marsh series develops in shallow depressions with gradually sloping sides.

The first stage in the marsh series consists of submerged plants such as pondweeds, elodea, mare's tail,

buttercups, algae, wild celery. The remains of these plants sink to the bottom and build up the soil. These are followed by the floating stage which comes in when the water is only 6 to 8 feet deep. Water lilies, pondweeds, smartweeds, duckweeds and many others come in during this stage. Following these, plants which grow with the foliage above the water invade the area of floating plants. These include bulrushes, cattail, water plantain, swamp loostrife and smartweeds. As the soil becomes too dry for the plants in this stage, plants come in that can withstand temporary dryness. Sedges, rushes, spiked rushes, mints, marsh marigold, and bedstraw are some of the plants coming in with the sedge-meadow stage. The soil of the sedge meadow is gradually built up until it becomes too dry for marsh plants, and the woodland stage of shrubbery willows, buttonbush, dogwoods, and alders come in. This will eventually be followed by the climax forest, in this locality the Maple-beech.

Bog succession develops in deep, steep-sided, undrained depressions. In the early submerged and floating plant stages the vegetation is similar to that found in the marsh series. Following the floating stage, however, a floating mat is formed growing inward from the edges. This mat is composed of sedges, rushes, swamp loosestrife, and sphagum. As the mat establishes itself on a firmer foundation, cranberries, leatherleaf, poison sumach, and many other plants

come in. These shrubs are followed by swamp trees such as tamarack and black spruce. In time this will be followed by the climax type.

Dry Kettle:

The course of succession of a kettle in which no water is present and in which the initial soil is rocky glacial debris would start with crustose lichens followed by foliose lichens. As soil is gradually formed in these stages, some of the xerophytic mosses will begin to come in. These are followed by a herbaceous stage consisting of such species as knotweed, mustards, cinquefoils, goldenrods, and various grasses. The shrub stage following this might consist of such plants as sumach, poison ivy, spirea, and some willows. These are followed by xerophytic trees and later by oaks and hickories and finally by the climax forest.

ANIMAL LIFE

Mammals

Method of study.

The period covered by this investigation extended from October 1939 to May 1940. The study of mammals was carried on by:

1. Direct observation
2. Animal signs
   - Tracks
   - Dens
   - Feces
3. Trapping
4. Reports from farmers and hunters

Direct observation on the mammals was made at the time of mapping and on subsequent visits to the kettle during winter and spring. The principal means of study in the winter was by tracking. Good tracking snow was to be had much of the time from January 15 to March 30. In tracking the attempt was made to determine the number of individuals using the kettle and to find out something of their activities. This method was used rather than a system of track counting which would have been inaccurate because of the small area of the habitat. A few tracks such as muskrat

were observed on soft ground in the fall and spring. Dens were studied mainly in conjunction with tracks. Hair found around the mouth of dens was identified. Although it cannot be definitely stated that animals leaving hair signs made their home in the den, it is possible to say that such an animal has made use of the den at some time. All feces found in kettles were identified and tallied. Trapping was used in the study of small mammals and will be discussed later. Reports by hunters and landowners were recorded as received. No attempt will be made to draw any conclusions from these reports except where they have been verified.

Game Mammals

Rabbit:

Rabbits or rabbit signs were observed in 22 of the kettles studied. Rabbits were flushed in 12 kettles. The percentage of kettles containing rabbits for each type is indicated in the following table:

Table 7

Type	Percent Containing Rabbits
Buttonbush	76
Dry Herbaceous	55
Grass	66
Sedge and Cattail Marsh	33

The main use of kettles by rabbits seemed to be for winter and refuge cover. Most of the rabbits flushed were in button-

bush kettles in the late fall or winter. During summer and early fall, vegetation outside the kettle affords good food and cover. In the fall when the leaves are off the rabbits tend to seek more dense brushy areas that afford more protection from predators. As very few of kettlehole plants have a dense winter foliage, the protection is due to the matted nature of the buttonbush which gives mechanical protection from bird predators. Root clumps, fallen logs and various burrows give added protection in the kettles. Food in the form of woody shoots is abundant for winter food. Rabbit browse in kettles has been observed on: buttonbush, rose, red maple, American elm, blackberry, raspberry, red osier dogwood, gray dogwood, grape, leatherleaf, spirea, red-berried nightshade, sumach, and willow. As refuge cover many kettles are excellent by nature of the mechanical and visual obstructions they offer against hunters. In some cases the vegetation is so dense in a kettle that it is difficult for dogs to work it. One owner of a dense kettle of about 10 acres of mixed type said that it was his custom to burn over the kettle each year so that hunting with dogs would be more successful. Rabbits leave the kettles and go out into the surrounding lands at the time of the spring thaw when the kettle usually becomes flooded.

Observations indicated that rabbits preferred moderately large kettles - one acre or over in size. One kettle (#45) of about an acre located in a large open field was the home

of 4 rabbits during a considerable period during the winter months. Rarely they may be found in smaller kettles, as in the case of a mixed herbaceous kettle of about 1/4 acre in S 12, Lodi Township, where observations made on the snow tracks over a period of about a month in January and February showed that the rabbit did not leave the kettle for more than 100 feet. A groundhog hole on the edge of the kettle was frequently used by the rabbit.

Squirrels:

No squirrels were observed in kettles that did not contain sizable trees. Red squirrels were the kind most frequently encountered although some fox squirrels were seen. Presence or absence of shrubby vegetation did not appear to have much influence on squirrel population as squirrels were observed in herbaceous kettles in the open that had one or two large den trees on the edges. Some foraging activities in the snow covered duff were noticed but no more than is usually done on the forest floor. It seems fair to conclude that kettles are of no particular value to squirrels other than the fact that they may cause trees to be left standing in an otherwise completely cultivated locality.

Raccoon:

These mammals, although not particularly numerous in this region, do furnish considerable sport for hunting with dogs. Raccoon signs were observed in 8 of the 50 kettles

studied. These signs were mainly feces and hair. Only one den was found in a kettle. This was under the roots of a large tree on the edge of #41, a dry herbaceous kettle on the edge of a woods. Observations on several days in March with good tracking snow showed that the raccoon used this den regularly. However, it did not appear that the den was located there because of any particularly favorable condition in the kettle. With the exception of this instance, no other tracks were observed in kettles during the winter.

Many of the feces observed contained remains of crayfish, indicating that they had been left in warm seasons, very likely when the kettle was flooded. The lack of winter tracks when the kettle is frozen and the evidence of feeding in warmer seasons, indicate that raccoons may use kettles in feeding activities during warm seasons, particularly when the kettle is flooded. The abundance of amphibians and crayfish found in temporary ponds would provide food for this mammal.

Fur Bearers

Muskrat:

Of the 50 kettles studied, 33 had signs of muskrat, either old or new. Of these it was evident that 11 were being used by muskrats at the time of observation. The following table shows the conditions in these kettles.

Table 8

No.	Size	Type	No. Dens	Estimated Population
2	1.55a	Open water	5 houses	15
8	10.4 a	Buttonbush	4 houses	12
10	.22a	Open water	2 houses	6
11	.24a	Sedge marsh	4 houses	12
22	.05a	Cattail marsh	1 bank den	3
27	5.24a	Open water	10 houses	30
30	5.64a	Open water (cattail)	5 houses	15
33	2. a	Open water	5 houses	15
34	2.2 a	Sedge marsh	1 bank den	3
41	.70	Dry mixed herbaceous	1 bank den	3
42	2.2 a	Dry mixed herbaceous	1 bank den	3

An estimated population of 3 muskrats to the house or den was used.

In the case of number 11, when first observed only 3 houses were present. In less than a month an additional house had been built. No standing water was in the kettle, but the water table was a few inches below the surface. The population seems excessive for this size kettle and very likely the estimate of 3 muskrats per house is too high in this case.

Kettle #22 of .05 acres located in a plowed field was trapped by the owner and yielded one muskrat. Further trapping failed to produce more rats. The ground surface in this kettle was free from standing water. As trapping only yielded one muskrat, the estimated population of 3 for this kettle is probably in error.

In general those kettles which were not flooded in the fall did not contain active signs of muskrats at that time. All permanent ponds observed were found to contain muskrats. In some cases muskrats will return to ponds when they are flooded. However, this is not always the case as many kettles containing old muskrat workings were not reinhabited by them in the spring. The length of time of flooding, determined by rainfall, is probably an important factor in influencing the habitation by muskrats of a kettle in any given year. A muskrat was observed swimming in a spring flooded kettle in section 16, Lodi Township. The kettle was located in a woods, free from vegetation and had been dry the previous fall.

Kettle #34 was the only other kettle trapped for muskrats. It yielded 9 rats and they were caught up to the last day of the season as it seems reasonable that the kettle was not trapped out.

A sedge marsh kettle of about 2 acres in section 22, Lodi Township, contained six large houses when flooded with about a foot of water in May 1939. By September 1939, the kettle

had dried up, the houses were broken down and trampled by cattle and all muskrats had left the area. However, this kettle was within 3 chains of a small creek containing muskrats so it is likely that they readily migrate back and forth during wet and dry seasons.

Evidences of muskrat feeding was observed on sedge and cattail roots and on various other herbaceous vegetation. Feeding on apples and potatoes was observed in two cases where kettles containing muskrats were adjacent to these crops. An instance of muskrat damage to corn crops was reported from a field adjacent to a kettle. Investigation of this report failed to disclose any serious damage other than a few ears which might easily have been taken by squirrels.

Skunk:

Skunk signs were observed in 16 of the 50 kettles. These were mainly feces and some snow tracks. Only one skunk den was found in a kettle. This was located in a dry portion. Two other dens were located on fence rows just outside the kettlehole boundary. It seems likely that most kettles are too damp for skunk habitation and they are only of use in dry portions and then merely as an undisturbed location.

Numerous instances were observed of skunk tracks crossing kettles. These all went across in more or less of a straight line with no stops. Apparently they had not entered the kettle for any definite purpose. The numerous feces in

kettles indicate that they may be of some use to skunks for foraging activities during warmer months. Amphibians, crayfish and insects which are found in the kettles would furnish food for them.

One dead skunk was found in a small grass kettle. No sign of skunk habitation was noticed. The carcass was badly decomposed and did not permit an autopsy.

Opossum:

Evidence of opossum activities were only found in 6 kettles. One den was located on the edge of a dry sandy kettle under a stump. Tracks of an opossum were observed for several days in a portion of section 12, Ann Arbor Township. The den was located about 3 chains from one kettle. The opossum made the daily rounds through 3 kettles close together, going from one to the other directly. Foraging activities of this animal was noticed around stumps and fallen logs. In one other instance an opossum was found to travel through a kettle several days in succession. Other observations were on feces. Food such as amphibians, crayfish, mice and berries may lead the opossum to seek out kettles in preference to other locations during parts of the year. Observations seem to indicate that kettles are not particularly valuable to the opossum rxcept in that they may furnish some food where the surrounding land does not contain a good supply.

Weasel:

Of the 50 kettles studied, 12 had signs of weasel. Most of these signs were feces; some were tracks in the snow. One weasel den was known to be in a brush kettle on the edge of a woods. Quick (1940) reports that two of four weasels studied had dens in kettleholes. Five observations of weasel tracks were made in kettles other than those intensively studied. All track observations were on weasels that traveled through the kettle, pausing only to investigate holes, fallen logs, and stumps. No evidence of feeding was observed except in one case where a weasel killed a mouse outside a kettle and carried it into the kettle to consume it. Small mammals, particularly meadow mice and deer mice are available as food in kettles.

Observations seem to indicate that weasels may use some brushy kettles for dens when suitable cover is available in them. Because of the inquisitive nature of the animal, they probably travel through them as they might through any similar thick cover.

Mink:

Signs of mink were found in 3 kettles. Two of these, #3 and #5, contained dens. These were brushy kettles in woods and the dens were located under stumps. In both cases large groups of feces were found near the dens. Kettle #27, a dry herbaceous kettle in the open, was crossed by a mink several times during January and February. On January 19,

a mink killed a mouse outside and took the mouse into the kettle before eating it. On February 28, the mink killed a pheasant in this kettle and partially consumed it.

The limited number of mink in this section of the country may account for the small number of observations in kettles. The presence of two dens seems to indicate that this type of habitat is favorable for them, particularly in a region where streams are not numerous. In warm weather crayfish, amphibians and small mammals would furnish food for this species.

Fox:

No fox signs were observed in kettles. In one instance, a fox passed within two chains of kettle #32 which was frequented by pheasants and quail. Kettles are probably of little value to the fox except in so much as they may contain more food species than the surrounding land.

Woodchuck:

The typical kettlehole is too damp for woodchuck habitation. Occasionally a woodchuck den will be found on a high dry edge. These edges are of value in that they provide a place free from the disturbing influences of agriculture.

Small Mammals

A detailed study of small mammals was made on 8 kettleholes both for the purpose of determining what species are

present in the different type of kettles and to get an indication of the species and numbers which would be available as food for various fur-bearers and predatory birds.

Eight kettleholes were selected that appeared to be fairly uniform in type and isolated by being surrounded by cover types radically different from those found in the kettle. The kettleholes selected are representative of the various types found in Southern Michigan. They include #26, a sedge-marsh kettle; #25 and #28, two grass kettles; #24, a brush kettle in the open; #3, a brush kettle in the woods; #35, a brush kettle containing standing water; #22, a moist kettle with much cattail, and #34 composed of a marsh type where the water table was an inch or two below the surface.

An attempt was made to exhaust the kettles of small mammals by leaving traps set for several nights until no more mammals were caught. Snap traps were set in quadrat fashion 5 paces apart. Traps were left in place until the results seemed to indicate that the kettle was trapped out.

The species taken were the meadow mouse (Microtus pennsylvanicus pennsylvanicus), white-footed mouse (Peromyscus leucopus noneboracensis), prairie deer-mouse (Peromyscus maniculatus bairdii), house mouse (Mus musculus musculus), and the short-tailed shrew (Blarina brevicanda talpoides).

Table 9 gives the catch and estimated population of each kettle trapped.

The results of this study indicate certain facts concerning the types of kettleholes inhabited by some of the small mammals.

Table 9

Small Mammal Trapping Results

Kettle No.	Catch	Area	Total	Estimated Population Per Acre
3	6 ♂, 14 ♀, White-footed mice	3.16	20	6.2
7	6 ♂, 3 ♀ Meadow mice 1 ♂ House Mouse 1 ♂ Prairie Deer-mouse 1 ♂ short-tailed shrew	.166	12	70.
22	None	.05	0	0
24	8 ♀ White-footed mouse 1 ♂ Prairie Deer-mouse	.62	9	13
25	5 ♂, 1 ♀ Meadow Mouse 5 ♂, 3 ♀ Prairie Deer-Mouse 1 ♂, 2 ♀ White-footed Mouse	.30	17	57
26	3 ♀, House Mouse 2 ♂, 2 ♀ White-footed Mouse 1 ♀ Prairie Deer-Mouse	1.65a	8	5
33	8 ♂, 9 ♀ Prairie Deer-Mouse 2 ♂ Meadow Mouse	2.1	19	9
34	None	2.0	0	0

White-footed Mouse (Peromyscus leucopus noveboracensis):

These mice were found to occur in brushy kettleholes containing mainly buttonbush and rose, either in the woods or in the open unless the area is exceedingly wet. They may also be encountered to a lesser degree in sedge marsh kettles.

Prairie Deer-Mouse (Peromyscus maniculatus bairdii):

Kettleholes containing numerous stumps and fallen logs with considerable grass were found to be inhabited by this mouse. They were found in both brushy and grassy kettles, but were not taken in the brushy kettle in an oak-hickory woods. All were taken from kettles in the open. Logs that had remained on the ground for some time seemed to provide excellent locations for the burrows of this mouse.

Meadow Mouse (Microtus pennsylvanicus pennsylvanicus):

Grass kettles with damp matted vegetation may contain the meadow mouse if sufficient moisture and green vegetation is available. These mice were taken in kettles having considerable brush only where grass was abundantly interspersed with the brush. The dominant grass encountered in these habitats was bluejoint (Calamagrostis canadensis). Hatt (1930) states that areas which undergo a period of annual drought are not favorable for this species. This condition is seldom encountered in kettlehole habitats.

House Mouse (Mus musculus musculus):

This mouse may be found anywhere, although in small

numbers. Sedge marsh kettles seem to be more favorable than other types for this species. Piles of junk and rubbish may provide a suitable habitat for this mouse. Nearness of the kettle to human habitation seemed to have little effect on house mouse population.

Short-tailed Shrew (Blarina brevicauda talpoides)

Although this shrew prefers moist woodland, it may be encountered wherever there is a large population of other small mammals.

Areas where the surface vegetation is saturated with water and where no hummocks are available may not be expected to be inhabited by the smaller mammals.

In the kettlehole located in oak-hickory woods, only white-footed mice were taken.

Because of the great possibility of wanderers coming in and the small size and varied composition of the habitats studied, no definite statement will be made concerning the populations. Populations varied from five to seventy per acre depending on such factors as available food and cover, moisture, and predators. None of the populations seem excessive. Hamilton (1939) states that the meadow mouse population in northeastern United States is seldom in excess of an optimum of three hundred per acre. Referring to table 9, it may be seen that in general as the size of the kettlehole decreased below half an acre, the estimated population rose rapidly. This is probably because of a dense concen-

tration in an area suitable for habitation and would be more dense in the smaller areas.

Birds

Method of Study:

At the time of mapping, notes were taken on the bird life of the kettles both by direct observations and by signs. During the hunting season, records were kept on the birds flushed from kettles by seven hunters. Observations were made during the winter by tracking and by direct observation. During the spring migration a study was undertaken on the use of kettles by waterfowl. This will be discussed later. Spring records were kept on nesting birds. Old nests were counted in kettles during the late winter. These nests were not recorded as to species, however, as it was found that it was extremely difficult to identify all old nests with certainty. Nests recorded were probably all of the previous seasons as they break down quickly under winter conditions.

Use by Game Birds

Ring-Necked Pheasant:

Of the 50 kettles studied, 29 had evidence of the pheasant. Birds were flushed from 11 of these. During the fall and winter many flushed birds flew to seek shelter in kettles. Tracks were found in the winter months in both brushy and herbaceous kettles. These were particularly prevalent

in dense herbaceous kettles. Kettle #26, a sedge marsh located in a section densely populated with pheasants, was used frequently for roosting at night and for shelter during the day. As many as 7 birds were flushed from this kettle at one time in February. Birds traveled back and forth between this kettle and a large marsh about 15 chains away. Pheasants frequently roosted in #27, a dry herbaceous kettle. Brush kettles in woods are also used as shelter by the birds. On three occasions pheasants flushed from a marsh flew 15 chains to the woods and finally came to rest in kettles #5 or #6 located close together. When flushed they returned to the marsh. Kettle #13 was often used as refuge cover during the hunting season by pheasants flushed from surrounding country. Considerable hunting was done in the vicinity of this kettle and as many as three pheasants at one time have sought refuge in it. Because of its high dense cover and large size it was almost impossible to reflush the birds from it without the aid of dogs. During early December hen pheasants were twice observed in kettle #30 on the cattail island in the center. During early spring when the kettles are flooded, they were vacated by the birds. Later the dryer edges were used as crowing areas. The mechanical protection afforded by brushy kettles and the poor visibility in dense herbaceous kettles make these types good refuge cover for the birds against predatory birds and hunters. However, they are not as good protection against ground hunting predators. A pheasant was killed by a mink on February 28

in #27, a dense hervaceous kettle. Spring floods seem to make them unfit for pheasant habitation. Later they are well used as crowing areas, particularly in the absence of other brushy cover in the vicinity.

Quail:

Quail, although not as numerous as pheasants in this section, were found to make considerable use of kettles. Signs of quail were found in 6 kettles. Quail were flushed from four of these. There was no uniformity of types from which these were flushed. #6, a small buttonbush kettle near the center of a large woodlot contained quail in October. The quail were observed from a distance to be dusting and scratching about an uprooted stump on the edge of the kettle. When flushed they flew to another location in the woods. Quail were flushed on two occasions during the hunting season from #13, a dense brush and herbaceous kettle. In one instance they had been previously flushed from the field and sought shelter in the kettle. Quail roosted for two successive nights, January 23 and 24, in a small kettle in section 1, Lodi Township. They disappeared from there and reappeared a few days later in #27, a large mixed herbaceous kettle about 20 chains away. After roosting here for several nights they again left. No quail were observed in kettles during the spring when they were flooded. They seem to serve about the same purpose for quail as for pheasants - that of refuge and roosting cover.

Ruffed Grouse:

These birds have been reported inhabiting kettleholes in Southern Michigan. In this locality grouse are sometimes found around large bogs such as Mud Lake, Webster Township. Kettles, that they would be likely to inhabit or visit, are large, dense, brushy kettles and those of the bog type found in the vicinity of concentrations of population of these birds. One would expect to find them in the wilder sections with rather large areas free from agriculture. Further north in more typical grouse sections of the glaciated regions they probably use kettles to a greater extent than in Southern Michigan.

Waterfowl:

During the hunting season observations on ducks were made on those kettles containing standing water. Only a very small proportion of the kettles have water during this season. For this reason they are probably of limited value in the fall migration as compared with large permanent lakes. However, ducks visited many of them and they provide easily accessible hunting grounds for many sportsmen who would otherwise be unable to go duck shooting. Several Ann Arbor hunters reported "pothole" duck shooting to be good in the northern townships of Washtenaw County during the fall of 1939. Heavy shooting on the larger lakes may cause the ducks to seek out the smaller kettlehole ponds. Ducks were observed in the fall on 6 kettles of the 50 studied.

On one occasion 4 scaups and 2 black ducks were observed on #30, a large cattail marsh kettle with standing water. A duck blind was located on the edge of this kettle. A half dozen empty shotgun shells indicated that it had been used that fall. On four occasions black ducks were flushed from #29, a mixed herbaceous kettle with standing water bordered by wheat and corn stubble fields. As many as six ducks at a time were seen on this kettle. Mallards were flushed on two occasions from #2, a brush kettle with standing water. A few days before the open season a hen mallard wounded by gunshot was picked up 4 chains away from this kettle. Other kettles in which ducks were observed in the fall were #33, #27, and a small kettle near #29.

A study was undertaken during the spring of 1940 to determine the proportion of kettles used by ducks during the spring migration. At this time many kettles ordinarily of no consequence are flooded. One has only to take a short airplane trip over the farm lands of Southern Michigan at this time of year to fully appreciate the great numbers of these temporary ponds. In this study 122 individual kettles were visited during the period from May 13 to May 22, 1940. Only kettles that appeared to be favorable for waterfowl were observed, that is those in which there was open water and situated away from disturbing influences such as buildings, main highways, etc. Kettles filled with buttonbush or other dense vegetation were not tallied. Ducks or other waterfowl were observed in 36 of these or about 30 percent.

Table 10

Waterfowl Studies

No.	Waterfowl Observed	App. Area	Kettle Description
1	2 Black Ducks 2 Mallard	2 a	Buttonbush with open water Permanent
2	1 Pied-billed Grebe	1/2a	Sedge marsh, Temporary
3	2 Black Ducks	1 a	Grass marsh, Temporary
4	10 Ring necks 1 Mallard	3 a	Sedge-Cattail marsh, Permanent
5	1 Black Duck 1 Bufflehead	1 a	Herbaceous marsh, Temporary
6	2 Baldpate	1/10 a	Depression in wheat stubble Temporary
7	3 Bufflehead 11 Ringneck	5 a	Open lake, Permanent
8	2 Ringnecks 1 Black	2 a	Herbaceous marsh Temporary
9	2 Scaups 1 G. B. Heron	1/2a	Sedge marsh Permanent
10	3 Blue wing teal 2 Blacks	1/4 a	Temporary pond in pasture
11	6 Mallard	1/10 a	Temporary pond in wheat stubble
12	2 Mallard	2 a	Herbaceous marsh, Temporary
13	2 Blacks	1/10 a	Herbaceous marsh, Temporary
14	1 Black 1 Pied-billed Grebe	8 a	Sedge marsh, Permanent
15	2 Mallard	2 a	Herbaceous marsh with trees Temporary
16	45 Scaups	10 a	Permanent open pond
17	2 Blue wing teal 2 Blacks	1/10a	Herbaceous marsh in wheat stubble, Temporary
18	2 Mallard	1a	Herbaceous marsh, Temporary

No.	Waterfowl Observed	App. Area	Kettle Description
19	1 Mallard	1/4 a	Buttonbush with open water, Temporary
20	2 Goldeneye	1 a	Grass marsh, Temporary
21	1 Wilson's snipe 3 Blue wing teal 1 Bufflehead	3 a	Sedge marsh, Temporary
22	1 Ringneck	1 a	Excavated kettle
23	2 Mallard 2 Blacks	1/4 a	Herbaceous marsh, Temporary
24	3 Baldpate 2 Blacks 3 Blue wing teal	1/10 a	Herbaceous marsh in wheat Temporary
25	5 Baldpate	3 a	Sedge-cattail marsh Permanent
26	2 Blacks	1/4 a	Buttonbush with open water Temporary
27	38 Ringneck 2 Mallard 2 Hooded Mergansers	10 a	Permanent open pond
28	2 Blacks	1/2 a	Herbaceous marsh, Temporary
29	12 Ringneck	1 a	Sedge marsh
30	1 Mallard	1/4 a	Herbaceous marsh, Temporary
31	2 Black 2 Mallard	1/4 a	Herbaceous marsh Temporary
32	Franklin's Gull Wilson's snipe	2 a	Herbaceous sedge marsh Temporary
33	2 Black	1 a	Sedge marsh, Temporary
34	1 Mallard 2 Black	1/2 a	Buttonbush with open water Temporary
35	4 Blue wing teal	1 1/0a	Herbaceous marsh in corn stubble, Temporary
36	6 Ringneck	2a	Cattail marsh

Table 10 gives the kettle description and the waterfowl observed in each.

Other than the fact that most of the birds were found in some sort of a herbaceous marsh, there seems to be no particular preference as to size, location or permanence of water. It may be seen that the temporary ponds are of some importance for waterfowl when flooded in the spring. Some of the birds appeared to be feeding on masses of floating seeds, others were feeding on the bottom. In most cases the water was from a few inches to a couple of feet deep. Samples of floating seeds that were collected and identified proved to be largely water plantain, sedge, smartweeds, and miscellaneous upland plant seeds in smaller numbers. Where birds were observed feeding on the bottom, in most cases it was found that fresh herbaceous vegetation, mainly grass, was growing there.

The black duck is the only one reported as nesting in kettles, but probably a few others do. A pair of black ducks was found to be nesting in #33, a brushy kettle with trees containing areas of open water.

Song Birds:

Kettles appeared to be utilized by song birds mainly for nesting and for winter cover. During the winter those birds most frequently found in kettles were the bluejay, cardinal, downy woodpecker, chickadee, and juncoes. Brush kettles, particularly those located in the open were most

frequently used. This type was the one most often used for nesting. Brush kettles in woods were found to contain few nests in comparison with those located in the open. The herbaceous types, particularly the sedge and cattail marshes, contained red-winged blackbird nests with an occasional marsh wren nest. Nest counts on the kettles studied varied from 0 to a maximum of 26 on #2, a brush kettle of 1 1/2 acres, containing permanent water. Nests most frequently encountered were those of the red-winged blackbird, goldfinch or yellow warbler, cardinal, and catbird. Birds observed or reported as nesting in the various types of kettles in this vicinity are as follows:

Marsh kettles

Red-winged blackbird
Sora rail
Least Bittern
American Bittern
Marsh wren
Black duck

Shrub kettle

Yellow warbler
Goldfinch
Red-winged blackbird
Cardinal
Bluejay
Catbird

Rose-breasted grosbeak

Black duck

American Bittern

Kettles with trees

Same as bushy kettels and in addition

Green heron

Black-crowned Night Heron

Small owls were the only predatory birds observed to be inhabiting kettles. Hawks were sometimes perched on woody vegetation in them. Although food species are abundant, hunting would be difficult, for these birds, in kettles except in the more open ones. A saw-whet owl was twice observed on #13, a large kettle containing many trees. A screech owl was observed on two occasions in #8, a mixed shrub and herbaceous kettle of about 10 acres. A marsh hawk was found to be nesting on leatherleaf bushes in #45, a large leatherleaf kettle.

Reptiles

Turtles and snakes were observed to use kettles to some extent. Garter snakes were observed in two kettles. Several of those kettles containing permanent water were inhabited by turtles. A census of turtles was made on #2, a brush kettle with standing waters, on a sunny day in May. A careful count revealed 12 central painted turtles (Chrysemys picta marginata) and 8 Blanding's turtles (Emys blandingii).

The area of this kettle was 1.55 acres. No turtles were found in temporary ponds. Although turtles have been reported as taken for food by a few of the hawks, it is doubtful if they are of much value as food for any birds or mammals. Snakes, although likewise of small food value, have been reported eaten by a greater number of mammals and birds. Some of these are the marsh, red-tail, red shouldered, and broad-winged hawks, a great blue heron, opossum, mink, fox, and skunk. Snakes probably do not occur in such large numbers in kettles as compared to elsewhere, so that the value of kettles to birds and mammals through this source is likely insignificant.

Fish

Only those larger kettles containing considerable permanent water were found to be inhabited by fish. Some of the larger pit lakes were known to be inhabited by such fish as great northern pike, wall-eyed pike, large-mouth bass, pickerel, sunfish, and perch. A kettle in section 15, Lodi Township, with a water area of about 4 acres, was fished with limited success. Perch and sunfish were the species most frequently encountered. Two dead fish were picked up from kettle number 3 in the early spring. The fish, although badly decomposed, appeared to be suckers. This kettle contained about an acre of water about 2 feet deep. Numerous dead shrubs and fallen logs were present in the water. It is thought that the fish may have been winter killed. This

hazard to fishes is often met with in shallow lakes containing a large amount of decaying vegetable matter, because the oxygen is used up in the process of decay at a time when the frozen surface prevents easy replacement of the oxygen lost by the water.

Amphibians

Amphibians, particularly frogs occur in great numbers in kettles, both temporary and permanent, during the spring and summer months. Nearly all ponds containing water were found to contain frogs of various species during the spring. Salamanders were found in several temporary ponds, particularly those in woods.

Observations on frogs and salamanders were made mainly at night with the aid of a light. Those species observed in kettles during early April are as follows:

Spotted salamander - Ambystoma maculatum

Tiger salamander - Ambystoma tigrinum tigrinum

Newt - Triturus viridescens

Red-backed salamander - Plethodon cinereus

Four-toed salamander - Hemidactylius scatatum

Spring peeper - Hyla crucifer

Swamp tree frog - Pseudacris triseriata t.

Wood frog - Rana sylratica cantabrigensis

Others reported as occurring in kettles and likely occurring later in the spring are as follows:

Leopard frog - Rana p. pipiens

Bullfrog - Rana catesheinana

Green frog - Rana clamitans

Pickerel frog - Rana palustris

Tree toad - Hyla versicolor

Cricket frog - Acris crepitans

Of these the most common were the spring peeper, swamp tree frog, wood frog, and the spotted salamander.

Temporary ponds in kettles are utilized by salamanders in mating activities. In a small kettle of about 1/10 acre located in a woods in S. 25, Ann Arbor Township, 4 mating groups of the spotted salamander were observed. These were distinguished by the concentrations of salamanders around groups of spermataphores which had been deposited on twigs and leaves. The number of salamanders to each group averaged around 10 to 15. This kettle also contained the tiger salamander and the newt in addition to several kinds of frogs.

Many mammals and birds are reported as feeding on amphibians. Salamanders are not taken by as many species as frogs, possibly because of the limited availability of the former. Some birds reported as taking salamanders as food are the red tail, red shouldered and broad winged hawks and the great blue heron. The frogs are taken by a large number of birds and mammals. Because of their dense concentrations in the great numbers of temporary ponds during the spring and early summer in Southern Michigan, it seems likely that frogs may be of considerable value as food to some birds and mammals

in this region. Some birds taking many frogs in their diet are the red shouldered and broad winged hawks, green heron, black crowned night heron, great blue heron, and American bittern. Other birds and mammals reported taking frogs as food are as follows: red tailed hawk, sparrow hawk, kingfisher, barred owl, screech owl, opossum, mink, skunk, and red fox.

Crayfish

In the spring crayfish burrows may be found in large numbers in the land surrounding many ponds both temporary and permanent. These animals use the ponds for mating activities during the wet season. As the ponds dry up in the summer the crayfish must burrow until water is again available. Dirt from the burrows of several species is packed around the openings to form characteristic chimneys up to 3 and 4 inches high. Because of the large amount of protective cover in kettleholes, it was difficult to observe many crayfish directly. However, their burrows on higher land gave an indication of their numbers and several partially eaten crayfish were found about the water's edge of some of the ponds. Those species likely to be found in temporary kettles in Southern Michigan are: Cambarus immunis, C. diogenes, and C. argillicola.

A great many mammals and birds are known to feed on crayfish. Some species using large numbers of them are

the barred owl, red tail hawk, great blue heron, and mink. Others in this locality that have been reported as feeding on them are as follows: Bufflehead, American goldeneye, scaup duck, hooded merganser, king rail, marsh hawk, broad winged hawk, rough leg hawk, pigeon hawk, kingfisher, screech owl, opossum, raccoon, and skunk. Numerous pellets containing crayfish remains were found around a barred owl nest during the spring of 1939. This nest, located in section 3, Lodi township, was within 10 chains of a large kettle (#16) which was flooded during the spring and early summer and which contained many burrows of the crayfish about its borders.

With the large number of temporary ponds providing habitation for the crayfish in this region, it is probable that they are an important food source for many birds and mammals during the spring and early summer.

Insects

During the spring, the predacious diving beetle (Dytiscus) was found to be quite numerous in the temporary ponds. It is likely that many other water inhabiting forms frequent them during this season, although no detailed study was undertaken in this field.

Conclusions on Wildlife Use

Wildlife use kettleholes in this region in a variety of ways.

The rabbit derives its greatest use from winter and refuge cover. Pheasants and quail use them in similar ways, particularly as roosting sites. Pheasants also use drier portions as crowing areas during the spring. Squirrels, particularly the red, inhabit kettles when they contain trees of sufficient size. The muskrat uses permanent ponds for habitation and in many cases also uses the temporary ones, often staying in them through the season when surface water has disappeared. The ruffed grouse may occasionally live in large,dense kettles.

The skunk, raccoon, and opossum use kettles as feeding grounds, particularly in the spring and summer. This is also true of the mink and weasel, who may also be found living in some dense, brushy kettles.

During migrations, particularly in the spring, waterfowl make use of those containing water for resting and feeding. They have value as nesting grounds for some ducks, particularly the black duck. Many song birds nest in kettles and some of the birds remain here in winter and use them as cover during this period.

USE BY LANDOWNERS

Hunting

Many farmers and their families used kettles on their own land and on adjacent farms for hunting. The farmer's boy derived the most benefit from hunting, the farmer in many cases having been out only a couple of times during the season. The most popular game animal appeared to be the rabbit, which was usually hunted with dogs. Reports as to the number killed in the kettles did not seem very reliable, varying from none to 50 rabbits reported as shot in a 10 acre kettle in 1938 (#8). Several pheasants were also taken in this kettle.

In general landowners did not express any particular enthusiasm for hunting. With the exception of a few they would go occasionally if they had the opportunity but not otherwise. Large moderately dense kettles were favored for hunting; the thick buttonbush or bush dettles being too hard to get through. Only one farmer had sufficient interest to attempt any hunting improvement. This was the owner of #8, the one in which 50 rabbits were reported shot. He said that it was his practice to burn the kettle each year to make the cover sparse enough to hunt in. This apparently had little damaging effect as it was still very dense and thick in the late fall.

Trapping

Few landowners were found to do any trapping in kettles. Three kettles of the 50 were trapped. Trapping was done only for muskrats. Those kettles trapped were Number 33, a brush kettle with about one-half acre of open water, Number 22, a cat-tail marsh of .05 acre with no standing water and Number 8, a mixed herbaceous and shrub kettle of 10 acres with no standing water. Number 33 had an estimated population of 15 muskrats. The total catch was 9 animals. Trapping was not done by the owner but by a resident of Ann Arbor. Number 22, with an estimated population of 3 rats, yielded 1 rat. This kettle would not have been trapped except that the owner was doing considerable trapping in a creek near by. Number 8, with an estimated population of 15 rats yielded 1 animal. It was the farmer's throry that because of the dry condition of the kettle, most of the muskrats had left it shortly before the season opened.

Collectively kettles are of considerble value to muskrats, but because of the small scattered concentrations it does not pay to trap any but the large ones unless other trapping activities are being carried on in the vicinity. Indirectly kettles may improve trapping for other mammals by providing more favorable living conditions.

Timbers

Cases have been observed where timber was cut from kettles, although not among those 50 studied. Timber cut is usually of poor quality and is used for firewood except where a kettle containing merchantable trees may be situated in a logging operation. In general, timber is not important in kettles, but there are occassions where elms, red maples, willows and some of the upland trees are of such size and quantity as to make them worth cutting for farm use.

Crops

Only those small shallow, comparatively dry kettles are cropped without draining. In these cases no special treatment is given the soil and crops are continued across the kettle as in the rest of the field. Crop success on larger reclaimed kettles will be discussed later.

Grazing

Of the 50 kettles studied, 15 were located in permanent pasture. Some others were pastured during portions of the year, usually after crops had been cut. In some large kettles, the owners believed that this was the best use to which they could be put.

Horses and cattle appeared to do the most damage to cover both through browsing and by trampeling. Sheep did not cause much damage. They seemed reluctant to browse or

even enter coarse herbaceous or marshy lands. In heavily grazed sheep pasture, no browsing was observed on easily accessible sedge growth. Cattle and horses, on the other hand, were found to graze it quite closely. Figures 10 and 11 illustrate the effect of sheep and cattle grazing on density of cover in similar types of sedge marsh kettles.

Figure 10

Sedge marsh kettle located in a heavily grazed sheep pasture. (#26)

One kettle (#8) located adjacent to a large pasture was fenced against grazing. The farmer said that he did not throw it open to grazing because it was too large and dense to easily locate the stock and his other pasture furnished ample forage.

Figure 11

Sedge marsh kettle located in a heavily grazed cattle pasture (#34)

Other Uses of Kettles by Landowners

A frequently employed use was as a disposal place of all farm refuse and junk. This, rather than detracting from wildlife values, benefited it in many cases by providing additional cover. In cases where junk is placed in the water, the iron rust may have a fowling effect which may be detremental to wildlife.

Another use frequently observed was that of providing domestic waterfowl with an open pond. This occurred mainly during the wet season as few permenent ponds were located near farm buildings.

Drainage of Kettles

Costs:

Drainage costs vary with the distance and depth of drainage ditch needed and the amount of clearing and filling in necessary after drainage. Drains used are of two types: (1) the open ditch drain and (2) the tile drain. The tile drain although more expensive is more satisfactory as it is possible to farm over it and it is not subject to filling in. The cost of open drains is that of labor in digging the ditch. Tile drains include this cost plus the cost of tile, plus filling in cost. Open ditches are usually constructed by farm labor during slack seasons. In some cases the services of a mechanical ditch digger is hired. The cost in this case remains fairly constant irrespective of the depth of ditch and varies as the length of the ditch. One farmer stated that he had drained a 2 acre kettle by this method at a cost of 45 cents per foot for having the ditch dug. The cost of tile and refilling the ditch was extra. The length of this ditch was about 100 feet. The farmer thought the cost justified as the kettle was shallow and without brushy cover. Four inch tile, the size most frequently used, cost 4 cents per foot.

Success of Drainage Projects:

Drainage was found to be successful in cases where the drain had been correctly laid out and where the kettle was not too deep and steep sided as to hinder successful cultivation. Many kettles were observed to have ditch drains that had filled in or may not have even worked when new because of poor grading.

The attempt was made to drain by tile number 22 and number 25, 2 small herbaceous kettles in a cultivated field. This was not successful on either one - the drains never having worked. This seems to indicate an error in laying out the grade for the drain. In some cases large kettles have been drained for the sole purpose of improving grazing. In this case the depth and possibility of cultivation is of little importance; the only requirements being that they be relatively free from brush and that the water be successfully drained out. When kettles are well drained and placed under cultivation, they are not readily noticed, and a surprising number of them come to light under investigation. Nearly every farmer can point out a "cathole" or two on his farm that he says is tile drained and which he is cultivating. These are in the main small shallow kettles which would not be of any great value to wildlife even if left untouched. No kettles with open ditch drains were observed to be successfully cultivated. However, this type of drain was practical where the main purpose was to dispose of spring waters quickly to open the kettle for grazing. As compared to upland pasture land, kettles, particularly those containing buttonbush, were inferior for grazing because of the poor forage species in them and the damp condition of the soil.

Drainage appears to be practical on shallow kettles in cultivated sections where a successful drain can be put in at a cost low enough so that a good return on the investment will be secured through future crops from the land. Other kettles may be drained and used for grazing if the vegetation is such as to provide good forage. However, because of the many unsuccessfully

drained kettles, it is important to carefully consider the expected success in relation to the present value and to lay out the drain with leveling instruments so that there will be no doubt that it will work. Crop success on kettlehole soil will be discussed later.

Effect of Drainage on Soil:

When areas containing peat are deprived of water, the rate of decay is increased. In a few years the substratum is reduced to a brownish-black, pulp-like mass. This changed into muck soil as the process is continued. The accumulation of disintegration products makes the medium unfavorable for the continued existence of the organisms involved in peat production and at the same time provided optimum conditions for the development of other vegetation. The alkaline undergrou d waters of this region favors bacterial growth and as this comes in when the kettle is drained, the peat decays more quickly. Cultivation of the soil exposes more of it to air and tends to mix it with mineral soil thus hastening decomposition. The result then of draining and cultivating a peat deposit is to change it to a muck soil within a few years.

Muck when thoroughly dry heats quickly. Also it often becomes powdery and the dry particles become to considerable degree impervious to water so that it will not readily absorb moisture in times of drought.

Crop Success in Drained Kettles:

Drained kettles seldom receive any special treatment for

cropping because of their small size and location in portions of already cultivated fields. The experiences of local farmers indicate that crops are not successful for the first couple of years after drainage. Timothy, red top, blue grass, clover and corn are said to do well until the peat becomes well disintegrated. Later such truck garden crops as celery, onions, lettuce, cabbage, carrot, parsnip, beet, radish, potatoes, strawberries, lupine, buckwheat, spinach, turnip, and peppermint will succeed. Farmers say that a good depth of muck is necessary for crop success. A few inches of muck underlain by hardpan cannot be successfully cultivated. Kettles covering extensive areas may merit special treatment to insure crop success. It is wise to carefully study peat areas before applying treatments as requirements vary greatly for different peat deposits. Some of the points to be considered in placing peat lands under cultivation are as follows:

1. Lower water table by drainage to 1 - 2' below the surface. A stable water level is important.
2. Remove vegetation cover and till soil.
3. Hays, other forage crops and corn do well the first few years as bacterial conditions of the freshly drained organic soil is not favorable to certain other crops.
4. The use of barnyard manure during the first few years will promote decomposition of the peat by introducing fungi and bacteria.

5. Crops that endure drought and early frosts should be selected. Early frosts are prevalent in these depressions because the cold air drains into them.
6. Muck soils will not endure continuous cropping unless attention is given to control of water level and to nitrogen and potash starvation. In some cases irrigation may be necessary. Muck soul is unfertile - potash and phosphate are frequently required. Lime should be used on very acid mucks.

Small kettles around human habitations may be used as flower gardens. In this case, orchids, wild rosemary fringed gentian, sundew, pitcher plant, and lobelias may be successful.

Conclusions on Use by Farmers

Many of the shallow kettles in agricultural land may be successfully drained and used for cultivation. However, a great many, particularly deep and brushy ones cannot be economically used for crops. Grazing on these kettles is generally inferior to grass pasture land. These kettles which cannot be used in any farm activity are useful only for wildlife. For this purpose they are admirably suited, being dense areas of undisturbed waste land in a locality where other suitable areas are used for agriculture or for timber production.

RECOMMENDATIONS FOR IMPROVEMENT

Principles of Management

In making plans for improvement of wildlife of kettles in Southern Michigan, it is necessary to consider three types of uses: (1) Farm game; (2) waterfowl; and (3) muskrats. These are the most important classes of wildlife using kettles and other types may be considered incidental. Improvement for these three classes will also improve conditions for all others. In most cases the improvement measures will overlap for these three classes, but in some cases special consideration must be given to waterfowl and muskrats.

Farm game, including rabbits, squirrels, pheasants, and quail will benefit from the improvement of all types of kettles.

Waterfowl may be expected to use all those kettles containing permanent open water if properly improved, and in addition many temporary ponds during the spring migrations.

Muskrats will use all ponds containing permanent water and also many ponds containing water for a large part of the year or those in which the water table closely approaches the surface.

In improving kettles for farm game, many of the conditions unfavorable for waterfowl and muskrats will also be remedied. Improvement measures should be considered from

the aesthetic standpoint and with a view to making these measures fit in with other farm activities at low cost to the landowner. A favorable environment for farm game should contain an assortment of various kinds of cover with suitable food species to be found in and adjacent to them. An ideal cover condition on farm land might consist of woodlots, dense fencerows, swamps, small brushy areas and fields of either crops or waste land. In considering the cover requirements for farm game, it is found that they need winter cover, escape cover, nesting cover, roosting cover, nesting cover, and travel lanes. After studying kettleholes, it is apparent that some of them fill requirements for winter cover, refuge cover, escape cover, roosting cover and resting cover. All of these requirements are of course not present in all kettles. Those kettles which have a dense brush or herbaceous cover during snow periods are suitable for winter cover. Planting of evergreens, willows, and wild plum will increase the value of those lacking this requirement.

Figure 12 illustrates the interior of a kettle having good winter cover.

Figure 12

Refuge cover is similar to the above and offers resistance to hunters by nature of its thick, dense vegetation. Escape cover, which includes all dense brushy kettles, offers mechanical protection from predatory enemies. Kettles containing a dense growth of herbaceous or shrubbery plants are used as nesting cover. Resting cover are those areas providing shade in summer and shelter from wind in winter.

Kettles are of limited value as nesting cover for farm game, although they are used as such by many other birds. This requirement may be met by leaving two or three swaths uncut about the edges of the kettle. Travel lanes, a very important requirement, are scarce in this region because of the prevalence of clean fencerows. These may be provided by allowing fencerows to grow up with brushy vegetation, leaving outer swaths of fields uncut adjacent to fences, and by planting up erosion gullies and drainage ditches leading away from kettles.

Waterfowl may be encouraged by allowing protective vegetation to grow up around kettle edges and by providing food species, particularly strips of grain adjacent to the kettles.

Increase in use by muskrats may be obtained by maintaining the water level, providing an undisturbed natural condition and by encouraging marsh and aquatic food plants.

Drainage Policy

It has been observed that drainage is unfavorable for wildlife both because of the agricultural uses to which the kettle is put after drainage and the effect on vegetaion if unused for

agricultural activities. Cropping of the kettle destroys all use by wildlife with the possible exception of a few weeks in the spring when it may be flooded and used by waterfowl. The effect of drainage on the kettle if unused for agriculture is to dry up the soil and discourage the growth of the natural marshy vegetation. Only in exceptional cases can kettles by successfully used for agriculture. In view of the many kettles where agriculture will not be entirely successful, it seems that these would serve a better purpose if allowed to remain undrained and improved for wildlife. Drainage is directly detrimental to muskrats, who require the presence of water. Every effort should be made to maintain the water level for these animals. In many cases if a natural or old drainage is dammed up, a sufficient supply of water will be maintained in the kettle to provide habitation for muskrats where before none existed.

Grazing Policy

Grazing in general appeared to be detrimental to wildlife cover in kettles. Sheep do not do as severe damage as cattle and horses because they do not feed on coarse marshy vegetation such as sedge and cattails. However, they do graze grass down to the edges and will browse low shrubby vegetation. Grazing conditions in most kettles are inferior to good pasture land. When practical a fence should be placed so as to exclude grazing from the kettle. As much of the surrounding land as expedient should be included within this fence to provide additional cover.

Planting

Conditions in many kettles are such that with the exclusion of grazing and agriculture, very little planting will be necessary. Food patches of standing grain left along the cultivated edges of kettles will greatly increase value for wildlife. Standing or shocked corn, wheat, rye, barley, and soy beans will serve as valuable winter food. Herbaceous kettles may be greatly improved by introducing shrubby vegetation around the borders and dryer areas. Some of those which will furnish both food and cover are sumach, grape, box elder, gray and red osier, dogwood, wild plum, chokeberry, virginia creeper, red-berried nightshade, greenbriar, and wild black cherry. The planting of evergreens about the edges will greatly improve winter cover conditions, will beautify the landscape, serve as windbreaks, and if the plantings are large enough may be expected to yield a cash crop in 5 - 7 years through the sale of Christmas trees. A valuable evergreen cover species observed to do well in this region on land surrounding kettles is the common juniper. This, in addition to providing excellent low cover the year round, also provides winter food for wildlife.

A wide variety of species in a kettle is to be preferred to large patches of one or two species. Plantings around the edges should be made with the view of stopping soil erosion where this is necessary. Some species to be planted on eroded areas valuable both for wildlife and soil retaining qualities are blackberry, lespedeza, wild plum, wild grape, virginia creeper, black locust, wild rose, honeysuckle, bittersweet, orchard grass

and Sudan grass.

Fencerows should be improved for travel lanes by allowing them to grow up and in some case introducing shrubby plants such as evergreens, hawthorn, blackberry, grape, honeysuckle, wild rose, and bittersweet. Narrow strips of grain left uncut along fences will also greatly increase their value as travel lanes.

In improving for muskrats, the prevention of drainage and grazing are the main points to be considered. Under these conditions, desirable food and cover plants will usually come in. In some cases cattail, willow shoots, bulrush, water plantain, sedge, pond lilies, and duck millet may be added if not already present.

Because of the limited number of permanent ponds, improvement for waterfowl must be undertaken mainly on those kettles subject to seasonal flooding. Plants must be selected that will withstand this condition. In many cases cultivated grains left standing and other food used by upland game will be sufficient to attract ducks. Where feasible, some of the following plants which withstand seasonal flooding may be planted for duck food: duck potatoe, wild millet, chufa, hardstem bulrush, nodding, water and marsh smartweeds, and yellow buttercup. Buttonbush, found in large quantities in many kettles, has a limited value to waterfowl through its seeds.

In selecting species for planting, it will be well to choose those easily available and which are known to do well in the locality being improved. In many cases shrubby and aquatic species may be transplanted from nearby regions of higher

concentration. Food strips can be left of the species being cultivated in the field in question.

A sample plan for the improvement of kettles number 33 and 34 for various forms of wildlife is illustrated in Figure 13 and 14.

These kettles are heavily grazed and trampled by cattle. Number 33 contains permanent water with brush and willows around the edges. Number 34, a herbaceous marsh, was found to have the water table a few inches below the surface during dry periods.

It is entirely feasible to improve these kettles for farm game, muskrats, and waterfowl as all have been observed there, though in small numbers.

The first step will be to erect a fence to exclude grazing from the kettles and the adjacent badly eroded lands. Exclusion of grazing will allow areas to grow up in grass and weeds and will allow marsh plants to grow unhampered. Scotch and Norway pines and juniper plantings at the points indicated on the map will provide permanent cover throughout the year.

Erosion gullies may be planted to Sudan grass, lespedeza or sweet clover interspersed with tree and shrubby forms such as blackberry, black locust, wild black cherry, and wild grape.

Around the edges of the herbaceous portions of the kettles, shrubby species such as wild rose, spirea, high bush crannberry, buttonbush, red berried nightshade, and wild grape may be introduced. A few mulberry trees may also be planted around the edges.

Fence rows should be allowed to grow up and a few food and cover species such as wild grape, blackberry, bittersweet,

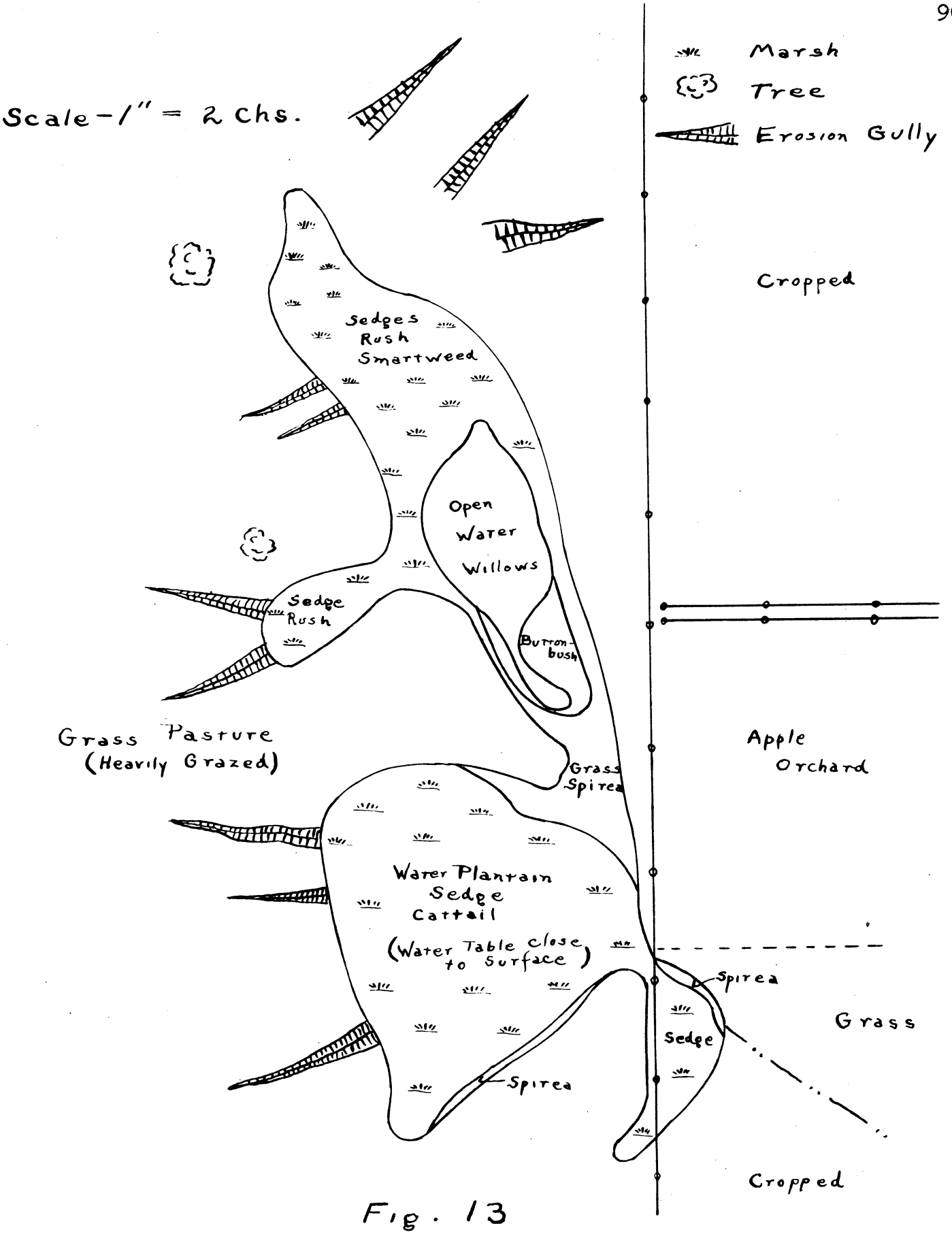
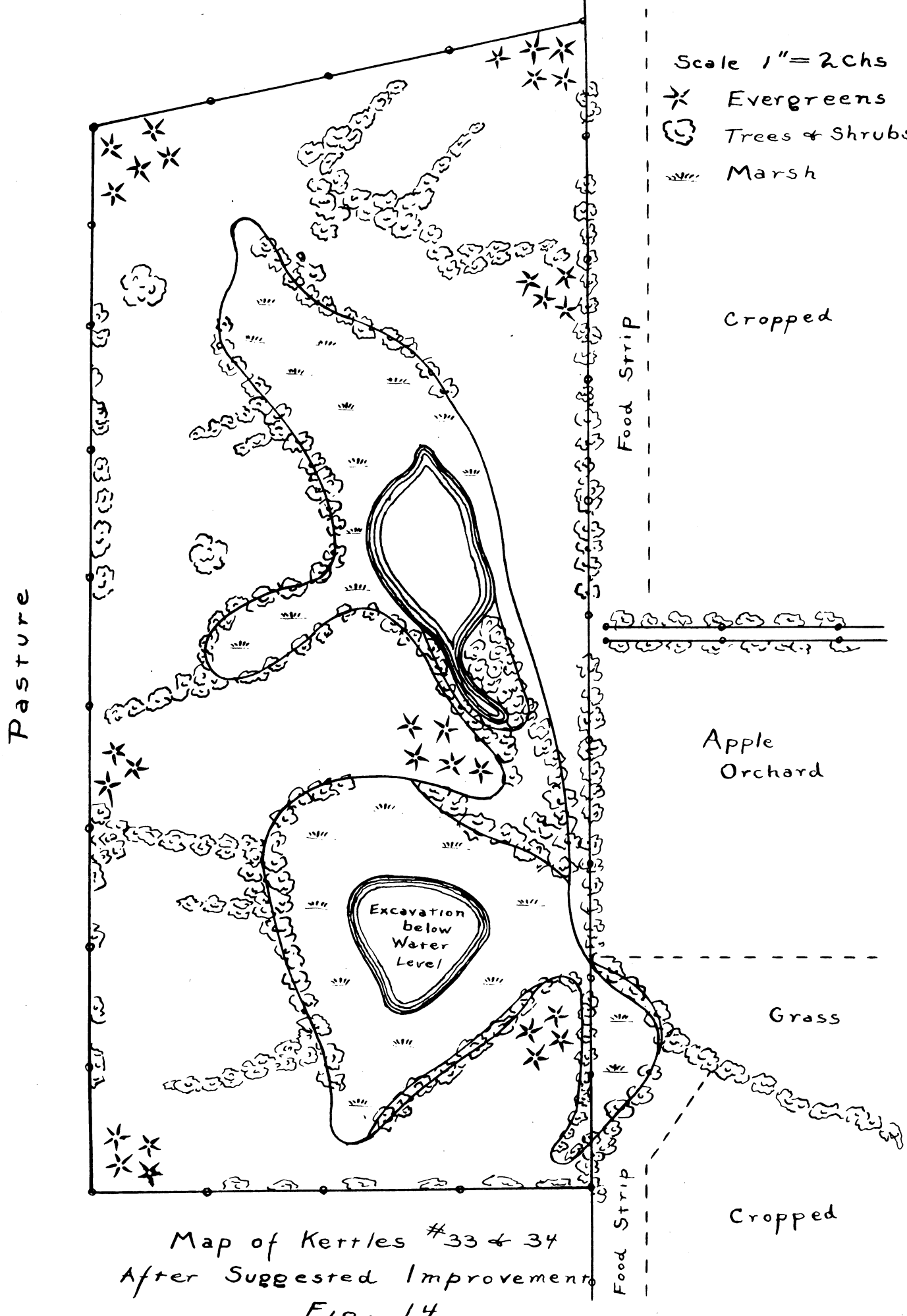


Fig. 13

Map of Kettles #33 & 34 Before Improvement



Map of Kettles #33 & 34
After Suggested Improvements
Fig. 14

greenbriar, wild rose, dogwoods, hawthorn, and honeysuckle. No planting should be attempted on the grazed side of the fence. These fence rows should be improved as travel lanes to extend to other cover such as woodlots.

Food strips may be left along the edges of cultivated fields bordering the kettles either in standing or shocked crops. Wheat, rye, barley, corn, buckwheat, oats, soy beans, cow peas, and millet will all serve as winter food.

The apple orchard may be underplanted with various grains or grasses during early summer to serve as additional food cover.

The herbaceous marsh portion can be improved for muskrats and waterfowl by digging out a shallow pond with a team and scoop. The size of the pond need not be in excess of one-half acre. This will provide two small open ponds on the area. Plants such as cattail, hard stem bulrush, sedge, duck potato, chufa and smartweed may be introduced in the ponds and around the edges to serve as food and cover for muskrats and waterfowl.

An estimation of the cost of such improvement might be as follows:

Materials:

Fence (280 rds. barbed wire, etc.).....	$12.00	
(Posts to be cut from woodlot)		
Planting		
Evergreens (200).....	2.00	
Miscellaneous seeds and plants.....	5.00	
		$19.00

Labor:

Cutting posts 3 man days @ $3.00.....	9.00	
Putting up fence 4 man days	12.00	
Excavating pond (1 day, man & team).....	6.00	
Planting 3 man days.....	9.00	
		$36.00
Total.....		$55.00

The initial cost of improvement would be by far the greatest. Annual upkeep costs on the project would consist mainly of food strips which are allowed to remain in the field after harvesting and upkeep on fences. Work on improvement may be done by farm labor during slack seasons.

Except for the sale of furs and the food value of animals taken from the kettle, it will be difficult to compute the expected return on the investment on a dollars and cents basis. Such improvement should provide a habitat for large numbers of pheasants, rabbits, muskrats, song birds and many other forms of wildlife and in addition will beautify the view from the farm dwellings.

CONCLUSION

Value of Kettleholes to Owner

With the exception of a few shallow dry kettles, few of them can be successfully drained and used for agriculture. Instead of undertaking expensive and frequently unsatisfactory reclamation projects on kettles, it will be well to first consider whether they will not serve a more useful purpose in providing habitat for wildlife. These kettles may be in the end of more value to agriculture in providing homes for insect destroying animals than they would if planted to crops.

Grazing may be justified in some cases where the only pasture land is largely occupied by a kettle containing suitable forage species. However, most of them are of such small size and of inferior grazing value that the exclusion of grazing will have little effect on the amount of available forage for livestock.

In view of the limited agricultural value of kettles, it appears as though the improvement of these areas for wildlife will be consistent with good farm management policies, that of getting the greatest use from the land.

Improvement of Kettleholes

Improvement should be undertaken for as many species as feasible. These plans should be made to fit in as well

as possible with other farm activities, that is, work should be done in slack seasons and species that are easily available should be selected for planting. Irregularly shaped kettles in cultivated fields may be squared off with shrub plantings in the corners, making it easier to cultivate around them.

We have then as a typically well improved kettle, one from which grazing has been excluded and drainage stopped. It should contain both dense brushy and herbaceous areas. Evergreens planted for year round cover may be located in the higher portions. Dense cover free from spring flooding should be provided for spring roosting and crowing areas. Nesting cover should be available adjacent to the kettle in portions of herbaceous fields free from harvesting activities. A wide variety of natural perennial species should be allowed to grow in the kettle to provide food and cover. Additional winter food may be provided for by allowing a few swaths or shocks of grain to stand in the cultivated fields adjacent to the kettle. Travel lanes in the form of dense fence rows, erosion gulleys, should be provided leading from the kettle to various other coverts. Where the kettle is wet through a large part of the year, open ponds should be provided for muskrat and waterfowl use. Food and cover species for these animals should be introduced into these ponds. If possible it would be well to exclude fall hunting from these kettles in order to provide sanctuary areas.

The size of the kettle being improved is not important. All those from 1/10 acre up may be used by wildlife. The larger the kettle, the greater number of individuals it may support, but numerous small kettles distributed over an area are to be preferred to one or two large kettles.

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