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# TULAREMIA IN WISCONSIN*

BANNER BILL MORGAN

*Department of Veterinary Science, University of Wisconsin, Madison*

*Published with the approval of the director of the Wisconsin Agricultural Experiment Station.

Although tularemia was first recognized by McCoy in 1910 as a "plague-like disease of rodents" in California ground squirrels (*Citellus beecheyi*) and later by Francis (1920) as "deer fly fever" in jack rabbits and man, the disease was not reported in Wisconsin until 1928. Probably the disease existed in Wisconsin before that time.

Tularemia is now known as a highly infectious disease occurring primarily in wild rabbits (Lagomorpha) and rodents (Rodentia); secondarily in man. The causative agent is classified as *Pasteurella tularensis,* one of the plague-like group, being related to the bubonic plague organism, *P. pestis.* The tularemia organism differs from *P. pestis* in cultural characteristics, growth requirements, and antigenic composition. It shows some degree of antigenic relationship to the *Brucella* group as it cross agglutinates with *B. abortus* (brucellosis, undulant fever). Microscopically, the bacterium is a small gram negative, non-motile, aerobic rod which has bacillary and coccoid tendencies.

Since the disease was first discovered in California, numerous cases have been reported in the United States. It is rapidly becoming an important disease with a human mortality rate of approximately 5 per cent. According to authorities, tularemia is the only disease of man first described from America. Forty-six states, District of Columbia, Alaska, and several foreign countries, namely Canada (1930), Sweden (1931), Austria (1935), Czechoslovakia (1937), Poland (1942), Russia (1920), Norway (1929), French West Africa, Tunisia (1938), Turkey (1938) and Japan (1925) have reported the occurrence of tularemia.

Tularemia is transmitted among wild animals and occasionally to man by blood sucking arthropods. The vectors in the United States include the deer fly (*Chrysops discalis*), ticks (*Dermacentor andersoni, D. variabilis,* and *D. occidentalis*), rabbit louse (*Haemodipsus ventricosus*), mouse louse (*Polyplox serratus*), squirrel flea (*Ceratophyllus acutus*), stable fly (*Stomoxys calcitrans*), and bed bug (*Cimex lectularius*).

Francis (1937) stated that cottontail rabbits, jack rabbits, and snowshoe hares accounted for over 90 per cent of the human cases in the United States. In most instances the disease was contracted by dressing rabbit carcasses. The organism can enter through unbroken skin, as well as the traumatized integument. Infection may occur also by consumption of improperly cooked infected meat or by inhalation. Since a large number of laboratory workers have contracted the disease despite extreme precautions, there is evidence for the belief that air-borne infection is of considerable importance. Another potential danger of tularemia infection has been demonstrated by the isolation of viable *P. tularensis* from cold water streams.

The infected rabbits and rodents show marked involvement of the liver, spleen, bone marrow and lungs. The surface of the viscera often shows many small white foci varying in size from microscopic to one sixteenth of an inch in diameter. These lesions develop within four days after the rabbit is infected.

In man, the disease has an incubation period of approximately three days with symptoms of headache, chills, general muscular aching, fever, nausea or vomiting. The symptoms somewhat resemble those of "flu." If infection has entered through a wound, an ulcer may form. The lymph glands generally become enlarged, tender and painful. Later, some of the glands may abscess. Patients show a slow convalescence requiring from two to four months.

Most of our knowledge of tularemia is derived from the extensive investigations of Edward Francis and his co-workers of the United States Public Health Service. Tularemia later was made a notifiable disease to this Federal agency.

In compiling the data for this report, tables and maps were compiled from the original records of the Wisconsin State Board of Health through the courtesy of Dr. H. M. Guilford.

The data presented may be affected to a variable extent by the progressive increase in the skill and ability of physicians to diagnose tularemia. Relatively few cases of tularemia had been reported in

Wisconsin prior to 1930. This may, perhaps in part, be ascribed to greater public awareness of tularemia as well as of recognition by and improved diagnostic skill of physicians and diagnostic laboratories. There is no way of knowing what per cent error may exist in the number of cases reported. There were 54 human cases of tularemia in the state in 1939, the highest number recorded for one year. According to a survey made by McCabe, 50 per cent of 160 farmers' interviews in 1940 curtailed cottontail rabbit hunting because of "rabbit sickness."

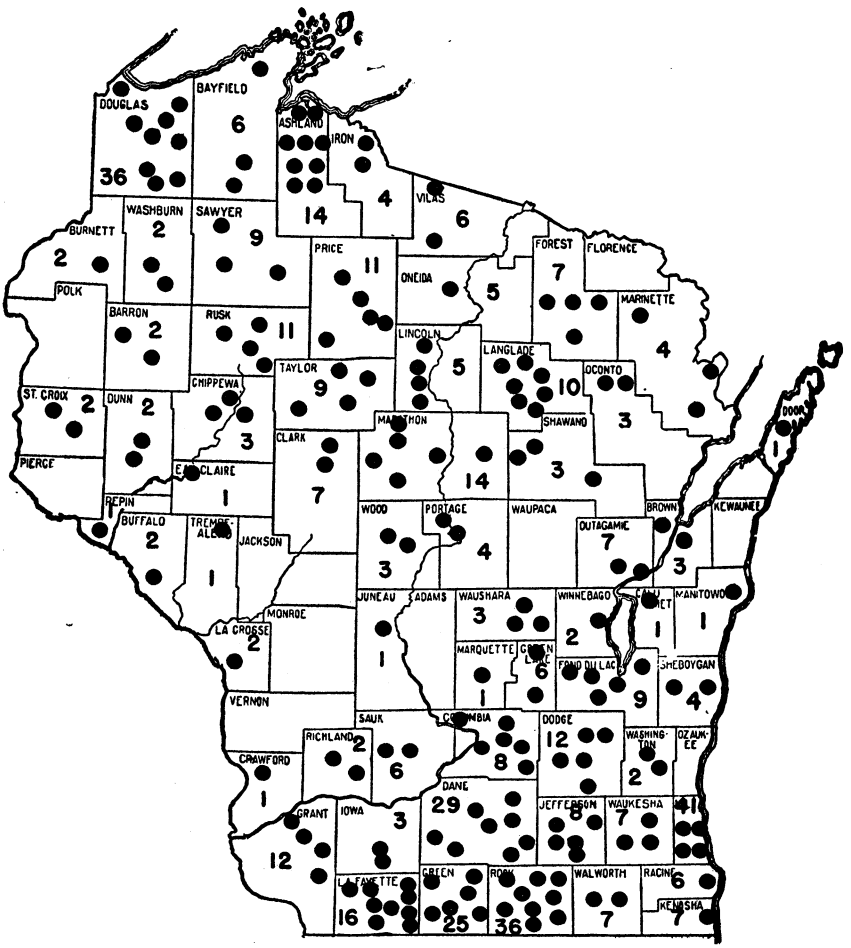


FIG. 1. Distribution of human cases of tularemia in Wisconsin by counties (1928-1946).

TABLE 1.
TOTAL NUMBER OF CASES OF HUMAN TULAREMIA REPORTED FOR EACH COUNTY OF WISCONSIN COVERING THE PERIOD 1928 TO 1946

| | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adams | | | | | | | | | | | | | | | | | | | | 0 |
| Ashland | | | | 4 | 3 | 4 | 1 | | | | | 1 | | 1 | | | | | | 14 |
| Barron | | | | | | | | | | | | | | | 2 | | | | | 2 |
| Bayfield | | | | 1 | 2 | 1 | 1 | | | | 1 | | | | | | | | | 6 |
| Brown | | | | 1 | | 2 | | | | | | | | | | | | | | 3 |
| Buffalo | | | | | | | | | | | 1 | 1 | | | | | | | | 2 |
| Burnette | | | | 1 | 1 | | | | | | | | | | | | | | | 2 |
| Calumet | | | | | | 1 | | | | | | | | | | | | | | 1 |
| Chippewa | | | | | 1 | | | | | | | 1 | | | | 1 | | | | 3 |
| Clark | | | | | 1 | | 1 | | | | 1 | | | | | 1 | | | 3 | 7 |
| Columbia | | | | | | 1 | 2 | | 1 | | 2 | | | | 1 | 1 | | | | 8 |
| Crawford | | | | | | | | | | 1 | | | | | | | | | | 1 |
| Dane | | | 3 | 2 | 4 | 6 | 2 | | 1 | | 2 | 5 | | 2 | 2 | | | | | 29 |
| Dodge | | | 1 | | | | | | | | 2 | 1 | | | 1 | 1 | | | 6 | 12 |
| Door | | | | | | | | | | | | | 1 | | | | | | | 1 |
| Douglas | | 4 | | 3 | 3 | 7 | 5 | 1 | | | 5 | 2 | 1 | 2 | | | | 2 | 1 | 36 |
| Dunn | | | | 1 | | | 1 | | | | | | | | | | | | | 2 |
| Eau Claire | 1 | | | | | | | | | | | | | | | | | | | 1 |
| Florence | | | | | | | | | | | | | | | | | | | | 0 |
| Fond du Lac | | | | | | 1 | | 1 | | 3 | 3 | | | | | | | 1 | | 9 |
| Forest | | | 1 | 1 | 1 | 3 | | | 1 | | | | | | | | | | | 7 |
| Grant | | | | 1 | 1 | 4 | 1 | | | | | 3 | 1 | | 1 | | | | | 12 |
| Green | | | 3 | 5 | 1 | 2 | | 3 | | 1 | | 3 | | 5 | 2 | | | | | 25 |
| Green Lake | | | | | | | | | | 1 | 1 | | 1 | | | | | 1 | 2 | 6 |
| Iowa | | | | | | | 1 | | | | 1 | | | | | | | 1 | | 3 |
| Iron | | | | | 3 | 1 | | | | | | | | | | | | | | 4 |
| Jackson | | | | | | | | | | | | | | | | | | | | 0 |
| Jefferson | | | | 1 | | 2 | 2 | | 1 | | | 1 | | | 1 | | | | | 8 |
| Juneau | | | 1 | | | | | | | | | | | | | | | | | 1 |
| Kenosha | | | | | 1 | | | 3 | 1 | | | | 2 | | | | | | | 7 |
| Kewaunee | | | | | | | | | | | | | | | | | | | | 0 |
| La Crosse | | | | | | | | | | | | 1 | | | | | 1 | | | 2 |
| Lafayette | | | 4 | | 1 | | | 1 | | | 1 | 6 | | 3 | | | | | | 16 |
| Langlade | | | 2 | | | 2 | 1 | 1 | 2 | | | | | | 1 | 1 | | | | 10 |
| Lincoln | | | | 2 | | 2 | | | 1 | | | | | | | | | | | 5 |
| Manitowoc | | | | | | | | | | | | | | | 1 | | | | | 1 |

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marathon | | | | 1 | 3 | 1 | 3 | 1 | | | 1 | 1 | 2 | | | 1 | | | | 14 |
| Marinette | 1 | | | 1 | 1 | | | | | | | | | 1 | | | | | | 4 |
| Marquette | | | | | | | 1 | | | | | | | | | | | | | 1 |
| Milwaukee | 1 | 1 | | | 2 | 1 | 2 | 2 | 11 | | 3 | 7 | 2 | 5 | | 2 | | | 2 | 41 |
| Monroe | | | | | | | | | | | | | | | | | | | | 0 |
| Oconto | | | | | | | 1 | | | | | | | | | | | | 2 | 3 |
| Oneida | | | | | 1 | 2 | | | 2 | | | | | | | | | | | 5 |
| Outagamie | | | | | 1 | | | | | 2 | | 2 | | | | | | | 2 | 7 |
| Ozaukee | | | | | | | | | | | | | | | | | | | | 0 |
| Pepin | | | | | | | | | | | | | | | | 1 | | | | 1 |
| Pierce | | | | | | | | | | | | | | | | | | | | 0 |
| Polk | | | | | | | | | | | | | | | | | | | | 0 |
| Portage | | | | | 2 | | | | | | | | | | | | | | 2 | 4 |
| Price | | | | | 3 | | | 1 | 1 | 1 | 1 | | | 1 | | | 1 | | 2 | 11 |
| Racine | | | | | | | | | | | 1 | 2 | 2 | 1 | | | | | | 6 |
| Richland | | | | | | | | | | | 1 | | 1 | | | | | | | 2 |
| Rock | 2 | | | 2 | 1 | 1 | 2 | 1 | 2 | | 1 | 12 | 3 | 6 | 1 | 1 | | 1 | | 36 |
| Rusk | | 1 | | | 1 | 6 | | | | 2 | | | | | | | | 1 | | 11 |
| St. Croix | | | | | 1 | | | | | | | | | | | | | 1 | | 2 |
| Sauk | | 1 | | 1 | | | | | | | 1 | | | 1 | 1 | | | | 1 | 6 |
| Sawyer | | | | 2 | 3 | | 1 | | | 1 | | | 1 | | | | | 1 | | 9 |
| Shawano | | | 1 | 1 | | | | | | | | | | | | 1 | | | | 3 |
| Sheboygan | | | | | | | 1 | | 1 | | | 1 | | | | 1 | | | | 4 |
| Taylor | | | 1 | | 1 | | 4 | 1 | 1 | 1 | | | | | | | | | | 9 |
| Trempealeau | | | | | | 1 | | | | | | | | | | | | | | 1 |
| Vernon | | | | | | | | | | | | | | | | | | | | 0 |
| Vilas | | | | 1 | | | 2 | | 1 | | | | | | | 1 | | | 1 | 6 |
| Walworth | | | | | | 1 | 3 | | | 1 | | 2 | | | | | | | | 7 |
| Washburn | | 1 | | | | | | | | | | | | | | 1 | | | | 2 |
| Washington | | | | | | | 2 | | | | | | | | 1 | | | | | 3 |
| Waukesha | | | | | | | 1 | | 1 | | 1 | 2 | | 1 | 1 | | | | | 7 |
| Waupaca | | | | | | | | | | | | | | | | | | | | 0 |
| Waushara | | | | | | | 1 | | | | | | | | | | 1 | 1 | | 3 |
| Winnebago | | | | | | | | | | | 1 | | | | | | | 1 | | 2 |
| Wood | | | | | | | | | 1 | | | | | | | | | | 2 | 3 |
| TOTALS | 5 | 8 | 17 | 32 | 43 | 52 | 42 | 16 | 29 | 14 | 31 | 54 | 17 | 29 | 16 | 14 | 3 | 11 | 26 | 459 |

From 1928 to 1946 there has been reported from Wisconsin a total of 459 cases of tularemia in 61 counties. The disease has not been recorded in ten counties. Table 1 shows the total number of human cases of tularemia reported for each county in Wisconsin for the 19-year period. Figure 1 indicates the distribution of tularemia

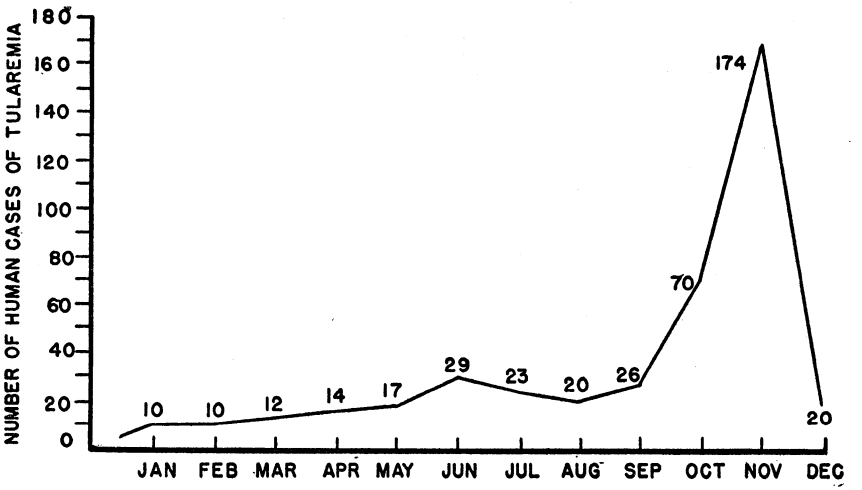


FIG. 2. Total number of human cases of tularemia in Wisconsin for each month over a 19 year period (1928-1946).

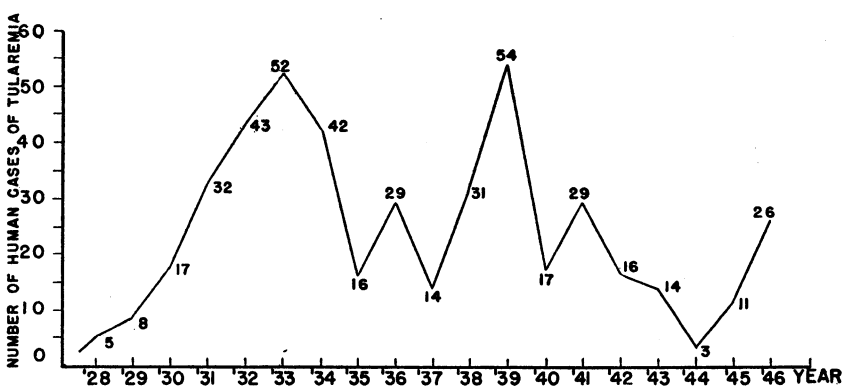


FIG. 3. Total number of human cases of tularemia in Wisconsin by year (1928-1946).

TABLE 2.
TOTAL NUMBER OF HUMAN CASES OF TULAREMIA REPORTED IN WISCONSIN FOR EACH MONTH OVER THE PERIOD JANUARY, 1928 TO DECEMBER, 1946

| YEAR | JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY | AUG. | SEPT. | OCT. | NOV. | DEC. | NOT SPECIFIED | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1928..... | | | | | | | | | | | | | 5 | 5 |
| 1929..... | | | | | | 2 | 2 | 1 | 1 | 1 | 1 | | | 8 |
| 1930..... | 1 | | 1 | | | 1 | | 3 | | 3 | 8 | | | 17 |
| 1931..... | | | | | | 1 | 3 | | 2 | 7 | 15 | 1 | 3 | 32 |
| 1932..... | 1 | | 1 | 1 | | 2 | 2 | | 8 | 13 | 9 | 2 | 4 | 43 |
| 1933..... | | | 1 | | 2 | 5 | 3 | 3 | 2 | 13 | 19 | | 4 | 52 |
| 1934..... | 1 | 2 | | | 2 | 2 | 2 | 4 | 6 | 7 | 14 | 1 | 1 | 42 |
| 1935..... | | | | 1 | 1 | | | 1 | 1 | 3 | 8 | 1 | | 16 |
| 1936..... | 1 | 1 | | | 2 | 3 | 1 | 1 | | 1 | 13 | 2 | 4 | 29 |
| 1937..... | 1 | 1 | 1 | | 1 | 2 | | 1 | | 2 | 2 | 1 | 2 | 14 |
| 1938..... | | 2 | | 2 | 3 | 1 | 2 | 2 | | 1 | 12 | 2 | 4 | 31 |
| 1939..... | | | | | | 2 | 1 | | 2 | 7 | 38 | 3 | 1 | 54 |
| 1940..... | | 1 | | | 1 | 1 | | | | 1 | 9 | 2 | 2 | 17 |
| 1941..... | 1 | | | | 1 | | | | 2 | 4 | 18 | 2 | 1 | 29 |
| 1942..... | 1 | | | 1 | | | 3 | 1 | | 5 | 5 | | | 16 |
| 1943..... | 1 | | 1 | 2 | | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 14 |
| 1944..... | | | 1 | | | | | | | | 2 | | | 3 |
| 1945..... | 2 | 2 | | | 2 | 1 | | | 1 | 1 | | 1 | 1 | 11 |
| 1946..... | | 1 | 6 | 7 | 2 | 4 | 3 | 1 | | | | 1 | 1 | 26 |
| TOTALS.. | 10 | 10 | 12 | 14 | 17 | 29 | 23 | 20 | 26 | 70 | 174 | 20 | 34 | 459 |

in Wisconsin by counties. Over half of the cases occurred in ten counties: Milwaukee (41), Rock (36), Douglas (36), Dane (29), Green (25), Lafayette (16), Marathon (14), Ashland (14), Dodge (12) and Grant (12).

Table 2 shows the total number of human cases of tularemia reported in Wisconsin for each month over the 19-year period (1928–1946). In constructing Figure 2, the indication is that tularemia was seasonal in Wisconsin with October and November the peak months with 70 and 174 cases, respectively. Another peak occurred in June with 29 cases. No month was free of tularemia.

According to Figure 3 the disease was somewhat cyclic with 1933 and 1939 the high years. There appears to be a relationship between human tularemia and the cottontail hunting season which opens in October and closes in February. The slight rise in June may indicate exposure to wood ticks (*D. variabilis*) or the handling of young wild rabbits. During the haying season, the nest and young are frequently located by farmers. There is no closed season for the snowshoe hare, and this may account for some cases reported outside of the regular cottontail hunting season. Hunting rabbits out of season, exposure to other infected animals, transmission of the disease by arthropods and faulty diagnosis appear to be other factors in tularemia dissemination to man. Since human tularemia has been reported in every month, there can be no safe period to handle potential tularemia-bearing wild game unless proper precautions are taken.

Information on histories of 459 cases of human tularemia in Wisconsin during 1929–1946 seem to cover all the above-mentioned possibilities. Rabbits (cottontails, snowshoe hares and jack rabbits) appeared to be the greatest single source of infection with 305 cases of such contact reported. Due to inability to trace the various histories, 79 cases had to be recorded as unknown or not reported. Woodticks (*Dermacentor variabilis*) were held accountable for 24 human cases. Eleven cases followed contacts with upland game birds: partridge, pheasant, prairie chicken. Ten infected persons had killed and skinned muskrats. Nine cases of tularemia have followed bites or scratches by cats. Four cases were associated with contact with squirrels and deer-fly bites appear to have caused three cases. Two cases each followed contact with skunks, horses, sick dogs which killed rabbits, foxes, muskrat or beaver, or possible contact with skunk, mink, muskrat or raccoon. One case was recorded from exposure to a contaminated stream.

Some of the case histories classified as unknown or unreported recorded statements which have little bearing on the transmission of the disease such as "scratch in raspberry patch," "cut in the woods," "mosquitoes or cut toe," "fox-farm employee," "wood splinter," "wire prick," and "bullhead fish injury."

The cases of infection apparently derived from rabbits varied in their mode of entrance into the body. The majority had histories of skinning wild rabbits, while cases which had ingested insufficiently cooked rabbit meat ranked next in number. Approximately 66.4 per cent of all cases were derived from direct contact with rabbits.

The mortality rate of tularemia in Wisconsin approaches the national average of approximately 5 per cent. Of 459 cases from 1928 to 1946, there were 19 deaths, a mortality of 4.13 per cent. The deaths were distributed over the 19-year period as follows: 1929 (1), 1930 (1), 1931 (1), 1932 (4), 1933 (4), 1938 (4), 1941 (1), 1943 (2) and 1944 (1).

Francis (1928) classified the different variation in the clinical manifestations of the disease according to the four clinical types:

1. *Ulceroglandular*: In this form there is a primary lesion which develops at the point of inoculation. A papule forms and eventually leaves an ulcer. Within a day or so painful swellings develop in the regional lymph nodes draining the area of inoculation. Of the 459 Wisconsin cases, 114 patients had the ulceroglandular type (22.4%).

2. *Glandular*: In this type of tularemia there are no visible primary lesions. In all other respects it is similar to the ulceroglandular type. There were 137 cases of this type (30.4%).

3. *Typhoidal*: This type is occasionally confused with clinical typhoid fever. There are no primary lesions or swelling of the regional lymph glands. There were 88 cases of typhoidal tularemia in the Wisconsin patients (19.6%).

4. *Oculoglandular*: The infection localizes in the conjunctiva, inoculation resulting by touching the eyelids with contaminated hands. Some of the symptoms and lesions include excessive lachrymation, irritation, edema of the lids and hyperemia of the conjunctiva. The regional lymph nodes also enlarge. Only six cases of this type (1.2%) were reported from Wisconsin.

Due to lack of complete records, 114 cases (22.4%) were listed as unclassified. Eight person died of the typhoidal type, six with ulceroglandular tularemia and five from unclassified forms of the disease.

The following is a list of the counties in Wisconsin indicating the

total number of cases of tularemia reported and the distribution according to towns for the years 1928 to 1946:

1. Adams (0).
2. Ashland (14): Ashland (6), Odanah (2), Morse (1), North York (1), Glidden (2), Mellen (1), Undesignated (1).
3. Barron (2): Cumberland (1), Barron (1).
4. Bayfield (6): Cable (1), Drummond (2), Iron River (1), Benoit (1), Undesignated (1).
5. Brown (3): DePere (1), State Reformatory (1), Green Bay (1).
6. Buffalo (2): Fountain City (2).
7. Burnette (2): Hertel (2).
8. Calumet (1): High Cliff (1).
9. Chippewa (3): Holcombe (1), Cornell (1), Bloomer (1).
10. Clark (7): Curtiss (1), Owen (1), Hoard Twp. (1), Dorchester (1), Withee (1), Undesignated (2).
11. Columbia (8): Poynette (1), Wisconsin Dells (2), Fall River (2), Columbus (1), Pardeeville (1), Rio (1).
12. Crawford (1): Ferryville (1).
13. Dane (29): Madison (16), McFarland (2), Primrose Twp. (1), Waterloo (1), Dane (1), Deerfield (1), Albion (1), Belleville (1), Cambridge (1), Undesignated (4).
14. Dodge (12): Mayville (2), Beaver Dam (2), Watertown (1), Juneau (1), Horican (6).
15. Door (1): Sawyer (1).
16. Douglas (36): Brule (2), Superior (16), Salon Springs (4), Poplar (2), Gordon (3), Foxboro (1), Lake Side (3), Maple (2), South Range (2), Undesignated (1).
17. Dunn (2): Menomonie (1), Undesignated (1).
18. Eau Claire (1): Eau Claire (1).
19. Florence (0).
20. Fond du Lac (9): Oakfield (1), Calumet Harbor (1), Rosendale (1), Fond du Lac (3), Ripon (1), Undesignated (2).
21. Forest (7): Laona Twp. (1), Crandon (3), Wabeno (1), Armstrong Creek (1), Nashville (1).
22. Grant (12): Fennimore (5), Platteville (5), Boscobel (1), Livingston (1).
23. Green (25): Brodhead (9), Monroe (9), Browntown (3), Brooklyn (1), Albany Twp. (1), Adams Twp. (1), Undesignated (1).
24. Green Lake (6): Berlin (4), Markesan (1), Undesignated (1).
25. Iowa (3): Dodgeville (2), Mineral Point (1).
26. Iron (4): Hurley (1), Gile (1), Kimball (1), Undesignated (1).
27. Jackson (0).
28. Jefferson (8): Lake Mills (2), Jefferson (1), Fort Atkinson (3), Sullivan (1), Undesignated (1).
29. Juneau (1): Cloverdale (1).
30. Kenosha (7): Kenosha (7).
31. Kewaunee (0).
32. La Crosse (2): La Crosse (2).
33. Lafayette (16): Darlington (5), Woodford (1), Belmont (1), Argyle

(2), Blanchardville (2), Shullburg (1), South Wayne (2), Calamine (1), Undesignated (1).

34. Langlade (10): Summit Lake (3), Antigo (2), Elcho (2), Pearson (2), Parrish (1).
35. Lincoln (5): Grandfather Falls (1), Tomahawk (2), Merrill (1), Undesignated (1).
36. Manitowoc (1): Two Rivers (1).
37. Marathon (14): Stratford (3), Hatley (1), Colby (1), Wausau (6), Athens (1), Hamburg (1), Undesignated (1).
38. Marinette (4): Peshtigo (1), McAllister (1), Pound (1), Goodman (1).
39. Marquette (1): Montello (1).
40. Milwaukee (41): Milwaukee (37), Hales Corners (1), Cudahy (1), West Allis (2).
41. Monroe (0).
42. Oconto (3): Lake Wood (1), Wheeler (1), Townsend (1).
43. Oneida (5): Rhinelander (3), Pelican (1), Harshaw (1).
44. Outagamie (7): Appleton (4), Kaukauna (3).
45. Ozaukee (0).
46. Pepin (1): Stockholm (1).
47. Pierce (0).
48. Polk (0).
49. Portage (4): Stevens Point (2), Junction City (2).
50. Price (11): Phillips (6), Lugerville (1), Prentice (1), Town of Knox (1), Worcester Twp. (1), Kennen (1).
51. Racine (6): Racine (6).
52. Richland (2): Lone Rock (1), Richland Center (1).
53. Rock (36): Janesville (12), Beloit (13), Orfordville (1), Evansville (4), Edgerton (1), Milton (2), Lima Center (1), Clinton (1), Undesignated (1).
54. Rusk (11): Bruce (1), Ladysmith (4), Conrath (3), Sheldon (2), Undesignated (1).
55. St. Croix (2): Baldwin (1), New Richmond (1).
56. Sauk (6): Lime Ridge (1), Loganville (2), Prairie du Sac (2), Hillpoint (1).
57. Sawyer (9): Winter (2), Hayward (4), Exeland (2), Reserve (1).
58. Shawano (3): Bernamwood (1), Matoon (1), Shawano (1).
59. Sheboygan (4): Plymouth (2), Sheboygan (2).
60. Taylor (9): Rib Lake (3), Gilman (2), Medford (3), Westboro (1).
61. Trempealeau (1): Osseo (1).
62. Vernon (0).
63. Vilas (6): Winegar (2), Arbor Vitae (1), Eagle River (1), Undesignated (2).
64. Walworth (7): Lake Geneva (3), Delevan (3), Whitewater (1).
65. Washburn (2): Spooner (2).
66. Washington (3): West Bend (2), Barton (1).
67. Waukesha (7): Sussex (1), Waukesha (2), Genesee Depot (2), Genesee Twp. (1), Oconomowoc (1).
68. Waupaca (0).
69. Waushara (3): Lohrville (1), Pine River (1), Red Granite (1).

In further attempts to correlate the number of cases of human tularemia with exposure to rabbits, several comparisons were made. Figure 4 (A) shows the ten leading counties according to total human population and their rank (Milwaukee, Dane, Racine, Winnebago, Brown, Sheboygan, Marathon, Washburn, Rock and Outagamie). This is compared to the ten counties having the largest rabbit population,

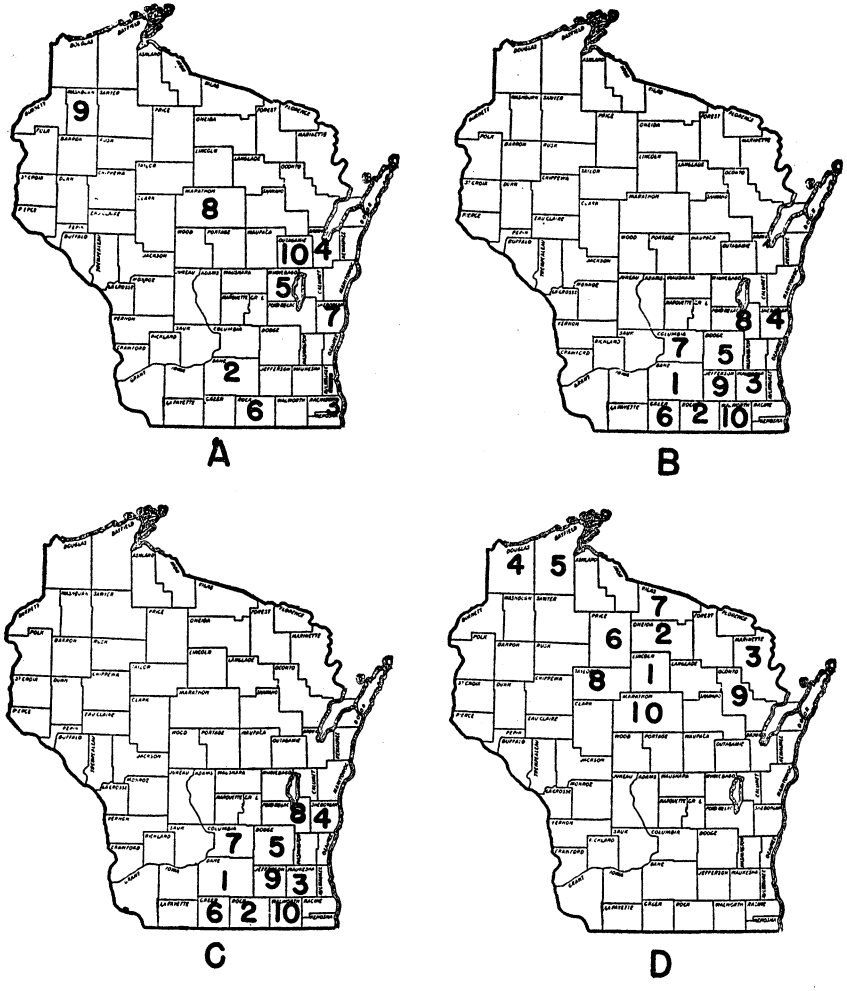


FIG. 4. (A) Ten leading counties according to total human population (B) Ten counties with the largest rabbit population (C) Ten leading counties for cottontail rabbit take (D) Ten leading counties for snowshoe hare take.

Figure 4 (B). Three counties are represented in both figures, Rock, Dane and Sheboygan. Figure 4 (E) shows the leading counties in density of the human population per square mile as compared to Figure 4 (F) which indicates the density of rabbit population per square mile. The correlation is a little more pronounced as five coun-

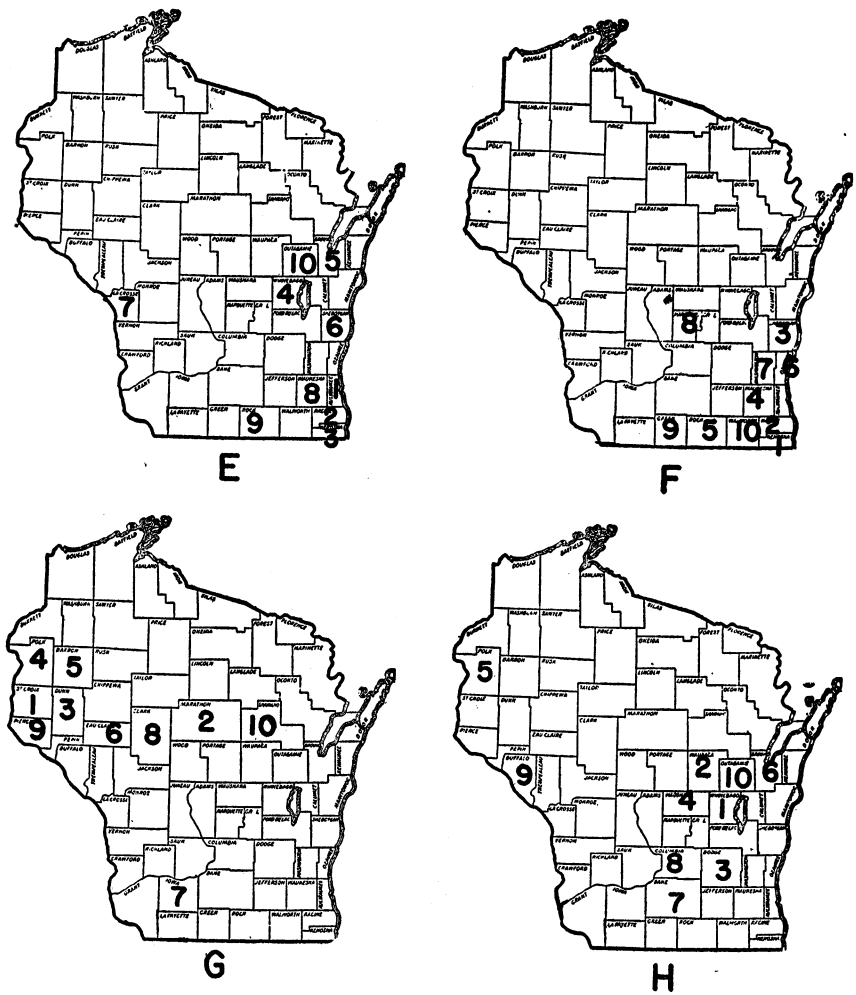


FIG. 4. (E) Ten leading counties in density of human population per square mile (F) Ten leading counties in density of rabbit population per square mile (G) Ten leading counties for jack rabbit take (H) Ten leading counties for muskrat take.

ties are represented in both maps (Rock, Kenosha, Racine, Waukesha and Sheboygan). Figure 4 (C, D, G, H) shows the average take for the cottontail, snowshoe, jack rabbit and muskrat, respectively, over a five-year period.

Rabbits, which account for 66.4 per cent of all the human cases of tularemia, are mostly located in southern Wisconsin. Milwaukee County, where the use of firearms is prohibited, has the greatest number of cases. This suggests that infection from rabbits is acquired by hunting in other counties.

It is interesting that Douglas County ranks fourth in snowshoe-hare take over a five-year period and ranks second in the total number of cases of tularemia. This would indicate that the snowshoe rabbit is an important animal source of human tularemia in the northern counties. Very little significance can be attached to the jack rabbit population in the incidence of tularemia infection in man.

An epizootic of tularemia was reported in acquatic mammals in March and April 1946 (musrat and beaver) near the Horicon Marsh, Dodge County, Wisconsin. Six human cases of tularemia were ascribed to infected muskrats in Dodge County which is the third leading county for muskrat take.

One case of tularemia in Wisconsin was thought to be water borne. Morgan (1947) found that six species of fish were not susceptible to the disease. Acquatic mammals would appear to be the major source of water-borne cases.

## Summary

A total of 459 human cases of tularemia have been recorded from 61 counties in Wisconsin over a 19-year period (1928–1946). Approximately 67 per cent of the cases were derived from direct contact with rabbits. The mortality rate was 4.1 per cent. Of the four clinical types of tularemia, 114 patients had the ulceroglandular type (22.4 per cent), 136 patients had the glandular type (30.4 per cent), 88 patients contracted the typhoidal type (19.6 per cent) and only 6 cases (1.2 per cent) had the oculoglandular tularemia. Due to incomplete records, 114 cases (22.4 per cent) were listed as unclassified. Over one half of the cases occurred in ten counties: Milwaukee (41), Rock (36), Douglas (36), Dane (29), Green (25), Lafayette (16), Marathon (14), Ashland (14), Dodge (12) and Grant (12). Tularemia is somewhat seasonal with November the high month, which coincides with the hunting season. The high year was 1939 with 54 cases.

## ACKNOWLEDGMENTS

The writer wishes to thank Dr. H. M. Guilford, Wisconsin State Board of Health, Madison, for permission to examine the original records on file at the State Board of Health Office. Thanks are also due to Mrs. Doris Orwig and Mr. Clayton Haberman for aid in compiling these data.

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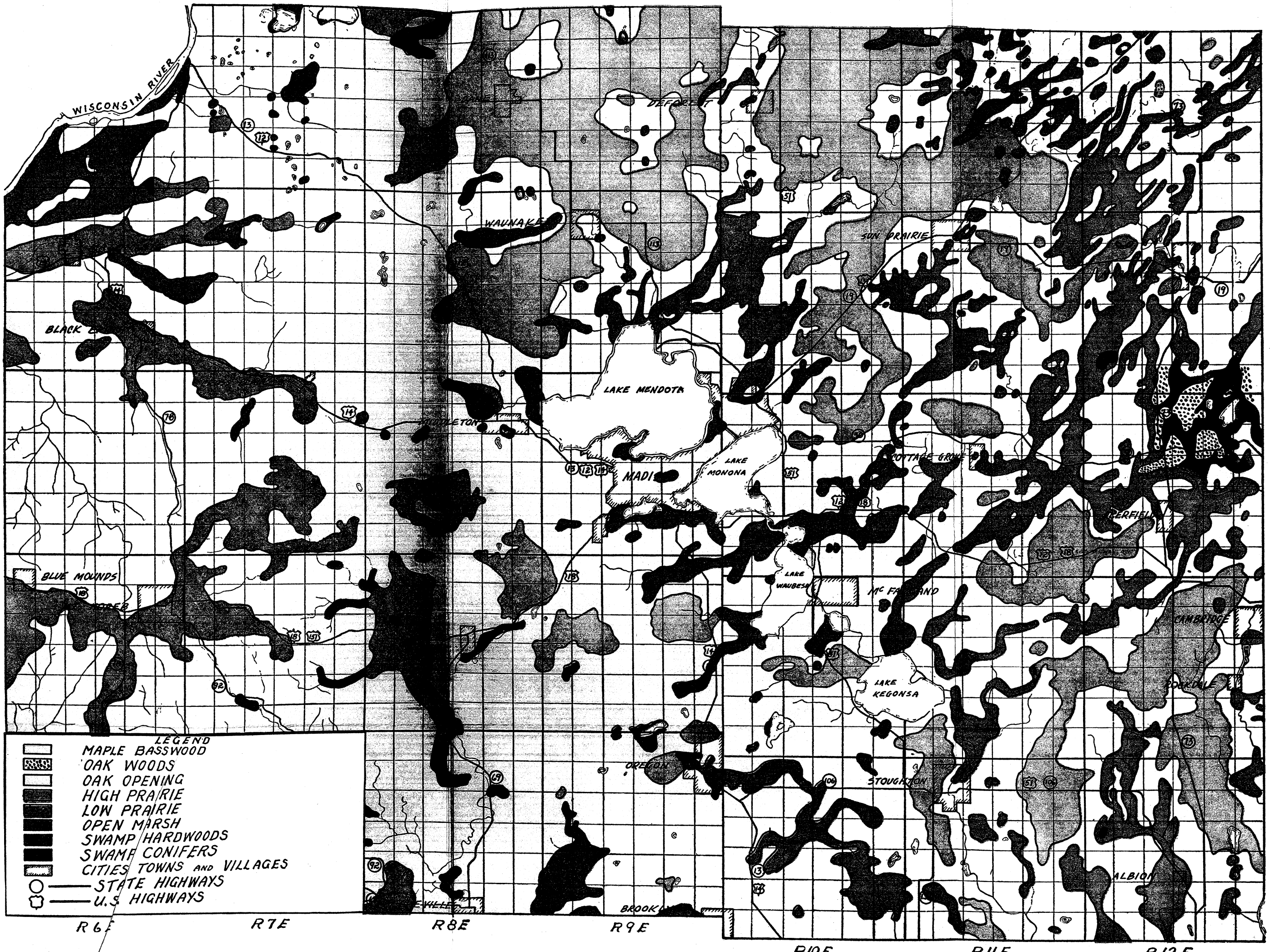
# PLATE 1.


WISCONSIN RIVER
DEFOREST
WAUNAKEE
SUN PRAIRIE
BLACK
LAKE MENDOTA
MIDDLETON
MADI
LAKE MONONA
COTTAGE GROVE
PERFIELD
LAKE WAUBESA
McFARLAND
CAMBRIDGE
BLUE MOUNDS
LAKE KEGONSA
POYNETTE
OREGON
STOUGHTON
ALBION
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R11E
R12E
LEGEND
MAPLE BASSWOOD
OAK WOODS
OAK OPENING
HIGH PRAIRIE
LOW PRAIRIE
OPEN MARSH
SWAMP HARDWOODS
SWAMP CONIFERS
CITIES TOWNS AND VILLAGES
STATE HIGHWAYS
U.S. HIGHWAYS

# THE VEGETATION OF DANE COUNTY WISCONSIN IN 1835

ROBERT SCOTT ELLARSON

Dane County is located in south central Wisconsin in what is now the heart of the rich dairy farming region of the state. Due to its advantageous location and high quality soils, much of the total land area is now under plow or is cleared pasture land; consequently, very little of the original vegetative cover remains. It was with this in mind that work was started to ascertain as closely as possible the type and distribution of the vegetative cover before its disturbance by white settlement.

Aside from the purely historical interest of this information, a map showing the areal distribution of the native vegetation before settlement in this region is also of great interest to the plant ecologist because Dane County lies within the prairie-forest ecotone and contains two widely divergent topographical regions.

The floristic associations recognized and mapped in this report are based on a list of plant associations devised by Dr. N.C. Fassett and used by him in mapping other areas within the state of Wisconsin. A chromatic system of colors is used to indicate the various associations and their inter-relationships. Eight different associations were recognized in the mapping of Dane County. The following is a list of these associations and the color used to indicate each on the map:

1 Open Marsh ..... Magenta
2 Low Prairie ..... Blue & Dots
3 High Prairie ..... Blue
4 Oak Opening ..... Green
5 Oak Woods ..... Green & Dots
6 Upland Hardwoods ..... Yellow
7 Lowland Hardwoods .. Magenta & Dots
8 Swamp Conifers ..... Black

The principal sources of information used in compiling the accompanying map (see Plate 1) were the survey notes made at the time of the original land survey in the years 1832–35. These notes are on

file in the office of the Commissioners of Public Lands in the State Capitol at Madison, and were made available through the courtesy of Mr. Tester H. Bakken.

The original survey was made by two separate survey crews. The first surveyed the exterior or township lines blocking off the land into townships six miles square. A list of the deputy surveyors and the exterior and interior township lines each was respectively responsible for, together with the dates of these surveys, is to be found in Appendix A.

The notes taken by the deputy surveyors during the course of this work vary both in amount and in quality of information. However, for the most part, sufficient information is incorporated to allow a clear picture of the country, as it then appeared, to be drawn. The only exception was found in the notes for the interior lines of townships 5 N., R. 6 E., and T. 5 N., R. 7 E., which were severely criticized in an addendum from the surveyor general's office for containing little information and this of poor quality. It was not deemed advisable to attempt to plot any of these data; hence, the omission of these two townships from the map. The manner in which the information obtained from the survey notes was interpreted will be discussed later.

Since Dane County is divided into two distinct geological regions, differing not only in relief and drainage patterns but also in soil-parent material, it seems advisable to divide the discussion on the basis of these two areas.

## I. THE VEGETATION OF THE GLACIATED REGIONS

This area lies mostly east of the Johnstown terminal moraine. However, there are areas lying to the west of the Johnstown moraine which must also be considered. (See Plate 2.) The first consists of a triangular tract of land partly in the southwest part of T. 5 N., R. 8 E., partly in the eastern portions of T. 5 N., R. 7 E., and in the south east ¼ of T. 6 N., R. 6 E., and extending into the north half of T. 8 N., R. 6 E. This region, while lying outside of the boundary formed by the Johnstown terminal moraine, is partially covered by glacial till of Illinoisian and early Wisconsin origin. The second of these areas is located in the north ½ of T. 8 N., R. 6 E., and extends into T. 9 N., R. 6 E. This area was not actually covered by glacial ice but rather by a deep layer of outwash material deposited by the Wisconsin River at the time of the recession of the Wisconsin ice-sheet; consequently, it is more closely allied to the glaciated region than to the Driftless Area where the soils are primarily residual. There are still other areas

lying west of the Johnstown moraine and covered by outwash materials. These areas as shown in Plate 2 are confined largely to the bottom lands of streams leading away from the region of the Johnstown terminal moraine, and they too must be considered in the discussion of the glaciated region.

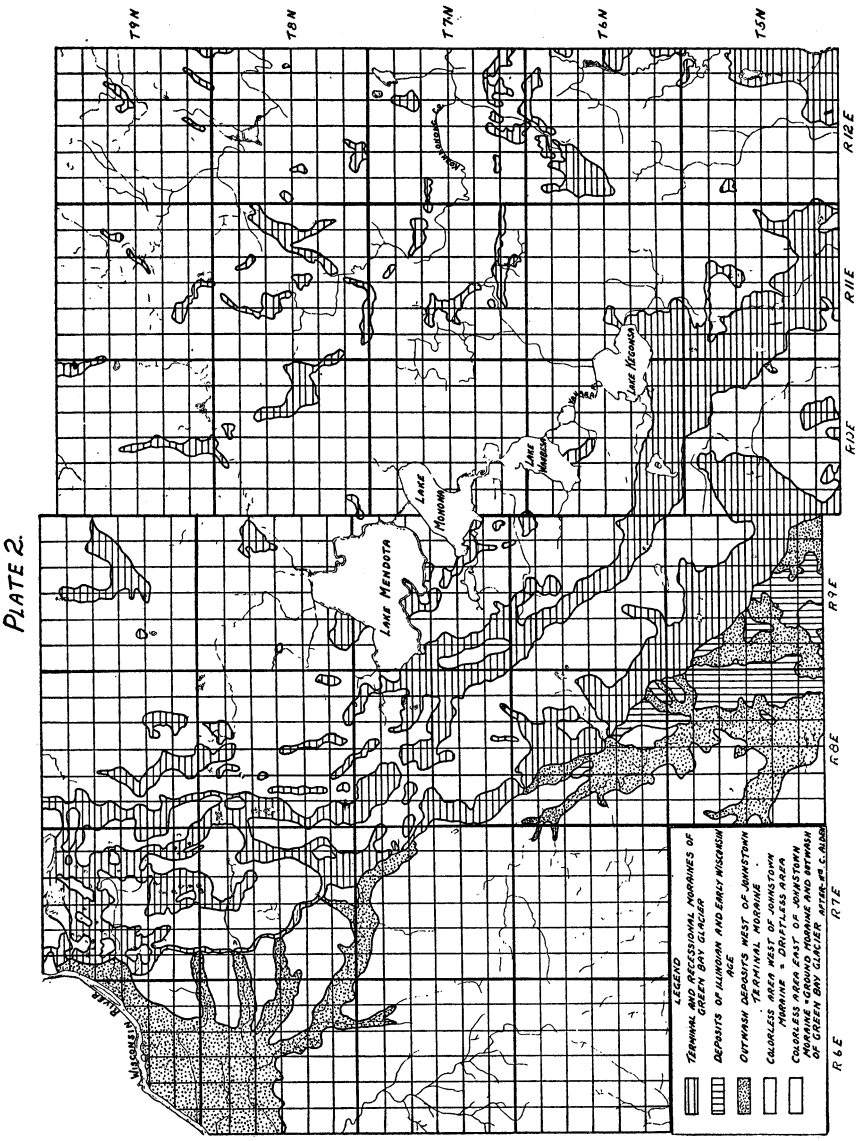


PLATE 2.

## High Prairie

The principal type of prairie mapped in the glaciated area of Dane County is the upland or high prairie. The surveyors' records make no mention of specific plants found on these upland prairies except to say that they contained "prairie grasses" or sometimes "grasses and weeds." However, the treeless condition of these prairie areas is attested to by the fact that, instead of marking witness trees to indicate section and quarter-section corners, the surveyors were forced to build mounds of earth and sod to locate these points. The following is an excerpt from the notes of the interior lines:

T.9.N. R.9.E. 4th Mer. N.W. Tery. = Territory North between Sections 11 & 12

40.00 Set quarter section post & raised a mound of earth & sod 4 feet square & 2½ feet high

80.00 Set post & raised a mound of earth & sod corner to Sections 1. 2. 11 & 12 land hilly prarie & first rate Growth grass

The figures 40.00 and 80.00 indicate the number of chains[1] from the section corner at which the surveyor commenced.

Occasionally one of the men would write of the prairie as "short grass prairie," but no mention is made in the entire county of tall grass on the prairie. Hence, it may be logical to assume that the surveyors were noting the exceptional short-grass prairies; but, since prairie grasses are not listed by species, it is impossible to tell definitely if this were true.

An attempt was made by the surveyors to classify land on the basis of its agricultural value, and in this respect prairie was usually classed as first-rate land, except in the more rolling and stony sections where it was referred to as second rate.

When the map of the original vegetation is compared to the map showing the surficial glacial deposits of Dane County, (see Plate 2) it is found that the prairie in the glaciated portion of the county was confined almost entirely to the areas covered by ground moraines of the Green Bay glacier. There are, of course, small inclusions of drumlins and outwash in these prairies, but the only major exception was found in the northwest part of T. 5 N., R. 11 E., extending into T. 6 N., R. 11 E., and into T. 6 N., R. 10 E., where a prairie was located entirely on a recessional moraine of the Green Bay lobe.

Another interesting correlation can be made between prairie areas and topography. The prairies were confined to broad areas of level

to gently rolling land which were undissicted by major streams or marshes. In view of this fact, the occurrence of prairie on the aforementioned recessional moraine is more readily understood, since the topography of this moraine is not characteristic of such deposits, but resembles the topography of a typical, gently rolling, ground moraine. The occurrence of high prairie on this particular type of topography was probably due largely to the influence of prairie fires. Since fire would encounter few natural barriers in these areas, such as steep hillsides, streams, and marshes, it could attain a maximum intensity and effectively eliminate or prevent the invasion of woody plant species, with the result that prairie was the only plant association capable of maintaining itself.

### Low Prairie

The major difficulty encountered in mapping this association was caused by the apparent failure of surveyors, other than Orson Lyon (see list of surveyors in Appendix A), to note its occurrence. No plants are mentioned by Lyon in describing these areas (he simply states that they were low or wet prairie). We are faced with the alternative of either discrediting this classification of low prairie or assuming that the surveyor was actually describing the vegetative association we consider today to be low prairie. The latter assumption appears to be a logical one, since Lyon appears to have deliberately differentiated low prairie from open marsh which was prevalent in the same townships.

From the present-day relict areas of low prairie, especially in eastern Dane County, it would appear that the low-prairie association was of much more frequent occurrence than the survey records would indicate. Other evidence which seems to bear out the theory that low prairie was more widespread than is indicated is the fact that in several localities, notably in townships 9 N., R. 11 E., T. 5 N., R. 11, E., T. 5 N., R. 9 E., and T. 6 N., R. 9 E., high prairie and open marsh are shown lying adjacent with no definite boundaries shown to exist between the two by the surveyors. In view of what we know about these two plant associations, it is logical to assume that there were transitional zones of low prairie separating the two. However, for the sake of uniformity and lack of sufficient field evidence, only those areas actually described by the surveyors as low prairie are so indicated on the map.

### Open Marsh

Open marsh was the principal type of lowland vegetation at the

time of the original land surveys. Little mention is made of the specific plants found growing in these marshes except in general terms, such as marsh grass, reeds, rushes, or flags, (see Appendix B) and, in most cases, no mention at all is made of vegetation, and the land is simply described as marsh. The following quotation from the surveyor's notes is one of the most graphic descriptions of open marsh found in the notes of eastern Dane County:

> T. 7 N. R. 12 E. 4th Mer. N.W. Tery. = Territory North between Sections 22 & 23
> 40.00 Set post in Marsh for ¼ Sec. = Section Cor. = Corner 2 No bearing trees near
> 44.40[2] To a creek 80 links wide crs. = Course East
> 64.50 to a creek .50 crs. N.E. current dull
> 80.00 Set post in Marsh far cor. to Sections 14 15 22 & 23 bearing (Bur Oak 12. N. 74. E. 3.74[3] This mile is flat marsh covered with blue flag & reeds and high coarse grass and is not susceptible of cultivation poor 3rd rate land.

(NOTE: Witness trees, used to locate the section corner, are not in the marsh but on high ground lying to the east of the marsh.)

Marshes form a characteristic pattern in eastern Dane County tending to run in more or less parallel lines bearing from northeast to southwest. This, of course, is due to their being formed in the lowlands created by glacial ice as it flowed in this same direction. In contrast, in the morainic regions, marshes tended to be more or less isolated as a result of their occurrence in glacial kettle holes.

In general, the marshes were usually classed as either second- or third-rate (as suitable for cultivation) land, by the surveyors, who probably arrived at this classification on the basis of the amount of water present in them. Notes were sometimes made regarding the value of the streams in the marshes for such uses as sources of water, milldam sites, and transportation. The following are a few excerpts from the general notes which were included as summaries of some of the townships.

T 7 N — R 11 E

> From the N.E. to the S.W. part of the twp there is a line or chain of marshes that lies so low & flat that cannot be drained so as to be of any use.—The streams are deep and muddy bottom current dull & sluggish. There are no springs except those that rise up in the marshes. This two (sic) might be classed as second rate.

T 5 N — R 10 E

> A deep creek rises near the N.W. corner, meanders across diag-

> onally leaves at the S.E. corner which with its tributaries forms a stream of some importance — but it is without sufficient fall for machinery its bottom is wide and marshy as will be seen by the map.

Referred to in this last excerpt is the sketch-map which was included in the survey notes for each township. These sketch-maps were of considerable value in furnishing the outlines of the marsh areas between the points of intersection with the town and section lines. There may be some areas in which errors occur in the general outline of the marshes since these lines were sketched in between section lines without the surveyors' actually traversing the marsh; however, when the marshy areas of the vegetational map are compared to present-day maps showing marsh soils, a high correlation is found between the two. Consequently, errors in marsh boundaries are undoubtedly negligible. Another possible source of error is in the failure of the surveyors to note small areas of marsh or other vegetation that lie wholly within a section. From the map it may be noted that a number of small marshes are recorded directly on the township section lines, but few, if any, are recorded as lying entirely within a section. This is, of course, because the surveyors surveyed the section lines and not the interiors of the sections.

## Oak Opening

The oak opening was by far the most widespread and abundant plant association at the time of the original land surveys. The term oak opening, as used here, refers to a plant association in which the oaks, primarily bur and white, but often black, are the dominant members of the association. It differs from oak woods in that the trees are rather widely and evenly spaced so that sufficient sunlight reaches the ground to sustain an undergrowth composed primarily of prairie grasses and forbs, although hazel and oak underbrush are frequently mentioned also. Blue-green is used to designate oak opening on the map because it appears to be a transitional form between the high prairie (blue) and true oak woods (green).

It is necessary here to review briefly the surveying technique used by these men so that the interpretation of the survey notes can be better understood. The usual survey crew was composed of five or six men whose duties appear to be as follows: the deputy surveyor was the instrument man and chief of the party, one marker marked the witness trees, and two axe-men cleared the brush and probably cut down any trees which were found directly on the line. The notes

which were written by the deputy surveyor consisted of a running description of the town or section line in which was noted the land cover and the points on the line where changes occurred, such as from timber to prairie or from prairie to swamp. Also noted were the trees which were found directly on the line, their species, their diameter at breast height, and the exact point on the line where they appeared.

For each section and quarter section, except when in an open marsh or on open prairie, two or more witness trees were marked. The species of tree, its diameter, and its distance and compass bearing from the true corner were noted. Upon completion of each section line, a brief summary of the land and vegetation was given, and when timber occurred along the line the tree species were usually given along with the type of undergrowth.

In interpreting the surveyors' notes, certain rather arbitrary distinctions sometimes had to be drawn to separate oak opening from true oak woods. In most cases however, the oak opening was fairly well defined. The following excerpt from the surveyors' notes for the interior lines of T. 9 N., R. 8 E., is an example of a clear-cut description of oak opening.

North between sec = section 35 & 36
40.00 B. = Black Oak 12 ¼ sec. corner
67.78 Burr oak 7
80.00 Set oak post far corner to sections 25, 26, 35, & 36
Burr oak 10 N 56° E .71 = links
do. 10 S 50 N .85
Land rolling 2nd rate thinly timbered with black and Bur oak.

From the foregoing it may be seen that only two trees, both of them bur oaks, were encountered directly on the line, and at the section corner the witness trees, both bur oaks, were respectively 46 and 57 feet from the corner and standing in opposite directions from the corner, so that the distance between these trees was approximately 100 feet. The descriptive summary further confirms the impression of the open nature of the country by the surveyors' use of the term "thinly timbered."

Still another description of a well-defined oak opening is found in the interior notes of T. 5 N., R. 8 E.

North between section 4 & 5
40.00 Set ¼ sec. = section post.
Bearings (B.O. = Black Oak 14 in. N. 9° W .45 L = Links
(Do. 11 in. N. 62°30 E. 42 L
77.83 intersect town line 28 L = Links N of post

Set post corner of sec = section 4 & 5
B (B.O. 10 in. S. 53° E 14.00 L
(Do. 14 in. S. 62° N .63 L
Land S part rolling N level 2nd rate B. W. & J. black, white, and jack Oak and hazel undergrowth brake Rosin and Rattlesnake week Prairie grass etc.
(See Appendix B for scientific names of above-listed plants.)

On this particular section line no trees were encountered and the witness trees ranged from 27 feet to 924 feet from the quarter section and section corners. The point of particular interest in this description lies in the notes regarding the timber and undergrowth. The timber was apparently all oak, as is to be expected in an oak opening. The mention of oak and hazel undergrowth plus brake (bracken fern), which may be considered components of an oak woods is somewhat confusing; but, upon reading further, we find that rosin and rattlesnake weed and prairie grasses were also present. Since the latter are good prairie indicators and common in oak opening we may conclude that the plant association was oak opening rather than oak woods.

From these two examples of well-defined descriptions of oak opening, there are gradations which approach a point where it becomes difficult to determine whether oak opening or oak woods is being described. When this point is reached, it is necessary to use some arbitrary divisions upon which to decide whether any given tract was oak woods or opening. Several factors must be taken into consideration before any conclusions can be reached. First, the tree species and size are considered. Trees such as ash, basswood, elm, and black walnut are not found in oak openings. Hickory, cherry, and aspen are occasionally found in oak opening, but are seldom over eight or ten inches in diameter. The trees of the black oak group, i.e. black, red, and jack oak, also follow this same pattern although in some areas of oak opening the black oaks are almost as numerous as white and burr though they seldom are of large size. In contrast to this, in oak woods, many black oaks were found to be two feet or more in diameter. The above conditions were undoubtedly brought about by the selective nature of the fires which swept this region. Fires tend to eliminate trees of the black oak group from all but the unburned or seldom burned areas; whereas, white and bur oaks are less severely damaged because of their higher fire resistance. The presence of a relatively high percentage of black oaks in certain oak openings can be explained on the basis of their ability to sprout from roots after the tops have been fire-killed. White oak was not found

to be a satisfactory indicator of oak opening, while bur oak was most valuable in this respect. The latter was usually found in abundance in oak openings, but was mostly lacking or represented by only one or two individuals in oak woods, and was never mentioned by the surveyor as a component of the forest in summarizing the timber of oak woods.

Second, the undergrowth of the forest serves as an important clue in determining whether an area is oak woods or oak opening, and as previously stated, the presence of prairie plants is a good indication of oak opening.

Third, the number of trees found on a line is a good index to the relative density of the stand. While this in itself does not constitute conclusive evidence when linked with the other factors, it is possible to reconstruct a fairly accurate picture of the vegetation.

The following notes are an illustration of the type which offered problems in interpretation:

T. 8 N., R. 12 E., 4th Mer. N.W. Tery. = territory North Between Sections 22 & 23
.96 Bur Oak 18 inches diameter
26.28 Red Oak 18 inches diameter
40.00 Set quarter Section Post
bearings (Bur Oak 16. S. 59. W. 44
(Black Oak 18. N. 22. E. 62
62.86 Bur Oak 18 inches diameter
80.00 Set post corner to Sections 14 15 22 & 23
bearings (Bur Oak 12. S. 37 W 1.27
(Do. 11. S. 56 E .64
Land level & 2nd rate. Timber White, Bur, Red & Black Oak & Hickory. Undergrowth Oak, grass & weeds
Mon. June 9th 1834

The presence of a large red and black oak, the occurrence of hickory, and the fact that three trees were present on the line would point toward this being oak woods. However, the large number of bur oaks listed, two on the line and three as witness trees, must result in its being classified as oak opening.

Further evidence which tends to substantiate the widespread occurrence of oak opening was found in a paper by L. S. Cheney and R. H. True on the flora of Madison and vicinity. The paper deals with the flora of the region lying adjacent to Lakes Mendota, Monona, Waubesa, and Kegonsa. They describe the vegetation of this region as follows:

The vegetation of the region under consideration varies some-

what with elevation and character of soil. The woods, confined chiefly to the uplands, are made up largely of oaks, with occasional limited areas characterized by maples, cottonwood, or White elm . . . Generally speaking, the low marshy meadow bordering on the lakes and streams yields chiefly grasses and sedges.[4]

The following is a list of plants with notes about their abundance taken from the same paper.

Ceanothus americana

Throughout the region on high land.

*Lupinus perennis* — Common.

*Amorpha canescens* — Throughout the region on dry soil.

*Liatris scariosa* (= *Aspera*)

Along railroads and dry wild land; everywhere.

*Asclepias tuberosa*

Dry open woods — common.

*Euphorbia corollata*

Dry ground everywhere.

*Andropogon furcatus*

Common in the dry portions of all wild lands, in fields and along rail roads.

*Andropogon scoparius*

Growing with *A. furcatus.* Much less common.[5]

This list, selected by the author as representative of the herbaceous species common to both oak opening and open prairie, plus the descriptive passage in which oaks are characterized as the dominant trees, points to a widespread occurrence of oak opening in this area. While this information is not contemporary with the surveyors' records, it is even more significant since it emphasizes the persistence of oak opening even after settlement, during which time, due to the cessation of fires, much additional tree growth is known to have taken place.

## Oak Woods

The oak woods association consisted of a forest made up primarily of white and black oak trees which differed from the trees of the oak opening in being more closely grown and taller. It also had an admixture of other trees such as aspen, hickory, cherry, white ash, black walnut, and occasionally basswood.

The understory differed quite markedly from the oak opening in that it was completely lacking in prairie plants. The surveyors referred to the undergrowth as hazel and brush oak, briers, and weeds (and, in this case, the weeds undoubtedly referred to the usual herbaceous vegetation present on the floor of the oak woods).

The following excerpt from the survey notes is a good example of the type of cover classed as oak woods:

T 7 N R 12 E 4th Mer NW Tery = territory North between Sections 10 & 11
3.69 White Oak 12 inches diameter
25.76 Aspen 20 inches diameter
40.00 Set post for ¼ Section corner
bearings (White Oak 8 S 78 W .15
(B.O.=Black Oak 20 N 61 E 21
46.61 Aspen 18 inches diameter
60.57 White Oak 10 inches diam
68.00 Entered Swamp
80.00 Set post in swamp corner to Sections 2. 3. 10 & 11
bearings (Tamarac 12 S 45 E 5.10
(White Oak 18 S 24 E 7.45
Land level & 2nd rate
Timber Aspen Black Oak
White Oak & Tamarac undergrowth same.

The oak woods were confined exclusively to a small area of land on the eastern edge of the county in townships 7 N., R. 11 E., and T. 8 N., R. 11 E. The woods were found on a series of drumlins in this area which were separated from each other by low-lying marshes and tamarack bogs. It is of considerable significance to note here that, with only two exceptions, the only tamaracks recorded in the entire county were in the bogs adjoining these oak woods. This phenomena appears to be due primarily to the affect of fires and shall be discussed more fully later.

More evidence tending to substantiate the occurrence of oak woods in the tract just described was found in the field notes kept by Mr. John Hooper[6] of Jefferson County during the years 1904–08, at which time he engaged in the collection of ginseng (*Panax quinquefolium*). One entry is listed for the "Big Woods" at Goose Lake, Dane County, which is located in the area shown as oak woods and tamarack on the map. The remaining six entries are recorded as Deerfield, Dane County. Deerfield Township is T. 7 N., R. 12 E. Since ginseng is a plant confined exclusively to deep woodland areas it is probably significant that the collecting was limited to the areas shown as woods on the map. It will be noted that oak woods is also shown on the small island in Hook Lake located in the southwest ¼ of T. 6 N., R. 10 E. The island was not surveyed at the time of the first government survey by Leonard Smith, and at this time oak woods was found to be the vegetative cover of the island. Hence it is entirely

possible that oak woods was present in 1835 even though it was not mentioned in the original notes.

### Maple Basswood

Maple basswood forest appears to be the climax forest association in Dane County today; although, at the time of the land surveys, as today, this forest type was confined to three relatively small tracts, all of which were located on the northeast or east side of the Madison chain of lakes. The first of these was located on a point of land in section 19, T. 6 N., R. 11 E., which juts out from the northeast shore of Lake Kegonsa. Lorin Miller, the deputy surveyor responsible for the notes on this township, included a description of these woods in his summary of the township. This summary is presented here in its entirety because of the interesting observations and thoughts it contains.

T 6 N R 11 E 4 Mer. = meridian

Remarks

This Township tho divided by its share of Crooked Marshes may be ranked as Good 2nd rate land.

The Soil is generally a warm light sandy loam which will richly repay the cultivator.

It may be said to be well watered by the narrow marshes in which is running water in some places contracted into brooks but mostly Expanded on the marsh.

The Foot & Outlet of the First Lake on sec 19.30 etc. a beautiful sheet of pure water abounding in Excellent Fish & great variety of water fowl offer fine inducements to the sportsman.

The Catfish Cr. at a moderate expense in deepening the Channel may become (and undoubtedly will) navigable for stream boats from Rock River to this Lake a distance by its meanders, of about 20 miles.

A branch of the White Water Creek rises on Section 24 running N. leaves the town on Section 12.

The surface of the country is for the most part rolling Timber Bur, White, & Yel. Oak rather thinly — a fine old Sugar Grove is noticed on Sec. 20.

The evident remains of artificial Mounds, Embankments etc. furnish food for the speculation of the Curious.

Lorin Miller March 4th, 1834

The second of these maple woods was located on a point of land on the eastern shore of Lake Waubesa, just north of the mouth of the Yahara River in sections 3 and 4 of T. 6 N., R. 10 E., and extending northward along the lake shore into section 33 of T. 7 N., R. 10 E. This tract, while being small in size, had a variety of tree species present, as listed by the surveyors, which leaves little doubt as to its

being a true maple-basswood association. The following tree species were listed as occurring along the line between sections 3 and 4: sugar-maple, black and white ash, hickory, elm, black walnut, butternut, hornbeam, and blue beech. The undergrowth was listed as "grass, vines, bittersweet, briers, etc."

The largest and most extensive tract of maple-basswood forest was situated north of the Yahara River between Lakes Mendota and Monona, extending around the northeast shore of Lake Mendota to just beyond Governor's Island. The following is a quotation from the surveyors' records regarding this forest:

> In sec 1 there is a perpendicular bluff of rocks about 60 feet high. There is on N.W. part of Sec 1 a fine grove of sugar tree containing about 200 acres of ground.

From this description, it would seem that the maple-basswood forest was actually much more restricted than is shown by the map; however, the situation probably found by the surveyors was one in which there was a central core of mature maple-woods centering in the vicinity of the present village of Maple Bluff. Surrounding the mature maple-basswood forest were woods in various successional stages between oak woods and fully mature maple-basswoods. A further quotation from the surveyors' notes from the section line between sections 34 and 35, T. 8 N., R. 9 E., tends to bring out the gradation between the mature central core and the outer edge of this forest. Here at the outer edge, the surveyors describe the timber as being black and white oak with sugar-tree undergrowth. Therefore it might be argued that the outer edges of this area should be classed as oak woods, but, since either basswood or sugar maple, or both, are mentioned on all of the lines within the area it has been decided to classify it as maple-basswood.

Another line of evidence which substantiated the evidence found in the surveyors' records was found in Cheney and True's report[7] from which the following list of plants was extracted.

*Isopyrum biternatum*
Lakes Waubesa and Kegonsa. Local.

*Dicentra canadensis*
Two specimens found on Governor's island
N.E. shore Lake Mendota growing with D. Culcullaria. Rare.

*Cornus alternifolia*
Observed in Fuller's woods east of Madison. Rare.

*Asarum canadense*
In low woodlands northeast of Lake Waubesa. Rare.

*Claytonia virginica*

In rich woods. Local.

*Erythronium albidum*

Rich woods about the Lakes.

*Trillium erectum*

In rich woods east of Lake Mendota. Not common.

These plants were selected by the author as being representative of the herbaceous flora of a typical mature maple-basswood association. All of the descriptions of range given for these plants emphasize its restricted nature, and for several species the range coincides exactly with those areas shown to be maple-basswood forest by the surveyors.

The peculiar distributional pattern of the maple-basswood forest leads to the conclusion that its confinement to these protected points of land was a result of fires which swept across the county, driven by the prevailing southwesterly winds. These fires would have elim-eliminated or prevented the development of a climax forest except in locations protected on the southwest by bodies of water broad enough to stop flying embers.

## Swamp Hardwoods

The swamp hardwoods of Dane County fall into three distinct categories although no attempt has been made to differentiate them in the mapping.

The first of these are the swamp hardwoods bordering the Wisconsin River in T. 8 N., R. 6 E. These are characterized by a relatively high percentage of red or river birch (*Betula nigra*) present in them. The following surveyor's note is a summary of the short section line between sections 29 and 30, T. 9 N., R. 6 E.: "Land level 2nd rate timber oak elm maple birch etc." The maple referred to here is undoubtedly silver maple, since this species is at the present time plentiful in the river-bottom woodlands.

The second of the swamp hardwood types was classified by the surveyors as black-ash swamp and was found in only two places on the eastern shore of the Madison chain of lakes. The first is along the Yahara River where it leaves Lake Mendota in T. 7 N., R. 9 E., and the second is on the section line between sections 28 and 33 in T. 7 N., R. 10 E., where the following tree species are mentioned: oak, ash, maple, and willow, while in the former swamp the area is described simply as being black-ash swamp.

The third category of swamp hardwoods was small areas east of the Madison lakes primarily in the northern two tiers of townships characterized as willow swamps. Since no trees are recorded on the

line in any of these swamps, it is probably safe to conclude that they contained willow brush similar to the cover present in many of these areas today. Here again it may be pointed out that trees unable to withstand repeated fires are confined to the protected portions of lake shores or river banks, while swamp hardwoods (in this case willows) are maintained in the scrub or brush stage in the areas subjected to frequent burning.

## Swamp Conifers

The swamp conifers found at the time of the land surveys were all of one species, tamarack. These trees were recorded in only three localities in the entire county. Tamaracks are mentioned in the summary of the timber occurring along the section line between sections 27 and 28, T. 7 N., R. 10 E. However, no swamp conifers were plotted on this line because of lack of any evidence about their location in relation to the line.

The survey notes contain a reference to a small tamarack swamp lying about 40 chains south of the quarter-section corner of the east-west line between sections 7 and 18, T. 5 N., R. 12 E. The definite location of this small swamp allowed it to be plotted as shown on the map.

The most extensive tract of tamarack recorded in the county was situated in the eastern portions of T. 7 N., R. 12 E., and T. 8 N., R. 12 E. As previously mentioned, the occurrence of tamarack in the lowlands was associated with oak woods on the uplands. The question immediately arises as to why this situation should obtain in this particular area and no other. A partial answer to this question may be afforded by information gained by the author while employed as engineering aide by the U.S.D.A. Soil Conservation Service during the summer of 1943. At this time, a reconnaissance survey was made by the Soil Conservation Service to determine the feasibility of draining a portion of this area for agricultural purposes. The survey was started at Koshkonong Creek in section 15, T. 7 N., R. 12 E., and from there ran northward through sections 15, 10, 9, 4, and 3, and ended at the town line between townships 7 and 8 north. When this line was plotted, it was found that a relatively step gradient existed for the first 3,000 feet; this flattened considerably for the next 12,000 feet, and was almost level for the last 5,000 feet. When this observation is compared with the vegetational map, it can be seen that the steepest portion of this lowland, the first 3,000 feet, was open marsh, whereas the remainder of flatter portions with poorer drainage was tamarack

swamp. It would appear that tamarack swamp occurred where surface drainage was sufficiently impeded to allow an area to remain wet throughout the year. This is probably not so important as a soil-moisture factor in promoting tree growth, as it is a factor in the prevention of fire from sweeping these areas regularly. While both of these factors are undoubtedly of importance, the latter would help to explain the presence of oak woods on the highlands between the tamarack swamps, since a lessening of the frequency of fires would allow the development of oak woods, while surrounding areas, frequently burned, would be maintained in the oak-opening stage. It might also be pointed out here that the occurrence of these oak woods can scarcely be attributed to a high water table influenced by the adjoining bogs, since the oak woods were all on steeply sloping glacial drumlins whose crests extend as much as 100 to 150 feet above the surrounding lowlands.

It will be noted that no definite lines of demarkation are shown between open marsh and tamarack bog. This is because the surveyors were indefinite in defining the boundaries existing between the two.

## II. THE VEGETATION OF THE NON-GLACIATED REGION

The vegetation throughout the Driftless Area of Dane County forms a relatively simple pattern which conforms closely to the topography of the region. In general, the steep hillsides and narrow ridge tops were timbered, the broad ridge tops were prairie, and the bottom lands were either prairie or marsh, although in a few areas these too were timbered.

As previously noted, T. 5 N., R. 6 E., and T. 5 N., R. 7 E., have been omitted from the map due to lack of sufficient information in the field notes. Although it is possible to determine from the field notes that the predominant vegetative cover of these two townships was oak opening, the prairie and marsh areas were so poorly defined that mapping was impossible. However, this omission should not interfere seriously with the overall picture of the vegetation, because there is a close correlation between topography and vegetation, and a correspondingly close similarity of topography throughout the Driftless Area. In all, four different plant associations were mapped: oak opening, open marsh, high prairie, and low prairie. These associations will be taken up and discussed individually.

### Oak Opening

The oak opening was by far the most widespread and abundant plant association present in the unglaciated part of Dane County at

the time of the surveys. It differed from the oak opening of the glaciated regions in that it appeared to have contained a somewhat larger proportion of bur oak.

It is unfortunate that the surveyor responsible for most of the townships within this area did not record any of the herbaceous species of plants found as undergrowth in the oak opening. Even without this information there can be little doubt as to the actual plant association, since throughout the field notes the descriptive phrases "thinly timbered with oak" and "timber scattering" are repeated over and over again. The following example from the field notes is typical of most of the section lines in the oak opening of the Driftless Area:

East boundary of Twp = Township 7 N., R 6 E 4th Mer = Meridian North on east side of Sec = Section 13
40.00 Set Oak post for ¼ Sec. = Section corner
Mark ¼ S 13
B = Black Oak 7 S 20 W .43 links
W = White Oak 18 N 6 W 1.31
Marked ¼ S 13
80.00 Set Oakpost corner to sections 12 and 13 Marked
R 6 E T 7 N 12 & 13
Burr Oak 16 S 47 W .89
Do 10 N 71 W 1.70
Land hilly and stony 3rd rate thinly timbered with oak
Oct 6th 1938

A description such as the foregoing eliminates any doubt about the timber, and needs no corroboration by the addition of herbaceous species to the description to enable it to be classed as oak opening.

Oak opening was found on practically all of the steep hillsides and ridge tops, and according to the field notes, appears to have been present in most of the narrower valley bottoms. A problem arises when the vegetation map is compared to a present-day soils map because all of the valley bottoms, regardless of their width, are shown as having prairie soils. Owen, one of the first geologists to work in Wisconsin, described the scenery of the Driftless Area in these terms:

> We have clumps of trees, disposed with an effect that might baffle the landscape gardener, now crowning the grassy height, now dotting the green slope with partial and isolated shade. From the hilltops the intervening valleys wear the aspect of cultivated meadows and rich pasture grounds, irrigated by frequent rivulets that wend their way through fields of wild hay fringed with flourishing willows. Here and there occupying its nook, on the bank of some stream, at some favorable spot, occurs the solitary wigwam, with its scanty appurtenances. On the summit levels spread the wide prairie, decked with flowers of

> the gayest hue; its long undulating waves stretching away till sky and meadow mingle in the distant horizon.[8]

This vivid description tends to substantiate further the author's opinion that the valley bottoms were primarily prairie while the hillsides were covered with oak openings. It is quite possible that the surveyors simply neglected to record prairie in the narrow valleys because the rest of the country was so thinly timbered that the contrast between the two might not have seemed important enough to record. It is significant that in most cases, where the valleys broaden out, either prairie or marsh is recorded.

### High Prairie

High prairie was found to occupy the broad, level ridges and the level valley bottoms in the Driftless Area of the county. The only major ridge prairie was that covering Military Ridge in T. 6 N., R. 6 E., and T. 6 N., R. 7 E. The prairie followed the level summit of this ridge, ran down the crest to where the sides break abruptly, and then gave way to oak opening. Nothing was said in the survey notes about the nature of the prairie; it was simply referred to as prairie. At one point in the northeast corner of T. 6 N., R. 6 E., the Military Ridge prairie was continuous with a prairie which extended down into the bottom land in the southern quarter of T. 7 N., R. 7 E. This was the only place where ridge prairie and bottom land prairie were continuous; in all other places, there occurred between the two an intervening band of oak opening.

The prairies of the bottom land were not differentiated from the ridge prairie in any way by the surveyors, and since no plant species were listed for either of the two, it is impossible to tell today if any differences did exist.

### Open Marsh

Open marsh in the Driftless Area was limited to lands immediately adjacent to the streams in the valley bottoms, and was found primarily in the narrower valleys. The discontinuous and isolated nature of most of these marshes suggest that they may have been more or less continuous along these streams, but due to variations in width, they were recorded only at their widest points where section intersected them. This is brought out in the following quotation from the survey notes:

> Township 7 North Range 7 East North Between sections 8 & 9
> 24.00 Enter Marsh
> 40.00 Set Oak post for ¼ sec. = section corner
> Burr Oak 6 S 87½ N = North S .30
> No other near

49.25 Stream 8 C. = Course N.E.
54.00 Same C. N.W.
63.00 Same C. N.E.
68.00 Leave Marsh
80.00 Set Oak post far Corner to Sections 4. 5. 8. 9.
B. = Black Oak 14 S 76 W .83
Burr Oak 10 N ½ E 1.41
Land level & marshy

The section line followed a valley bottom, crossing and recrossing a stream, and we find marsh recorded as continuous along the stream, whereas in T. 6 N., R. 7 E., and T. 6 N., R. 8 E., marshes are recorded primarily as small tracts on the section lines where these lines intersect the streams.

In townships 8 N., R. 6 and 7 E., two relatively large marshes were recorded in the wider valleys. It is difficult to determine the exact nature of these areas listed as marsh, as is shown by the following description:

Township 8 North Range 6 East North Between sections 23 & 24
20.00 Top of a high ridge E & N
40.00 Set Oak post for ¼ sec. = section corner
Burr Oak 10 S 66 E 48
W = White Oak 7 S 18 W 73
58.00 Entered Marsh
80.00 Set Oak Post for corner to sections 13 14 23 24
Raised a mound of sods 3 feet square & 3 feet high
Land third rate first half hilly & stony last half marsh

No plants are listed, but the surveyors built a mound of "sods" three feet square and three feet high which would strongly indicate that the area was actually low prairie, since it is hardly conceivable that such a mound would be built in an area wet enough to be considered marsh. This view is further strengthened by the fact that only one small tract of low prairie was recorded by the surveyors in the Driftless Area where it was presumably more common than this would indicate. However, since there is no conclusive evidence to prove that these marsh areas were actually low prairie they have been shown as open marsh on the map.

## SUMMARY AND CONCLUSIONS

The principal sources of information used in compiling the map of the vegetation of Dane County as it appeared in 1835 were the survey notes taken at the time of the government land surveys during the years 1832–35.

Eight different plant associations, as inferred from the surveyors'

descriptions, were recognized in mapping the county.

Dane County contains two widely differing geological regions and a discussion of the vegetative cover can be conveniently divided on the basis of these two regions.

Three major factors, namely, topography, drainage, and fires, seem to have had the greatest influence on the distribution and pattern of vegetational types found in the county in 1835.

In those areas which had a flat to gently rolling topography, and were undissected by streams or marshes, fires were undoubtedly most severe, and these areas were found to be predominantly high prairie. Hillier areas and areas broken by marshes and streams were found to be oak opening, since fires would have been less severe in these locations. Lowlands were of three different types: open marsh or willow brush in those areas frequently burned; swamp hardwood in areas protected from fire by wide lakes or rivers; and tamarack bog in those areas with surface drainage so poor that fire was excluded.

Climax forest (maple-basswood) was found only on points of land on the northeast shores of the Madison chain of lakes which received complete protection from fires sweeping up from the southwest.

Oak woods were found only on drumlins in the glaciated regions where they received at least partial fire protection from the tamarack bogs adjoining or surrounding them.

Low prairie was mapped in only a few localities within the county, yet relict areas of low prairie are so extensive today that it is quite possible that many areas of this association were overlooked by the surveyors.

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## APPENDIX A

### Interior Lines

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Twp | 5 | N | R | 6 | E | not used | J. W. Stephenson | 1833 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Twp | 5 | N | R | 7 | E | J. W. Stephenson | 1833 |
| W½ | Twp | 5 | N | R | 8 | E | J. W. Stephenson | 1833 |
| E½ | Twp | 5 | N | R | 8 | E | Orson Lyon | 1835 |
| | Twp | 5 | N | R | 9 | E | Lorin Miller | 1833 |
| | Twp | 5 | N | R | 10 | E | Lorin Miller | 1833 |
| | Twp | 5 | N | R | 12 | E | Lorin Miller | 1833 |
| | | | | * | * | * | * * | | | |
| | Twp | 6 | N | R | 6 | E | John Mullett | 1833 |
| | Twp | 6 | N | R | 7 | E | John Mullett | 1833 |
| | Twp | 6 | N | R | 8 | E | Lorin Miller | 1833 |
| | Twp | 6 | N | R | 9 | E | Lorin Miller | 1833 |
| | Twp | 6 | N | R | 10 | E | Lorin Miller | 1833–34 |
| | Twp | 6 | N | R | 11 | E | Lorin Miller | 1834 |
| | Twp | 6 | N | R | 12 | E | Lorin Miller | 1833 |
| | | | | * | * | * | * * | | | |
| | Twp | 7 | N | R | 6 | E | John Mullet | 1833 |
| | Twp | 7 | N | R | 7 | E | John Mullet | 1833 |
| | Twp | 7 | N | R | 8 | E | Orson Lyon | 1834 |
| | Twp | 7 | N | R | 9 | E | Orson Lyon | 1834 |
| | Twp | 7 | N | R | 10 | E | Orson Lyon | 1834 |
| | Twp | 7 | N | R | 11 | E | Orson Lyon | 1834 |
| | Twp | 7 | N | R | 12 | E | Orson Lyon | 1834 |
| | | | | * | * | * | * * | | | |

INTERIOR LINES

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Twp | 8 | N | R | 6 | E | John Mullett | 1833 |
| | Twp | 8 | N | R | 7 | E | John Mullett | 1833 |
| | Twp | 8 | N | R | 8 | E | John Mullett | 1833 |
| | Twp | 8 | N | R | 9 | E | Orson Lyon | 1834 |
| | Twp | 8 | N | R | 10 | E | Orson Lyon | 1834 |
| | Twp | 8 | N | R | 11 | E | Orson Lyon | 1834 |
| | Twp | 8 | N | R | 12 | E | Orson Lyon | 1834 |
| | | | | * | * | * | * * | | | |
| | Twp | 9 | N | R | 6 | E | John Mullett | 1833 |
| | Twp | 9 | N | R | 7 | E | John Mullett | 1833 |
| | Twp | 9 | N | R | 8 | E | John Mullett | 1833 |
| | Twp | 9 | N | R | 9 | E | Orson Lyon | 1834 |
| | Twp | 9 | N | R | 10 | E | Orson Lyon | 1834 |
| | Twp | 9 | N | R | 11 | E | Orson Lyon | 1834 |
| | Twp | 9 | N | R | 12 | E | Orson Lyon | 1834 |

EXTERIOR

East and West Lines

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Between | Twps | 4 | & | 5 | N | R | 8 | E | John Mullett | 1832 |
| Between | Twps | 4 | & | 5 | N | R | 7 | E | John Mullett | 1832 |
| Between | Twps | 4 | & | 5 | N | R | 6 | E | John Mullett | 1832 |
| Between | Twps | 4 | & | 5 | N | R | 9 | E | Mullett and Brink | 1833 |
| Between | Twps | 4 | & | 5 | N | R | 12 | E | Mullett and Brink | 1833 |
| Between | Twps | 4 | & | 5 | N | R | 11 | E | Mullett and Brink | 1833 |
| Between | Twps | 4 | & | 5 | N | R | 10 | E | Mullett and Brink | 1833 |

* * * * *

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Between Twps | 5 | & | 6 | N | | R | 6 | E | Mullett and Brink | 1832 |
| | Between Twps | 5 | & | 6 | N | | R | 7 | E | Mullett and Brink | 1832 |
| | Between Twps | 5 | & | 6 | N | | R | 8 | E | Mullett and Brink | 1832 |
| | Between Twps | 5 | & | 6 | N | | R | 9 | E | Mullett and Brink | 1833 |
| | Between Twps | 5 | & | 6 | N | | R | 10 | E | Mullett and Brink | 1833 |
| | Between Twps | 5 | & | 6 | N | | R | 11 | E | Mullett and Brink | 1833 |
| | Between Twps | 5 | & | 6 | N | | R | 12 | E | Mullett and Brink | 1833 |

* * * * *

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Between Twps | 6 | & | 7 | N | | R | 6 | E | Mullett | 1832 |
| | Between Twps | 6 | & | 7 | N | | R | 7 | E | Mullett | 1832 |
| W½ | Between Twps | 6 | & | 7 | N | | R | 8 | E | Mullett | 1832 |
| E½ | Between Twps | 6 | & | 7 | N | | R | 9 | E | Mullett and Brink | 1833 |
| | Between Twps | 6 | & | 7 | N | | R | 10 | E | Mullett and Brink | 1833 |
| | Between Twps | 6 | & | 7 | N | | R | 11 | E | Mullett and Brink | 1833 |
| | Between Twps | 6 | & | 7 | N | | R | 12 | E | Mullett and Brink | 1833 |

EXTERIOR

East and West Lines

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Between Twps | 7 | & | 8 | N | | R | 6 | E | John Mullett | 1832 |
| | Between Twps | 7 | & | 8 | N | | R | 7 | E | John Mullett | 1832 |
| | Between Twps | 7 | & | 8 | N | | R | 8 | E | John Mullett | 1832 |
| | Between Twps | 7 | & | 8 | N | | R | 9 | E | Mullett and Brink | 1833 |
| | Between Twps | 7 | & | 8 | N | | R | 10 | E | Mullett and Brink | 1833 |
| | Between Twps | 7 | & | 8 | N | | R | 11 | E | Mullett and Brink | 1833 |
| | Between Twps | 7 | & | 8 | N | | R | 12 | E | Mullett and Brink | 1833 |

* * * * *

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Between Twps | 8 | & | 9 | N | | R | 6 | E | John Mullett | 1832 |
| | Between Twps | 8 | & | 9 | N | | R | 7 | E | John Mullett | 1832 |
| | Between Twps | 8 | & | 9 | N | | R | 8 | E | John Mullett | 1832 |
| W¼ | Between Twps | 8 | & | 9 | N | | R | 9 | E | John Mullett | 1832 |
| E¾ | Between Twps | 8 | & | 9 | N | | R | 9 | E | Mullett and Brink | 1833 |
| | Between Twps | 8 | & | 9 | N | | R | 9 | E | Mullett and Brink | 1833 |
| | Between Twps | 8 | & | 9 | N | | R | 10 | E | Mullett and Brink | 1833 |
| | Between Twps | 8 | & | 9 | N | | R | 11 | E | Mullett and Brink | 1833 |
| | Between Twps | 8 | & | 9 | N | | R | 12 | E | Mullett and Brink | 1833 |

* * * * *

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Between Twps | 9 | & | 10 | N | | R | 7 | E | John Mullett | 1832 |
| | Between Twps | 9 | & | 10 | N | | R | 8 | E | John Mullett | 1832 |
| W½ | Between Twps | 9 | & | 10 | N | | R | 9 | E | John Mullett | 1832 |
| E½ | Between Twps | 9 | & | 10 | N | | R | 9 | E | Mullett and Brink | 1833 |
| | Between Twps | 9 | & | 10 | N | | R | 10 | E | Mullett and Brink | 1833 |
| | Between Twps | 9 | & | 10 | N | | R | 11 | E | Mullett and Brink | 1833 |
| | Between Twps | 9 | & | 10 | N | | R | 12 | E | Mullett and Brink | 1833 |

EXTERIOR

North and South Lines

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Twp | 5 | N | between | R | 7 | & | 8 | E | | John Mullett | 1832 |
| Twp | 5 | N | between | R | 6 | & | 7 | E | | John Mullett | 1832 |
| Twp | 5 | N | between | R | 5 | & | 6 | E | | John Mullett | 1832 |
| Twp | 5 | N | between | R | 8 | & | 9 | E | | Mullett and Brink | 1833 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Twp | 5 | N | between | R | 9 | & | 10 | E | | Mullett and Brink | | 1833 |
| Twp | 5 | N | between | R | 10 | & | 11 | E | | Mullett and Brink | | 1833 |
| Twp | 5 | N | between | R | 11 | & | 12 | E | | Mullett and Brink | | 1833 |
| Twp | 5 | N | between | R | 12 | & | 13 | E | | Mullett and Brink | | 1833 |
| | | | | | * | * | * | * | * | | | |
| Twp | 6 | N | between | R | 5 | & | 6 | E | | Mullett and Brink | | 1832 |
| Twp | 6 | N | between | R | 6 | & | 7 | E | | Mullett and Brink | | 1832 |
| Twp | 6 | N | between | R | 7 | & | 8 | E | | Mullett and Brink | | 1832 |
| Twp | 6 | N | between | R | 8 | & | 9 | E | | Mullett and Brink | | 1833 |
| Twp | 6 | N | between | R | 9 | & | 10 | E | | Mullett and Brink | | 1833 |
| Twp | 6 | N | between | R | 10 | & | 11 | E | | Mullett and Brink | | 1833 |
| Twp | 6 | N | between | R | 11 | & | 12 | E | | Mullett and Brink | | 1833 |
| Twp | 6 | N | between | R | 12 | & | 13 | E | | Mullett and Brink | | 1833 |
| | | | | | * | * | * | * | * | | | |
| Twp | 7 | N | between | R | 5 | & | 6 | E | | Mullett | | 1832 |
| Twp | 7 | N | between | R | 6 | & | 7 | E | | Mullett | | 1832 |
| Twp | 7 | N | between | R | 7 | & | 8 | E | | Mullett and Brink | | 1833 |
| Twp | 7 | N | between | R | 8 | & | 9 | E | | Mullett and Brink | | 1833 |
| Twp | 7 | N | between | R | 9 | & | 10 | E | | Mullett and Brink | | 1833 |
| Twp | 7 | N | between | R | 10 | & | 11 | E | | Mullett and Brink | | 1833 |
| Twp | 7 | N | between | R | 11 | & | 12 | E | | Mullett and Brink | | 1833 |
| Twp | 7 | N | between | R | 12 | & | 13 | E | | Mullett and Brink | | 1833 |

EXTERIOR

North and South Lines

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Twp | 8 | N | between | R | 5 | & | 6 | E | | John Mullett | | 1832 |
| Twp | 8 | N | between | R | 6 | & | 7 | E | | John Mullett | | 1832 |
| Twp | 8 | N | between | R | 7 | & | 8 | E | | John Mullett | | 1832 |
| Twp | 8 | N | between | R | 8 | & | 9 | E | | John Mullett | | 1832 |
| Twp | 8 | N | between | R | 9 | & | 10 | E | | Mullett and Brink | | 1833 |
| Twp | 8 | N | between | R | 10 | & | 11 | E | | Mullett and Brink | | 1833 |
| Twp | 8 | N | between | R | 11 | & | 12 | E | | Mullett and Brink | | 1833 |
| Twp | 8 | N | between | R | 12 | & | 13 | E | | Mullett and Brink | | 1833 |
| | | | | | * | * | * | * | * | | | |
| Twp | 9 | N | between | R | 6 | & | 7 | E | | John Mullett | | 1832 |
| Twp | 9 | N | between | R | 7 | & | 8 | E | | John Mullett | | 1832 |
| Twp | 9 | N | between | R | 8 | & | 9 | E | | John Mullett | | 1832 |
| Twp | 9 | N | between | R | 9 | & | 10 | E | | Mullett and Brink | | 1833 |
| Twp | 9 | N | between | R | 10 | & | 11 | E | | Mullett and Brink | | 1833 |
| Twp | 9 | N | between | R | 11 | & | 12 | E | | Mullett and Brink | | 1833 |
| Twp | 9 | N | between | R | 12 | & | 13 | E | | Mullett and Brink | | 1833 |

## APPENDIX B

A list of common plant names used by the surveyors and their scientific equivalent as interpreted by the author.

Ash
- Black ..... *Fraxinus nigra*
- White ..... *Fraxinus americana*

Aspen ..... *Populus grandidentata*

Basswood ..... *Tilia americana*

Birch ..... *Betula nigra*

| | |
|---|---|
| Bittersweet | *Celastrus scandens?* |
| Black walnut | *Juglans nigra* |
| Blue Beech | *Carpinus caroliniana* |
| Brake | *Pteris aquilina* |
| Briers | *Rubus* sp. |
| Butternut | *Juglans cinerea* |
| Cherry | *Prunus serotina* |
| Elm | *Ulmus americana* |
| Flags | *Iris virginica?* |
| Hazel | *Corylus americana* |
| Hickory | *Carya ovata* |
| Horn beam | *Ostrya virginiana* |
| Marsh grass | ? |
| Maple | *Acer sacharrinum?* |
| Oak | |
| Black | *Quercus velutina* |
| Bur | *Q. macrocarpa* |
| Jack | *Q. ellipsoidalis?* |
| Red | *Q. rubra* |
| White | *Q. alba* |
| Yellow | *Q. velutina* |
| Prairie grass | *Andropogon Gerardi (furcatus) A. scoparius and Sorghastrum nutans* etc. |
| Rattlesnake weed | *Eryngium yuccifolium* |
| Reeds | *Phragmites communis?* |
| Rosin weed | *Silphium* sp. |
| Rushes | ? |
| Sugar | *Acer Sacharrum* |
| Sugar maple | *Acer Sacharrum* |
| Tamarack | *Larix laricina* |
| Willow | *Salix* spp. |

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[1] 1 chain = 66 feet
1 link = 7.22 inches
100 links = 1 chain
80 chains = 1 mile

[2] Indicating, 44 chains and 40 links (about 2,928 feet) north of the corner.

[3] Indicating a bur oak 12 inches diameter, breast height, direction 74 degrees east of north, distance from corner, 3 chains and 74 links (about 242 feet).

[4] Cheney, L. S. and True, R. H., "On the Flora of Madison and Vicinity, a Preliminary Paper on the Flora of Dane County, Wisconsin." Transactions of the Wisconsin Academy of Sciences, Arts and Letters; 9 Part 1:48. 1893.

[5] *Ibid.*, 61—111.

[6] Moore, E. B. and Sanford, Russell, "Spring Flora of Farmer's Island, Lake Mills, Wisconsin," Transactions of the Wisconsin Academy of Sciences, Arts, and Letters; 32:71—74. 1940.

[7] Cheney, L. S. and True, R. H., "On the flora of Madison and Vicinity, A Preliminary Paper on the Flora of Dane County, Wisconsin." Transactions of the Wisconsin Academy of Sciences, Arts and Letters, 9 Part 1 : 53—104. 1893.

[8] Martin, Lawrence, *Physical Georgraphy of Wisconsin.* 2nd edition, Madison, 42. 1932.

# FUNGI OF THE UNIVERSITY OF WISCONSIN ARBORETUM[1]

H. C. GREENE

The extension of our already considerable knowledge of the fungi parasitic on plants which occur in Wisconsin is the writer's special interest. Intensive and regular collecting has been carried on in the University Arboretum during the five seasons of 1942 through 1946. The results are striking in showing how much can be found by persistent collecting in even a relatively small area.

The University Arboretum at Madison is a 1200-acre tract which has a diversity of soil types, from almost pure sand to peat and heavy clay, and a variety of habitats from marsh to upland meadow and natural oak woods. There are numerous plantings of both coniferous and hardwood forest types, and several representative prairie areas have been established. Because of the plantings there is perhaps a larger number of species of higher plants growing in the Arboretum than would usually be encountered in an area of this size in southern Wisconsin. The sandier portions of the Arboretum and the coniferous plantings offer environmental conditions which especially favor the development of certain types of fleshy fungi, while the relatively large number of potential host species favors the presence of a diverse parasitic fungus flora.

Madison is in the region of forest-prairie transition, and a good many species of higher plants, primarily more western in their distribution, do well in the vicinity. The presence of essentially western hosts naturally favors the presence of western parasitic fungi, and collections made in the Arboretum have very materially extended the known eastward range of several species of such fungi.

A total of about 1250 items, involving 795 species of fungi, including non-parasitic fungi and parasitic fungi on 467 hosts, have been determined. Only a start has been made in the listing of non-parasitic forms, but it is felt that the account of parasites and their hosts is quite comprehensive. Specimens of most of the parasites have

[1] Journal Paper No. 10, University of Wisconsin Arboretum.

been placed in the University of Wisconsin Cryptogamic Herbarium under a special Arboretum label. The larger fleshy fungi have been collected and determined, but in most cases have not been preserved.

Approximately 615 species of parasites have been determined. Of these, 33 have been described as new species or varieties. Seventy-seven species previously described, but not before reported to occur in Wisconsin, have been found, making a total of 110 species not hitherto listed for the state. In addition to this, parasites have been collected on about 135 host plants not previously reported to bear the fungi mentioned in Wisconsin. A considerable number of these host records are new, not only to Wisconsin, but to all other localities, so far is known. Where new or noteworthy, the results of these investigations have been incorporated into a series of eleven papers, already published or in press. Although these papers are not exclusively based on Arboretum collections, a very large, if not the major, portion of the material contained in them is derived from that source. The papers have appeared, or will appear, in the *Transactions of the Wisconsin Academy of Sciences, Arts and Letters, Farlowia* and the *American Midland Naturalist.*

The list of fungi which follows is alphabetical. When the fungi are parasites the host plants on which they occur are mentioned. Also, where non-parasitic fungi have developed on recognizable dead plants, such substrata are listed. Fungi, such as those mushrooms which occur on soil or much rotted wood, are catalogued by name only. In the case of parasites, new species are indicated by †* preceding the name, species not hitherto reported for the state by † preceding the name, and additional hosts by * preceding the name.

ACANTHOSTIGMA OCCIDENTALE (Ell. & Ev.) Sacc.
On *Artemisia ludoviciana, Cirsium discolor*
AECIDIUM PHYSALIDIS Burr.
On **Physalis heterophylla*
ALBUGO BLITI (Biv.) O. Ktze.
On *Amaranthus retroflexus*
ALBUGO CANDIDA (Pers.) O. Ktze.
On *Capsella bursa-pastoris, Cardamine bulbosa, *Lepidium campestre, Rorippa palustris* var. *glabrata, Sisymbrium altissimum, S. officinale.*
ALBUGO PORTULACAE (DC.) O. Ktze.
On *Portulaca oleracea*
ALBUGO TRAGOPOGONIS (DC.) S. F. Gray
On *Cirsium muticum*
ALEURODISCUS OAKESII (B. & C.) Cke.
On *Quercus alba*

ALTERNARIA sp.
On *Petalostemum candidum*
ALTERNARIA BRASSICAE (Berk.) Sacc.
On *Brassica arvensis*
AMANITA COTHURNATA Atk.
AMANITA FROSTIANA Peck
AMANITA MUSCARIA (L.) Pers.
AMANITA PECKIANA Kauffm.
AMANITA PHALLOIDES (Fr.) Quel.
AMANITA RUBESCENS Pers.
AMANITA SOLITARIA Bull.
AMANITA STROBILIFORMIS Vitt.
AMANITA VERNA (Bull.) Quel.
AMANITA VIROSA (Fr.) Quel.
AMANITOPSIS VAGINATA (Bull.) Roze
ARMILLARIA MELLEA (Vahl) Quel.
ASCOCHYTA sp.
On *Chrysanthemum balsamita* var. *tanacetoides, Leonurus cardiaca.*
ASCOCHYTA COMPOSITARUM J. J. Davis
On *Eupatorium urticaefolium*
ASCOCHYTA GRAMINICOLA Sacc.
On **Muhlenbergia foliosa, *Panicum capillare*
†*ASCOCHYTA HYDROPHYLLI-VIRGINIANI H. C. Greene
On *Hydrophyllum virginianum*
ASCOCHYTA LOPHANTHI J. J. Davis
On *Lycopus americanus, L. uniflorus*
ASCOCHYTA NEPETAE J. J. Davis
On *Nepeta cataria*
ASCOCHYTA PISI Lib.
On *Lupinus perennis, Vicia villosa*
†ASCOCHYTA SYRINGAE Bres.
On *Syringa vulgaris*
†ASCOCHYTA VERBENAE Siemaszko
On *Verbena stricta*
ASCOCHYTA WISCONSINA J. J. Davis
On *Sambucus canadensis*
ASTERINA RUBICOLA Ell. & Ev.
On *Rubus occidentalis, R. strigosus.*
ASTEROMA RIBICOLUM Ell. & Ev.
On *Ribes americanum*
ASTEROMA TILIAE Rud.
On *Tilia americana*
ASTEROMELLA ANDREWSII Petr.
On *Gentiana andrewsii*
ASTEROMELLA ASTERICOLA J. J. Davis
On **Aster ericoides, *Solidago altissima.*
BASIDIOPHORA ENTOSPORA Roze & Cornu
On *Aster novae-angliae, Erigeron canadensis.*

BOLETUS AMERICANUS Peck
BOLETUS CASTANEUS Bull.
BOLETUS GRANULATUS L.
BOLETUS SUBTOMENTOSUS L.
BOTRYTIS sp.
On *Puccinia rubigo-vera* on *Thalictrum dasycarpum*
BOTRYTIS sp.
On *Vicia villosa*
BOVISTA PILA B. & C.
BREMIA LACTUCAE Regel
On *Lactuca canadensis, *L. ludoviciana, L. scariola, L. spicata.*
BULGARIA RUFA Schw.
CALVATIA CRANIFORMIS (Schw.) Fr.
CALVATIA GIGANTEA Batsch.
CANTHARELLUS AURANTIACUS Fr.
CANTHARELLUS CIBARIUS Fr.
CAPNODIUM (?) sp.
On *Pinus strobus*
CENANGIUM POPULNEUM (Pers.) Rehm
On *Populus tremuloides*
†*CERCOSEPTORIA BELPHILIAE H. C. Greene
On *Blephilia ciliata, Pycnanthemum virginianum*
†*CERCOSEPTORIA CERASTII H. C. Greene
On *Cerastium vulgatum*
CERCOSEPTORIA LEPTOSPERMA (Pk.) Petr.
On *Aralia nudicaulis*
CERCOSEPTORIA LONGISPORA (Pk.) Petr.
On *Lupinus perennis*
CERCOSPORA ACALYPHAE Peck
On *Acalypha virginica*
†CERCOSPORA ACETOSELLAE Ell.
On *Rumex acetosella*
†CERCOSPORA ACNIDAE Ell. & Ev.
On *Acnida tuberculata*
CERCOSPORA ALISMATIS Ell. & Holw.
On *Alisma plantago-aquatica*
CERCOSPORA ALTHAEINA Sacc.
On *Althaea rosea, Hibiscus trionum.*
CERCOSPORA AMPELOPSIDIS Peck
On *Psedera vitacea*
CERCOSPORA ARCTI-AMBROSIAE Hals.
On *Arctium minus*
†CERCOSPORA ASTRAGALI Woronichin
On *Astragalus canadensis*
CERCOSPORA AVICULARIS Wint.
On *Polygonum achoreum, P. aviculare*
CERCOSPORA BARBAREAE (Sacc.) Chupp
On *Barbarea vulgaris*

†CERCOSPORA BERTEROAE Hollos
On *Berteroa incana*
CERCOSPORA BIDENTIS Tharp
On *Bidens cernua, *B. coronata.*
CERCOSPORA BLEPHILIAE Chupp & Greene
On *Lycopus uniflorus*
†*CERCOSPORA BOUTELOUAE Chupp & Greene
On *Bouteloua curtipendula*
†CERCOSPORA CANNABIS (Hara) Chupp
On *Cannabis sativa*
CERCOSPORA CARICINA Ell. & Dearn.
On *Carex interior, C. rosea, *C. stipata.*
CERCOSPORA CEANOTHI Kell. & Sw.
On *Ceanothus americanus*
†CERCOSPORA CHENOPODIICOLA Bres.
On *Chenopodium hybridum*
CERCOSPORA CICHORII J. J. Davis
On *Cichorium intybus*
CERCOSPORA CIRCUMSCISSA Sacc.
On *Prunus virginiana*
CERCOSPORA CLAVATA (Ger.) Cke.
On *Asclepias incarnata, A. syriaca.*
CERCOSPORA COMANDRAE Ell. & Dearn.
On *Comandra umbellata*
CERCOSPORA CORDATAE Chupp & Greene
On *Zizia aurea*
CERCOSPORA CORNI J. J. Davis
On *Cornus racemosa*
CERCOSPORA CUCURBITAE Ell. & Ev.
On *Cucurbita maxima*
†CERCOSPORA CYNOGLOSSI Van Hook
On *Lappula virginiana*
CERCOSPORA CYPRIPEDII Ell. & Dearn.
On *Cypripedium candidum*
CERCOSPORA DAVISII Ell. & Ev.
On *Melilotus alba, M. officinalis.*
CERCOSPORA DEPAZEOIDES (Desm.) Sacc.
On *Sambucus canadensis*
CERCOSPORA DESMODII Ell. & Kell.
On *Desmodium acuminatum*
†CERCOSPORA DESMODIICOLA Atk.
On *Desmodium canadense*
CERCOSPORA DIFFUSA Ell. & Ev.
On *Physalis heterophylla, P. virginiana.*
CERCOSPORA DUBIA (Riess) Wint.
On *Atriplex patula* var. *littoralis, Chenopodium album.*
CERCOSPORA DULCAMARAE (Pk.) Ell. & Ev.
On *Solanum dulcamara*

CERCOSPORA ECHINOCHLOAE J. J. Davis
On *Echinochloa crusgalli*
CERCOSPORA ECHINOCYSTIS Ell. & Mart.
On *Echinocystis lobata*
†CERCOSPORA ELAEOCHROMA Sacc.
On *Asclepias amplexicaulis*
CERCOSPORA FINGENS J. J. DAVIS
On *Thalictrum dasycarpum*
CERCOSPORA FUSIMACULANS Atk.
On **Leptoloma cognatum*, **Panicum perlongum*, **P. praecocius*, **P. scribnerianum.*
CERCOSPORA GALII Ell. & Holw.
On *Galium triflorum*
CERCOSPORA GEI Fckl.
On *Geum triflorum*
†CERCOSPORA GENTIANICOLA Ell. & Ev.
On *Gentiana procera*
CERCOSPORA GERARDIAE Ell. & Dearn.
On *Gerardia grandiflora*
CERCOSPORA GNAPHALIACEA Cke.
On *Gnaphalium polycephalum*
CERCOSPORA GRANULIFORMIS Ell. & Holw.
On *Viola cucullata*
CERCOSPORA GRAPHOIDES Ell.
On Prunus serotina
†CERCOSPORA GRISEA Cke. & Ell.
On *Polygala sanguinea*
CERCOSPORA HELIANTHI Ell. & Ev.
On *Helianthus occidentalis*
CERCOSPORA HEUCHERAE Ell. & Mart.
On *Heuchera* sp.
†CERCOSPORA INCARNATA Ell. & Ev.
On *Asclepias verticillata*
CERCOSPORA LAXIPES J. J. Davis
On *Spiraea salicifolia*
†*CERCOSPORA LECHEAE Chupp & Greene
On *Lechea intermedia*
†CERCOSPORA LEPIDII Peck
On *Lepidium campestre*
CERCOSPORA LEPTANDRAE J. J. Davis
On *Veronica virginica*
CERCOSPORA LESPEDEZAE Ell. & Dearn.
On *Lespedeza capitata*
†*CERCOSPORA LITHOSPERMI Chupp & Greene
On **Lithospermum canescens, L. croceum.*
†CERCOSPORA LOBELIAE Ell. & Ev.
On *Lobelia spicata*
†CERCOSPORA LONGISSIMA Sacc.
On *Lactuca scariola*

†CERCOSPORA LYCII Ell. & Halst.
On *Lycium halimifolium*
CERCOSPORA LYTHRI (West.) Niessl
On *Lythrum alatum*
†CERCOSPORA MACROMACULANS Heald & Wolf
On *Syringa vulgaris*
†*CERCOSPORA MADISONENSIS Chupp & Greene
On *Gerardia grandiflora*
†CERCOSPORA MALVARUM Sacc.
On *Malva rotundifolia*
CERCOSPORA MEDICAGINIS Ell. & Ev.
On *Medicago lupulina*
CERCOSPORA MICROSORA Sacc.
On *Tilia americana*
CERCOSPORA MUHLENBERGIAE Atk.
On *Muhlenbergia foliosa, M. racemosa.*
CERCOSPORA NASTURTII Pass.
On *Nasturtium officinale, Rorippa palustris* var. *hispida.*
CERCOSPORA OMPHACODES Ell. & Holw.
On *Phlox pilosa*
CERCOSPORA OSMORHIZAE Ell. & Ev.
On *Osmorhiza claytoni*
CERCOSPORA PARVIMACULANS J. J. Davis
On **Solidago altissima, *S. juncea, *S. riddellii, S. rigida, S. serotina, S. uliginosa.*
CERCOSPORA PASTINACAE (Sacc.) Peck
On *Pastinaca sativa*
CERCOSPORA PENTSTEMONIS Ell. & Kell.
On **Pentstemon digitalis*
CERCOSPORA PERFOLIATA Ell. & Ev.
On *Eupatorium maculatum, E. perfoliatum, E. urticaefolium*
CERCOSPORA PHYSALIDIS Ell.
On *Physalis heterophylla*
CERCOSPORA PLANTAGINIS Sacc.
On **Plantago rugelii*
CERCOSPORA POLYGONACEA Ell. & Ev.
On **Polygonum convolvulus, P. tenue.*
CERCOSPORA POLYGONORUM Cke.
On *Polygonum hydropiper* var. *projectum*
†*CERCOSPORA POTENTILLAE Chupp & Greene
On *Potentilla norvegica* var. *hirsuta, P. recta.*
†*CERCOSPORA QUARTA Chupp & Greene
On *Aster umbellatus*
CERCOSPORA RACEMOSA Ell. & Mart.
On *Teucrium occidentale*
CERCOSPORA RATIBIDAE Ell. & Barth.
On *Lepachys pinnata*
CERCOSPORA RHOINA Cke. & Ell.
On *Rhus glabra, R. typhina.*

†CERCOSPORA RIBIS Earle
On *Ribes americanum*
CERCOSPORA ROSICOLA Pass.
On *Rosa* sp.
CERCOSPORA SAGITTARIAE Ell. & Kell.
On *Sagittaria latifolia*
CERCOSPORA SEDOIDES Ell. & Ev.
On *Penthorum sedoides*
CERCOSPORA SENECIONICOLA J. J. Davis
On **Senecio balsamitae*
CERCOSPORA SETARIICOLA Tehon & Daniels
On *Setaria lutescens*
CERCOSPORA SILPHII Ell. & Ev.
On *Silphium laciniatum, S. terebinthinaceum.*
†*CERCOSPORA SOLIDAGINIS Chupp & Greene
On *Solidago juncea*
†*CERCOSPORA TERTIA Chupp & Greene
On *Aster ptarmicoides*
†CERCOSPORA TRAGOPOGONIS Ell. & Ev.
On *Tragopogon pratensis*
CERCOSPORA TRIFIDAE Chupp
On **Ambrosia artemisiifolia, A. trifida.*
CERCOSPORA UMBRATA Ell. & Holw.
On *Bidens vulgata*
CERCOSPORA VARIA Peck
On *Viburnum lentago, V. opulus* L.
CERCOSPORA VELUTINA Ell. & Kell.
On *Baptisia leucophaea (bracteata)*
†CERCOSPORA VERBASCICOLA Ell. & Ev.
On *Verbascum thapsiforme, V. thapsus.*
CERCOSPORA VERBENICOLA Ell. & Ev.
On *Verbena stricta*
CERCOSPORA VERNONIAE Ell. & Kell.
On *Vernonia fasciculata*
CERCOSPORA VEXANS C. Massal.
On *Fragaria virginiana*
CERCOSPORA VIOLAE Sacc.
On **Viola pedata, *V. sagittata.*
†CERCOSPORA VULPINAE Ell. & Kell.
On *Vitis vulpina*
†*CERCOSPORA WISCONSINENSIS Chupp & Greene
On *Prenanthes alba, P. racemosa.*
†CERCOSPORA XANTHICOLA Heald & Wolf
On *Xanthium italicum*
CERCOSPORA ZEBRINA Pass.
On *Trifolium hybridum, T. pratense.*
CERCOSPORELLA APOCYNI (E. & K.) Trel.
On *Apocynum cannabinum*

CERCOSPORELLA CANA Sacc.
On *Erigeron annuus, E. canadensis, *E. philadelphicus, E. ramosus.*
CERCOSPORELLA DEARNESSII Bubak & Sacc.
On *Solidago altissima, *S. riddellii.*
CERCOSPORELLA EXILIS J. J. Davis
On *Phryma leptostachya*
CERCOSPORELLA FILIFORMIS J. J. Davis
On *Anemone patens* var. *wolfgangiana*
CERCOSPORELLA NIVEA Ell. & Barth.
On **Solidago serotina*
†CERCOSPORELLA ONTARIENSIS Sacc.
On *Euthamia graminifolia*
CERCOSPORELLA PYRINA Ell. & Ev.
On *Pyrus ioensis*
CERCOSPORELLA SAXIFRAGAE Rostr.
On *Saxifraga pennsylvanica*
CHLOROSPLENIUM AERUGINOSUM (Oed.) de Not.
CICINNOBOLUS CESATI DeBary
On *Erysiphe cichoracearum*
CINTRACTIA JUNCI (Schw.) Trel.
On **Juncus dudleyi*
CLADOSPORIUM sp.
On *Acer negundo*
†*CLADOSPORIUM AMERICANUM H. C. Greene
On *Prunus americana*
CLADOSPORIUM AROMATICUM Ell. & Ev.
On *Rhus copallina, R. glabra, R. typhina.*
CLADOSPORIUM ASTERICOLA J. J. Davis
On **Aster sagittifolius, *Solidago altissima, *S. nemoralis, *S. speciosa, *S. ulmifolia.*
†*CLADOSPORIUM LYSIMACHIAE H. C. Greene
On *Lysimachia terrestris*
CLADOSPORIUM TRIOSTEI Peck
On *Triosteum aurantiacum*
CLADOTRICHUM LEERSIAE Atk.
On *Leersia oryzoides*
CLAVICEPS PURPUREA (Fr.) Tul.
Sclerotia on *Agropyron repens, Bromus inermis, Calamagrostis canadensis, Dactylis glomerata, Glyceria borealis, Koeleria cristata, Phalaris arundinacea, Secale cereale.*
CLITHRIS QUERCINA (Pers.) Fr.
On *Quercus* sp.
CLITOCYBE DEALBATA Sow.
CLITOCYBE INFUNDIBULIFORMIS (Schaeff.) Fr.
CLITOCYBE MULTICEPS Peck
CLITOCYBE OCHROPURPUREA Berk.
CLITOPILUS ABORTIVUS (B. & C.) Sass.
COCCOMYCES DENTATUS (Kze. & Schum.) Sacc.
On *Quercus velutina*

COCCOMYCES LUTESCENS Higgins (Cylindrosporium stage)
On *Prunus serotina*
†COLEOSPORIUM DELICATULUM (A. & K.) Hedgc. & Long
On *Euthamia graminifolia*
COLEOSPORIUM SOLIDAGINIS (Schw.) Thum.
On *Aster azureus, A. ericoides, A. laevis, A. lateriflorus, A. lucidulus, A. macrophyllus, A. novae-angliae, A. oblongifolius, *A. pilosus, A. sagittifolius, A. tradescanti, A. umbellatus, Pinus banksiana, P. resinosa, Solidago altissima, *S. juncea, S. nemoralis, S. riddellii, *S. rigida, S. serotina, S. uliginosa, S. ulmifolia.*
COLEOSPORIUM TEREBINTHINACEAE (Schw.) Arth.
On **Silphium terebinthinaceum*
COLEOSPORIUM VIBURNI Arth.
On *Viburnum lentago, *V. opulus* L.
COLLETOTRICHUM sp.
On *Pyrola elliptica*
COLLETOTRICHUM GRAMINICOLUM (Ces.) Wils.
On *Calamagrostis canadensis, Panicum virgatum.*
COLLETOTRICHUM HELIANTHI J. J. Davis
On *Helianthus strumosus*
COLLETOTRICHUM SILPHII J. J. Davis
On **Silphium integrifolium*
COLLETOTRICHUM SOLITARIUM Ell. & Barth.
On **Solidago juncea, S. riddellii.*
COLLETOTRICHUM SORDIDUM J. J. Davis
On *Menispermum canadense*
COLLETOTRICHUM VIOLAE-ROTUNDIFOLIAE (Sacc.) House
On **Viola pedata, V.* sp.
COLLYBIA RADICATA var. FURFURACEA Peck
CONIOSPORIUM ARUNDINIS (Cda.) Sacc.
On *Phragmites communis*
CONIOTHECIUM TORULOIDES Cda.
On *Salix* sp.
CONIOTHYRIUM CONCENTRICUM (Desm.) Sacc.
On *Yucca filamentosa*
COPRINUS ATRAMENTARIUS (Bull.) Fr.
COPRINUS COMATUS Fr.
CORTICIUM INVESTIENS (Schw.) Bres.
On *Quercus* sp.
CORTICIUM SCUTELLARE B. & C.
On *Quercus* sp.
CREPIDOTUS VERSUTUS Peck
CRONARTIUM COMANDRAE Peck
On *Comandra umbellata*
CRYPTOSPHAERIA POPULINA (Pers.) Sacc.
On *Populus deltoides*
CRYPTOSPORELLA ANOMALA (Pk.) Sacc.
On *Corylus americana*

CYCLOMYCES FUSCUS Ktze.
CYLINDROSPORIUM APOCYNI Ell. & Ev.
On *Apocynum androsaemifolium*
CYLINDROSPORIUM ARTEMISIAE Dearn. & Barth.
On *Artemisia ludoviciana*
CYLINDROSPORIUM BETULAE J. J. Davis
On **X Betula sandbergii*
CYLINDROSPORIUM CALAMAGROSTIDIS Ell. & Ev.
On *Calamagrostis canadensis*
CYLINDROSPORIUM CAPSELLAE Ell. & Ev.
On *Capsella bursa-pastoris*
†CYLINDROSPORIUM CELTIDIS Earle
On *Celtis occidentalis*
CYLINDROSPORIUM CRESCENTUM Barth.
On *Pastinaca sativa*
CYLINDROSPORIUM EMINENS J. J. Davis
On *Helianthemum* sp.
CYLINDROSPORIUM ERYNIGII Ell. & Kell.
On *Erynigium yuccifolium*
CYLINDROSPORIUM GLYCERIAE Ell. & Ev.
On *Glyceria striata*
CYLINDROSPORIUM SALICIFOLIAE (Trel.) Davis
On *Spiraea salicifolia*
CYLINDROSPORIUM THALICTRI Ell. & Ev.
On *Thalictrum dasycarpum*
CYLINDROSPORIUM TOXICODENDRI (E. & M.) Ell. & Ev.
On *Rhus toxicodendron*
CYLINDROSPORIUM TRIFLORI H. C. Greene
On *Geum triflorum*
CYTOSPORA RHOINA Fr.
On *Rhus glabra*
CYTOSPORA RUBI Schw.
On *Rubus allegheniensis*
DACRYMYCES sp.
DAEDALEA CONFRAGOSA (Bolt.) Pers.
DAEDALEA UNICOLOR (Bull.) Fr.
DARLUCA FILUM (Biv.) Cast.
On various *Uredineae*
DAVISIELLA sp.
In *Phyllachora boutelouae*
DIAPORTHE ORTHOCERAS (Fr.) Nitsch.
On *Lactuca canadensis*
DIATRYPE AMERICANA var. QUERCUS Rehm
On *Quercus macrocarpa*
DIATRYPE STIGMA (Hoffm.) Fr.
On *Quercus* sp.
DICOCCUM NEBULOSUM Ell. & Ev.
On *Fraxinus americana*

DILOPHOSPORA ALOPECURI Fr.
On *Calamagrostis canadensis, *Phalaris arundinacea.*
DILOPHOSPORA GERANII Schroet.
On *Geranium maculatum*
DIPLOCARPON ROSAE F. A. Wolf (Actinonema stage)
On *Rosa* sp.
DIPLODIA TAXI (Sow.) De Not.
On *Taxus* sp.
DOASSANSIA ALISMATIS (Nees) Cornu
On *Alisma plantago-aquatica*
†ELLISIELLA CAUDATA (Pk.) Sacc.
On *Andropogon furcatus, Sorghastrum nutans, *Sporobolus heterolepis.*
ELSINOE VENETA (Speg.) Jenkins
On *Rubus occidentalis*
ENTOLOMA GRAYANUM Peck
ENTOLOMA SERICATUM Britz.
ENTOMOSPORIUM THUEMENII (Cke.) Sacc.
On *Crataegus mollis*
ENTYLOMA AUSTRALE Speg.
On *Physalis virginiana*
ENTYLOMA COMPOSITARUM Farl.
On *Ambrosia artemisiifolia, Lepachys pinnata, Senecio aureus.*
ENTYLOMA LOBELIAE Farl.
On *Lobelia inflata*
ENTYLOMA NYMPHAEAE (Cunn.) Setch.
On *Castalia* sp.
ENTYLOMA POLYSPORUM (Pk.) Farl.
On *Ambrosia trifida*
EPICOCCUM NEGLECTUM Desm.
On *Andropogon scoparius, Sporobolus heterolepis.*
ERYSIPHE CICHORACEARUM DC.
On *Acalypha virginica, Ambrosia artemisiifolia, A. trifida, *Aster azureus, A. lucidulus, *A. novae-angliae, A. oblongifolius, *A. pilosus, A. sagittifolius, A. tradescanti, Cirsium discolor, C. muticum, Eupatorium maculatum, *E. urticaefolium, *Galium aparine, Helianthus strumosus, Lactuca canadensis, L. scariola, L. spicata, Lappula virginiana, Mentha arvensis* var. *canadensis, *Monarda fistulosa, Parietaria pennsylvanica, Plantago rugelii, *Scutellaria lateriflora, Solidago altissima, *S. riddellii, *S. serotina, Verbena hastata, V. stricta, V. urticaefolia, Vernonia fasciculata.*
ERYSIPHE GALEOPSIDIS DC.
On *Chelone glabra, *Eupatorium urticaefolium.*
ERYSIPHE GRAMINIS DC.
On *Agropyron repens* (perithecia produced), *Poa palustris, P. pratensis.*
ERYSIPHE POLYGONI DC.
On *Caltha palustris, Lupinus perennis, Oenothera biennis, Ranunculus abortivus, Thalictrum dasycarpum, Trifolium hybridum, T. pratense.*
†EXOSPORIUM DEFLECTENS Karst.
On *Juniperus communis* var. *depressa, *J. virginiana.*

FABRAEA RANUNCULI (Fr.) Karst.
On *Ranunculus pennsylvanicus*
FAVOLUS CURTISII Berk.
On *Quercus* sp.
FAVOLUS EUROPAEUS Fr.
On *Quercus* sp.
FLAMMULA POLYCHROA Berk.
FLAMMULA SAPINEA (Fr.) Quel.
FOMES APPLANATUS (Pers.) Gill.
On *Quercus velutina*
FROMMEA OBTUSA (Str.) Arth.
On *Potentilla canadensis*
FUMAGO VAGANS Pers.
On *Populus tremuloides*
FUSICLADIUM DEPRESSUM (B. & Br.) Sacc.
On *Angelica atropurpurea*
FUSICLADIUM DEPRESSUM var. PLATYSPORA (E. & H.) Davis.
On **Oxypolis rigidior*
FUSICLADIUM RADIOSUM (Lib.) Lind.
On *Populus grandidentata, P. tremuloides.*
GANODERMA LUCIDUM (Fr.) Karst.
On *Quercus* sp.
GEASTER HYGROMETRICUS Pers.
GLOEOSPORIUM BETULARUM Ell. & Mart.
On *Betula nigra*
GLOEOSPORIUM CANADENSE Ell. & Ev.
On *Quercus alba, Q. macrocarpa.*
GLOEOSPORIUM CORYLI (Desm.) Sacc.
On *Corylus americana*
†GLOEOSPORIUM HEPATICAE Peck
On *Hepatica acutiloba*
†GLOEOSPORIUM LEPTOTHYRIOIDES Kab. & Bub.
On *Betula papyrifera,* X *B. sandbergii.*
GLOEOSPORIUM RIBIS (Lib.) Mont. & Desm.
On *Ribes americanum, R. missouriense.*
GLOEOSPORIUM SALICIS Westd.
On *Salix* sp.
GLOEOSPORIUM SEPTORIOIDES Sacc.
On *Quercus velutina*
GLOMERULARIA LONICERAE Peck
On *Lonicera tatarica*
GLONIUM STELLATUM Muhl.
GNOMONIA ULMEA (Schw.) Thum.
On *Ulmus americana*
GRAPHIUM GRACILE Peck
On *Rubus strigosus*
GRAPHYLLIUM sp.
On *Phragmites communis*

GYMNOCONIA PECKIANA (Howe) Trotter
On *Rubus allegheniensis, R. occidentalis.*
GYMNOSPORANGIUM GLOBOSUM Farl.
On *Crataegus mollis*
GYMNOSPORANGIUM JUNIPERI-VIRGINIANAE Schw.
On *Juniperus virginiana, *X Pyrus prunifolia, P. ioensis.*
HELMINTHOSPORIUM AVENAE Eidam
On *Avena sativa*
HELMINTHOSPORIUM BROMI Died.
On *Bromus inermis, *B. japonicus.*
†HELMINTHOSPORIUM INCONSPICUUM var. BUCHLOES Ell. & Ev.
On *Bouteloua curtipendula, B. hirsuta.*
†HELMINTHOSPORIUM ROSTRATUM Drechsler
On *Eragrostis cilianensis, *E. pectinacea, *E. spectabilis.*
HELMINTHOSPORIUM SATIVUM Pamm., King & Bakke
On **Agropyron repens, *Muhlenbergia foliosa.*
HELVELLA MITRA L.
HENDERSONIA CELTIFOLIA Cke.
On *Celtis occidentalis*
HENDERSONIA TYPHAE Oud.
On *Typha angustifolia*
HETEROSPORIUM GRACILE (Wallr.) Sacc.
On *Iris* sp.
†*HYALOTHYRIDIUM CALAMAGROSTIDIS H. C. Greene
On *Calamagrostis canadensis*
HYDNUM OCHRACEUM Pers.
HYDNUM REPANDUM L.
HYPHOLOMA SUBLATERITIUM Schaeff.
HYPOXYLON PRUINATUM (Kl.) Cke.
On *Populus tremuloides*
INOCYBE RIMOSA (Bull.) Quel.
IRPEX CINNAMOMEUS Fr.
ISARIOPSIS ALBOROSELLA (Desm.)
On *Cerastium vulgatum, Stellaria aquatica.*
ITHYPHALLUS IMPUDICUS (L.) E. Fisch.
KUEHNEOLA UREDINIS (Lk.) Arth.
On *Rubus allegheniensis*
LACCARIA LACCATA (Scop.) B. & Br.
LACTARIUS DELICIOSUS (L.) Fr.
LACTARIUS PIPERATUS (Scop.) Fr.
LACTARIUS VOLEMUS Fr.
LENTINUS LECONTEI Fr.
LENTINUS LEPIDEUS Fr.
LEPIOTA CLYPEOLARIA Fr.
LEPIOTA CRISTATA Alb. & Schw.
LEPIOTA PROCERA Scop.
LEPTOSPHAERIA OGILVIENSIS (B. & Br.) Ces. & DeNot.
On *Lactuca canadensis*

LEPTOSTROMA PINASTRI Desm.
On *Pinus resinosa*
LEPTOTHYRIUM DRYINUM Sacc.
On **Quercus macrocarpa*
†LEPTOTHYRIUM PUNCTIFORME B. & C.
On *Erigeron annuus, E. ramosus.*
LEPTOTHYRIUM SIMILISPORUM (Ell. & Davis) Davis
On **Solidago altissima, *S. nemoralis, S. rigida, S. serotina.*
LOPHODERMIUM ARUNDINACEUM (Schrad.) Chev.
On *Gramineae* indet.
LOPHODERMIUM JUNIPERINUM (Fr.) DeNot.
On *Juniperus communis* var. *depressa, J. virginiana.*
†LOPHODERMIUM NITENS Darker
On *Pinus strobus*
LOPHODERMIUM PINASTRI (Schrad.) Chev.
On *Pinus resinosa*
LYCOPERDON GEMMATUM Batsch.
MACROSPORIUM SARCINAEFORME Cav.
On *Trifolium pratense*
MARASIMIUS CAMPANULATUS Peck
MARASIMIUS SICCUS (Schw.) Fr.
MARSONIA CORONARIAE Sacc. & Dearn.
On *Pyrus ioensis*
MARSONIA FRAXINI Ell. & Davis
On *Fraxinus americana*
†*MARSONIA GLOEODES H. C. Greene
On *Fraxinus americana*
MARSONIA JUGLANDIS (Lib.) Sacc.
On *Juglans cinerea, J. nigra.*
MARSONIA KRIEGERIANA Bres.
On *Salix longifolia*
MARSONIA MARTINI Sacc. & Ell.
On *Quercus alba, Q. macrocarpa.*
MARSONIA POPULI (Lib.) Sacc.
On *Populus deltoides*
MARSONIA POTENTILLAE (Desm.) Fisch.
On *Potentilla arguta, P. palustris.*
MARSONIA POTENTILLAE var. TORMENTILLAE Trail
On *Fragaria vesca* var. *americana, Rubus triflorus.*
MELAMPSORA ABIETI-CAPREARUM Tub.
On *Salix longifolia*
MELAMPSORA BIGELOWII Thum.
On *Salix* sp.
MELAMPSORA MEDUSAE Thum.
On *Populus deltoides, P. tremuloides.*
MELASMIA ULMICOLA B. & C.
On *Ulmus americana*
MERULIUS TREMULLOSUS Schrad.

MICROSPHAERA ALNI (Wallr.) Wint.
On **X Betula sandbergii, Corylus americana, Lonicera tatarica, Quercus alba, Q. macrocarpa, Q. velutina, Syringa vulgaris, Viburnum affine, V. lentago.*
MICROSPHAERA ALNI var. LUDENS Salm.
On *Desmodium canadense*
MICROSPHAERA DIFFUSA C. & P.
On **Desmodium illinoense, Lespedeza capitata.*
MICROSPHAERA GROSSULARIAE (Wallr.) Lev.
On *Sambucus canadensis*
MICROSPHAERA RUSSELLII Clinton
On *Oxalis europea, O. stricta.*
MICROSTROMA JUGLANDIS (Bereng.) Sacc.
On *Carya ovata, Juglans cinerea, J. nigra.*
MOLLISIA DEHNII (Rabh.) Karst.
On *Potentilla norvegica* var. *hirsuta*
MORCHELLA CRASSIPES (Vent.) Pers.
MYCENA CORTICOLA (Schum.) Quel.
MYCENA FILIPES Bull.
MYCENA GALERICULATA (Scop.) Quel.
†*MYCOSPHAERELLA CALAMAGROSTIS H. C. Greene
On *Calamagrostis canadensis*
MYCOSPHAERELLA IMPATIENTIS (Pk. & Clint.) House
On *Impatiens biflora*
MYCOSPHAERELLA KRIGIAE (Ell. & Ev.) Greene
On Krigia biflora (amplexicaulis)
MYCOSPHAERELLA LETHALIS Stone (with imperfect ASCOCHYTA MELILOTI stage)
On *Melilotus alba*
MYCOSPHAERELLA THALICTRI (E. & E.) Lind.
On *Thalictrum dasycarpum*
NAEMACYCLUS NIVEUS (P. ex Fr.) Sacc.
On *Pinus sylvestris*
NAPICLADIUM ARUNDINACEUM (Cda.) Sacc.
On *Phragmites communis*
NECTRIA CINNABARINA (Tode) Fr.
On *Ulmus fulva*
†NEOTTIOSPORA ARENARIA Sydow
On *Carex rostrata*
NUMMULARIA ATROPUNCTA (Schw.) v. Hoehn.
On *Quercus* sp.
NUMMULARIA BULLIARDI Tul.
On *Quercus* sp.
OIDIUM spp.
Undetermined powdery mildews have been collected on the following hosts: *Achillea millefolium, Aster laevis, A. linariifolius, A. umbellatus, Cacalia tuberosa, Ceanothus americanus, Coreopsis palmata, Cornus racemosa, Desmodium acuminatum, Erucastrum gallicum, Euthamia graminifolia, Hieracium canadense, H. longipilum, Lactuca ludoviciana, Pilea pumila,*

*Ranunculus recurvatus, Rosa* sp., *Rubus allegheniensis, Rudbeckia hirta, R. laciniata, Solanum carolinense, Solidago speciosa.*

OMPHALIA CAMPANELLA Batsch.

†OPHIODOTHIS HAYDENI (B. & C.) Sacc.
On *Aster lucidulus, A. tradescanti.*

OVULARIA MONOSPORIA (West.) Sacc.
On *Rumex crispus*

OVULARIA PULCHELLA var. AGROPYRI J. J. Davis
On **Bromus inermis*

PANUS STYPTICUS (Bull.) Fr.
On *Quercus* sp.

PASSALORA FASCICULATA (C. & E.) Earle
On *Euphorbia corollata*

PATELLARIA ATRATA (Hedw.) Fr.

PATELLINA sp.
On *Penthorum sedoides*

PAXINA ACETABULUM (L.) Kze.

PAXINA SULCATA (Pers.) Kze.

†PELLICULARIA FILAMENTOSA (Pat.) Rogers
On *Equisetum arvense, Lepidium campestre, Melilotus officinalis, Physalis heterophylla.*

PENIOPHORA CINEREA (Pers.) Cke.
On *Quercus* sp.

PERICONIA BYSSOIDES Pers.
On *Erigeron philadelphicus, Polygonum pennsylvanicum.*

PERONOSPORA ALTA Fckl.
On **Plantago purshii, P. rugelii.*

PERONOSPORA CALOTHECA DeBary
On *Galium aparine, G. boreale, G. triflorum.*

PERONOSPORA CORYDALIS DeBary
On *Dicentra cucullaria*

PERONOSPORA EFFUSA (Grev.) Rabh.
On *Chenopodium album*

PERONOSPORA GRISEA Unger
On *Veronica peregrina*

PERONOSPORA HEDEOMAE Kell. & Sw.
On *Hedeoma hispida*

PERONOSPORA HYDROPHYLLI Waite
On *Hydrophyllum virginianum*

PERONOSPORA LINARIAE Fckl.
On *Linaria canadensis*

PERONOSPORA PARASITICA (Pers.) Tul.
On *Brassica arvensis, Dentaria laciniata, Nasturtium officinale, Sisymbrium altissimum.*

PERONOSPORA POTENTILLAE DeBary
On *Agrimonia gryposepala, Geum canadense, Potentilla norvegica* var. *hirsuta.*

PEZIZA SYLVESTRIS (Boud.) Sacc. & Trott.

PHACIDIUM sp.
On *Taxus* sp.

†PHAEOSEPTORIA CALAMAGROSTIDIS R. Sprague
On *Calamagrostis canadensis*
†PHAEOSEPTORIA FESTUCAE var. MUHLENBERGIAE R. Sprague
On *Elymus virginicus*
PHLEBIA RADIATA Fr.
PHLEBIA ZONATA B. & C.
On *Populus tremuloides*
PHLEOSPORA ACERIS (Lib.) Sacc.
On *Acer rubrum*
PHLEOSPORA ANEMONES Ell. & Kell.
On *Anemone virginiana*
PHLEOSPORA MORI (Lev.) Sacc.
On *Morus* sp.
PHOMA QUERCINA (Pk.) Sacc.
On *Quercus* sp.
PHOMA REVELLENS Sacc.
On *Corylus americana*
PHOMA THAPSI Ell. & Ev.
On *Verbascum thapsus*
PHOMOPSIS DIACHENII Sacc.
On *Pastinaca sativa*
PHOMOPSIS MISSOURIENSIS Bubak
On *Asclepias incarnata*
PHRAGMIDIUM AMERICANUM (Pk.) Diet.
On *Rosa carolina*
PHRAGMIDIUM DISCIFLORUM (Tode) James
On *Rosa* sp. (cult.)
PHRAGMIDIUM IVESIAE Sydow
On **Potentilla norvegica* var. *hirsuta, P. recta.*
PHYLLACHORA AMBROSIAE (B. & C.) Sacc.
On *Ambrosia artemisiifolia*
PHYLLACHORA BOUTELOUAE Rehm
On *Bouteloua curtipendula*
PHYLLACHORA GRAMINIS (Pers.) Fckl.
On *Agropyron repens, Calamagrostis canadensis, Elymus canadensis, E. virginicus, *Hordeum jubatum, Panicum virgatum.*
PHYLLACHORA LESPEDEZAE (Schw.) Sacc.
On *Lespedeza capitata*
PHYLLACHORA LUTEOMACULATA (Schw.) Orton
On *Andropogon furcatus*
PHYLLACHORA PUNCTA (Schw.) Orton
On **Leptoloma cognatum, Panicum latifolium, P. scribnerianum.*
PHYLLACHORA VULGATA Theiss. & Syd.
On *Muhlenbergia foliosa, M. racemosa.*
PHYLLACTINIA CORYLEA (Pers.) Karst.
On *Celastrus scandens, Cornus racemosa, C. stolonifera, Quercus* sp.
PHYLLOSTICTA SPP.
On *Carya ovata, Osmorhiza claytoni, Syringa vulgaris, Viburnum opulus* L., *Zizia cordata.*

†PHYLLOSTICTA ACETOSELLAE Smith & Ramsb.
On *Rumex acetosella*
PHYLLOSTICTA ANEMONICOLA Sacc. & Syd.
On **Anemone cylindrica*
†PHYLLOSTICTA ANGELICAE Sacc.
On *Angelica atropurpurea*
PHYLLOSTICTA ANTENNARIAE Ell. & Ev.
On *Antennaria fallax*
PHYLLOSTICTA APOCYNI Trel.
On *Apocynum androsaemifolium, A. cannabinum.*
PHYLLOSTICTA ASTERICOLA Ell. & Ev.
On *Aster umbellatus*
†PHYLLOSTICTA CANNABIS (Kirchn.) Speg.
On *Cannabis sativa*
†PHYLLOSTICTA CHENOPODII-ALBI Siemaszko
On *Chenopodium album*
†PHYLLOSTICTA CIRSII Desm.
On *Cirsium undulatum, C. vulgare.*
†*PHYLLOSTICTA COREOPSIDIS H. C. Greene
On *Coreopsis palmata*
PHYLLOSTICTA CRUENTA (Fr.) Kickx.
On *Polygonatum commutatum*
PHYLLOSTICTA CRUENTA var. PALLIDIOR (Pk.) Davis
On *Smilacina racemosa, S. stellata.*
PHYLLOSTICTA DECIDUA Ell. & Kell.
On *Aralia racemosa, Epilobium* sp., **Geum strictum, *Monarda fistulosa, *Solanum dulcamara.*
PHYLLOSTICTA DESMODII Ell. & Ev.
On **Desmodium canadense, D. illinoense.*
†PHYLLOSTICTA GROSSULARIAE Sacc.
On *Ribes missouriense*
†PHYLLOSTICTA GUTTULATAE Halst.
On *Oxalis europea, O. stricta.*
†PHYLLOSTICTA HIERACII Allesch.
On *Hieracium longipilum*
PHYLLOSTICTA IRIDIS Ell. & Mart.
On *Iris virginica* var. *shrevei*
PHYLLOSTICTA LIATRIDIS J. J. Davis
On **Liatris spheroidea* (*scariosa*)
PHYLLOSTICTA LIVIDA Ell. & Ev.
On *Quercus macrocarpa*
PHYLLOSTICTA MINUTISSIMA Ell. & Ev.
On *Acer rubrum*
†PHYLLOSTICTA MONARDAE Ell. & Barth.
On *Blephilia ciliata, Mentha arvensis* var. *canadensis, Monarda fistulosa.*
PHYLLOSTICTA NEBULOSA Sacc.
On **Silene dichotoma, *S. latifolia.*

PHYLLOSTICTA NEGUNDINIS Sacc. & Speg.
On *Acer negundo*
PHYLLOSTICTA PHOMIFORMIS Sacc.
On *Quercus alba, Q. macrocarpa.*
†PHYLLOSTICTA POLYGONORUM Sacc.
On *Polygonum natans* f. *hartwrightii*
PHYLLOSTICTA PRUNICOLA Sacc.
On *Prunus serotina*
†PHYLLOSTICTA ROSAE Desm.
On *Rosa* sp.
PHYLLOSTICTA RUDBECKIAE Ell. & Ev.
On *Rudbeckia laciniata*
†PHYLLOSTICTA SALICICOLA Thum.
On *Salix* sp.
†*PHYLLOSTICTA SICCATA H. C. Greene
On *Solidago serotina*
†*PHYLLOSTICTA SOLIDAGINICOLA H. C. Greene
On *Solidago serotina*
†PHYLLOSTICTA SOLIDAGINIS Bres.
On *Solidago serotina*
†PHYLLOSTICTA SOLITARIA Ell. & Ev.
On *X Pyrus prunifolia*
PHYLLOSTICTA SPERMOIDES Peck
On *Vitis vulpina*
PHYLLOSTICTA STEIRONEMATIS Dearn. & House
On *Steironema ciliatum*
†PHYLLOSTICTA TILIAE Sacc. & Speg.
On *Tilia americana*
PHYLLOSTICTA TYPHINA Sacc. & Malb.
On *Typha latifolia*
†*PHYLLOSTICTA UMBRINO-FUMOSA H. C. Greene
On *Eupatorium urticaefolium*
PHYLLOSTICTA VERBASCICOLA Ell. & Kell.
On **Verbascum thapsiforme, V. thapsus.*
PHYLLOSTICTA VIOLAE Desm.
On *Viola* sp.
PHYLLOSTICTA VITICOLA (B. & C.) Thum.
On *Psedera vitacea, Vitis vulpina.*
†*PHYLLOSTICTA ZANTHOXYLI H. C. Greene
On *Zanthoxylum americanum*
PIGGOTIA FRAXINI B. & C.
On *Fraxinus americana*
PIGGOTIA NEGUNDINIS Ell. & Dearn.
On *Acer negundo*
PILACRE FAGINEA Fr.
PILEOLARIA TOXICODENDRI (B. & Rav.) Arth.
On *Rhus toxicodendron*
PIRICULARIA GRISEA (Cke.) Sacc.
On *Setaria viridis*

PIRICULARIA PARASITICA Ell. & Ev.
On *Phyllachora graminis, *P. vulgata.*
PLACOSPHAERIA PUNCTIFORMIS (Fckl.) Sacc.
On *Galium boreale*
PLASMOPARA GERANII (Pk.) Berl. & DeToni
On *Geranium maculatum*
PLASMOPARA HALSTEDII (Farl.) Berl. & DeToni
On *Ambrosia artemisiifolia, A. trifida, Bidens cernua, B. vulgata, Erechtites hieracifolia, Eupatorium urticaefolium, Helianthus grosseserratus, *H. rigidus, H. strumosus, Silphium integrifolium, S. terebinthinaceum.*
PLASMOPARA HUMULI Miyabe & Takah.
On *Humulus americanus*
PLASMOPARA ILLINOENSIS (Farl.) Davis
On *Parietaria pennsylvanica*
PLASMOPARA OBDUCENS Schroet.
On *Impatiens biflora*
PLASMOPARA PYGMAEA (Ung.) Schroet.
On *Anemone canadensis, A. quinquefolia, Hepatica acutiloba.*
PLASMOPARA VITICOLA (B. & C.) Berl. & DeToni
On *Vitis vulpina*
PLEOSPORA sp.
On *Curcurbita maxima*
PLEUROTUS OSTREATUS Jacq.
On *Quercus* sp.
PLOWRIGHTIA (DIBOTRYON) MORBOSA (Schw.) Sacc.
On *Prunus serotina, P. virginiana.*
PLUTEUS CERINUS Schaeff.
PODOSPHAERA OXYACANTHAE (DC.) DeBary
On *Prunus virginiana, Spiraea salicifolia.*
POLYPORUS ADUSTUS (Willd.) Fr.
On *Populus deltoides*
POLYPORUS BETULINUS Fr.
On *Betula papyrifera*
POLYPORUS BRUMALIS Fr.
POLYPORUS DICHROUS Fr.
POLYPORUS FRONDOSUS Fr.
POLYPORUS GIGANTEUS (Pers.) Fr.
POLYPORUS GILVUS Schw.
On *Quercus* sp.
POLYPORUS NIDULANS Fr.
POLYPORUS POCULA B. & C.
POLYPORUS SULPHUREUS (Bull.) Fr.
On *Quercus* sp.
POLYSTICTUS (POLYPORUS) CINNABARINUS (Jacq.) Fr.
On *Quercus* sp.
POLYSTICTUS CONCHIFER (Schw.) Sacc.
POLYSTICTUS HIRSUTUS Fr.
POLYSTICTUS PERGAMENUS Fr.
POLYSTICTUS VERSICOLOR (L.) Fr.

POLYTHRINCIUM TRIFOLII Kze.
On *Trifolium hybridum, T. repens.*

†PROTOCORONOSPORA NIGRICANS Atk. & Edg. emend. Wolf
On *Vicia villosa*

PSEUDOPEZIZA AUTUMNALIS (Fckl.) Sacc.
On *Galium tinctorium*

PSEUDOPEZIZA MEDICAGINIS (Lib.) Sacc.
On *Melilotus alba*

PUCCINIA ABSINTHII (Hedw. f.) DC.
On *Artemisia ludoviciana*

PUCCINIA ANDROPOGONIS Schw.
On *Andropogon furcatus, A. scoparius, Comandra umbellata.*

PUCCINIA ANEMONES-VIRGINIANAE Schw.
On *Anemone cylindrica, A. virginiana.*

PUCCINIA ANGUSTATA Peck
On *Lycopus americanus, *Monarda fistulosa, Scirpus atrovirens, S. cyperinus* var. *pelius.*

PUCCINIA ARGENTATA (Schultz) Wint.
On *Impatiens biflora*

PUCCINIA ASPARAGI DC.
On *Asparagus officinalis*

PUCCINIA ASTERIS Duby
On *Aster ericoides, A. lucidulus, A. tradescanti.*

PUCCINIA BARDANAE (Wallr.) Cda.
On *Arctium minus*

PUCCINIA BOLLEYANA Sacc.
On *Sambucus canadensis*

PUCCINIA CALTHAE (Grev.) Link
On *Caltha palustris*

PUCCINIA CALTHAECOLA Schroet.
On *Caltha palustris*

PUCCINIA CARICIS (Schum.) Schroet.
On *Carex lacustris, C. stricta, Ribes americanum, R. missouriense, Urtica gracilis.*

PUCCINIA CIRCAEAE Pers.
On *Circaea lutetiana*

PUCCINIA CIRSII Lasch.
On *Cirsium discolor, C. vulgare.*

PUCCINIA CNICI Mart.
On *Cirsium vulgare*

PUCCINIA CONVOLVULI (Pers.) Cast.
On *Convolvulus sepium*

PUCCINIA CORONATA Cda.
On *Agropyron repens, *Agrostis alba, Calamagrostis canadensis, *Elymus canadensis, Rhamnus cathartica.*

PUCCINIA CYPERI Arth.
On *Cyperus filiculmis, Erigeron annuus, E. ramosus.*

PUCCINIA ELEOCHARIDIS Arth.
On **Eleocharis acicularis, E. palustris, Eupatorium maculatum, E. perfoliatum.*
PUCCINIA EMACULATA Schw.
On *Panicum capillare*
PUCCINIA EXTENSICOLA Plowr.
On *Aster lucidulus, A. sagittifolius, A. tradescanti, A. umbellatus, *Carex interior* Bailey, *C. muhlenbergii, C. scoparia, *C. stellulata* var. *cephalantha, C. vulpinoidea, Erigeron annuus, E. ramosus, Hieracium canadense, H. longipilum, H. scabrum, Lactuca canadensis, L. spicata, Oenothera biennis, Phryma leptostachya, Solidago altissima, S. serotina, *S. ulmifolia.*
PUCCINIA GRAMINIS Pers.
On *Agropyron repens, Agrostis alba, Berberis vulgaris, Hordeum jubatum, Phleum pratense.*
PUCCINIA HELIANTHI Schw.
On *Helianthus giganteus, H. grosseserratus, *H. occidentalis, H. rigidus, H. strumosus.*
PUCCINIA HIERACII (Schum.) Mart.
On *Hieracium canadense, H. scabrum, *Taraxacum erythrospermum, T. officinale.*
PUCCINIA KUHNIAE Schw.
On *Kuhnia eupatorioides*
PUCCINIA LIATRIDIS (Webber) Bethel
On *Koeleria cristata, Liatris pycnostachya, L. spheroidea* (*scariosa*), **L. squarrosa.*
PUCCINIA MALVACEARUM Bert.
On *Althea rosea, Malva rotundifolia.*
PUCCINIA MENTHAE Pers.
On *Mentha arvensis* var. *canadensis, Monarda fistulosa, M. punctata, Pycnanthemum virginianum.*
PUCCINIA OBTECTA Peck
On **Scirpus acutus, S. americanus, S. validus.*
PUCCINIA OBTEGENS (Lk.) Tul.
On *Cirsium arvense*
PUCCINIA PANICI Diet.
On *Euphorbia corollata, Panicum virgatum.*
PUCCINIA PERIDERMIOSPORA (Ell. & Tr.) Arth.
On *Spartina pectinata*
PUCCINIA PHRAGMITIS (Schum.) Korn.
On *Phragmites communis*
PUCCINIA PHYSALIDIS Peck
On **Physalis heterophylla, P. virginiana.*
PUCCINIA PIMPINELLAE (Str.) Mart.
On *Osmorhiza claytoni*
PUCCINIA POAE-SUDETICAE (West.) Jorstad
On *Poa pratensis*
PUCCINIA POLYGONI-AMPHIBII Pers.
On *Geranium maculatum, Polygonum coccineum* var. *pratincola, P. convolvulus, P. natans* f. *hartwrightii, P. scandens.*

PUCCINIA PUNCTATA Link
On *Galium concinnum, G. triflorum.*
PUCCINIA PYGMAEA Erikss.
On *Calamagrostis canadensis*
PUCCINIA RUBIGO-VERA (DC.) Wint.
On *Agropyron repens, Agrostis alba, A. hyemalis, Bromus ciliatus, Elymus virginicus, Hordeum jubatum, Thalictrum dasycarpum.*
PUCCINIA SCHEDONNARDI Kell. & Sw.
On *Muhlenbergia foliosa*
PUCCINIA SEYMOURIANA Arth.
On *Asclepias syriaca*
PUCCINIA SILPHII Schw.
On *Silphium integrifolium*
PUCCINIA TUMIDIPES Peck
On *Lycium halimifolium*
PUCCINIA VERNONIAE Schw.
On *Vernonia fasciculata*
PUCCINIA VERONICARUM DC.
On *Veronica virginica*
PUCCINIA VEXANS Farl.
On *Bouteloua curtipendula*
PUCCINIA VIOLAE (Schum.) DC.
On *Viola cucullata, V. eriocarpa.*
†PUCCINIA VIRGATA Ell. & Ev.
On *Sorghastrum nutans*
PUCCINIA XANTHII Schw.
On *Ambrosia trifida, *Xanthium italicum.*
PUCCINIASTRUM AGRIMONIAE (Schw.) Tranz.
On *Agrimonia gryposepala*
PUCCINIASTRUM AMERICANUM (Farl.) Arth.
On *Rubus strigosus*
PUCCINIASTRUM PUSTULATUM (Pers.) Diet.
On *Epilobium coloratum*
RAMULARIA AEQUIVOCA (Ces.) Sacc.
On *Ranunculus abortivus, *R. pennsylvanicus.*
RAMULARIA ANOMALA Peck
On *Polygonum persicaria*
RAMULARIA ARVENSIS Sacc.
On *Potentilla canadensis, P. norvegica* var. *hirsuta.*
RAMULARIA ASTERIS (Phil. & Plowr.) Bubak
On *Aster novae-angliae, A. pilosus.*
RAMULARIA BRUNELLAE Ell. & Ev.
On *Prunella vulgaris*
RAMULARIA CALTHAE Lindr.
On *Caltha palustris*
RAMULARIA CELASTRI Ell. & Mart.
On *Celastrus scandens*
RAMULARIA CONCOMITANS Ell. & Holw.
On *Bidens vulgata*

RAMULARIA DESMODII Cke.
On *Desmodium canadense, D. illinoense.*
†RAMULARIA EQUISETI C. Massal.
On *Equisetum laevigatum*
RAMULARIA GEI (Eliass.) Lindr.
On *Geum strictum*
RAMULARIA IMPATIENTIS Peck
On *Impatiens biflora, I. pallida.*
RAMULARIA LYSIMACHIAE Thum.
On *Lysimacha thyrsiflora*
RAMULARIA OCCIDENTALIS Ell. & Kell.
On *Rumex britannica*
†*RAMULARIA OVULARIOIDES H. C. Greene
On *Anemone cylindrica*
RAMULARIA PLANTAGINIS Ell. & Mart.
On *Plantago* sp.
RAMULARIA PRATENSIS Sacc.
On *Rumex britannica*
RAMULARIA PUNCTIFORMIS (Schl.) v. Hoehn.
On *Epilobium coloratum*
RAMULARIA ROSEA (Fckl.) Sacc.
On *Salix* sp.
RAMULARIA RUFOMACULANS Peck
On *Polygonum coccineum* var. *pratincola, P. natans* f. *hartwrightii.*
RAMULARIA SPIRAEAE Peck.
On *Physocarpus opulifolius*
RAMULARIA STOLONIFERAE Ell. & Ev.
On *Cornus stolonifera*
RAMULARIA TARAXACI Karst.
On **Taraxacum erythrospermum, T. officinale.*
RAMULARIA TULASNEI Sacc.
On *Fragaria virginiana*
RAMULARIA UREDINIS (Voss) Sacc.
On *Melampsora* on *Populus deltoides, Melampsora* on *Salix* sp.
RAMULARIA URTICAE Ces.
On *Urtica gracilis*
RAMULARIA VARIABILIS Fckl.
On *Verbascum thapsus*
RAMULARIA VARIATA J. J. Davis
On *Mentha arvensis* var. *canadensis, Monarda fistulosa.*
RAMULARIA VIRGAUREAE Thum.
On **Aster ptarmicoides, *A. umbellatus, Solidago altissima, *S. juncea, S. nemoralis.*
RHOPOGRAPHUS CLAVISPORUS (C. & P.) Ell. & Ev.
On *Phragmites communis*
RHYNCOSPORIUM SECALIS (Oud.) Davis
On *Bromus inermis*
RHYTISMA ACERINUM
On *Acer saccharinum*

"RHYTISMA" SOLIDAGINIS Schw.
On *Euthamia graminifolia*
ROSELLINIA AQUILA (Fr.) DeNot.
On *Quercus* sp.
ROSENSCHELDIA HELIOPSIDIS (Schw.) Theiss. & Syd.
On *Helianthus (giganteus?), *H. rigidus.*
RUSSULA ALUTACEA (Pers.) Fr.
RUSSULA VARIATA Bann.
SARCINELLA HETEROSPORA Sacc.
On *Acer negundo, Ceanothus americanus, Cornus stolonifera, Corylus americana.*
SCHIZONELLA MELANOGRAMMA (DC.) Schroet.
On *Carex pennsylvanica*
SCHIZOPHYLLUM COMMUNE Fr.
On *Sambucus canadensis*
SCLERODERMA AURANTIUM (Vaill.) Pers.
SCLERODERMA BOVISTA Fr.
†SCLEROPHOMA PITHYOPHILA (Cda.) v. Hoehn.
On *Larix laricina, Pinus banksiana, P. resinosa, P. strobus, P. sylvestris.*
SCLEROTINIA FRUCTICOLA (Wint.) Rehm.
On *Prunus americana*
SCLEROTINIA SEAVERI Rehm
On *Prunus serotina*
†SCLEROTIUM MENDAX Sacc.
On *Solidago altissima*
SCOLECOTRICHUM GRAMINIS Fckl.
On *Agrostis alba, Dactylis glomerata, *Glyceria borealis, Muhlenbergia racemosa, Phleum pratense, Poa compressa, *P. palustris, P. pratensis.*
SCORIAS SPONGIOSA (Schw.) Fr.
On *Alnus vulgaris*
†SELENOPHOMA DONACIS (Pass.) Spr. & Johnson
On *Panicum virgatum*
SEPTOGLOEUM CONVOLVULI Ell. & Ev.
On **Convolvulus arvensis*
SEPTOGLOEUM ULMI (Fr.) Died.
On *Ulmus americana*
SEPTORIA sp.
On *Lycium halimifolium*
SEPTORIA AGRIMONIAE-EUPATORII Bomm. & Rouss.
On *Agrimonia gryposepala*
†SEPTORIA AGROPYRINA Lobek
On *Agropyron repens*
SEPTORIA ALNI Sacc.
On *Alnus incana, *A. vulgaris*
SEPTORIA AMPELOPSIDIS (E. & E.) Ell.
On *Psedera vitacea*
SEPTORIA ANDROPOGONIS J. J. Davis
On *Andropogon furcatus*

†*SEPTORIA ANDROPOGONIS var. SORGHASTRI Sprague & Greene
On *Sorghastrum nutans*
SEPTORIA ANEMONES Desm.
On *Anemone cylindrica, A. virginiana.*
SEPTORIA ANGULARIS Dearn. & Barth.
On *Euthamia graminifolia*
SEPTORIA AQUILINA Pass.
On *Pteridium aquilinum* var. *latiusculum*
SEPTORIA ASCLEPIADICOLA Ell. & Ev.
On *Asclepias incarnata*
SEPTORIA ASTERICOLA Ell. & Ev.
On **Aster pilosus*
SEPTORIA ATROPURPUREA Peck
On *Aster laevis, A. novae-angliae, A. tradescanti, *Solidago altissima.*
SEPTORIA BACILLIGERA Wint.
On *Ambrosia trifida*
SEPTORIA BETULAE (Lib.) West.
On *Betula papyrifera*
SEPTORIA BETULICOLA Peck
On *Betula papyrifera, *X B. sandbergii.*
SEPTORIA BRUNELLAE Ell. & Holw.
On *Prunella vulgaris*
SEPTORIA CACALIAE Ell. & Kell.
On *Cacalia suaveolens, *C. tuberosa.*
SEPTORIA CAMPANULAE (Lev.) Sacc.
On *Campanula aparinoides*
SEPTORIA CARICINELLA Sacc. & Roum.
On *Carex bebbii*
†SEPTORIA CARICIS Pass.
On *Carex stricta*
SEPTORIA CENCHRINA J. J. Davis
On *Cenchrus carolinianus*
SEPTORIA CHRYSANTHEMELLA Cav.
On *Chrysanthemum leucanthemum* var. *pinnatifidum*
SEPTORIA CIRSII Niessl
On *Cirsium arvense, C. vulgare.*
SEPTORIA COMMONSII Ell. & Ev.
On *Cirsium discolor, C. muticum.*
SEPTORIA CONSPICUA Ell. & Mart.
On *Steironema ciliatum, S. lanceolatum, S. quadriflorum.*
SEPTORIA CONVOLVULI Desm.
On *Convolvulus arvensis*
SEPTORIA CORNICOLA Desm.
On *Cornus racemosa, C. stolonifera.*
SEPTORIA CORYLINA Peck
On **Corylus americana*
SEPTORIA CRYPTOTAENIAE Ell. & Rau.
On *Cryptotaenia canadensis*

SEPTORIA DEARNESSII Ell. & Ev.
On *Angelica atropurpurea*
SEPTORIA DIMERA Sacc.
On *Silene latifolia*
SEPTORIA DIVARICATA Ell. & Ev.
On *Phlox divaricata*
SEPTORIA EPILOBII Westd.
On *Epilobium coloratum*
SEPTORIA ERIGERONTIS Peck
On *Erigeron annuus, E. canadensis, E. philadelphicus, E. ramosus.*
†SEPTORIA ERYNGICOLA Oud. & Sacc.
On *Eryngium yuccifolium*
†SEPTORIA EUPATORII Rob. & Desm.
On *Eupatorium perfoliatum*
SEPTORIA FUMOSA Peck
On **Solidago altissima, S. serotina, *S. ulmifolia.*
SEPTORIA GEI Rob. & Desm.
On *Geum canadense*
SEPTORIA GLYCINES Hemmi
On *Soja max*
†*SEPTORIA GRINDELIICOLA H. C. Greene
On *Grindelia squarrosa*
SEPTORIA HELIANTHI Ell. & Kell.
On *Helianthus decapetalus, H. grosseserratus, H. rigidus, H. strumosus, H. tuberosus.*
SEPTORIA KRIGIAE Dearn. & House
On *Krigae biflora (amplexicaulis)*
SEPTORIA LACTUCAE Pass.
On *Lactuca scariola*
SEPTORIA LACTUCICOLA Ell. & Mart.
On *Lactuca canadensis, *L. ludoviciana, L. scariola, L. spicata.*
SEPTORIA LAPPARUM Sacc.
On *Arctium minus*
SEPTORIA LEPACHYDIS Ell. & Ev.
On **Echinacea purpurea, Lepachys pinnata.*
SEPTORIA LEPIDIICOLA Ell. & Mart.
On *Lepidium virginicum*
SEPTORIA LEPTOSTACHYAE Ell. & Kell.
On *Phryma leptostachya*
SEPTORIA LIATRIDIS Ell. & Davis.
On **Liatris cylindracae, L. ligulistylis, L. pycnostachya, L. spheroidea (scariosa), *L. squarrosa.*
†*SEPTORIA LINARIAE H. C. Greene
On *Linaria canadensis*
†*SEPTORIA LITHOSPERMI Davis & Greene
On *Lithospermum canescens*
SEPTORIA LOBELIAE Peck
On *Lobelia siphilitica, L. spicata.*

SEPTORIA LUPINICOLA Ell. & Dearn.
On *Lupinus perennis*
SEPTORIA LYCOPI Pass.
On *Lycopus uniflorus*
SEPTORIA LYSIMACHIAE West.
On **Lysimachia terrestris*, **L. thyrsiflora.*
SEPTORIA LYTHRINA Peck
On *Lythrum alatum*
SEPTORIA MELANDRII Pass.
On *Lychnis alba*, **Silene dichotoma.*
†SEPTORIA MENTHAE (Thum.) Oud.
On *Monarda fistulosa*
SEPTORIA MENTHICOLA Sacc. & Let.
On *Mentha arvensis* var. *canadensis*
SEPTORIA MIMULI Ell. & Kell.
On *Mimulus ringens*
SEPTORIA NABALI B. & C.
On *Prenanthes alba*
SEPTORIA NEGUNDINIS Ell. & Ev.
On *Acer negundo*
SEPTORIA OENOTHERAE West.
On *Oenothera biennis, O. pumila.*
SEPTORIA PACHYSPORA Ell. & Holw.
On *Zanthoxylum americanum*
SEPTORIA PARIETARIAE J. J. Davis
On *Parietaria pennsylvanica*
SEPTORIA PENTSTEMONIS Ell. & Ev.
On *Pentstemon digitalis*
SEPTORIA PILEAE Thum.
On *Pilea pumila*
SEPTORIA PLANTAGINEA var. PLANTAGINIS-MAJORIS Sacc.
On *Plantago aristata, P. purshii, *P. rugelii.*
SEPTORIA POLYGONORUM Desm.
On *Polygonum coccineum* var. *pratincola, P. lapathifolium, P. pennsylvanicum, P. persicaria.*
SEPTORIA POPULI Desm.
On *Populus deltoides, P. tremuloides.*
SEPTORIA PSILOSTEGA Ell. & Mart.
On *Galium boreale*
†*SEPTORIA RECTAE H. C. Greene
On *Potentilla recta*
SEPTORIA RHOINA B. & C.
On *Rhus typhina*
SEPTORIA RIBIS Desm.
On *Ribes americanum, R. missouriense.*
SEPTORIA RUBI West.
On *Rubus allegheniensis, R. occidentalis, R. strigosus.*
SEPTORIA RUDBECKIAE Ell. & Hals.
On *Rudbeckia hirta*

SEPTORIA SACCHARINA Ell. & Ev.
On *Acer saccharum*
SEPTORIA SALICINA Peck
On *Salix sp.*
SEPTORIA SAMBUCINA Peck
On *Sambucus canadensis*
†*SEPTORIA SCROPHULARIAE var. AGALINIS H. C. Greene
On *Gerardia (Agalinis) paupercula*
SEPTORIA SCUTELLARIAE Thum.
On *Scutellaria galericulata, S. lateriflora, *S. parvula* var. *ambigua.*
SEPTORIA SENECIONIS-AUREI J. J. Davis
On **Senecio balsamitae*
*SEPTORIA SICYI Peck*
On *Echinocystis lobata*
SEPTORIA SII Rob. & Desm.
On *Cicuta maculata, Oxypolis rigidior, Sium suave.*
SEPTORIA SILPHII Ell. & Ev.
On *Heliopsis scabra, *Silphium integrifolium.*
SEPTORIA SMILACINAE Ell. & Mart.
On *Smilacina racemosa*
SEPTORIA SOLIDAGINICOLA Peck
On *Aster lucidulus, A. tradescanti, A. umbellatus, *Solidago nemoralis, S. serotina.*
SEPTORIA STACHYDIS Rob. & Desm.
On *Stachys palustris*
SEPTORIA TANDILENSIS Speg.?
On *Panicum implicatum, P. praecocius.*
SEPTORIA URTICAE Rob.
On **Urtica gracilis*
SEPTORIA VALERIANAE Sacc. & Fautr.
On *Valeriana ciliata*
SEPTORIA VERBENAE Rob. & Desm.
On *Verbena bracteosa, V. hastata, V. urticaefolia.*
SEPTORIA VERONICAE Desm.
On *Veronica virginica*
SEPTORIA VIOLAE West.
On **Viola sagittata.*
SEPTORIA WILSONI G. W. Clint.
On *Chelone glabra*
†*SEPTORIA WISCONSINA H. C. Greene
On *Astragalus canadensis*
†SPHACELOTHECA OCCIDENTALIS G. P. Clint.
On *Andropogon furcatus*
SPHAERIA SOLIDAGINIS Schw.
On **Aster lucidulus, Solidago serotina.*
SPHAEROPSIS sp.
On *Zanthoxylum americanum*
SPHAEROPSIS CORYLI Ell. & Ev.
On *Corylus americana*

SPHAEROPSIS PINASTRI (Lev.) Sacc.
On *Larix laricina*
SPHAEROTHECA HUMULI (DC.) Burr.
On *Agrimonia gryposepala, Geranium maculatum, Geum canadense, G. strictum, G. virginianum, *Humulus americanus, Rhus glabra, Rubus triflorus.*
SPAEROTHECA HUMULI var. FULIGINEA (Schl.) Salm.
On *Bidens cernua, B. vulgata, Erigeron canadensis, Pedicularis lanceolata, Taraxacum officinale, Veronica virginica.*
†SPORODINIA GRANDIS Link
On *Strobilomyces strobilaceus*
STAGONOSPORA sp.
On *Andropogon furcatus, Panicum scribnerianum, Phragmites communis, Sorghastrum nutans.*
STAGONOSPORA sp.
On *Lycium halimifolium*
STAGONOSPORA APOCYNI (Pk.) Davis
On *Apocynum androsaemifolium, A. cannabinum.*
STAGONOSPORA BAPTISIAE (E. & E.) Davis
On *Baptisia leucantha*
STAGONOSPORA BROMI Smith & Ramsb.
On **Bromus ciliatus, B. inermis.*
STAGONOSPORA CARICINELLA Brun.
On *Carex pennsylvanica*
†STAGONOSPORA CONVOLVULI Dearn. & House
On *Convolvulus sepium*
†*STAGONOSPORA CRYPTOTAENIAE H. C. Greene
On *Cryptotaenia canadensis*
STAGONOSPORA INTERMIXTA (Cke.) Sacc.
On *Agrostis alba, Phalaris arundinacea.*
†*STAGONOSPORA MACROMACULANS H. C. Greene
On *Celtis occidentalis*
STAGONOSPORA MELILOTI (Lasch) Petr.
On *Medicago sativa, Melilotus alba, M. officinalis.*
STAGONOSPORA SMILACIS (E. & M.) Sacc.
On *Smilax herbacea*
STAGONOSPORA SPARGANII (Fckl.) Sacc.
On *Sparganium eurycarpum*
†*STAGONOSPORA TEPHROSIAE H. C. Greene
On *Tephrosia virginiana*
STAGONOSPORA TETRAMERA J. J. Davis
On *Carex lacustris*
STAGONOSPORA ZONATA J. J. Davis
On *Asclepias incarnata*
STEREUM FASCIATUM Schw.
On *Quercus* sp.
STEREUM FRUSTULOSUM (Pers.) Fr.
STEREUM RUFUM Fr.
On *Populus tremuloides*

STEREUM UMBRINUM B. & C.
On *Quercus* sp.
STREPTOTHRIX FUSCA Cda.
On *Ulmus americana*
STROBILOMYCES STROBILACEUS Berk.
SYNCHYTRIUM ANEMONES (DBy) Wor.
On *Anemone quinquefolia*
SYNCHYTRIUM DECIPIENS Farl.
On *Amphicarpa monoica*
†SYNCHYTRIUM HOLWAYI Farl.
On *Monarda fistulosa*
TAPHRINA CAERULESCENS (Mont. & Desm.) Tul.
On *Quercus velutina*
TAPHRINA CORYLI Nishida
On *Corylus americana*
†TAPHRINA LUTESCENS Rostr.
On *Dryopteris thelypteris*
TAPHRINA POTENTILLAE (Farl.) Johans.
On *Potentilla arguta.*
TITAEOSPORA DETOSPORA (Sacc.) Bubak
On **Equisetum laevigatum*
TRANZSCHELIA FUSCA (Pers.) Diet.
On *Anemone quinquefolia*
TRANZSCHELIA PRUNI-SPINOSAE (Pers.) Diet.
On *Anemone quinquefolia, Hepatica acutiloba, Prunus serotina.*
TRANZSCHELIA THALICTRI (Chev.) Diet.
On *Thalictrum dasycarpum*
TREMELLA FRONDOSA Fr.
On *Quercus* sp.
TUBERCULINA PERSICINA (Ditm.) Sacc.
On *Gymnoconia peckiana, *Puccinia panici.*
UNCINULA NECATOR (Schw.) Burr.
On *Psedera vitacea, Vitis vulpina.*
UNCINULA SALICIS (DC.) Wint.
On *Populus tremuloides, Salix bebbiana.*
UREDINOPSIS MIRABILIS (Pk.) Magn.
On *Onoclea sensibilis*
UREDINOPSIS STRUTHIOPTERIDIS Storm.
On *Athyrium angustum* var. *rubellum, Dryopteris thelypteris.*
URNULA CRATERIUM (Schw.) Fr.
UROCYSTIS ANEMONES (Pers.) Schroet.
On *Anemone quinquefolia, Hepatica acutiloba.*
UROMYCES ACUMINATUS Arth.
On *Phlox pilosa, Polygonatum commutatum, Spartina pectinata.*
UROMYCES ASCLEPIADIS (Schw.) Cke.
On *Asclepias syriaca*
UROMYCES CALADII (Schw.) Farl.
On *Arisaema triphyllum*

UROMYCES GRAMINICOLA Burr.
On *Panicum virgatum*
UROMYCES LESPEDEZAE-PROCUMBENTIS (Schw.) Curt.
On *Lespedeza capitata*
UROMYCES PECKIANUS Farl.
On *Plantago purshii*
UROMYCES PROEMINENS (DC.) Pass.
On *Euphorbia* sp.
UROMYCES PUNCTATUS Schroet.
On *Astragalus canadensis*
UROMYCES SCIRPI (Cast.) Burr.
On *Scirpus fluviatilis*
UROMYCES SILPHII (Burr.) Arth.
On *Juncus macer, Silphium integrifolium, S. terebinthinaceum.*
UROMYCES SPARGANII C. & P.
On *Sparganium eurycarpum*
UROMYCES TRIFOLII (Hedw. f.) Lev.
On *Trifolium hybridum, T. pratense*
USTILAGO NEGLECTA Niessl
On *Setaria lutescens*
USTILAGO STRIIFORMIS (West.) Niessl
On *Poa pratensis*
USTILAGO UTRICULOSA (Nees) Tul.
On *Polygonum pennsylvanicum*
USTILAGO VIOLACEA (Pers.) Fckl.
On *Arenaria lateriflora*
VALSA AMBIENS (Pers.) Fr.
On *Corylus americana, Rhus glabra, Tillia americana.*
VALSA LEUCOSTOMA (Pers.) Fr.
On *Prunus serotina*
VALSA NIVEA (Hoffm.) Fr.
On *Populus tremuloides*
VENTURIA ACERINA Plakidas (Cladosporium stage)
On *Acer rubrum*
VENTURIA INAEQUALIS Wint. (Fusicladium stage)
On *Pyrus ioensis, P. malus.*
VERTICILLIUM sp.
On *Omphalia campanella*
XYLARIA DIGITATA (L.) Grev.

ADDENDA — 1947.

ASCOCHYTA COMPOSITARUM J. J. Davis
On **Echinacea purpurea*
ASCOCHYTA GRAMINICOLA Sacc.
On **Bromus commutatus*
CERCOSPORA CLAVATA (Ger.) Cke.
On *Asclepias phytolaccoides*
CERCOSPORA GRISEA Cke. & Ell.
On **Polygala polygama*

CERCOSPORA VIOLAE Sacc.
On **Viola pedatifida*
*CLADOSPORIUM BAPTISIAE H. C. Greene
On *Baptisia leucophaea*
COLEOSPORIUM SOLIDAGINIS (Schw.) Thum.
On *Solidago speciosa* var. *rigidiuscula*
COLLETOTRICHUM GRAMINICOLUM (Ces.) Wils.
On *Sorghastrum nutans*
COLLETOTRICHUM SILPHII J. J. Davis
On *Silphium perfoliatum*
COLLETOTRICHUM VIOLAE-ROTUNDIFOLIAE (Sacc.) House
On **Viola pedatifida*
CONIOTHYRIUM sp.
On *Celtis occidentalis*
DIDYMARIA ALISMATIS (Oud.) J. J. Davis
On *Alisma plantago-aquatica*
DILOPHOSPORA ALOPECURI Fr.
On **Leersia oryzoides*
*DIPLODIA THALICTRI Ell. & Dearn.
On *Thalictrum dasycarpum*
EPICHLOE TYPHINA (Pers.) Tul.
On *Koeleria cristata*
ERYSIPHE CICHORACEARUM DC.
On *Coreopsis palmata*
ERYSIPHE GRAMINIS DC.
On *Koeleria cristata*
FUSARIUM MONILIFORME Sheldon
On *Astragalus canadensis*
*GLOEOSPORIUM BRUNNEO-MACULATUM H. C. Greene
On *Trillium grandiflorum*
HYPHOLOMA LACRIMABUNDUM Fr.
OIDIUM sp. (powdery mildew)
On *Hieracium scabrum*
PERONOSPORA FICARIAE Tul.
On *Ranunculus fascicularis*
PERONOSPORA PARASITICA (Pers.) Tul.
On *Capsella bursa-pastoris*
PHOMA IOWANA Sacc.
On *Aster ptarmicoides*
PHYLLOSTICTA spp.
On *Aruncus sylvester, Cenchrus carolinianus*
*PHYLLOSTICTA CACALIAE H. C. Greene
On *Cacalia tuberosa*
*PHYLLOSTICTA PENTSTEMONICOLA H. C. Greene
On *Pentstemon hirsutus*
PHYLLOSTICTA PHASEOLINA Sacc.
On **Apios tuberosa*
PHYLLOSTICTA VIOLAE Desm.
On **Viola pedatifida*

POLYPORUS SQUAMOSUS Fr.
On *Salix* sp.

PUCCINIA EXTENSICOLA Plowr.
On *Carex siccata*, **Krigia virginica*

PUCCINIA GRAMINIS Pers.
On *Koeleria cristata*

PUCCINIA RUBIGO-VERA (DC.) Wint.
On *Agropyron trachycaulum* var. *glaucum*

PUCCINIA SILPHII Schw.
On *Silphium laciniatum, S. terebinthinaceum*

RAMULARIA sp.
On *Hieracium longipilum*

RAMULARIA PRATENSIS Sacc.
On **Rumex acetosella*

SCLEROSPORA GRAMINICOLA (Sacc.) Schroet.
On *Setaria viridis*

SCOLECOTRICHUM GRAMINIS Fckl.
On *Hordeum jubatum*

SEPTORIA ASCLEPIADICOLA Ell. & Ev.
On **Asclepias phytolaccoides*

SEPTORIA BROMI Sacc.
On **Bromus commutatus*

SEPTORIA CIRSII Niessl
On **Cirsium undulatum*

SEPTORIA FUMOSA Peck
On **Solidago juncea, S. missouriensis* var. *glaberrima*

*SEPTORIA HEDEOMAE Dearn. & House
On *Hedeoma hispida*

SEPTORIA KRIGIAE Dearn. & House
On *Krigia virginica*

SEPTORIA MACROPODA Pass.
On *Poa annua*

SEPTORIA MALVICOLA Ell. & Mart.
On *Malva rotundifolia*

SEPTORIA OSTRYAE Peck
On *Ostrya virginiana*

SEPTORIA PTELEAE Ell. & Ev.
On *Ptelea trifoliata*

STAGONOSPORA ZONATA J. J. Davis
On **Asclepias ovalifolia*

THELEPHORA TERRESTRIS Fr.

UROMYCES ACUMINATUS Arth.
On *Polemonium reptans, Smilacina stellata*

UROMYCES POLYGONI (Pers.) Fckl.)
On *Polygonum aviculare*

UROMYCES SILPHII (Burr.) Arth.

On *Silphium perfoliatum*

XENOGLOEA ERIOPHORI (Bres.) Syd.

On *Scirpus atrovirens*

# A WISCONSIN CHEMICAL PIONEER — THE SCIENTIFIC WORK OF LOUIS KAHLENBERG

NORRIS F. HALL

In the then small village of Two Rivers, Wisconsin, on the western shore of Lake Michigan, during the early eighties of the last century, a brilliant, adventurous boy with a love of boats and sailing was growing to manhood. The son of an immigrant German butcher, Louis Kahlenberg grew up in a community of Evangelical Lutherans. A tradition of piety, study of the Bible, and strict standards of personal conduct seem to have characterized the life of the little community, still strongly oriented toward its cultural and linguistic Fatherland, but also fully a part of the raw, driving opportunism and political self-confidence of its new home. Early successes in mathematics, combined with his interest in sailing-craft, led Kahlenberg to master the fundamentals of navigation and surveying while still a young boy, and he was well on the way to become a midshipman at Annapolis when he decided to take a quite different road, and to be a teacher. One reason for this decision was apparently a stratagem on the part of his mother, who had no liking for the sea. Another element was undoubtedly the strong influence of a highly exceptional instructor. This man, Arthur Birch, was the principal, and sole teacher, of the little village high school. Here Birch, who evidently had a real knowledge of nature and love of science, working with small groups of students among whom at least one other beside Kahlenberg was specially gifted, succeeded in inspiring the boys to such a degree that Kahlenberg, for example, constructed in his own father's workshop many pieces of physical apparatus badly needed at the school and made great progress in botany, mathematics and chemistry as well. After graduating at the early age of fifteen, he spent the next five years partly teaching school, and partly studying at Oshkosh and Milwaukee, and in 1890 came to the University of Wisconsin from which he received the B.S. degree in 1892 and the M.S. in 1893. During his study for the master's degree he held the first fellowship in Chem-

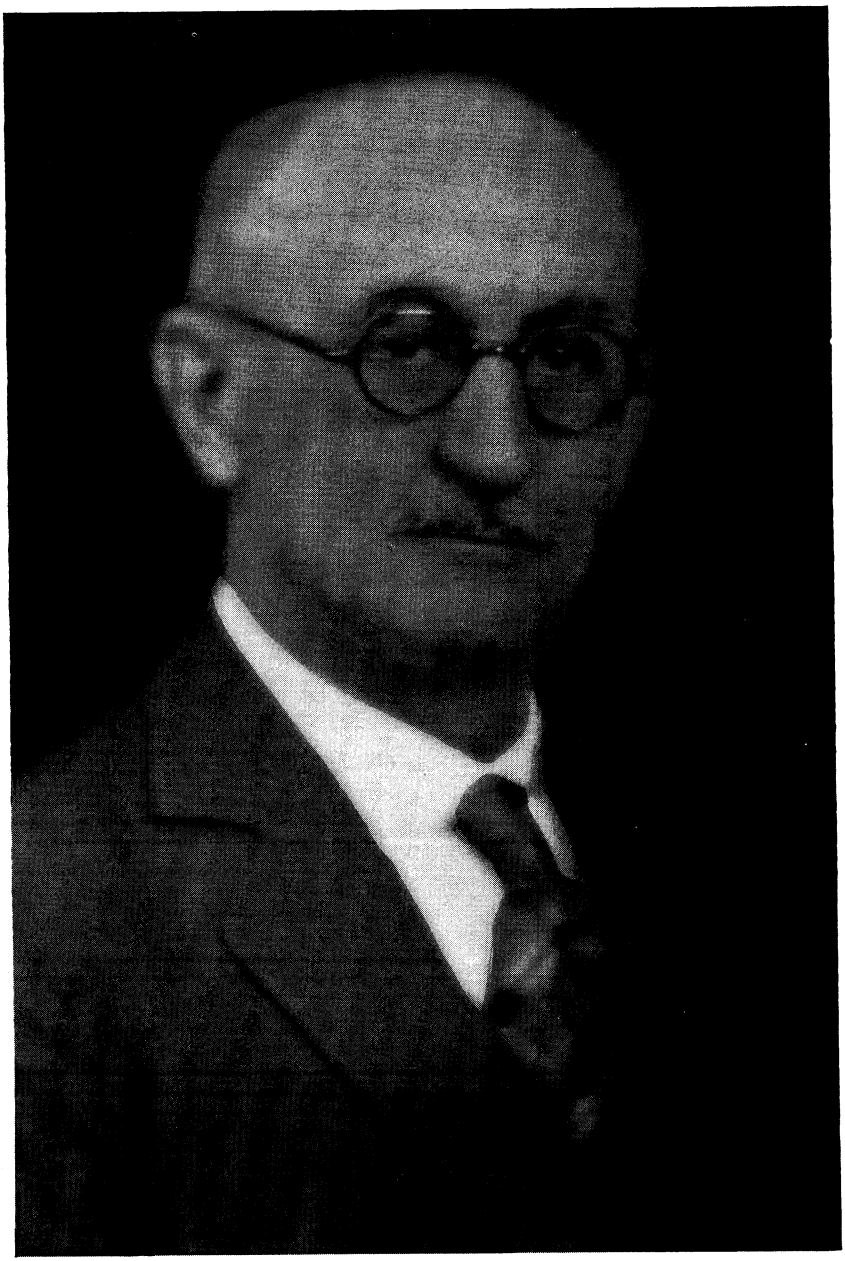
istry to be established at the University. His bachelor's and master's theses each became the subject of a research paper published in collaboration with H. W. Hillyer.

He was appointed instructor in Chemistry, and in this his first year of University teaching, not only carried out an original research of his own but also directed the chemical studies of his boyhood companion and lifelong friend Herman Schlundt, later to head the Chemistry department at the University of Missouri. Both these investigations were published in 1894, while Kahlenberg himself had gone to Germany, there to study in the laboratory of Wilhelm Ostwald at Liepsic, and also to spend some time with J. Wislicenus, Wiedemann, Zirkel, and Pfeffer.

His Leipsic doctoral dissertation appeared in 1895, and obviously dealt with a problem of his own choosing, since it was essentially an extension of his bachelor's and master's work with Hillyer. His first appointment on his return to Wisconsin the following year, was not in Chemistry, but in Pharmacy, where a place was made for him by Edward Kremers. Back in the Chemistry department the following year, he passed rapidly through the intermediate grades, becoming Professor of Chemistry in 1900, a position he held until his retirement in 1940. He died in 1941.

During his long and active association with the University he published over a hundred papers, including a large number of substantial original investigations, and directed the work of several score candidates for advanced degrees. He was also the author of several textbooks and a popular treatise on Chemistry. He was an associate editor of both the Swiss and the *American Journal of Physical Chemistry*, was at one time President of the Electrochemical Society and the Chemistry Section of the American Association for the Advancement of Science. He also was a President of the Wisconsin Academy of Sciences, Arts and Letters.

By his researches, as well as by his views on the theory of electrolytic dissociation, which were forcefully sustained in the various chemical journals, and through his personal appearances in public symposia in this field, he became for a time widely known among chemists both in this country and abroad. This phase of his scientific work will be discussed more fully a little later. In a period of rapidly increasing specialization, he strongly emphasized the unity of the chemical field, and although he was primarily an electrochemist and a student of solutions, he never hesitated to invade other branches of



Dr. Louis Kahlenberg.

chemistry and even ranged over pharmacy, physiology, and medicine as his interests led him.

He had a boundless optimism and self-confidence, and never seemed to doubt his powers to make worthwhile contributions to other specialties than his own. He enjoyed broad, comprehensive but careful surveys of a field, usually made with very simple equipment, and seldom attempted measurements of high precision, developed novel apparatus, or was greatly concerned with extreme purity of his reagents. His joyful buccaneering spirit no doubt sustained him in his battles with the high priests of orthodox solution theory, though he was evidently grievously wounded that his views were not more sympathetically received.

In the last 12 years of his life, when I knew him, his pugnacity had apparently somewhat abated, but he still seemed heartily to enjoy an occasional political battle in Department or Faculty meeting — Kahlenberg against the field! This side of his nature was one of the things which contributed to his great success as a lecturer. He had a ready wit and was a formidable debater, quick to seize upon any point that could be turned to a laugh against his adversary, and was quite unscrupulous in pursuing his advantages. His booming voice and German accent, his quaint philippics against the use of tobacco and similar vices, his amusing digressions on every conceivable topic, and his great talent for making complex phenomena seem simple, and mathematical theories ridiculous, all endeared him greatly to many college generations of Freshmen. Few if any teachers at this University have so vividly impressed so many students. On a more intimate level, many men of his own generation and many advanced students have testified to his friendly and helpful counsel, and his penetrating and constructive criticism of their work. He was unusually conversant with chemical history, and for many years gave interesting lectures on this topic.

However, it is as a contributor to the edifice of science, and to that of physical chemistry in particular, that his worth should chiefly be assessed. Before he went to Germany, we hear of him spending his Sunday holidays, while on a summer job in the field of Geology, studying Ostwald's Grundriss, and he evidently became thoroughly familiar at this time with the work of Arrhenius, Van't Hoff and Nernst.

One may search in vain through the first fourteen papers from

Kahlenberg's laboratory, published in the years 1893–1898, for any sign of his later vigorous opposition to the theory of electrolytic dissociation. On the contrary, he speaks frequently of the successes of this theory, of the "opposition it at first encountered," and evidently regards his own results as confirming its predictions. However, all the work of this first period was carried out in water solution.

In 1899, he published with A. T. Lincoln,[1] the results of a preliminary investigation of "The dissociative power of solvents." Here the solubilities of four metallic chlorides in over seventy non-aqueous liquids were roughly tested and where solutions could be made, their conductivities were studied. The underlying idea was that if a conducting solution was formed, then according to the dissociation hypothesis as proposed by Arrhenius, the molar conductance should increase with dilution, and the apparent molecular weight of the solute should be abnormally low. In certain cases the observed results were in harmony with this prediction, but various anomalies appeared, and the authors raise the question: "Can it be true that after its glorious success in explaining the properties of aqueous solutions of acids, bases and salts, the dissociation theory will need the help of its old rival, the hydrate theory, (perhaps in somewhat modified form), to explain the facts in the case of non-aqueous solutions? Further diligent experimental investigation only can definitely answer this question."[2] The "diligent experimental work" was soon forthcoming. Lincoln extended his studies to still other solvents. Kahlenberg measured the differences of potential between metals and non-aqueous solutions of their salts. Schlundt studied dielectric constants and transference numbers, while Patten measured conductances over a wide concentration range in a variety of solvents. Taken all together this work constitutes a very extensive pioneering survey of the hitherto neglected electrochemistry of non-aqueous solutions, — some of it, such as the work on liquid hydrogen cyanide, and the study of metallic oleates dissolved in benzene, is characterized by a high degree of originality, boldness, and experimental skill. At the same time, our author continued his work in aqueous solutions as well, studying the toxic effects of many substances on a number of different plant and animal organisms over a wide concentration range.

As a result of all this labor, which brought the total number of papers from his laboratory to 59 by 1904 and to 95 by 1911, Kahlenberg had reached some very definite conclusions.

These were first set forth in detail in 1901 in a long paper in the

bulletin of the University of Wisconsin.[3] In the following year he made a briefer statement of his position before the first general meeting of the Americal Electrochemical Society.[4] In Britain, the Faraday Society heard him present his views at a meeting in the autumn of 1904,[5] and the next spring the *Chemiker-Zeitung*[6] brought them more directly to the attention of German chemists. Now these ideas of Kahlenberg's were of the highest importance. The chemistry of solutions had been dominated since 1895 by the Arrhenius theory of partial electrolytic dissociation, which was regarded almost universally as having been placed on a firm experimental basis by the studies of Ostwald on weak acids, and Bredig on weak bases, and by the way in which it accounted for the troublesome factor *i* in Van't Hoff's equation of state for solutions. True, the fact that solutions of strong electrolytes showed no approximation whatever to the Ostwald dilution law constituted a troublesome anomaly, but most investigators still felt that in spite of inadequacies the theory was so successful in certain fields, and gave such valuable guidance in the interpretation of analytical chemistry, that it should be retained in spite of difficulties.

Not so Kahlenberg. According to Arrhenius, the molecular conductivity must always increase with the dilution. Kahlenberg found cases where it decreased, remained constant, or both increased and decreased in different concentration ranges. According to the theory, the degree of dissociation calculated from the colligative properties should agree with that calculated from the conductance ratio. Kahlenberg found many instances of wild divergence between these figures. It was believed, following Nernst and Thomson, that the higher the dielectric constant of a solvent, the more conducting should be the solutions in it. Kahlenberg and Schlundt found that this rule had so many exceptions as to appear valueless. It was widely held that the only very rapid reactions are those between free ions. Kahlenberg showed that many instantaneous ractions occurred in solutions which conducted no better than pure benzene! The effect of excess precipitant, usually called the common-ion effect, was also demonstrated in these solutions. Kahlenberg showed that many acids displayed their characteristic acid properties when in completely non-conducting solutions, and drew the natural conclusion that acids do not, as claimed by Arrhenius, owe their properties to the presence of free hydrogen ions. He attacked the notion that a solvent is a sort of

vacuum in which ionized and other solutes disport themselves, and urged the importance of the specific mutual chemical interaction of solvent and solute. Now on all these points he was on solid ground, — but chemists were still so hypnotized by the observed regularities in the behavior of a few dilute aqueous solutions that most of his arguments fell upon deaf ears. His evidence was discounted, and his conclusions greeted with hostility, incredulity, or silence. Actually, contemplation of the evidence permitted two courses. On the one hand one could reject the theory of electrolytic dissociation completely, and fall back upon the notion that conductivity had nothing to do with ionization, and that all the manifold phenomena the latter was supposed to correlate were explicable only as the highly specific behavior of individual groups of substances. This was in a sense a counsel of despair, — but to the direct, courageous, and iconoclastic mind of Kahlenberg it seemed the only possibility.

On the other hand, one could adopt an attitude of "wait and see." The triumph of Arrhenius' theory had been so complete, within the narrow range of its apparent applicability, and the evidence for the existence of ions from other fields of physical science was accumulating so rapidly, that most scientists were convinced of the theory's essential truth. Some attempted to bolster up the theory with auxilliary hypotheses, — with the result in most cases, as Kahlenberg gleefully pointed out, that the theory was stripped of its essential character, and reduced to a collection of *ad hoc* assumptions and empirical formulae. Others simply adopted a kind of dualistic philosophy, retaining a faith in the underlying correctness of the theory, even though they were forced to admit either tacitly or explicitly, that it was in many cases contradicted by the facts.

Here the matter rested for several years. Kahlenberg continued to uncover new inconsistencies, and became more and more convinced of the untenability of the majority's position. Other chemists continued to exploit the dilute aqueous field, and to ignore the painful implications of Kahlenberg's facts, or to brush them aside as beyond the proper range of application of the theory. In a sense, both sides were later justified.

It was in the nineteen-twenties that a comparatively satisfactory resolution of these difficulties was reached. At that time two ideas of fundamental importance became prevalent: the idea of *complete* dissociation and the idea of the electrical interaction of ions. After

other preliminary attempts, Debye and Huckel succeeded in calculating in a straight-forward manner many of the properties of conducting solutions from the principles of electrostatics and kinetic theory. Their work was extended by Onsager and others and is still being developed and further refined.

In many respects this development has vindicated Kahlenberg. The tacit assumption of Arrhenius, that the mobility of ions is independent of the presences of other ions, has been rejected. The direct calculation of the degree of dissociation from conductance and colligative properties is now inadmissible, and the agreements by which the Arrhenius theory was first supported are seen to be, as Kahlenberg claimed, largely fortuitous. On the other hand, many of the anomalies uncovered by Kahlenberg in non-aqueous solutions, are now understood as the natural consequences of the greatly increased interionic attractions in media of dielectric constant, and the conception of ionization, far from being discarded, has proved continually more useful.

In later years the interionic attraction theory, involving in the limit no adjustable parameters at all, and no parameters peculiar to the individual solutes studied, has been brilliantly confirmed in the field of strong electrolytes, exactly where the original Arrhenius hypothesis was so signally inadequate, and has led to many novel developments such as the Wien effect, and the high-frequency dispersion of conductance.

What, then, was Kahlenberg's reaction to such developments? One would like to record that he had welcomed these clarifications, and devoted his great gifts of poineering intuition to further illuminating researches in this field. Unfortunately this is not the case. As is so often observed with men who have attained great competence in a scientific field, and advanced it by their own early researches, he was unable to appreciate the later advances of others. Partly by reason of the naturally empirical bent of his mind, — and partly no doubt because of his strong feeling of disillusionment both in the theory to which he had subscribed in his youth, and in the other scientists who had seemed to refuse him his due measure of esteem, – he turned away. More and more he shut himself off from all advances, not only of the theory of solutions but of all physicochemical theory, and seemed determined to ignore not merely new theories, but even

new facts, unless they happened to appear important within the limits of his self-imposed prison.

I do not mean to suggest in any sense that he abandoned scientific work. On the contrary, he remained active and productive almost until his retirement, but the innovating quality which had illumined his earlier work was no longer there. His Freshman teaching was still highly popular, – his knowledge of chemical facts was still encyclopedic, – his mind was clear and incisive, – and the researches which he continued to direct were still numerous and creditable, – but he no longer was a leader in the field of his specialty. His distrust of theory drove him into a dogmatic empiricism which severly limited his scope, and led him on occasion to condone both in himself and in graduate students mere ignorance in the name of healthy scepticism.

In spite of these weaknesses, his scientific reputation rests on sound foundations. Many excellent research problems could be found today in working over and extending the paths he cut through the jungle of non-aqueous solutions. His career must be judged against the background of his time and his opportunities. He was a true pioneer. He was a courageous architect of progress. Let it never be forgotten that it was he more than any other man of his time, who brought to the department of chemistry at Wisconsin the admirable tradition of sound, careful, painstaking research, – of following the facts without fear or favor, wherever they may lead, – and the hundreds of Doctors of Philosophy who have been trained in our laboratories in the last forty-five years, may proudly claim him as one of their spiritual fathers.

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I am greatly indebted to my colleague, Professor Henry A. Schuette, President of this Academy, for making available to me his collection of documents relating to the life and work of Professor Kahlenberg. It has also been a great convenience to consult the bound collection of Kahlenberg's papers, assembled with great initiative, patience and skill by Professor Schuette, and made available through the generosity of a group of Kahlenberg's former students.

N. F. H.

Madison, Wisconsin

April 12, 1946

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# ANTIBIOTIC ASPECTS OF COPPER TREATMENT OF LAKES

ARTHUR D. HASLER

*Department of Zoology, University of Wisconsin*

Nearly everyone knows that the life span of a lake is comparatively short. It is here today and gone tomorrow, geologically speaking. A flight over Wisconsin reveals clearly the boggy remains of many former Wisconsin lakes. In the youthful stage lakes are generally unproductive; seldom do algae erupt to a point where they cause a nuisance. As the aging process progresses the water becomes enriched and the lake gets shallower due to accumulated erosion and organic debris. This stage may be accelerated by encroachments from civilization: fertilizers from eroded lands, agricultural and domestic drainage.

Once the lake has progressed toward this enriched (eutrophic) stage, massive developments of algae scums may be anticipated, varying in intensity and persistence, of course, with edaphic conditions.

Lake use, be it for bathing, boating, fishing, esthetic appreciation, or municipal water is affected by the biological events that arise from increased enrichment (Hasler, 1947).

When algae blooms begin to decay all of the uses cited above are reduced — a problem arises. In this enriched state scums form on the surface which are repulsive to the nose, abhorrent to bathers, repugnant to boaters, unsightly to visual esthetics, a hazard to health, and a problem in filtration and treatment for tastes and odors if the water is used municipally.

Obviously many methods have been employed to prevent such nuisances. Most effective has been to spray the surface waters, at a time when a bloom is anticipated, with $CuSO_4$ solution so that the surface waters attain a concentration toxic to algae (the Cu combines with the plant substance to kill it). If done properly this anticipated bloom may be inhibited.

This treatment imposes a serious problem because, if we adopt the maxim that ideal lake use is to maintain the lake in its *natural state* for the longest possible period, copper becomes an antagonizing agent. Not only is it toxic at the moment, but being a heavy metal it is not destroyed nor made biologically inert even after combining with carbonate or organic substances. It is accumulative — after many years of use concentrations may be built up to a level where many forms of aquatic life cannot exist.

The question is not how little can be used to avoid killing fish, but what will be the effect of accumulations of copper in lake muds or as fine colloidal particles swept about by currents.

Specifications and precautions for copper treatment of lakes have been advanced by the Wisconsin Committee on Water Pollution (1939, 1946). They claimed the copper was precipitated rapidly as insoluble copper carbonate in hard water and that the real copper concentration left in the water was not high. They stated further that in soft water the killing dose is much smaller, a fact also stressed by Ellis (1937). Riley (1939) concluded that at least five factors affect the naturally occurring copper content of lake waters. They are:

1. Precipitation which lowers Cu content by dilution.
2. Sedimentation; removal from solution by adsorption on organic matter.
3. Regeneration from mud.
4. Liberation of Cu in autumn from decomposition of littoral vegetation; they also remove it in summer.
5. Liberation of Cu in autumn by decomposition of vegetation surrounding the lake.

The Wisconsin report (l.c.) states that fish would tolerate as much as 250 p.p.m. (equivalent to 250 parts of $CuSO_4$ in one million parts of water) of $CuSO_4$ during short exposures (in Lake Mendota water with 150 p.p.m. $CaCO_3$). No studies were made over longer periods.

Short time experiments, however, may have little significance as a measure of toxicity levels of copper customarily used in lake treatment. Clarke (1946) has proved barnacles and mussels to be sensitive to prolonged exposure to copper but after absorbing enormous quantities (in some cases 100 times as much as normally present) they will excrete much of the excess to survive if returned to fresh sea water.

Experiments by DeGiusti (1941) on the effect of copper on mixed cultures of animals and plants, showed that 1.25 p.p.m. killed goldfish, *Daphnia magna*, tadpoles, and the alga Cladophora in 14 days or less,

while 0.25 p.p.m. did not kill any of these forms within 20 days.

Riley (l.c.c.) found the tolerance level of ten representative freshwater invertebrates was from 0.03 to 0.5. p.p.m. of copper. He recorded also that in some lakes it is normally high enough in autumn to be toxic to some animals and plants, but in the other months naturally occurring copper, though present, was largely combined with organic matter. In addition his studies showed that copper was contributed to the lake water from the bottom mud.

According to a personal communication from Dr. D. H. Thompson, formerly of the Illinois Natural History Survey, the city of Bloomington, Illinois, has put about 500 lbs. of $CuSO_4$ into a 900 acre lake every week, presumably in summer, since 1930. He stated that no aquatic plants exist there and that "blooming" no longer occurs.

In "A fishery survey of important Connecticut lakes" (1942) several comments are made which indicate that fish populations have suffered from the practice of copper sulphate treatment of lakes.

Allee, et al. (1940) claim that traces of copper in distilled water markedly increase the death rate of goldfish.

Guilford and Noland (1943) investigated the effect of copper ion on the large pond snail, *Lymnaea stagnalis, using* Madison municipal water which contains 341 parts per million calcium carbonate. He found they could not tolerate 0.25 p.p.m. of dissolved copper for more than 64 hours but would tolerate 0.12 p.p.m.

In Africa a disease in humans, Bilharzia (schistomiasis), is controlled by eliminating snails which are intermediate hosts to the organism causing the disease. Copper sulfate is employed extensively in Egypt to exterminate snails. Worthington (1946) was critical of a $10,000,000 snail control project in Egypt because of the careless methods proposed. In addition he says, "The copper sulfate may not kill fish but it certainly kills the bulk of their food supply and so influences the fisheries."

Locally, in Michigan and Wisconsin, snails are eliminated from bathing beaches where swimmers' itch has ocurred, by spreading copper carbonate (Wis. Committee on Water Pollution, 1946). Though a comparatively insoluble copper salt it dissolves sufficiently to be toxic to snails.

Plant physiology and ecology students, working in recent years with Professors Curtis and Stauffer in the Department of Botany at the University, have studied the effect of copper on the growth of

various algae and higher aquatic plants. They have demonstrated that many floating plants are inhibited or killed by lower concentrations of copper than those needed to control algae. For instance Elser (1941) found that *Spirodela, Azolla, Lemna* and *Riccia* were all killed at 0.3 p.p.m. of copper in Lake Mendota water, while the last two species were inhibited by 0.03 p.p.m. Churchill (1946) reported that the addition of copper to mixed cultures of algae in Lake Mendota water greatly altered the composition of the population, since the free floating, unicellular plankton algae were all killed by 0.25 p.p.m. of copper (some were killed at 0.08 p.p.m.) while the filamentous forms were inhibited by 0.33 p.p.m., but not killed at concentrations less than 0.66 p.p.m. Thus it can easily be seen that the continued treatment of a lake with copper might result in profound changes in the populations of the basic food plants.

In view of evidence that copper is absorbed by aquatic animals from very dilute solutions a reappraisal of the physiological effects of copper toxicity should be made. The total quantity of copper available may be more significant than its immediate concentration in parts per million. For this reason the volume of the test container should be considered as an important experimental factor. One part per million in a 100 ml. flask might not be lethal, whereas 1 part per million in a liter might be toxic because of the greater quantity of copper available for absorption.

Sawyer, et al. (1945), also Nichols, et al. (1946) have analyzed the bottom deposits of the Madison lakes. Surface muds of Mendota, Monona, Waubesa and Kegonsa contained 85, 605, 300 and 223 milligrams of copper per kilogram of dry mud, respectively. Lake Mendota had not been treated with copper sulfate while the other three received regular treatments for several years. What is the effect of these large quantities of a toxic, heavy metal on the bottom organisms? The circumstantial evidence suggests an unfavorable effect. Lakes Mendota and Monona are quite similar eutrophic lakes, limnologically speaking, yet the above report stated that the summer standing crop of bottom-dwelling organisms, as measured in 1944 by Sarah Elizabeth Jones, is about 9,000 per square meter in Lake Mendota muds and only 800 per square meter for Monona. It is also significant that there were no small clams (Pisidium) in the muds of Monona.

Frey (1940), in a doctoral thesis on growth and ecology of the carp in four lakes of the Madison region, points out that both the aquatic

vegetation and the molluscan fauna of Monona, Waubesa and Kengonsa have decreased in recent years concomitantly with the addition of copper.

More recently the toxicity of copper to marine organisms has been thoroughly studied because its use in paints is known to be effective in preventing the fouling of ships' bottoms. In a study by Ketchum, et al. (1945), it was concluded that to maintain a uniform adequate copper leaching rate for one year, a paint film must contain at least 3.6 mg. of copper per sq. cm. of surface area. It has been shown that the solution of 10 micrograms of copper per sq. cm. of paint surface per day will prevent attachment of marine growths, such as barnacles, which normally present a serious problem.

From the above citations of copper toxicity for aquatic organisms one must admit this substance is a poison which, even on a single application, may cause serious disturbances in the balance of aquatic environments. Repeated treatment may result in its accumulation to a point where toxic quantities dissolve from the lake bottom (as proved by Riley) just as from a ship-bottom paint.

The crux of the argument is then, why should a permanent poison be employed to combat a temporary nuisance? This question becomes a challenge to the scientist, conservationist and public official to initiate alternative programs which will aid in alleviating the nuisance. Some proposals are:

1. Establishment of a large scale and coordinated study of the causes of lake blooming, algae nutrition, and also a search for an organic compound to replace copper much as 2-4D in recent years has replaced heavy metals in the control of weeds on land.

2. Populations of algae and large aquatic plants should be considered as a natural crop from a productive medium, just as hay is from an area of soil. Any productive area of the globe produces a surplus crop. Why should a lake's crops decompose in the lake? Why should it be its own cesspool returning the nutrients to aggravate the cycle in the next season? The author suggests this crop be utilized and, as in Milwaukee, use its elements on the market to help defray the costs of keeping lakes beautiful. In a world scarce in food and fertilizers are we justified in any wastage? Why not sponsor some engineering research for the design of machinery to harvest this crop?

With a well organized, enthusiastically directed public program bathing beaches of lakes could be seined several times daily with a

fine mesh seine as a sanitary measure. Most of the clumps of algae which antagonize an esthetic bather could be collected this way, buried or removed from the vicinity. Large aquatic plants in bays and selected shallows could be cut and removed with their associated filamentous algae. Again, to devise adequate machinery to harvest the aquatic crops is indeed a challenge to engineers.

3. A zoning plan has been suggested wherein certain lakes would be set aside for bathing and boating; others for wildlife and fish. The former could be controlled with copper until an effective but non-accumulating toxic agent is discovered.

4. Since it is well established that the watershed of a lake contributes nearly all of the lake's fertility, a soil erosion control program should be initiated to prevent or diminish the inflow of nutrients.

Once more, the question is not: How little can be used to avoid killing fish? but, What will be the effect of a slow accumulation of copper in lake muds? The question is similar to an agricultural one—How little arsenic can be sprayed on apples to kill insects but not kill the man who eats the apple? A slow accumulation of arsenic in orchards because of repeated sprayings has upset the soil biota and the trees have become sick (Rodale, 1945). Therefore man is indirectly affected.

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# STREAM POLLUTION ABATEMENT STUDIES IN THE PULP AND PAPER INDUSTRY

By Willis M. Van Horn, Research Associate

*The Institute of Paper Chemistry, Appleton, Wisconsin*

## I. The Importance of Water in Pulp and Paper Manufacture.

In the light of present technological knowledge it would be impossible to manufacture pulp or paper without water. Water is used both directly and indirectly in this important industry. Directly it is used in digesting the wood, which is the raw material of most pulp and paper manufacture, it is used in treating the pulp after digestion, and it is used in the formation of the sheet on the paper machines. Indirectly it is used for power and steam generation. It is used for cooling bearings, for condensers, for vacuum evaporators. Finally it is used as a means of carrying wastes away from the plant (1).

Indeed, water is so essential to the pulp and paper manufacturing process that, in locating a new plant, first consideration is given to the availability of a cheap source of water of suitable properties (2).

## II. Problems Arising From The Use of This Water.

Because large amounts of water are so essential and because, in using this water, materials are added, a pulp or paper mill is usually responsible for polluting the stream to some degree. To be sure, there are cases where the degree of pollution is so small as to be insignificant. But, in other cases, the pollution is in extent sufficient to create changes in the stream which may harm its aesthetic value, as well as affect the aquatic environment so that the stream biota may be changed or even destroyed.

The situation confronting the pulp and paper manufacture is this: (1) Large amounts of water are essential to the manufacturing process; (2) the only economically favorable source of such water is from surface bodies, such as rivers, and (3) the use of this water by the pulp and paper industry may decrease or destroy its value to other users. The question then arises: How can the industry return this water to the stream in essentially the same condition that it found it?

## III. The Attack on the Problem.

### A. Organizations Participating.

Everyone familiar with the problem of stream improvement in Wisconsin knows of the contributions made by the Bureau of Sanitary Engineering. This organization has poineered both in the state and in the nation in its efforts to clean up our streams. It is logical that, in a state such as ours, its attention should be directed to the pollution problems of the pulp and paper industry. Naturally, abatement activities must be based on the technology and capacities of the particular industries involved. Many years ago a Special Advisory Committee was set up, consisting of representatives of the Wisconsin Pulp and Paper Industry and of the Bureau of Sanitary Engineering. The purpose of this committee is to exchange technical and other information and to study ways and means of applying such information to achieve pollution abatement. The accomplishments of this committee pointed the way for the activities described in the following paragraphs.

At first, the problem was attacked in the individual mill laboratories and considerable progress was made. Notable was the work done by the Marathon Corporation described below.

In 1939, the sulphite pulp manufacturers in Wisconsin organized into what was known as The Sulphite Pulp Manufacturers Committee on Waste Disposal (3). The name of this organization has recently been changed to the Sulphite Pulp Manufacturers Research League, Inc. The investigations conducted by this group are supported entirely by the participating companies. The Sulphite League has directed its attention to the problem of sulphite waste liquor. Its research program may be roughly classified into two phases. One is concerned with the chemical utilization of the waste materials. Investigations in this field are being pursued by the staff of The Institute of Paper Chemistry. The other phase is concerned with biological disposal of the waste. These investigations are under the direction of the League's own technical staff, in residence at the Institute.

In the field of kraft waste studies, there has been organized the Committee on Kraft Waste Disposal, consisting of representatives of kraft companies of the state and of the Bureau of Sanitary Engineering. The activities of this committee are discussed below.

Recently there has been organized the National Council for Stream

Improvement of the Pulp, Paper and Paperboard Industries, Incorporated. This organization draws its support from the pulp and paper industry on a national scope and, therefore, its research activities are similarly on a national scope. Various Wisconsin companies have been co-operating with the National Council.

Outside of Wisconsin several pulp and paper groups have made notable contributions which will be discussed later.

B. Problems Arising from Chemical Pulping.

1. Acid Pulping — Sulphite Waste Liquor.

In the sulphite pulping process the wood is treated, at high temperature and at high steam pressure, with an aqueous solution of sulphurous acid in which lime or some other base has been dissolved. The action of this liquor is to free the cellulose fibers from the lignin, hemicelluloses, and other cementing materials in the wood. At the conclusion of a "cook", therefore, a digester contains the free cellulose fibers suspended in the spent cooking liquor in which is dissolved the constituents of the wood other than the fibers. When the digesters are emptied, this spent liquor is drained from the fibers, or pulp, and is commonly called sulphite waste liquor.

This liquor contains the soluble products of digestion, amounting to slightly more than 50% of the original wood. In other words, for every ton of pulp produced, about one ton of these soluble products are waste. There are about 2500 gallons of this waste liquor for every ton of fiber produced. It contains normally 10% solids, the bulk of which are lignin and carbohydrates. Because, in the past, this sulphite waste liquor has been sent to the river, it has constituted, and does now constitute, the most serious waste disposal problem facing the industry.

The approach to this problem has ranged all the way from measures which would change the fundamental pulping process to simple lagooning of the wastes. In general there have been two approaches to the problem, one of the utilization of the liquor and one of disposal.

One of the first significant advances was the development of the Howard Process at the Marathon Corporation in Wisconsin (4). By fractional precipitation of the liquor solids with lime, it is possible to recover material that can be sent to the boilers for heat and chemical recovery; another fraction can be used in plastic manufacture, and still another fraction can be used in the manufacture of vanillin. Although the process is suitable for operation in all sulphite mills, the

market for the products is limited and, therefore, the process does not offer an opportunity for use in all mills.

The Sulphite Pulp Manufacturers Research League has, for a number of years, been investigating ways and means of utilizing and/or disposing of this waste. They have explored the possibilities of utilizing the waste as road binder, its use in the manufacture of adhesives, for binders in the manufacture of coal briquets, for alcohol production, the economics of evaporating and burning the liquor, and many more.

This group has carried out exhaustive researches on the feasibility of disposing of the sulphite waste liquor by methods employed in sanitary sewage disposal, with emphasis on the trickling filter process. This work has been carried through laboratory and pilot-plant stages. The results indicated that the B.O.D. of sulphite waste liquor could be reduced materially if nutrient materials, such as nitrates and phosphates, were added. There are a number of phases of this investigation that require further exploration before the process can be made generally applicable.

More recently The Sulphite Manufacturers Research League has been investigating the possibility of reducing the B.O.D. of the liquor by biological utilization. It has been shown that, under carefully controlled conditions, fodder yeast can be grown using the sugars in the liquor as a source of food. Laboratory experiments indicate that, by this process, the B.O.D. contribution of a sulphite mill may be reduced as much as 60%. The process shows enough promise so that a commercial scale plant is to be constructed on the premises of one Wisconsin sulphite mill. It has been calculated that, if similar plants are erected to process the waste liquor from the mills located on the Lower Fox River; the B.O.D. requirements of the liquor would be lowered to the extent that considerable improvement in the dissolved oxygen content would be effected.

Besides these activities, The Sulphite Manufacturers Research League is supporting at The Institute of Paper Chemistry a long range research program involving the fundamental aspects of waste lignin utilization. Much progress has been made. Among the products of this investigation is ethyl vanillate, a compound that promises wide use as a food preservative (5). This material is extremely effective in controlling the growth of certain types of bacteria, and yet it has been shown that it is nontoxic to human beings in the concentrations used.

Another phase of the treatment of sulphite waste liquor by fermentation is that of ethyl alcohol production. Investigations of this method of treatment have been in operation for a great many years. At present, at least two plants are actively producing alcohol, one in Thorold, Ontario (6) and one in Bellingham, Washington. Some people believe that alcohol produced from sulphite waste liquor cannot successfully compete on the market with that made from molasses. Others apparently feel differently. A final verdict on this outlet will probably not be reached until present abnormalities have evened themselves out and the long range cost factors are brought into proper balance.

It should be pointed out that, in Germany and Scandanavia, many sulphite pulp plants have for years, operated yeast and alcohol plants. Their successful operation is due to the fact that there is a greater premium on both products in those countries than there is in our own.

Another significant contribution to the sulphite waste liquor disposal problem has been made by the Pulp Division of the Weyerhaeuser Timber Company in Longview, Washington (7). These people have devised a method in which magnesium replaces calcium in the cooking liquor. This substitution makes it possible to evaporate the waste liquor to approximately 40% to 50% solids, and burn it in the boilers, thus recovering heat as well as chemicals which are re-used in forming more cooking liquor. The economic success of this process depends upon almost complete recovery of the chemicals and it has been indicated on the pilot-plant scale that the method is feasible. At the present time the Weyerhaeuser people are building a large plant based on this process, and the industry as a whole is watching the progress of this plant with great interest.

Several attempts have been made in times past to evaporate and burn calcium base sulphite waste liquor, but these attempts for one reason or another have not been successful.

Other mills in the United States have been entirely or partially successful in disposing of their sulphite waste liquor by utilizing its lignin. Among the products so manufactured are those that can be used as adhesives, for hardening cement, in the manufacture of ceramics, as insecticides, in the manufacture of dyes, in electroplating, in emulsions, as fertilizer, in soaps, and in tanning. In many of these uses a single 100-ton mill would produce in one day the amount of sulphite waste liquor necessary to manufacture the product in amount sufficient for the nation's annual demand. For that reason such util-

ization of the liquor promises little in the way of pollution abatement (8).

2. Alkaline Pulping.

During recent years the sulphate pulping process, and its modification, the kraft process, have come to occupy a major position in the pulp and paper industry. These are alkaline processes, as compared with the acid sulphite process, and depend, for their economic feasibility, on the ease by which the spent cooking liquor is recovered, and the chemicals contained therein re-used in the formation of new cooking liquor.

It will be recalled that, in the sulphite process, the spent liquor is waste and, therefore, the source of a major pollution problem. In the kraft process, however, the spent cooking liquor is sent to a recovery plant. Here it is reduced in volume by evaporation, until it is readily combustible, and burned in specially designed furnaces. The heat of combustion is recovered as steam, and the chemicals recovered as sulphides, carbonates and caustic. As indicated above, these chemicals are reworked to form fresh cooking liquor.

Theoretically, if a kraft pulp mill and its recovery plant are efficiently operated, there should be a minimum stream pollution problem. However, when the pulp is washed after being blown from the digester, there comes a time when the wash water contains such a small amount of spent liquor that it is no longer feasible to evaporate it, so it is sent to the sewer. This very dilute wash water is one of the major sources of polluting material coming from this type of mill. Other polluting materials may be found in the condensate coming from the evaporators, from the digester de-gassing condensates, and from the digester blow-down condensate.

It was stated that the principal stream polluting effect of sulphite waste liquor was its action in reducing the dissolved oxygen content of the river water, or in other words its high B.O.D. The normal waste from a kraft mill does not have a very high B.O.D. Indeed, if there is adequate stream flow this aspect of the waste is not particularly troublesome. It has been shown by several investigators, however, that kraft wastes contain chemicals that are toxic to fish and other aquatic forms, if present in sufficient volume.

For example, the condensates, referred to above, may contain mercaptans, sulphides, turpentine, disulphides, and methyl alcohol. Furthermore, it has been demonstrated that, in addition to these chemi-

cals, the dilute wash waters may contain certain amounts of what is known as "sulphate soap." This soap is the sodium salt of the resin and fatty acids which are extracted from the wood in the cooking process. In addition to these products, the black liquor washings may contain other sodium salts, any one of which may be dangerous to the aquatic environment, if present in sufficient quantities.

Many years ago the Wisconsin State Board of Health, through its Bureau of Sanitary Engineering, initiated at its own expense, a research program designed to determine (a) the cause of dangerous pollution from a kraft mill and (b) such remedial measures as could be devised to prevent such pollution. This work (9) definitely confirmed earlier observations by workers in Scandinavia (10) that there were toxic materials in kraft pulping wastes.

Later the Wisconsin kraft mills organized a Waste Disposal Committee which, working in close co-operation with The Bureau of Sanitary Engineering, extended these observations and initiated a critical study of the kraft process with the objective of modifying it so that the undesirable wastes could be prevented from reaching the stream. This committee is now closely co-operating with the National Council for Stream Improvement and the investigational work is being done at The Institute of Paper Chemistry.

In an effort to remove these objectionable materials from the wastes, a quick easy method for their detection has been devised.

At the present time the work is concerned with a critical analysis of all waste waters produced in Wisconsin kraft mills; the objective is to find the place in the mill where the materials are formed and to treat them before they reach the stream.

It would be pertinent to discuss here some of the pollution abatement measures currently in use in this industry. One great source of toxic material was eliminated when the mills adopted the practice of recovering turpentine from their digester blow-down condensates. The process is quite simple and from one to three gallons of turpentine per ton of product is recovered. Similarly, most mills are now recovering tall oil from the black liquor skimmings. This material is rich in fats and is widely used in the manufacture of soaps and paints. In this case, however, the effect on pollution abatement is less, because the tall oil was formerly burned in the boilers.

3. Other Types of Pulping.

As a source of cellulose fiber, old paper may be regarded as important. In this case the pulping process consists of breaking the waste

sheet into its component parts, which includes the fiber, the filler and, in some cases, size and ink. From the pollution point of view the de-inking wastes are important. Such wastes contain a high percentage of inorganic solids which renders their treatment difficult. One mill has successfully met this problem by the construction of a lagoon, large enough to retain the wastes for a period of three months. During the period of retention the solids settle out, and bacterial action further reduces the organic materials present to the extent that the effluent from the lagoon is suitable for emptying into the stream.

At the present time, the National Council for Stream Improvement is maintaining an active and fruitful research program on de-inking wastes in the Kalamazoo Valley in Michigan.

The waste from ground wood pulping is relatively harmless when compared with those thus far discussed. Its B.O.D. is moderate and it contains no toxic materials.

D. Paper Machine Wastes.

Large amounts of water are used on a paper machine. Suspended in this water are the materials of which the paper is made. These may be classified as follows (1):

1. The cellulose fibers, the basic materials from which the sheet is formed.
2. Sizing, usually resin, alum or both.
3. Filler. This may be china clay, talc, calcium sulphate, barium compounds, titanium dioxide, zinc sulphide, and/or calcium carbonate.
4. Coloring. Dyestuffs.
5. Glue, casein, and other compounds used as an adhesive in some coated papers.

The water containing these materials flows onto a moving wire screen upon which the sheet is formed as the water drains through the wire. This water is known as "white water" and contains the residue of the mixture after the sheet is formed. It usually contains small amounts of whatever materials were originally used.

Years ago all white water was passed to the sewer after the sheet was formed. Now-a-days, however, a machine is operated on what is called a closed or partially closed system, which means that all or almost all the white water is recirculated over the wire, and the amount of materials equivalent to the paper formed are added for each cycle. This process of recirculation has resulted in a great saving

of materials and, incidentally, in a great reduction in the amount of white water going to the stream.

In spite of this method of reducing fiber and white water loss, there may be some fibers passing to the streams. For a number of years The Bureau of Sanitary Engineering, in co-operation with the mills, has made a study of this loss (11). As a result of these studies, many installations of save-alls and other similar machines have been made. These advances have further reduced the amount of fibers passing to the stream. In this connection, it might be of interest to compare our Wisconsin mills with those of the industry in general.

| Type of Fiber | Entire Industry | Wisconsin |
|---|---|---|
| | % | % |
| Wrapping | 5 | 1.12 |
| Tissue | 10 | 1.96 |
| Board | 10 | 0.6 |
| Book | 15 | 0.96 |

At the present time methods are being studied by the industry to prevent more completely the passage of fibers to the river. Although it is too early as yet to predict success for this work, it is likely that sooner or later improvements will be made that will enable the industry to achieve this end.

## IV. What of the Future?

The effort being made by the Pulp and Paper Industry to abate the stream pollutional aspects of its wastes has been discussed. It has been stated that neither pulp nor paper can be manufactured without the use of large amounts of water. Morally speaking the industry has as much right to the use of this water as any other group or groups. But it does not have the right to leave the water in a state that impairs or destroys its value to other groups. The industry recognizes this fact and feels sure that, in time, it will be able to correct or eliminate the abuses that have occurred in the past. This objective may be achieved only by extending our knowledge of the problem beyond the limits of this present sphere. As in the case of most all research, this extension is slow. But we hope it is sure.

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# HOW CHEMICALS ENTERED THE OFFICIAL PHARMACOPOEIAS

GEORGE URDANG

*Professor, History of Pharmacy, University of Wisconsin*

*Director of the American Institute of the History of Pharmacy*

It is generally agreed upon that what we call modern therapy received its first authoritative recognition through the introduction of chemicals for internal use into the official standards of pharmacy. The question how and when this happened is, therefore, of historical importance.

The first representative of the European drug standards issued and legally enforced in the various political units and later generally called pharmacopoeias, was the Florentine *Nuovo Receptario Composito*, published in 1498. It took half a century and more until the next official pharmacopoeiae of general importance appeared, the Nuremberg *Dispensatorium Valerii Cordi* of 1546, the Augsburg *Enchiridion sive Dispensatorium* of 1564 and the *Dispensarium Reipublicae Coloniensis* of 1565. As pointed out by Husemann, all of these official formularies represented "the orthodox teaching of medicine as contrasted with that of Paracelsus and his followers, who raged against the teachings of Greek and Arabic medicine."[1]

The great past-medieval reformer of medicine, Theophrastus Bombastus Paracelsus of Hohenheim, had died in 1541. Only twelve years later, in 1553, an English Act of Parliament authorized the Royal College of Physicians of London "to survey and examine the stocks of apothecaries, druggists, distillers and sellers of waters and oils, and preparers of chemical medicines."[2] However, what was, in the middle of the sixteenth century, implied in the term chemical?

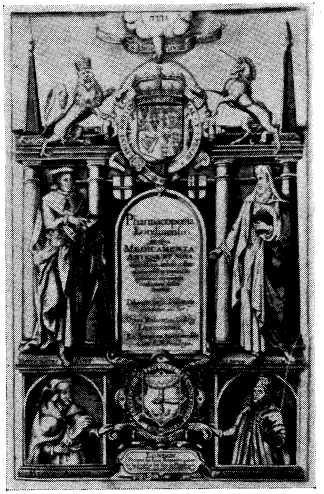
The situation has been greatly obscured because, in the modern sense, the term chemical processes has acquired a different meaning from that which is implied in the writings of Paracelsus. Modern pharmaceutical literature classifies aromatic waters, tinctures, and

extracts with galenicals, although they were unknown to Galen. According to Paracelsus, they were prepared by means of chemical processes as he understood the word. Paracelsus also advocated the use of inorganic chemicals for internal medication. It is this advocacy that primarily caused his and his followers' quarrels with the Galenists and Hippocratists.

The chemical concept as indicated, greatly antedates Paracelsus. Thus the process of distillation was regarded as a chemical process. It was known to the ancients and developed by the Arabs during the Middle Ages. If any one individual were to be accredited therewith, this individual would not be Paracelsus but Arnaldus de Villanova who introduced, in the end of the thirteenth century, distilled waters into European therapy.

Not only heat, but destructive fire was employed in the preparation of empyreumatic oils and more particularly in the preparation of the so-called fixed salts resulting from the incineration of organic drugs and the lixiviation of the resulting ashes. The production of so-called "essential" forms from crude drugs was implied in the designation chemical, whether this was accomplished by separating the finer parts from the grosser parts by distillation or by boiling down the mother liquid concerned and allowing crystallization. In like manner the "essential," even "quintessential" parts were obtained by extraction, whether the product be termed a tincture or extract. To these methods of technique, there were added those now commonly regarded as distinctively chemical.

Have the early pharmacopoeias mentioned above indeed declined all chemical preparations? The interesting fact has to be noticed that the most progressive of these formularies, the Augsburg Enchiridion of 1564, contains several chemical preparations for external use known already before Paracelsus, namely, Aqua fortis, i.e., nitric acid, a solution of corrosive sublimate listed as Aqua cum Mercurio, and an aqueous suspension of lead sulfate and basic acetate called Lac Virgineum. Furthermore the book gives formulas for oil of turpentine to be obtained by direct distillation from the oleoresin and an oil of juniper to be prepared by destructive distillation of juniperwood. It finally lists a series of volatile oils and other preparations, among them oil of vitriol, i.e., sulfuric acid without, however, saying more about these products than that they "may be prepared by the experts by distillation." For the preparation of distilled waters, general directions are given.



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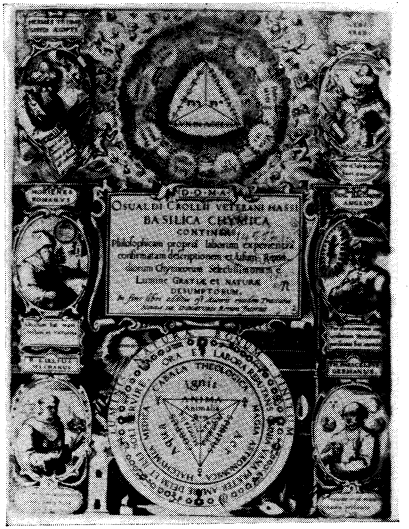


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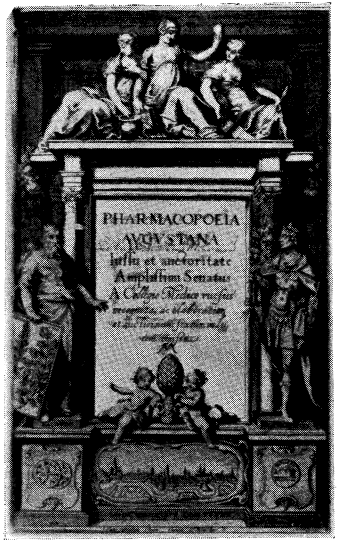


3

FIG. 1. Title page of Minderer's *Pharmacopoeia* Londoninensis.

FIG. 2. Title Page of Croll's Basilica Chymica.

FIG. 3. Title page of the *Pharmacopoeia Augustana.*

Neither extracts nor vegetable salts, nor one of the new chemical compounds for internal use, however, can be found in the first edition of the Augsburg Enchiridion or the later editions of this Pharmacopoeia until 1613. Of these typical innovations introduced by Paracelsus and his followers there was not even an intimation in the early Augsburg pharmacopoeias.

All the early official pharmacopoeias were issued by one or the other Italian or German City Republics of this period and their legal authority was, naturally, restricted to the territories of these comparatively small political units. Thus it certainly electrified the physicians and pharmacists in the whole of Europe when, in 1585, it became known that the Royal College of Physicians of London intended to issue a pharmacopoeia with the view to have this standard made obligatory for all England. The question in everybody's mind was, naturally, whether and to what extent the authors of the English standard would recognize the claims of the new chemico-therapeutical movement. A decision one way or the other had to be reached.

Who were the members of the Royal College of Physicians of London who took upon themselves such a grave responsibility, and what kind of decision could be expected of them?

The principal places for the cultivation of the chemico-therapeutical movement were the universities of Basel (Switzerland), Leyden (Holland) and to a certain extent the Universities of Padua (Italy) and those of Montpellier and Nantes (France). The principal place of resistance, the bulwark of medical conservatism, was the University of Paris.

Although more than a third of the members of the Pharmacopoeia Committee established by the College in 1589 had graduated abroad, it is significant that not one of them had completed his studies in Paris. They had graduated in Nantes, Padua, Leyden, and three of them in Basel. A doctor of Basel was the prominent member of the College, Thomas Muffett, also spelled Moffett and Moufet (1553–1604) of whom his biographer said that he, "while on the continent, adopted with enthusiasm the Paracelsian system of medicine, and when he settled again in England he shared with John Hester[3] the chief burden of upholding the principles therein."[4]

However, Muffett wrote also a digest of Hippocrates. He was no fanatic, but decided to take the good wherever he found it.

It was undoubtedly this progressive eclectic, as we may call him, who was influential in the first English pharmacopoeia movement

and its direction. It corresponds with this assumption that the "order and classification" of the planned pharmacopoeia, as noticed in the Annals of the London College of Physicians under the date of October 10, 1589, lists all the old groups of remedies, the *Julapia, Tragemata, Eclegmata* and so forth, but also a group, the insertion of which in an official pharmacopoeia of this period would have meant a revolutionary step, namely *"Extracts, Sales, Chemica, Metallica,"* i.e., the group of drugs connected with the name of Paracelsus and the very subjects of the Galenico-iatrochemical controversy.

Unfortunately, we do not know what chemicals had been proposed nor whether they were intended for internal or merely for external use. The plan of a London pharmacopoeia conceived in the late sixteenth century has never been realized. No explanation has been found why the work did not progress and why it finally was dropped. It may be that the political uncertainty which prevailed during the last decade of the reign of Queen Elizabeth was responsible. It is, however, by no means unlikely that there had developed sufficient opposition within the College against so progressive an undertaking as the one planned.

Soon after, in the early seventeenth century, there appeared two books written by ardent Paracelsists, which summarized the pharmaceutico-chemical experience of the early Paracelsic epoch: the *Pharmacopoea Dogmaticorum Restituta . . .* of the French physician Joseph Du Chesne, latinized Quercetanus (1601) and the *Basilica Chymica* of his German colleague Oswald Croll (1608). Both books, especially that of Croll, exerted an extraordinary influence.

The title page of Croll's *Basilica Chymica* (Figure 1) pictures the mysterious symbolism of alchemy rather than the undeniable endeavor of the author towards scientific clarity. There is the celestial and the terrestial sphere, and within the latter the four Aristotelian elements, fire, air, earth and water, have found their place quite as well as the symbols of the Paracelsic three essential substances, sulfur, mercury and salt. Of the six men portrayed three, i.e., Hermes Trismegistos, Morienes Romanus and Geber, are mystical figures whose writings are apocryphal. Of the writings of Raimundus Lullus and Roger Bacon, just the alchemical ones are likewise considered as apocryphal. It is the figure of Paracelsus with the accompanying motto "separate and lead to maturity (perfection)" that actually symbolizes the spirit of Croll's Basilica Chymica.

It was not until 1614, twenty years after the first plan of an official English pharmacopoeia had been mentioned in the Annals of the Royal College of Physicians of London for the last time, that the members of the College took up the idea again, and this time they succeeded. For the revival of the plan as well as for its success apparently two men were primarily responsible: Dr. Henry Atkins (1558–1635) who had received his Doctor's degree at the University of Nantes (France) and who had participated in the earlier attempt, and the famous Theodore de Mayerne (1573–1665).

Sir Theodore Turquet de Mayerne, Baron D'Aubonne and Dr. of Medicine of the University of Montpellier, knew what it meant about 1600 to adhere to the doctrines of Paracelsus. Born in Mayerne (near Geneva), Switzerland, in 1573, he began his medical career in Paris, but spent his later life in England. He was the first of several French physicians and pharmacists who, being Protestants and Paracelsists, sought refuge in Great Britain. After being anonymously attacked because of his public recommendation of chemical remedies, Mayerne published in 1603 a pamphlet proving that the use of chemicals in therapy does not contradict the teachings of Hippocrates and Galen. At once an anonymous reply appeared which was filled with abuse, and shortly later, still in 1603, the College of Physicians in the University of Paris condemned Mayerne by a unanimous vote, ordered physicians not to meet him in consultation, and recommended that he should be deprived of his office.[5]

It is very likely that the idea of reviving the plan to create an official London Pharmacopoeia originated with Atkins. In the realization of this plan, however, Mayerne was certainly very instrumental. Being, as far as we know, the only one of the members of the College of Physicians of London, doing his own and successful chemical research, he was undoubtedly responsible for the chemical part of the first issue of the London Pharmacopoeia, 1618, and may even have prepared it. Thus Theodore de Mayerne may well have been the first one to have given the Paracelsistic movement the first adequate recognition within official European pharmacy if there would not have appeared, in 1613, the sixth issue of the Augsburg Pharmacopoeia, edited by Raymund Minderer (1570–1621).

While the father of the first attempt at an official London Pharmacopoeia, Thomas Muffet, as well as the man who helped the second attempt to become a success, Theodore Mayerne, grew Paracelsist during their studies, Raymund Minderer, the son and grandson of

*"chymici"* was born with Paracelsism. Nevertheless, like the men mentioned before, he was eclectic and very anxious not to hurt too much the feelings of the Galenists. In his introduction to a treatise which he wrote on vitriol (1617), Minderer explained his point of view as follows:

> Even though, having been born among chemical vapors, and having been brought up amidst spagyric furnaces, I not infrequently adhere to their vaults — being derived from two excellent and illustrious chemists of their times, as I may state without boasting, my grandfather on my mother's side being Laurentius Danus, and my father Balthasar Minderer — I have as physician always followed the Hippocratic and Galenical method. Even now I esteem it and adhere to it and shall not deviate therefrom by the breadth of a finger. If I do not always use remedies from the animal and vegetable kingdoms, but occasionally employ metallic and mineral remedies, I do this that they may supplement vegetables pure and simple to which new and graver, or inveterate diseases will not yield. This I do that medicine may not despair.[6]

Minderer went rather far in his attempt to prevent medicine from despair by putting at its disposal the preparations recommended by Paracelsus and his followers. Here they are, the simple extracts (33) and the more compounded ones (9), the *sales artificiosi* from plants (14) and furthermore *Sal Saturni* (lead acetate), *Sal Vitrioli* (ferrous sulfate), *Nitrum Sulfure purgatum* (a mixture of potassium nitrate and sulfate), *Crocus Martis* (ferric oxide), Flores Sulfuris (sublimed sulfur), *Flores ac Vitrum Antimonii* ($S_2O_3$ with small amounts of $Sb_2S_3$), *Antimonium diaphoreticum* (mixture of antimony oxide and potassium antimoniate) and *Turbethum minerale* (mercuric sulfate). Finally formulae are given for *Lapis septicus* (caustic potash) and *Lapis Philosophorum* (fusion of alum, vitriol, bolus, cerussa, camphor and vinegar), and there is a large increase in the number of items listed in the chapter on distilled waters.

In a decree of the Augsburg Senate, issued in 1582 and appended to the fifth edition of the Augsburg Pharmacopoeia published in 1597, the apothecaries were still admonished not to prepare or offer for sale "substances which are known to be detrimental or poisonous, such as *Labdanum minerale,* the so-called antimony, also *Turpethum minerale* and other purging mercurials."

In view of the fact that the Augsburg Pharmacopoeia of 1613 listed these banned chemicals, this decree naturally had to be changed. Thus the authorities concerned published on September 3, 1613, another edict which authorized the sale and use of "spagyric"

remedies when "prepared according to directions and prescribed by very experienced physicians who know how to combine rationality and experiment."[7]

Nothing in the beautiful title page of the, in every respect, new book, however, betrays the change of therapeutic principle which it augurs. It is still King Salomon of Bible fame and King Mithridates of Pontus (132 — 63 B.C.), the inventor of the time honored panacea theriac who are presented as the Patron Saints of this, in the opinion of the Galenists, certainly extremely unholy sixth edition of the *Pharmacopoeia Augustana* (Figure 2).

Succeeding and not preceding Minderer's *Pharmacopoeia Augustana,* 1613, the London Pharmacopoeia, 1618, did not offer anything revolutionary. However, being the first official drug formulary to be made obligatory not for the comparatively small territory of a city republic but for a great country, for all England, its recognition of the chemico-therapeutical movement was of highest general importance. Furthermore the book of Minderer only listed the *Vitrum Antimonii,* the *Turpethum minerale,* the *Nitrum Sulphure purgatum,* etc., and referred the reader to the authors of the formulae concerned, i.e., to*"Andernacum, Osvaldum Crollium, Quercetanum et alios,"* while the London Pharmacopoeia, 1618, put the formulas, selected with knowledge and discrimination, directly at the disposal of its readers. Finally the London Pharmacopoeia, 1618, contained three real chemicals not listed in the *Pharmacopoeia Augustana,* 1613, i.e., *Tartarus vitriolatus* (potassium sulfate) *Mercurius Vitae* (a mixture of of SbOCl and $Sb_2O_3$) and, above all, *Mercurius dulcis,* i.e., mercurous chloride or, as it was commonly called since the end of the eighteenth century, calomel.

Theodore de Mayerne has generally been accredited with the introduction of calomel into therapy. This is correct if we restrict this claim to official therapy. The London Pharmacopoeia, 1618, was indeed the first official formulary to include a formula for the preparation of this drug which for centuries was the most popular chemical to be taken internally. Mayerne did not come to his formula, however, quite on his own. It was already preconceived by somebody else, although in somewhat uncertain terms. The British Museum owns the copy of the second issue of the London Pharmacopoeia, 1618, which once was in the possession of Mayerne. It is replete with annotations written in Mayerne's own hand. The anno-

tation penned to the directions for the preparation of calomel by precipitation reads: "Croilly in *Basil, chym.* p. 130." Thus we know from Mayerne himself where he took his formula from or at least got his inspiration.

On page 130 of Oswald Croll's Basilica Chymica the following *"duo secretissimi modi tractandi Mercurium pro medicina corporis"* (two very secret methods of treating mercury for being used for bodily relief) are given, not in a special monograph, but at the end of that dealing with *Arcanum corallinum Paracelsi, seu Mercurius sublimatus rubeus non corrosivus* (HgO).

> In the first case mercury may by itself change back into a very red cinnabar without any admixture merely by means of certain implements.
>
> In the second case there may be killed the destructive spirits of vitriol and salt in mercury sublimate by which wonderful and simple adequate artifice there results a crystalline, completely tasteless powder: One of the most outstanding cathartics, by itself as well as combined with other drugs for internal medical use, it radically expels from the body everything harmful. This will not appear miraculous to those who know that mercury is nature's balsam in which is the virtue of incarnation and regeneration mysteriously renewed and freed from all impurities.[8]

It is undoubtedly the second of these two "very secret methods" to which the note of Mayerne refers and it cannot be said that Croll tries to reveal the secret. Clandestine (*"verstekt"*) calls the historian of Chemistry, Hermann Kopp, the way in which "Oswald Croll described the preparation of Calomel in his *Basilica Chymica in* 1808."[9] As a matter of fact, he did not "describe" it at all. Only one very familiar with the occult language of alchemy could interpret the allusion given as meaning to use salt in order to achieve, by the way of precipitation, a mild and tasteless cathartic out of an acid (vitriol) solution of mercury. Theodore de Mayerne apparently was such a highly versed interpreter. What was even more, he was an excellent chemical experimenter himself. He did not simply take over what he found in the books of other authors. He checked and, if thought necessary, modified it.

According to the Mayerne formula in the first issue of the London Pharmacopoeia, 1618, dated May 7th, the mercurous chloride was obtained by precipitation from a solution of mercury in *Aqua fortis*, i.e., nitric acid, with an aqueous solution of Sal marinus, i.e., sea salt, whereby the mercury solution had to be poured into the salt solution, not the reverse. The precipitate was deprived of its acrimony by

washing. In addition to this formula, in the second issue of the London Pharmacopoeia, 1618, dated December 7th, another one directing the preparation of mercurous chloride by sublimation of mercury chloride and mercury was introduced. This latter formula soon became the one generally used and superceded the older one almost entirely until the method of precipitation, somewhat modified, was revived by the great apothecary Scheele who presented it before the Royal Swedish Academy of Science in 1777.

Although calomel is undoubtedly the most interesting and most important of the three chemicals introduced by the London Pharmacopoeia, 1618, into official internal therapy, the two other ones are likewise worthy of some consideration. For the formula of *Tartarus vitriolatus,* i.e., potassium sulfate, Oswald Croll's *Basilica Chymica,* had likewise served as source. In this case some literal conformity offers evidence. Prescribing the saturation of Sal Tartari, i.e., potassium carbonate, with *Oleum Vitrioli,* i.e., sulfuric acid, the formula was, for this period, extremely rational. The name of the preparation, *Tartarus vitriolatus,* likewise given to it by Oswald Croll, represents one of the few early attempts to intimate in the designation of a product its chemical nature. It is, however, characteristic of the mistakes to which even the great chemists of this period were subject that the same author thought the same substance, when prepared by the double decomposition of potassium carbonate and ferrous sulfate, to be a different product which he called *Specificum Purgans Paracelsi,* thereby accrediting Paracelsus with this process of manufacture.

The so-called *Mercurius Vitae* offers an even more striking example of the unsecure ground on which the chemists of this period were working. The preparation was obtained by pouring *Butyrum Antimonii,* i.e., antimony trichloride, into water. Because antimony trichloride on its part was obtained by distilling a mixture of antimony and bichloride of mercury, Paracelsus thought that it contained mercury. It was for this reason that he called the precipitate obtained by pouring the antimony trichloride into water, *Mercurius Vitae.* It took centuries until it was definitely stated that *Mercurius Vitae* does not contain even a trace of mercury and the mistake of Paracelsus was corrected.

It is understood that like the book of Minderer, the *Pharmacopoeia* Londinensis too avoided any display of its tolerant attiture towards the new chemical therapy which could be provocative. The title page of the issue of December 7, 1618, which was to be official (with slight modification in later reprints) until 1650, refrains from any hint at

the innovation (Figure 3). It is the figures of the Greek Hippocrates, the Graeco-Roman Galen, the Arab Avicenna and the apocryphical pseudo-Arab, Mesue Jr., *i.e.,* the pronounced representatives of pre-Paracelsic therapy, who were chosen to symbolize the spirit of this pharmacopoeia.

Dr. Theodore de Mayerne dared to publish in an official pharmacopoeia formulas for chemical preparations to be used as internal remedies. He did not, however, dare to openly explain what that in reality meant. On the contrary, he took the utmost care in concealing the importance of his venture. Wherever possible the authorship of the formulas is indicated in the London Pharmacopoeia, 1618. The only groups wherein the individual formulae are not supplied with references to either author or place of origin are the *Olea Chymica* and the *Praeparationes Chymica.* In his personal copy Dr. de Mayerne had added the name of Oswald Croll to the formula for mercurous chloride, but apparently it had not seemed expedient to give a Paracelsist official recognition.

True the name of Paracelsus appears once. It is quoted, however, not in connection with any chemical preparation but after his famous wound plaster. In other words the old line surgeon, the author of the *Grosse Wundtarzney,* not the medical reformer and chemist was thus recognized in the London Pharmacopoeia. Minderer, in the Augsburg Pharmacopoeia, 1613, concealed the formulas of the dangerous chemicals but referred to the Paracelsistic authors concerned. Mayerne, in the London Pharmacopoeia, 1618, apparently thought it less dangerous to reveal the formulas concerned than the names of their authors.

The England of the early seventeenth century was, in every respect, less orthodox than the European continent, and especially France. However, Mayerne was a burnt child. He adhered to his principles, but he tried to console the adversaries of the chemico-therapeutical movement by utmost modesty. The preface to the London Pharmacopoeia, 1618, which was written by Mayerne, refers to the chemical drugs as follows:

> Although we revere the wisdom of the old masters and have arrayed their preparations, so to speak, in the first line of battle, nevertheless we have not rejected or disdained in this book the auxiliary troops of the new chemistry, but have granted them a place, a corner in the rear guard, so as to have them at the disposal of dogmatic medicine, i.e., ready for service, like auxiliaries.[10]

This statement is doubtless much more apologetic than that of

Minderer, quoted before.

In another passage of the same preface Mayerne explains why the authors of the London Pharmacopoeia have not followed the custom of other formularies to describe the use and the medical attributes of the drugs listed.

> It is said: From this quiver, the itinerant drug peddlers and the quacks, being as ignorant as they are unscrupulous, equip themselves for their medical practice, and seizing our weapons, are responsible for the death of the sick, to the great detriment of the state. We, therefore, do not add anything about the efficacy of the medicines. We write this book only for the learned, for the disciples of Apollo, and for the welfare, not for the information of the common people.[11]

It is not necessary to set forth at length what part chemicals play in modern therapy, hence, in the pharmacopoeias of today. From the modest role of "auxiliary troops" hidden in a corner of the rear guard, they have advanced to the very front and represent the most important armament of modern medicine in the eternal fight against disease and premature death.

The story of the relations between scientific chemistry and pharmacy is long and intricate, but always enjoyable. The contributions of pharmacy to chemistry have been so large and important and the work done in the fields concerned has been so intimately correlated that the famous historian of chemistry, Hermann Kopp, even called pharmacy the mother of chemistry and Paul Walden called them twin sisters.[12] The very nature of chemistry and pharmacy makes it sure, that these intimate relations, which have proved so beneficial to society, will never change.

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[1] *A Facsimile of The First Edition of the Pharmacopoeia Augustana With Introductory Essays by Theodor Husemann, Edited by Edward Kremers,* Madison, Wis., 1927, p. X.

[2] Kremers-Urdang, *History of Pharmacy,* Philadelphia, 1940. p. 90.

[3] John Hester (d. 1593) was a distiller, or, as he styled himself, a "practitioner in the Spagercall Arte." He published several translations of excerpts from the books of Paracelsus and other "spagerick" authors.

[4] *Dictionary of* (English) *National Biography,* 38:101, (London 1894).

[5] *Ibid.,* 37:150, (London 1894).

[6] *Facsimile of Pharmacopoeia Augustana,* 1 c., p. XXXIV.

[7] *Facsimile of Pharmacopoeia Augustana,* 1 c., p. XXXIV.

[8] The author's translation from the Latin original.
[9] Hermann Kopp, *Geschichte der Chemie,* v. 4, Leipzig, 1847, p. 192.

[10] The author's translation from the Latin original.
[11] The author's translation from the Latin original.

[12] Paul Walden, *Der Apotheker als Kulturtrager,* Pharm. Zeit. 76:1311, 1930.

# THE PROBLEM OF SPEECH-MIXTURE IN THE GERMAN SPOKEN IN NORTHWESTERN DANE COUNTY, WISCONSIN

LESTER W. J. SEIFERT

Department of German, University of Wisconsin

The problem of speech-mixture is hardly new to any of us, for here in Wisconsin we are confronted with it constantly. Various aspects of the problem have also been subjected to rather close scrutiny, but much is still unknown about the phenomenon as a whole. When speakers of different languages are suddenly brought into close contact, what happens to the languages involved? We know that there is a good deal of give and take under certain circumstances, but what are the conditions? And do the processes of mixture follow any definite patterns?

Wisconsin is an unusually good place to study this problem because of the great population-mixture which took place here. The settlement of southwestern Wisconsin began in the 1820's with miners from Illinois, Kentucky and Tennessee who came up to work the lead mines. In the early 1830's the farmer settlers from New England, New York and Ohio began moving into southeastern Wisconsin. In the late 1830's the immigration of the Germans began. The influx of the Germans increased until the 1880's and then tapered off.

The total population of Wisconsin according to the census of 1890 was 1,693,330. Almost one-third of this number, or 519,199, was foreign-born; and of this foreign-born third, over one-half, or 259,819, was German-born. In addition there were 293,039 born in Wisconsin whose parents were both born in Germany. There are no readily available statistics for the third generation. Moreover, these figures do not take into account the number of German-speaking Swiss, Austrians, Poles, Hungarians, etc. These figures were cited merely to give an idea of the percentage of our total population which at one time spoke or at least understood the German language.

One other thing must be taken into account. These Germans did not settle in an even distribution throughout the state, but tended to settle in the block of counties east of the Wisconsin River, north of the southern tier of counties, and south of the forest lands of northern Wisconsin; and to a lesser extent, also in other smaller areas. As a result of this concentration, there are still localities in which both the English and the German languages are used. The degree of bilingualism varies considerably, depending upon locality and individual. Such bilingual communities, of course, furnish the conditions under which speech-mixture can most readily take place.

In order to study this problem, the University of Wisconsin granted me a Post-Doctoral Research Fellowship from November 1945 to September 1946. I went around to different German communities, chiefly in Dane, Jefferson, Dodge, Washington and Columbia Counties, and recorded specimens of the German spoken by certain individuals whom I shall hereafter refer to as informants. Speech-specimens of 39 such such informants were recorded.

Two methods of recording were used — the one by hand in a rather close phonetic transcription, the other by machine with a small but good portable recording device. The attempt was made to do both hand and machine recording with each informant, but for various reasons this attempt was not always successful, and accordingly I have either only hand-recorded or only machine-recorded speech-specimens for 15 of the 39 informants. The amount of time that the individual informants were able or willing to give me varied greatly, and therefore I have more material for some than for others. In order to have comparable material, the course of each interview was in part rigidly directed. To do this, I used a questionnaire in which the items, dealing chiefly with situations out of everyday life, were arranged topically; e.g. questions about the house and home, about animals, about crops and implements were grouped together. I would start out with an introductory statement, such as: "How do you say in German 'The rye is cut', 'the barley is ripe', 'We will cut the oats soon'" and then go on in this way. To go through the entire questionnaire takes from four to eight hours, depending upon the quickness of the informant and the frequency with which he goes off into discussions of other matters.

This, of course, is a translation method and the possibility of suggestion through the direct use of English is undeniable. Certainly

one or the other of the informants used the English word *beef* instead of the German *Rindfleisch* because of the English influence of the way in which this item was posed: 'This is good beef'. To check the over-all reliability of the responses, I tried to record with the machine a considerable piece of free conversation for each informant. Again this attempt was not always successful, because some informants were either not talkative enough to keep on speaking of their own accord, even for a couple of minutes, or else they closed up tightly, when the direct stimulus of specific questions was lacking. But what I did get in the way of free conversation was more than enough to convince me of the reliability of the entire method used.

At present I am analyzing these hand and machine records, and for certain reasons I have so far concentrated upon the records made in northwestern Dane County, where I recorded speech-specimens of fourteen informants in the following localities: one each at Pine Bluff, the Danz neighborhood (just north of Black Earth), and Martinsville; two each at Cross Plains, Marxville and Roxbury; five at Ashton. Eight of the fourteen informants preferred to use a variety of Standard German, called *hoch Deitsch* by the informants, six used the dialect of Cologne and vicinity, called *Koelsch* by the informants. For the purposes of this study I have restricted myself to the speech of the eight informants who used *hoch Deitsch.*

It has generally been recognized that the problem of speech-mixture is closely connected with certain social factors. It is of paramount importance that English has always been the dominant language in Wisconsin despite the great number of German-speaking inhabitants. Most of our social institutions made this inevitable — schools, law, business. The church, originally a stronghold of the foreign language, was also forced to turn to the use of English, partly because of the influence of the other institutions mentioned, partly in order to appeal to the English-speaking population. Thus the German-speaking individual soon finds it to his advantage to speak English. It may even be a mark of prestige that he can speak English and, conversely, a matter of ridicule if he can speak only German or broken English. On the other hand, he may find it advantageous to speak German in the more immediate contacts of family and locality. But it is almost certain that his knowledge of English either consciously or subconsciously influences the German he now speaks. An English word replaces some German word, e.g *heifer* for the German "die Faerse", "die Starke", "das junge Rind"; or the elements of English

words are translated directly into German, e.g. *Butterfliege* from English 'butterfly', replacing one of the numerous German words for this insect such as "der Schmetterling", "der Falter", "der Fiefalter", "die Flattermaus" (dialectal in this meaning). Pronunciation may be colored, English syntactical patterns may be imitated. Once an individual, especially an influential individual, has used such an English form, there is a chance that other speakers will follow the example.

Some borrowings are clearly the result of cultural differences between America and the Germany of 50 to 100 years ago. The 'sink' in the kitchen was virtually unknown in Germany at the time most of the Germans came to Wisconsin. Instead of creating some new German word (e.g. a descriptive compound of the type "der Gussstein"), or extending the meaning of some existant German word to include the concept 'sink', it was simpler to take over the English name together with the object. However, only a comparatively small number of the English words used in the German spoken in America can be explained by this difference in cultures. In my eight records with which I am here dealing, I look upon the following as clear-cut cases:

| | |
|---|---|
| *der Renter* | *die Fence* |
| *der Pasture* | *die Car* |
| *der Counter* (in the store) | *die* or *das Sink* |
| *die Condensery* | *das Loghaus* |
| *die Creamery* | *das Framehaus* |

But in applying this principle we soon run into doubtful cases.

These general observations seem to hold good whenever a dominant and a lower language are used in the same locality. But in order to understand how this mixture takes place and to find out to what extent it can be carried, we must look at the speech of representative individuals and we must examine the factors which may have been influential in molding their speech.

The immediate family is the most important factor in the development of the speech of most individuals. And it has been observed again and again that the speech of the children usually follows the pattern set by the mother. However, in one family I am studying, the youngest child follows the pattern set by the father, the four oldest children follow the mother. Fortunately, in many instances it is quite easy to get this information. But family influences too still need very careful study.

After the family, neighborhood relationships are of greatest importance. Now a neighborhood is a rather fluid entity and its delim-

itation is not always an easy matter. By neighborhood I mean 'a group of families having localized, personal, inter-family associations'. This, on the whole, is the definition used by Professor John H. Kolb of the University of Wisconsin in his studies dealing with rural sociology. The substance of this definition may be found on page 46 of the monograph *Neighborhood-Community Relationships in Rural Society* by John H. Kolb and Douglas G. Marshall, Research Bulletin 154 of the Agricultural Experiment Station of the University of Wisconsin, November 1944. This monograph is based upon a careful study of the neighborhoods of Dane County. Such an exhaustive study has not been made for any other county, and this is one of the reasons I have concentrated upon Dane County.

Despite the difficulties involved, the linguist who wants to study the problem of speech-mixture must examine these inter-family, neighborhood relationships. What does this entail? Professor Kalb has found that neighborhoods hold together and remain active if the families involved participate in two or more of these five broad activities (page 2 of the above-mentioned monograph):

1. Education.
2. Religion.
3. Social life for entertainment or improvement.
4. Economic life.
5. General communication (telephone exchange, mail, roads).

This means that the investigator of speech-mixture must know something about the schooling of his informants, about their religious life and affiliation, about the social organizations to which they belong, about the families with which they exchange visits or work, and where they do their trading. For the local milk-plant, store, garage and filling-station are not only places of business, but they are also centers where one individual meets others and opinions concerning crops, weather, politics and the latest happenings are exchanged.

Certain other factors must also be considered. How long has the informant and his family lived in the neighborhood? To what extent are the families in the neighborhood connected by blood-ties? Close blood-connections force the young men and women to go outside the neighborhood to find suitable mates. Closely connected with this is the question of the nationality background of the neighborhood. Were the original settlers and are the present-day inhabitants predominantly of one nationality or of mixed nationality? If the latter is the case, which element was and is the stronger or strongest? And finally

there is the matter of land tenure. If the land is mostly owner-operated, the same families remain in the neighborhood, and conversely, if a large number of the farms are renter-operated, there is a comparatively quick turn-over in the families. To investigate all these things, even cursorily, is a considerable task, and although I have used Professor Kolb's work as a starting point, I am still far from finished with the investigation of all these factors as they pertain to my Dane County informants. But certain principles are already becoming clear.

The eight *hoch Deitsch* informants mentioned above live in the following six neighborhoods, not necessarily villages: one each in Pine Bluff, Danz, Martinsville and Ashton; two each in Marxville and Roxbury. The population components of these six neighborhoods are not entirely the same. The settlers of Pine Bluff were half Irish, half Germans from Cologne and Trier. The original friction between these two groups has been overcome, intermarriage has increased and as an active language German has almost died out. Ashton was settled almost entirely by Germans, mostly from Cologne with some from Trier and a sprinkling from elsewhere. The German language is still very much alive. Martinsville was settled almost entirely by Germans who came in fairly equal proportions from Cologne and Trier with a sprinkling from elsewhere. German is very much alive. Roxbury was settled almost entirely by settlers from Cologne, Trier and Bavaria—all three in fairly equal proportions—with a sprinkling from elsewhere. German is very much alive. Marxville was a mixed English and German settlement, although the Germans soon predominated. These Germans came mostly from Cologne and Trier with more than a sprinkling from elsewhere. German is very much alive. Danz was also a mixed English and German settlement with the Germans predominant. These Germans came from Cologne and Trier with more than a sprinkling from elsewhere. Here German is rapidly losing ground.

In view of these differences in population components and the resultant differences in inter-family, neighborhood relationships, there is a surprising constancy in the influence which English has had upon the German spoken in all the neighborhoods. By contrast the differences of the English influence in the different localities are very small. For example, the informant from Pine Bluff, where German can scarcely be called an active language any more, has a higher number of English loanwords in the total vocabulary recorded than any

other informant; his *l*-sound is frequently Americanized and the midwestern American *r*-sound has largely replaced the German tongue-tip trill, even in native German words. Yet this man's wife was almost twenty when she came from Austria and they always used German in the family until the oldest children were grown-ups. It must be added that this midwestern American *r*-sound was also used sporadically by the informants from the very German neighborhoods of Ashton and Roxbury. But the records must be studied in greater detail and the linguistic data must be more closely examined in connection with the social factors outlined above, before anything more definite can be said about these differences of the English influence in the different neighborhoods. In the rest of this study only certain general principles of the English influence will be presented and illustrated, principles drawn from the records of the eight informants taken as a whole rather than individually.

The influence of English is most noticeable in the vocabulary. In the speech of the eight informants, which totals from 20 to 25 hours of speaking, the borrowings from English are restricted to nouns, verbal forms, adverbs and interjections. No English adjectives, except past participles used in predicate position, no pronouns, numerals, prepositions or conjunctions were recorded. Words borrowed from English are usually but not always treated like native words. This means that sounds and sound clusters which are peculiar to English (at least in certain positions) are usually replaced by approximate German sounds; e.g. the diphthongal English *o*-sound in 'grocery' is replaced by the German pure long *o*-vowel, the initial *st*-combination in 'store' is replaced by the German initial *st*-cluster. The English plural of nouns is at times retained, but at other times the plural of the borrowed word follows the pattern of some native German type of plural-formation. To the nouns one of the three German genders must be assigned. In this there is some vacillation. The statistics are:

Total number of nouns taken over directly from English — 146.
Number of nouns recorded more than once — 75.
Number of nouns recorded only once — 71.
Number of nouns recorded more than once, varying in gender — 12. (These are not included in the following tabulations.)
Number of nouns to which feminine gender has been assigned — 44.
Number of feminines recorded more than once — 22.
Number of feminines recorded only once — 22.
Number of nouns to which masculine gender has been assigned — 34.

Number of masculines recorded more than once — 21.
Number of masculines recorded only once — 13.
Number of nouns to which neuter gender has been assigned — 4.
Number of neuters recorded more than once — 3.
Number of neuters recorded only once — 1.
Number of nouns in such context that gender is not revealed — 52.
Number of nouns of unknown gender recorded more than once — 17.
Number of nouns of unknown gender recorded only once — 35.

We turn first to the twelve words which varied in gender. Two nouns were recorded as feminine, masculine and neuter:

*die, der, das Match*
*Heifer*

Six nouns vacillated between feminine and masculine:

| | |
|---|---|
| *die, der Box* | *die, der Driveway* |
| *Marsh* | *Lawn* |
| *Floor* | *Handle* |

One noun was both feminine and neuter:

*die, das Sink*

Three nouns varied between masculine and neuter:

*der, das Barrel*
*Buggy*
*Store*

The nouns which were recorded more than once and only as feminines are:

| | | | |
|---|---|---|---|
| *die Attic* | *die Train* | *die Farm* | *die Yeast* (or *East*) |
| *Owl* | *Car* | *Whip* | *Yard* |
| *Strawberry* | *Quilt* | *Ceiling* | *Lake* |
| *Raspberry* | *Creamery* | *Station* | *Road* |
| *Mosquito* | *Granary* | *Story* | *Railroad* |
| *Town* | *Fence* | | |

The 22 feminines which were recorded only once are:

| | | | |
|---|---|---|---|
| *die Pantry* | *die Cousin* | *die Village* | *die Mainroad* |
| *Pond* | *Court* | *Whey* | *Countryroad* |
| *Clothesbrush* | *Condensery* | *Highway* | *Gravelroad* |
| *Drag* | *Country* | *Surrey* | *Sideroad* |
| *Candy* | *Grass-widow* | *Lane* | *Hall* |
| *Cornice* | *Whistle* | | |

The nouns which were recorded more than once and only as masculines are:

| | | | |
|---|---|---|---|
| *der Pail* | *der Bundle* | *der Cousin* | *der Shock* (of grain) |
| *Slop-pail* | *Bushel* | *Faucet* | *Spree* |
| *Pasture* | *Tavern-keeper* | *Farmer* | *Renter* |
| *Parlor* | *Keg* | *Suit* | *River* |
| *Boar* | *Counter* | *Butchershop* | *Living-room* |
| *Butcher* | | | |

The 13 masculines recorded only once are:

| | | | |
|---|---|---|---|
| *der Orchard* | *der Dresser* | *der Grandson* | *der Dish-rag* |
| *Swillpail* | *Gander* | *String* | *Rooster* |
| *Mitten* | *Garlic* | *Skirt* | *Grasshopper* |
| *Market* | | | |

The nouns which were recorded more than once and only as neuters are:

*das Beef*
*Baby*
*Supper*

The one neuter which was recorded only once is:

*das Chick*

The 17 nouns which were recorded more than once but in such context that their gender is not revealed are:

| | | | |
|---|---|---|---|
| *Ankle* | *Mumps* | *Pneumonia* | *Sod* |
| *Pie* | *Tractor* | *Cake* | *Lilacs* |
| *Smallpox* | *Depot* | *Cookies* | *Raisins* |
| *Bug* | *Drink* | *Credit* | *Hornets* |
| *Measles* | | | |

The 35 nouns of unknown gender recorded only once are:

| | | | |
|---|---|---|---|
| *Automobiles* | *Mountains* | *News* | *Silage* |
| *Mix-up* | *Molars* | *Fried-cakes* | *Song* |
| *Safety-pins* | *Movies* | *County* | *Sparrow* |
| *Bumblebee* | *Team* | *Cream* | *Starlings* |
| *Bureau* | *Tavern* | *Crickets* | *Slums* |
| *Business* | *Cigarettes* | *Christmas* | *Lettuce* |
| *Bat* (animal) | *Cottage-cheese* | *Gallon* | *Leghorns* |
| *Lightning-bug* | *Jar* | *Glasses* | *Horseradish* |
| *Lilac-bush* | *Dishes* | *Waist* (blouse) | |

In all the examples cited above, the English nouns were taken over directly into the German. In compounds, however, three other possibilities exist. The first part of the compound may be translated into German and the English second part may be retained. Thirteen examples of this were recorded:

| | |
|---|---|
| *die Hei-mow* 'hay-mow' | *der erste Floor* 'first floor' |
| *zweite Crop* 'second crop' | *Grund floor* 'ground-floor' |
| *Kaese-factory* 'cheese-factory' | ? *Hei-pens* 'hay-pens' |
| *Vieh-yard* 'cattle-yard' | *Feier-bugs* 'fire-bugs', 'fire-flies' |
| *Haupt-road* 'main road' | *Fett-cakes* 'fat-cakes', 'doughnuts' |
| *der Wasser-pail* 'water-pail' | *Huehner-hawk* 'chicken-hawk' |
| *Ueber-coat* 'overcoat' | |

In fourteen examples the English first part of the compound is

retained and the second part is translated. The gender, of course, is that of the second, German part:

*die Smoke-wurst* 'smoke-sausage'
*Scoop-schaufel* 'scoop-shovel'
*District-schule* 'district-school'
*der Maiden-name* 'maiden-name'
*Cottage-kaese* 'cottage-cheese'
*Tom-katz* 'tom-cat' (gender!)
*Dish-lappen* 'dish-cloth'
*der Dish-lumpen* 'dish-cloth'
*Drake-hahn* 'drake' (dial. *Entehahn*)
*das Waste-land* 'wasteland'
*Back-haus* 'back-house'
*Brick-haus* 'brick-house'
*Frame-haus* 'frame-house'
*Log-haus* (or *Logs-haus*) 'log-cabin'

In seven examples both parts of the English compounds are translated. Here also the gender is that of the second component:

*die Bulldistel* 'bull-thistle'
*Kanadadistel* 'Canada-thistle'
*Butterfliege* 'butter-fly'
*Feierfliege* 'fire-fly'
*der Fettkuchen* 'fat-cake', 'doughnut'
*Fusstuhl* 'foot-stool'
*Pferdsrettich* 'horse-radish'

In both nouns and verbs one other thing may occur. The meaning of a native German word is extended by association with a similar English word. There are, however, not many clear-cut examples of this in my records.

*das Korn* 'maize'. All the informants used the word in this sense through association with the English word 'corn'. In Germany "das Korn" is either 'wheat' or 'rye'.

*die Hand* 'hand of the clock'. In Germany this is "der Zeiger" or dialect variants thereof.

*er geht mit die* 'he goes with her'. Extension of the meaning of "gehen" after the English pattern.

*die Feierfliegen sind raus* 'the fire-flies are out'. This is a direct translation of the English expression.

*er geht raus butcher-n* 'he goes out butchering'. he German infinitive is here used as the direct equivalent of the English *-ing* form.

*ich fuehle schlecht* 'I feel bad'. In Standard German the verb is reflexive in this meaning.

*er rennt unsre Farm* 'he is running our farm'. In Standard German "rennen" is only intransitive.

*ich weiss die Country darauf* 'I know the country up there'. By association with the English verb 'to know', the German verb "wissen" not only means 'to know a fact' but also 'to be acquainted with'.

*gleichen* 'to like', 'to be fond of'. Used in this sense by all the informants. In Germany this verb means 'to be like', 'to resemble'. By simultaneous association with the English verb and adverb 'like', the meaning of the German word has been extended.

Verbs may also be taken over directly from English. These verbs are then treated exactly like native German verbs and in their inflection they follow the pattern of the German weak verb; e.g. the infinitive *smoke-n 'to smoke,'* the present, *er smoke-t* 'he smokes,' the past participle *ge-smoke-it* 'smoked'. The following eight verbs were

used by more than one informant, cited in one of the sentences recorded:

*er hat einen Apfel ge-pick-t* 'he picked an apple'
*die Enten sind ge-butcher-t* 'the ducks are butchered'
*wer teach-t bei eich?* 'who teaches in your school?'
*der Frosch ist ins Wasser ge-jump-t* 'the frog jumped into the water'
*die Tasse ist ge-crack-t* 'the cup is cracked'
*ich habe ge-farm-t* 'I was a farmer'
*das Kalb suck-t* 'the calf is sucking'
*er smoke-t die Pfeife* 'he is smoking his pipe'

The folowing thirteen simple verbs were recorded only once, again cited in context:

*das wurde ge-mix-t mit Teich* 'that was mixed with dough'
*er mower-t die Marsh* 'he is cutting the marsh' (verb based on English noun)
*ich habe die Brennessel ge-touch-t* 'I touched the nettles'
*das ist fuer can-n* 'that's for canning'
*die Huehner sind am cackle-n* 'the chickens are cackling'
*die Bienen sind condemn-t worden* 'the bees were condemned'
*er cultivate-t das Korn* 'he is cultivating corn'
*der Kaese wird ge-cure-t* 'the cheese is cured'
*whistle nicht!* 'don't whistle!'
*er tut sie spark-n* 'he is courting her'
*er tut yawn-n* 'he is yawning'
*wir raise-n kein Kopfsalat* 'we don't raise head-lettuce'
*ich konnte es nicht handle-n* 'I couldn't handle it'

Verbs also may be hybrid German and English compounds. In the only type so far recorded the adverbial prefix is German, the verb stem is English. Two such verbs were recorded more than once: *auf-pick-n* 'to pick up'. *sie pick-n die Krankheit auf* 'they pick up the sickness'. *auf mix-n* 'to mix up'. *es wird alles auf-ge-mix-t* 'everything is mixed up'.

One such a hybrid was recorded once:

*rein-stir-n* 'to stir into'. *ein Ei wird rein-ge-stir-t* 'an egg is stirred into it'.

Sixteen adverbs and adverbial phrases showing English influence were recorded, of which ten were used more than once and six only once. Nine expressions were taken over directly from English. Those used more than once are:

*er geht outside* 'he goes outside'
*ich habe anyway(s) drei Westen* 'I have at least three vests'
*ich habe anyhow drei Westen* 'I have at least three vests'
*das ist plenty schlimm* 'that's plenty bad'. *plenty* is also used as a noun in such expressions as *er hat Plenty* 'he has enough'.
*sure, gehe ich* 'certainly I'm going'

Four adverbial expressions taken over directly from English were recorded only once:

*er hat drei Maedchen in all* 'he has three girls in all'

*sonst bin ich allright* 'otherwise I'm allright'
*otherwise geht er nicht* 'otherwise he won't go'
*of course, gehe ich* 'of course, I'm going'

Seven expressions recorded are translations of part or all of the English equivalents. Five were recorded more than once:

*er hat alles auf Credit gekauft* 'he bought everything *on credit*'
*sonst bin ich allrecht* 'othrewise I'm *allright*'
*ich war da eine kleine Weile zurueck* 'I was there *a little while ago*'
*du warst da drei Wochen zurueck* 'you were there *three weeks ago*'
*ein Jahr zurueck war das Wetter besser* '*a year ago* the weather was better'

Two such translated expressions were recorded only once:

*die sind ziemlich eben* 'they are *quite even*'
*ich habe es ueber die News gehoert* 'I heard it *over the news*'

Ten English interjections were recorded, five of them calls to animals:

*pooey! pooey! pooey!* 'call to pigs' (Great variation in pronunciation)
*chick(ie)! chick(ie)! chick(ie)!* 'call to chicks and chickens'
*come boss!* 'to call cows from the pasture'
*giddap!* 'to make horses go'
*whoa!* 'to make horses stop'
*oh sure! das weiss ich* 'oh sure! that I know'
*(by) golly! die ist schoen!* '(by) golly! she is beautiful!'
*no! ich habe keine Schwester* 'no! I don't have a sister'
*well! das koennen wir rechnen* 'well! that we can figure out'
*say! da war einer in Cross Plains* 'say! there was a fellow in Cross Plains'

There are finally more than a few items in the vocabulary so far recorded about which I am in doubt, whether their provenience is to be found in the German dialects or in English. Such are the pronominal forms:

*der hier, das hier, die hier* 'this'. For Standard German "dieser", "dieses", "diese".
*was ein* 'what a'. For Standard German "was fuer ein".
*jedereins* 'everyone'. For Standard German "jeder", "jedes", "jede".

In pronunciation the influence of English has been much more limited. We find the Americanization of the *l*- and *r*-sounds, and this has spread from loanwords to native German words. One informant who speaks German much more than English, and much more fluently also, uses the midwestern American *r*-sound quite frequently. It is interesting to note that in the word for the 'rat', four of the seven informants for whom I have this item recorded use the midwestern American *r*-sound, *die Ratt*(e). Three English vowels were recorded sporadically, but their use is limited to loanwords. These are: the vowel in English 'but', recorded in such words as *of course, die Condensery, die Country;* the vowel in English 'cat', recorded in such words as *der, das, die, Match, der Pasture, der Grasshopper;* the vowel

in English 'all', recorded in such words as *allright, die* or *der Lawn, der Huehner-hawk.*

In morphology I can at present ascribe only one feature to English influence, that is the spread of the *s*-plural of the noun. This plural formation is not unknown in the northern and western German dialects, but it is used with a smaller number of words than in my records. Very often the *s*-plural was borrowed with the English noun, but not always, and from here it must have spread to native German nouns which originally formed their plurals in different ways.

In the sphere of syntactical influence, the records have not yet been studied closely enough to say very much. It has already been mentioned that one reflexive verb "sich fuehlen" has become intransitive, recorded in the sentence *ich fuehle schlect* 'I feel bad'. We see the influence of the English verb 'feel'. One intransitive verb is now also transitive, "rennen", recorded in the sentence *er rennt unsre Farm* 'he is running our farm'. Again the English influence is evident. There is the sentence, recorded only once, *ich weiss nicht was zu tun* 'I don't know what to do', which seems to be a direct translation from English. Intensive study of the word-order must still be undertaken. In many of the instances in which the word-order differs from that of Standard German, we need not necessarily be dealing with English influence at all, but with German dialect influence.

This paper does not offer a definitive solution of the problem of speech-mixture. The attempt was made to show, first, what non-linguistic factors are involved in the study of this problem, and second, that the influence of English upon German follows certain definite trends despite differences in family and neighborhood relationships.

# A PRELIMINARY CREEL CENSUS OF PERCH FISHERMEN ON LAKE MENDOTA, WISCONSIN

KENNETH M. MACKENTHUN and ELMER F. HERMAN

*Wisconsin Conservation Department*

## INTRODUCTION

For many years, Lake Mendota has been fished intensively for "jumbo" perch during the winter ice fishing season. To the authors' knowledge, no attempt has ever been made to determine the number of fishermen on the lake or the number of fish a given fisherman was catching. In an effort to determine the number of perch removed by the winter fishermen, a census was conducted on the number of fishermen and a check was made on their catch during the ice fishing season of 1947.

## COUNTING FISHERMEN BY AIR

The idea of counting fishermen from the air on Lake Mendota was first obtained from Dr. John Greenbank, in charge of the Upper Mississippi River Survey. He successfully employed the method on 120 miles of the Mississippi River and is to publish a paper on his methods in the future.

Before our work began, there were many estimates as to the number of fishermen on Lake Mendota. These estimates ranged all the way form 2,000 to 6,000 fishermen. When compared with actual air counts, these estimates were found to be too high, but the number of fishermen on the lake was still unusual for a lake of 9,730 acres.

Arrangements for flying time for the project were made with the the Morey Airplane Company of Middleton, Wisconsin, because of the proximity of their airport to the lake. The Middleton field is only a few minutes flying time from Mendota Beach, consequently little time was lost in reaching the objective.

An outline map, using points and landmarks as shown in Figure 1, was made of Lake Mendota blocking it off into sections A, B, C, D, E, F, G, H, and I. A copy of the map was given to the pilot of the plane and the sections were flown as indicated by the arrows from A through I. This was routine procedure, permitting the counter to always count to the right or on the same side on which he sat in the airplane. After flying at levels of 1,100 and 300 feet, it was found that 400 feet altitude was the most satisfactory. At 400 feet, the angle of vision was still sufficient for the counter to cover the whole section and distinguish sleds and duffle from fishermen. It was also possible to distinguish fishermen behind windbreaks.

A study of Plate 1 shows how the fishermen appeared from a height of approximately 400 feet. The number of fishermen were recorded on an Adams Hand Tally.

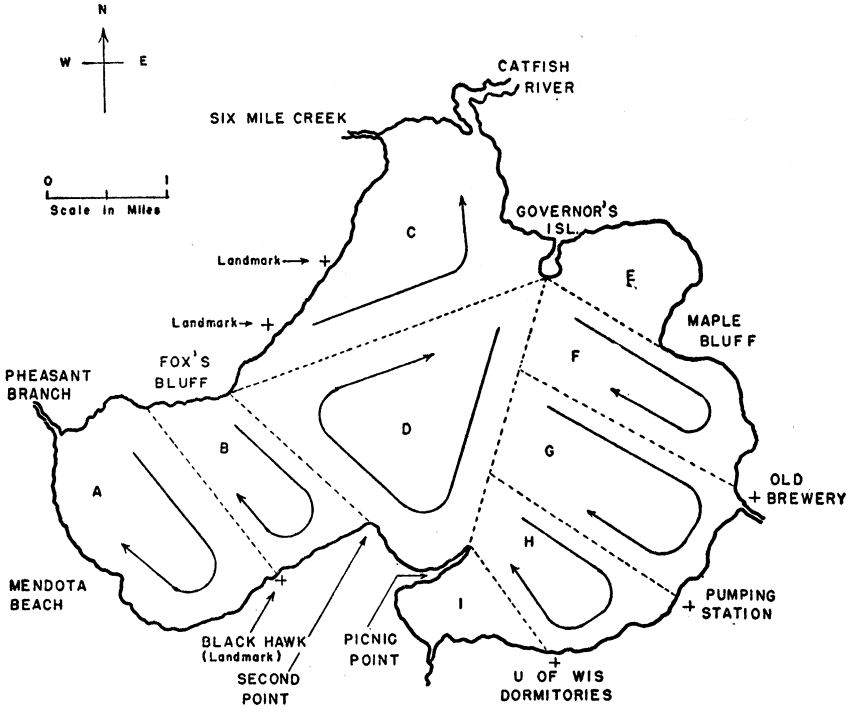


FIG. 1. Outline map of Lake Mendota showing general plan of counting fishermen from the air.

Table 1 is a tabulation of the days on which the flights were made, the time spent in the air, the cost of flying per day, and the number of fishermen counted per day. To count a total of 6,605 fishermen on a lake of 9,730 acres on six different dates required 280 minutes or 4.66 hours at an approximate cost of $0.153 per minute or $9.24 per hour.

TABLE 1. TABULATION OF DATES FLOWN, COST OF FLYING, AND NUMBER OF FISHERMEN COUNTED.

| DATE | TIME (minutes) | COST | NUMBER OF FISHERMEN |
|---|---|---|---|
| Jan. 25 | 70 | $10.73 | 1,136 |
| Jan. 26 | 45 | 6.90 | 1,697 |
| Feb. 22 | 40 | 6.13 | 1,062 |
| Mar. 2 | 40 | 6.13 | 773 |
| Mar. 9 | 60 | 9.20 | 1,614 |
| Mar. 11 | 25 | 3.83 | 323 |
| TOTALS | 280 | $42.92 | 6,605 |

Seventy minutes flying time was used in covering Lakes Mendota, Wingra, Monona, Waubesa and Kegonsa on January 25. Our plans at the beginning of the experiment were to count the fishermen on the Madison lakes. Two fishermen were seen on Lake Wingra, three on Lake Monona, and none on the other lakes. Consequently, the rest of the counting was confined to Lake Mendota. On March 9, about 20 minutes were spent in photographing fishermen. An average of 40 minutes per day at a cost of $6.13 gave adequate time for counting the fishermen on Lake Mendota.

The method admittedly had some errors but in all probability it is as accurate as a ground count on such a large area and much less expensive.

## CREEL CENSUS BY A CARD METHOD

Originally a man-to-man creel census on the lake was instigated by members of the conservation department. This was a laborious and time-consuming process and it soon became apparent that several important facts would be lacking from this type of survey. No information could be obtained on the number of fishermen catching their limit, the total number of hours fished per man, or the total

number of fish caught per man. Lake Mendota has too many points of exit which are used by the fishermen to make any system of checking these points feasible. In a search for a more thorough method of obtaining this data, it was found that Wandell (1946) used a card system to census game hunters in Massachusetts, Connecticut and Oregon. Wandell attributed the accuracy of such a card method to the simplicity of the card and the fact that no signature was requested on the card.

A similar card with certain modifications was constructed for use on Lake Mendota (Plate 2). A short pencil was attached to the card and a thumbtack anchored with scotch tape was inserted through the card. The following questions were asked on the cards: How many fishermen in your party? How many fish did you catch? How many hours did you fish? What kind of fish did you catch?

The cards were placed under the windshield wipers of the fishermen's cars (Plate 3). After the fisherman had filled out the card, he tacked it to the nearest tree or post (Plate 4). The cards were distributed about 10:00 A.M. on one day and were picked up on the following morning. Cards were distributed on week days as well as holidays and Sundays. Approximately 48 man-hours were expended in conducting this study excluding the time spent in preparing the the cards and tabulating the data.

Table 2 presents a tabulation of the data collected by this card method. In this study, 1,024 cards were placed on the fishermen's cars. A total of 923 or 90.1 per cent of the cards were returned. The number of fishermen contacted by this method was 2,287 or 2.5 fishermen for each car that was tagged. It was found that 262 fishermen or 11.5 per cent of the number contacted caught their limit of 25 perch. The per cent of fishermen catching their limit was found to be the most variable factor during the course of the census.

A total of 13,545 man-hours were fished by this group in which time they caught 24,909 fish. This represents 1.84 fish caught per man-hour. The number of fish caught per man-hour was found to remain fairly constant on all days on which the creel census was conducted. The average fisherman spent 5.9 hours fishing per day, in which time he caught 10.9 perch. The average fisherman stayed on the ice a little longer on week-ends than on week days.

It is interesting to attempt an estimation of the total perch removal per day by multiplying the number of perch caught per day by the

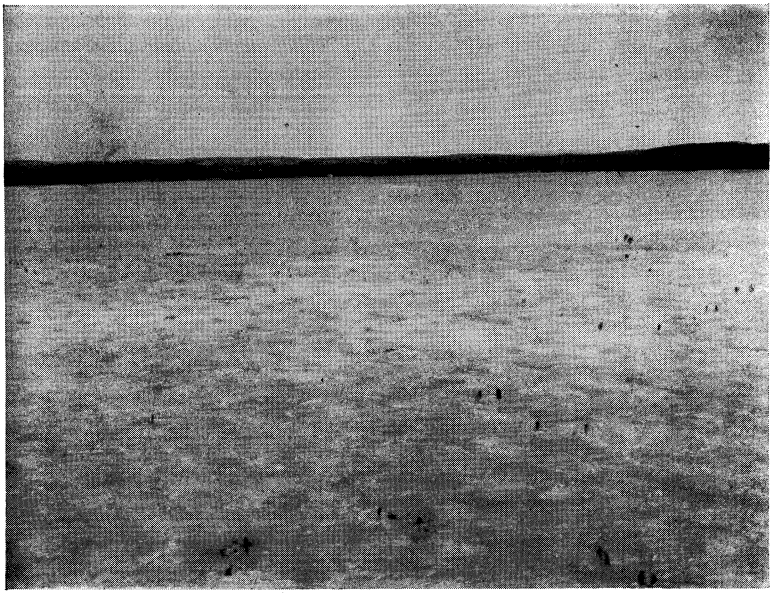

PLATE 1. View of fishermen on Lake Mendota taken from the air.

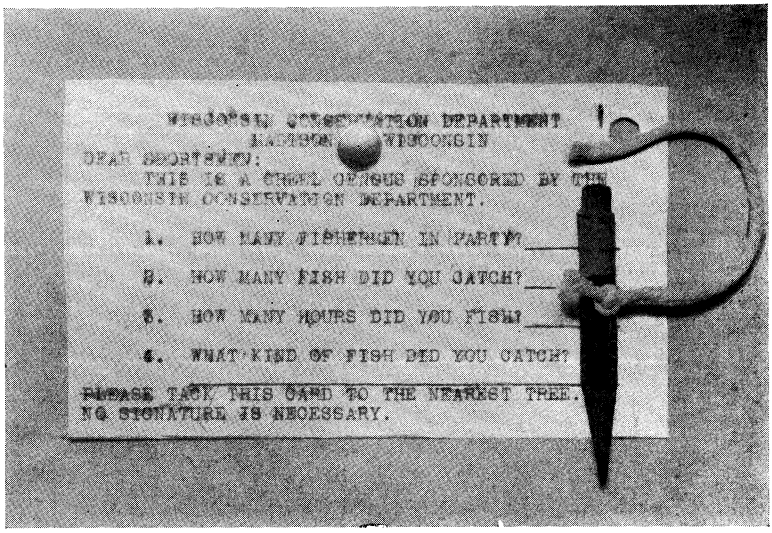


PLATE 2. Sample of a 3 x 5 mimeographed card which was placed under the windshield wiper of the fisherman's car.

PLATE 3. A parking lot near Maple Bluff showing the creel census cards on the fishermen's cars.

PLATE 4. A tree in the parking lot area showing the completed cards placed there by the angler.

TABLE 2.
TABULATION OF DATA COLLECTED FROM CREEL CENSUS CARDS

| | Feb. 13 Thurs. | Feb. 14 Fri. | Feb. 16 Sun. | Feb. 22 Sat. | Feb. 25 Tues. | Feb. 28 Fri. | Mar. 2 Sun. | Mar. 3 Mon. | Mar. 4 Tues. | Mar. 5 Wed. | Mar. 6 Thurs. | Mar. 7 Fri. | Mar. 8 Sat. | Mar. 9 Sun. | Mar. 11 Tues. | Mar. 12 Wed. | Total and/or average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of cards distributed..... | 39 | 45 | 99 | 89 | 30 | 36 | 79 | 27 | 61 | 73 | 70 | 63 | 100 | 110 | 68 | 35 | 1024 |
| No. of cards returned..... | 35 | 38 | 91 | 80 | 29 | 31 | 72 | 26 | 53 | 69 | 68 | 51 | 92 | 97 | 60 | 31 | 923 |
| Per cent of cards returned..... | 89.7 | 84.4 | 91.9 | 89.9 | 96.7 | 86.1 | 91.1 | 96.3 | 86.9 | 94.5 | 97.1 | 80.9 | 92.0 | 89.1 | 88.2 | 88.6 | 90.1 |
| No. of anglers contacted ..... | 84 | 75 | 258 | 222 | 55 | 69 | 189 | 50 | 125 | 159 | 167 | 119 | 252 | 275 | 121 | 67 | 2287 |
| No. of anglers per car..... | 2.4 | 2.0 | 2.84 | 2.8 | 1.9 | 2.2 | 2.6 | 1.9 | 2.4 | 2.3 | 2.5 | 2.3 | 2.7 | 2.8 | 2.0 | 2.2 | 2.5 |
| No. of limits taken..... | 10 | 7 | 51 | 7 | 5 | 20 | 31 | 2 | 15 | 7 | 16 | 3 | 34 | 31 | 13 | 10 | 262 |
| Per cent of anglers taking limit. | 11.9 | 9.3 | 19.8 | 3.2 | 9.1 | 29.0 | 16.4 | 4.0 | 12.0 | 4.4 | 9.6 | 2.5 | 13.5 | 11.3 | 10.7 | 14.9 | 11.5 |
| No. of man-hours fished..... | 433 | 352 | 1605 | 1279 | 290 | 402 | 1038 | 260 | 685 | 945 | 1037 | 612 | 1697 | 1867 | 657 | 386 | 13545 |
| No. of fish caught..... | 691 | 623 | 3141 | 1919 | 855 | 998 | 2018 | 550 | 1269 | 1850 | 1956 | 1322 | 2929 | 2493 | 1308 | 987 | 24909 |
| Fish per man-hour..... | 1.60 | 1.77 | 1.96 | 1.50 | 2.95 | 2.48 | 1.94 | 2.12 | 1.85 | 1.96 | 1.89 | 2.16 | 1.73 | 1.34 | 1.99 | 2.56 | 1.84 |
| Ave. fishing day (hours)..... | 5.2 | 4.7 | 6.2 | 5.8 | 5.3 | 5.8 | 5.5 | 5.2 | 5.5 | 5.9 | 6.2 | 5.1 | 6.7 | 6.8 | 5.4 | 5.8 | 5.9 |
| Ave. No. of fish caught..... | 8.2 | 8.3 | 12.2 | 8.6 | 15.5 | 14.5 | 10.7 | 11.0 | 10.1 | 11.6 | 11.7 | 11.1 | 11.6 | 9.1 | 10.8 | 14.7 | 10.9 |

total number of fishermen counted from the air for that particular day. Unfortunately, only four such correlations can be made. On Saturday, February 22, the total number of fish removed must have been in excess of 9,133 fish or about one fish per acre. At least one-third more could be added to the number of fishermen counted from the air since the flights were made in the morning and did not account for the number of new fishermen on the ice in the afternoon. On Sunday, March 2, the number of fish removed must have been in excess of 8,271. The number of fish removed on Sunday, March 9, must have been in excess of 14,687; and on Tuesday, March 11, in excess of 3,488.

Unfortunately, time was not available to census all fishermen on any given day. Hence, this is a preliminary report developing a method of checking the anglers' catch which will be undertaken more intensively next season. A more complete picture of the anglers' catch will be obtained when cards are distributed on days chosen at random throughout the ice fishing season.

## Length, Weight, and Age of Fish Caught

A total of 339 fish from the fishermen's creel were weighed, measured, and scales were taken for growth analyses. One hundred and fifteen measurements were taken in 1946 and the remainder were taken in 1947. The measurements were taken at random as a field crew contacted the fishermen on the lake.

TABLE 3. Correlation of the Age-groups with the Average Total Length and Weight of Perch Caught

| Age | Number of Fish | Total Length (inches) | Weight (pounds) |
|---|---|---|---|
| III | 30 | 7.4 | 0.18 |
| IV | 91 | 8.4 | 0.29 |
| V | 144 | 9.3 | 0.40 |
| VI | 57 | 9.9 | 0.48 |
| VII | 16 | 10.4 | 0.59 |
| VIII | 5 | 11.0 | 0.62 |

Table 3 correlates the age-group with the average total length and weight of the perch examined. The age-groups represented in the anglers' catch ranged from three to eight years, but 69 per cent of the perch taken were in the four- and five-year age-class. (Figure 2).

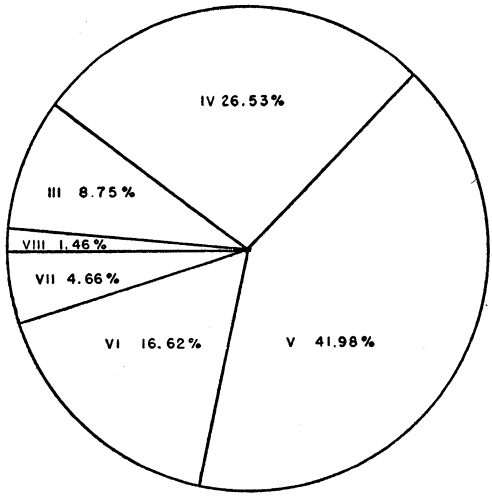


FIG. 2. Percentage of the age groups of perch caught by anglers.

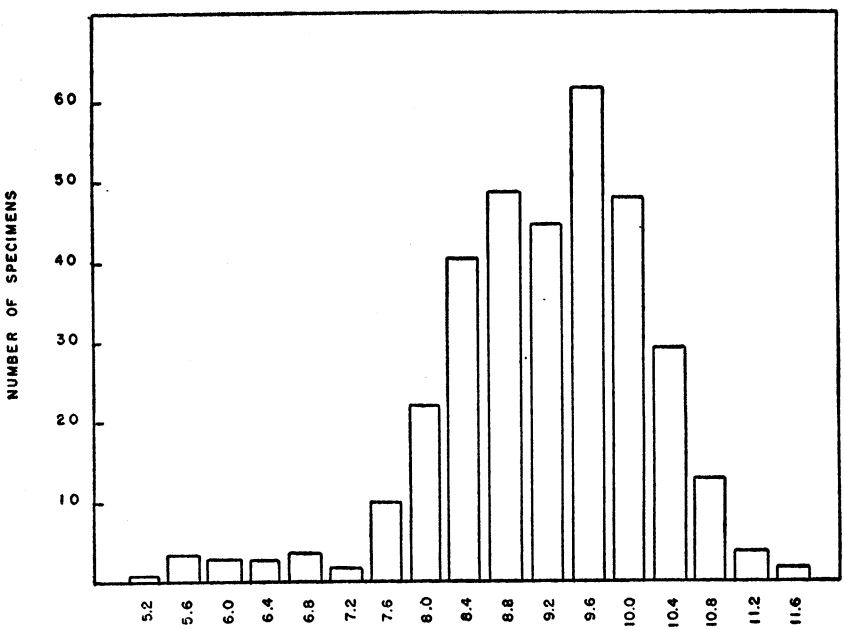


FIG. 3. Length frequency histogram of perch caught by anglers

The length frequency distribution is shown in Figure 3. The perch ranged from 5.2 inches to 11.6 inches with the majority of those caught being quite uniform in size. The mean total length of the perch examined was 9.2 inches. Pearse and Achtenberg (1920) recorded the length of 499 adult fish captured by hook and line in the winter time and by gill nets during the summer months. The mean length listed by them was 166 mm. or 6.5 inches. Hasler (1945) listed a mean total length of 202 mm. or 8.0 inches from 188 adult perch taken by gill net. The perch taken by Hasler were smaller and were younger than the majority of those taken by the angler. This was no doubt because of gill-net selectivity. The data presented tend to indicate an increase of about 2.7 inches in the length of a catchable fish over the past 27 years. The apparent increase in length might be attributed to a reduction in the perch population caused by an infection from a sporozoan, *Myxobolus*. This mortality was first observed in the

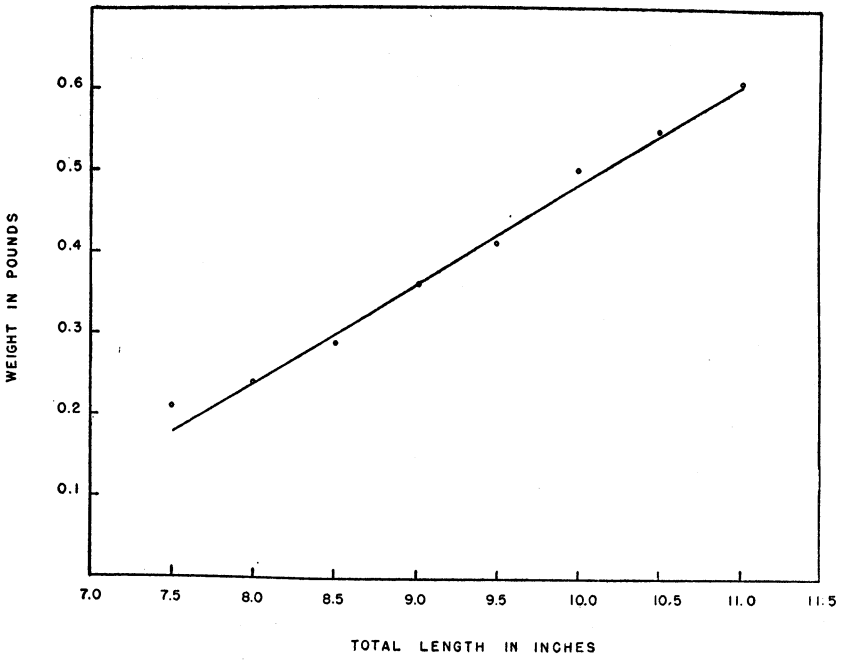


FIG. 4. Correlation of length and weight of perch caught by anglers.

early summer of 1939 and has continued every summer since that time. No reliable estimates are available as to the number of perch killed but one city official of the Madison Parks Department thought that about ten tons of perch were removed from an area covering ten city blocks in one week during last summer's removal operations.

Figure 4 correlates the total length with the weight of the perch caught. The average fish caught weighed 0.38 pounds, and the majority ranged from 0.20 pounds to 0.60 pounds.

## SUMMARY

1. Perch fishermen on Lake Mendota were counted from the air. A creel census was conducted on the ground by means of cards which were placed under the windshield wipers of the fishermen's cars and were later picked up after they had been filled out by the angler.

2. To count a total of 6,605 fishermen from the air on a lake of 9,730 acres on six different dates required 280 minutes or 4.66 hours at an approximate cost of $0.153 per minute or $9.24 per hour.

3. By using the card method in checking the creel, it was found that the average fisherman spent 5.9 hours fishing per day in which time he caught 10.9 perch or 1.84 fish per man-hour.

4. By computing the total yield of the lake for the days on which air counts were made, it was found that about one fish per acre was removed per day on week-ends and holidays. Probably only one-third fish per acre was removed on week days.

5. The mean total length of 339 perch taken by anglers was 9.2 inches and the average fish weighed 0.38 pounds. Sixty-nine per cent of the perch taken were in the four- and five-year age class.

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# THE BLACK BEAR IN EARLY WISCONSIN

A. W. SCHORGER

The presence of a black bear (*Euarctos a. americanus*) was second only to the approach of an Indian war party in its power to raise the early settlers to a high pitch of excitement. The ferocity of this animal is purely traditional but this fact did not prevent the bear from being slain as "vermin" at every opportunity. The wild bear is a very wary animal and is not to be feared unless wounded.

It was at one time of considerable economic importance. The meat, usually prepared "like pork,"[1] was eaten extensively though there are wide differences of opinion as to its sapidity. The skins were used locally for bedding and clothing, and were exported in large quantities for the use of the British and Russian guards. The fat, or oil, found wide use for culinary purposes, the French in America considering it a worthy substitute for olive oil. Bartram says that his hunter killed a bear in Florida that yielded "15 or 16 gallons of clear oil . . . his fat, though I loathed the sight of it at first, was incomparably milder than hogs-lard, and near as sweet as oil of olives."[2]

Muir, who lived in Marquette County, Wisconsin, from 1849–60, mentions that some of the enterprising neighbors drove to the pine regions every fall to hunt: "Their loads consisted usually of half a dozen deer or more, one or two black bears, and fifteen or twenty bushels of cranberries; all solidly frozen. Part of both the berries and meat was usually sold in Portage; the balance furnished their families with abundance of venison, bear grease, and pies."[3]

The Indians had great faith in the oil as an alleviative ointment. Kalm mentions that the Canadian Indians daubed all of the exposed parts of the body with it to protect them from the bites of gnats and that, "With this oil they likewise frequently smear the body, when they are excessively cold, tired with labour, hurt, and in other cases, and makes the body pliant, and is very serviceable to old age."[1a]

When Radisson was hunting with the Indians in northern Wisconsin

the winter of 1661–62, he and his companions killed in two and one-half months so great a number of bears that for "a thousand moons we wanted not bear's grease to annoint ourselves, to runne the better."[4]

The Europeans used the oil extensively for dressing the hair. Pennant wrote: "Bear's grease is in great repute in Europe for its supposed quality of making the hair grow on the human head. A great chymist in the Haymarket in London used to fatten annually two or three bears for the sake of their fat."[5] The demand for the oil for this purpose continued to the end of the last century. John Perry of Algoma, Wisconsin, killed a bear in the fall of 1867 for which he obtained $80.00 exclusive of the meat, this being left in the woods. He obtained $10.00 for the hide, $64.00 for eight gallons of pure, strained oil, and $6.00 for two gallons of crude oil.[6] In 1872 a Coloma, Waushara County, hunter killed a bear that yielded "ten gallons of hair oil."[7] Some bears became obligingly fat. One killed in Waushara County in the fall of 1875 is stated to have yielded 212 pounds of fat, the latter being five inches thick on the rump.[8]

On the other side of the ledger was the destruction of livestock and corn. There are statements in the early literature that the bear is strictly a vegetarian; however, the Wisconsin settlers had the usual experience of loss of hogs, sheep, and calves, particularly when the bears were emigrating. The bear frequently, if not generally, begins to eat its prey before killing it, hence the loud squealing of a pig when caught. The habit was mentioned by Byrd[8.1] in 1728 and subsequently by Sibley.[9] Godman wrote: "When the bear seizes a living animal he does not, as most other beasts do, first put it to death, but tears it to pieces and devours it, without being delayed by its screams or struggles, and may actually be said to swallow it alive."[10] This trait has been rarely mentioned by subsequent naturalists. There are several references to it in the Wisconsin newspapers. For example, the following incident occurred in Dunn County: "Last week Wednesday [September 8, 1880], a fine 300 pound hog belonging to Mr. R. Furbur, of Sherman, while feeding in the woods, was attacked by a bear and pretty roughly handled. . . . The hog returned 'all broke up,' as the saying goes, and evidently mortally wounded. Bruin had taken pork enough to make a square meal from all appearances. Mr. Furbur was obliged to kill the hog and thereby end its misery."[11] Stephenson was living in eastern Wisconsin when he watched the killing of a bear

that had captured a pig. The latter ran away, "though the half of one side was nearly torn off it."[11.1]

## Original Range

The black bear was to be found on occasion at least in every county in the state. It was not common south of a line drawn from Milwaukee westward to the Mississippi River. This region, consisting largely of prairies and oak openings, was penetrated during the bear irruptions. A gentleman who had resided at Racine for seven years, writing in 1844, stated that he had heard of but one bear in the neighborhood during that period.[12] Le Claire[13] mentions that there were very few in the Milwaukee region during the period 1800–09. Ficker [14] came to the town of Mequon, Ozaukee County, the winter of 1848–49. There were no bears present at that time but they were to be found farther north. However, several were killed subsequently in the county.

Mukwonago, Waukesha County, according to Vieau,[15] who was born in Milwaukee in 1820, is a corruption of *mukwa* (bear) and *onahko* (fat), and means fat bear. He states: "This was a popular place for hunting black bears; the greatest in the West, I used to be told. I have eaten of many that came from there. When the Indians of this region wanted to have a big feast, they would send young hunters thither, from all along the lake shore even as far off as Kewaunee."

Another version has been recorded by Camp[16] who came to Mukwonago, the "place of the bears," in 1836. An old Indian told him that long ago, during a rainless year, there was locally a heavy crop of white oak acorns. Large numbers of bears assembled there and the Indians killed over eighty. It is difficult to distinguish fact from tradition. Mukwonago has also been translated as *ladle*[17] and *bear-lair*.[18] The species was uncommon when Chapman came to Waukesha in 1841. He wrote: "Occasionally a bear or grey wolf, by some depredation, gave us notice of his presence."[19]

The killing of a bear in the town of La Fayette, Walworth County, in 1836, was considered an event.[20] Hiram Brown came to the town of Albany, Green County, in March, 1842. In August, 1844, he killed the first bear known for that section.[21] In the winter of 1839–40, some Winnebagoes camped north of Watertown, Jefferson County. They took about $100 worth of pelts including bear.[22]

Bears are said to have been plentiful in the towns of Dunn and Verona, Dane County, when first settled.[23] Major Tenney came to Madison in 1845, at which time "bears were common."[24] In September, 1899, workmen excavating a lagoon in Tenney Park, Madison,

unearthed an old bear trap.[25] Published records of bears killed during the early years show that bears were not common at Madison, or elsewhere in the county, except during the irruptions.

Rodolph, who came to Lafayette County in 1832, stated that there was "once in a while a bear."[26] Another settler, S. E. Roberts, who arrived in the county in 1846, mentioned that "now and then a black bear would stray in from the northern part of the state in fall."[27]

While at Prairie du Chien in February, 1834, Hoffman learned that hunters had to go a distance from the fort to secure bear and other large game. North of Mineral Point, Iowa County, "the tracks of bears and other wild animals were to be seen on every side."[28] Hollman came to Platteville in 1828 when bear and other large game were to be found in "astonishing quantities."[29] Bears were found occasionally at Prairie du Sac, Sauk County,[30] in 1840, and in Richland County[31] when first settled.

The northern three-fourths of the state contained a large number of bears except along Lake Superior. Schoolcraft, in 1820, found it a "country almost destitute of game."[32] In 1856 it was stated that game had become exceedingly scarce here, there being only "a few bears, rabbits, and porcupines and some partridges."[33] However, the missionary James Peet, while at Bayfield wrote in his diary on June 23, 1858: "Bears are very numerous in the woods on this part of Lake Superior now."[34]

Verwyst[35] came to Hollandtown, Brown County, in 1848 when bears were plentiful. They were abundant near Kaukauna, Outagamie County, in 1853.[36] Allouez[37] wrote in February, 1677, that a Potawatomie Indian was killed by a bear near Green Bay. During the winter his friends and relatives made war on the bears with such success that over 500 were slain. It should be borne in mind that the early French were fond of dealing in large, round numbers. Carver,[38] in 1766, found bears and deer very numerous on the upper Fox River.

When Le Seur[39] went up the Mississippi in 1700, he noted the numerous caves near Lake Pepin to which the bears retreated in winter. This region remained favored by bears. The family of W. W. Cooke[40] settled near Gilmanton, Buffalo County, in 1856. During the first ten years his father killed 16 old bears and captured five cubs alive in Beaver Valley. In the fall of 1857 he killed two of a drove of six bears found in a thicket.[41]

## Abundance

The black bear at times and places throughout its range has been

very numerous. There may be a concentration due either to abundance of food or to emigration. Lawson,[42] (1714), states that 500 bears were killed in two counties in Virginia during one winter. Charlevoix[43] mentions that during the winter of 1720–21, over 400 bears were killed on Point Pelee, northern shore of Lake Erie. This appears to have been an emigration.

During pioneer times the Kanawha Valley contained heavy stands of beech. According to Atkinson, "The heavy beech masts never failed to attract wild-turkeys, pigeons, and bears, in numberless flocks, and companies, every Fall."[44] The bears became fat and unwary, and the pioneer hunters came every fall to secure a supply of bear's meat for the winter. Benjamin Morris killed 13 bears in one afternoon a few miles above Charleston, West Virginia, and this was not considered an exceptional feat.

The valleys of the Big Sandy and Guyandotte rivers in West Virginia were also famous bear regions due to the abundance of oak and chestnut trees. During the years 1805, 1806, and 1807, hunters took 8,000 bear skins in the districts traversed by these streams.[45] Cuming was at Oldtown Creek, on the Ohio, July 25, 1807, when he wrote: "Two or three years ago when bear skins were worth from six to ten dollars each, he [Buffington] and another man killed one hundred and thirty-five bears in six weeks."[46]

An Indian from Fond du Lac (Superior, Wisconsin) told Schoolcraft[47] in July, 1828, that the 54 hunters in his band of 220 persons killed 994 bears during the fall and winter of 1827–28. There was undoubtedly an influx of bears in the fall of 1827 to have permitted the slaughter of so large a number. Another emigration seems to have taken place in the same region four years later, the fall of 1831. Lt. Allen,[48] in June, 1832, was informed by Mr. Abbott, a trader from Leech Lake, Minnesota, that the returns for the year were "principally bears." William A. Aitkin, of Fond du Lac, who was in charge of nine trading posts in Minnesota, informed Allen that "the proportion of bear skins this year being very great at most posts west of Fond du Lac."

The returns from the northern trading posts in Wisconsin do not show that the bear was numerous. While stationed at Lac du Flambeau the winter of 1804–05, Malhiot[49] acquired only 69 large and 18 small bearskins. Curot[50] secured 13 skins at the Yellow River post the winter of 1803–04. The shipment of furs from Green Bay made by Grignon[51] in June, 1815, contained the skins of 12 bears and five

cubs; and that of July, 1816, 85 bearskins at $5.50 each, 20 cub skins at $2.75, and 24 bearskin covers at $1.50. Nearly a half century later, 1859, the skins were still quoted at $2.50 to $5.00 at Eau Claire.[52] In 1887 the skins brought $9.00 to $18.00, and the oil $4.00 a gallon.[53]

It is not possible to estimate the primitive bear population of the state wtihout making a wild guess; however, the following data show that the species must have been abundant in the central portion of the state:

1854. Two men killed 8 bears in one day near the Wolf River.[54]
1855. A band of hunters returned from Richland County with 10 bears and a large number of deer.[55]
1856. Nine men killed 13 bears in one day in Waupaca County.[56]
1856. Within a period of two weeks, 17 bears were killed within eight miles of New London.[57]
1858. J. F. Stone and Charles Buckman, the famous hunters of Eau Claire County, trapped 32 bears from August 15 to the latter part of October. Only one day in every four was devoted to this pursuit.[58]
1858. Ambrose Hammond killed five old bears and four cubs in three days in Portage County.[59]
1858. Daniel Weed killed seven bears in two weeks in a patch of blackberries covering one half of a square mile four miles south of Mosinee.[60]
1858. "Bear-skin robes will be plenty here [Stevens Point] next winter; some forty or fifty have been killed in the vicinity the two last weeks."[61]
1858. In the town of Waupaca, Waupaca County, eight bears were killed in one day the end of September.[62]
1864. Four hunters, including J. Livermore, killed 14 bears in the town of Bridge Creek, Eau Claire County.[63]
1868. A hunter at Knowlton, Marathon County, killed 14 bears during the fall season.[64]
1870. Three men in two days killed five bears weighing from 310 to 420 pounds in Portage County.[65]
1874. Charles Martin and three companions, camped near Hamilton's Falls, killed 12 bears and 11 deer in seven days. Six of the bears were killed in less than five minutes.[66]
1875. A party of hunters in Barron County in two days saw 29 bears and killed four of them.[67]
1875. Four hunters in Eau Claire County killed 26 bears and 107 deer in two and one-half months.[68]
1875. "A party of hunters on Otter Creek [Dunn County] saw nineteen bears in one day and killed five of them."[69]
1877. Four hunters killed 26 bears and 118 deer on the North Fork of the Eau Claire River from September 1 to December 31.[70]
1878. Charles Martin and James Terry camped on the North Fork of the Eau Claire River. "It was late in September. One morning

we went out and Mr. Martin killed two bear. . . . About five o'clock in the afternoon we went out again and I ran into seven bear, three old ones and four cubs. Martin killed an old bear and two cubs and I killed two old bear and the other two cubs . . . That fall from the middle of September to the middle of December, Martin and I killed twenty bear and one hundred deer."[70a]

1880. Three hunters, in approximately three weeks, killed 28 bears at Spaulding, Jackson County.[71]


FIG. 1. Dates of the last appearance of bears in the southern counties. The present range (1946) was furnished by Walter E. Scott, Wisconsin Conservation Department.

1887. During the fall season the Hicks brothers of Sumner, Barron County, killed 32 bears.[72]

1896. "There have been fifty black bear shot or trapped in this county [Burnett] the past year."[73]

The Winnebagoes, living from Stevens Point to La Crosse, according to Paquette,[74] were taking only a few bears by the year 1887. A general picture of the decline of the bear in the southern half of the state can be obtained from Figure 1 showing the present range and the last dates of its appearance.

The bear is still common in the state. It is estimated that 80 bears were killed in each of the two counties, Bayfield and Douglas, during the season 1945–46. The annual kill in the state during recent years is given in the table below.

TABLE 1.

ESTIMATED NUMBER OF BEARS KILLED IN WISCONSIN*

| Season | Number of bears |
|---|---|
| 1934–35 | 216 |
| 1935–36 | No open season |
| 1936–37 | 273 |
| 1937–38 | 157 |
| 1938–39 | 186 |
| 1939–40 | 438 |
| 1940–41 | 314 |
| 1941–42 | No open season |
| 1942–43 | 647 |
| 1943–44 | 684 |
| 1944–45 | 489 |
| 1945–46 | 575 |

*Data furnished by the Wisconsin Conservation Department.

## HUNTING

The Indians held the bear in great veneration and offered profound apologies for taking its life. Calkins states that the Wisconsin Chippewas performed a singular ritual prior to hunting the bear in winter. The chief medicine man addressed a stuffed bear cub as follows:

"O, my brother! we are very hungry; and we are on the point of starving, and I wish you to have pity on us, and tomorrow when the young men go out to hunt you, I want you to show yourself. I know very well that you are concealed somewhere close by my camp here. I give you my pipe to smoke of, and I wish you would have pity on us, and give us your body that we may eat and not starve."[75]

The Indians had several methods for securing bears, the hunting being confined largely to the fall and winter months. A den tree was located by the tracks in the snow leading to it, or by the claw marks

on the trunk. Penicaut[76] relates that at Mankato, Minnesota, the winter of 1701–02, the Indians placed against the den tree a small tree that would extend to the hole. This a man ascended and tossed burning, dry wood into the opening to drive out the bear that was then shot. This method was employed by all of the Indians from the Mississippi River to the Atlantic Ocean. Birch bark when available was the preferred combustible material. Du Pratz[77] mentions that the Indians on the lower Mississippi climbed a tree adjacent to the den tree and hurled burning reeds into the opening.

The trees were sometimes felled after the introduction of steel axes. Henry,[78] in Michigan, worked with an Indian family for a day and a half in order to fell a tree with light axes.

The bear was also tracked to ground dens and shot. While Henry[78a] was at Chequamegon Bay, Wisconsin, the winter of 1765–66, the Indians followed a bear to its den from the very slight depressions remaining after later snows had covered the tracks made early in the winter.

Deadfalls made of logs were used commonly for taking the bear. This method was in use as late as 1883 in Wood County.[79] When Schoolcraft[32] ascended the Ontonagon River in June, 1820, the Indians took a bear measuring five feet in length from a deadfall. Copway[80] mentions the use of this trap "in the immediate vicinity of Lake Superior."

Kohl[81] has described a trap that he examined at Lac du Flambeau. A corridor of posts was driven into the ground and covered with branches and thorns to prevent the bear from securing the bait, usually meat, except from the entrance. In front of the latter was balanced a log, weighted at both ends by logs and stones. This log, "l'assommeur" (killer), was placed at such a height that the bear had to stoop to reach the bait. A trigger released the weighted log allowing it to fall on the bear's spine. Since the Indians as well as the Canadians had names for all the parts of the deadfall, Kohl believed that it was an invention adopted by the Europeans. The deadfall was in use by the Indians at least by 1684, the year that La Hontan[82] came to Canada. Detailed descriptions and illustrations of the deadfalls used by modern Indians are given by Cooper,[83] and by Mason.[84] The trap used by the Minnesota Chippewas is described briefly by Densmore.[85] They visited the deadfall every two days.

The majority of white hunters used steel traps. Prof. Moore[86] states that there was a ridge covered with white oaks near his home in Ke-

waunee County, Wisconsin, where the bears fed prior to denning. The bait used in trapping consisted of a quarter of venison that was soaked in the presence of codfish for about two days. This was dragged across the ridge for about one half a mile and the traps set on this trail. Usually about four traps, baited with either fresh fish, beef, or venison, were set. Each year 10 to 12 bears were caught during a period of ten days.

## Size and Weight

There are few data on the size and weight of Wisconsin bears that carry the stamp of full reliability. Cory[87] states that adult males from Wisconsin will measure 60 to 70 inches in length and weigh 250 to 350 pounds. While there are a large number of statements on size and weight, all too frequently the round numbers given betray that these were estimates. The manner in which the measurements were taken is usually not stated. The large measurements sometimes given were without doubt made from the tip of the nose to the claws of the hind feet with the legs extended. This was a common procedure by hunters and was even followed by Cory. A Florida bear measured "six feet two inches from nose to tail" and "eight feet two inches from hind claw to nose."[88]

The best approximate weights of bears of various age classes, based on field specimens, were obtained by Gerstell[89] and are given in Table 2.

TABLE 2.

Estimated Average Weights of Black Bears

(Figures pertain to late fall)

| Age | Estimated Average Pounds | Estimated Range Pounds |
|---|---|---|
| Cubs (10 months) | 55 | 30 to 80 |
| Yearlings (22 months) | 105 | 80 to 130 |
| 2-year-olds (34 months) | 155 | 125 to 185 |
| 3-year-olds (46 months) | 205 | 180 to 240 |
| 4-year-olds (58 months) | 255 | 215 to 295 |
| 5-year-olds (70 months) | 305 | 255 to 350 |
| Older Animals | (Up to 600 pounds) | |

When food is abundant individuals will be found that exceed the ranges given in the table. Beatty[90] weighed a pair of cubs, approximately ten months of age, of which the female weighed 80 pounds

and the male 120 pounds. He states that adults do not attain full size until the sixth or seventh year.

The average loss by hog-dressing, found by Gerstell,[89] was 14.1 per cent of the live weight. Females lost less than the males. Schoonmaker[91] states that a bear weighing 475 pounds after being shot lost 90 pounds, or 18.9 per cent, by dressing. The large bear mentioned by Gordon[92] lost 15 per cent by dressing.

Some exceptionally large individuals have been recorded throughout the range of the black bear. One killed in Pennsylvania was nine feet in length, and had a live weight of 633 pounds and 538 pounds hog-dressed.[92] An animal caught in July, 1921, on Anticosta Island, weighed 635 pounds in September when received by the New York Zoological Society. Hornaday[93] mentioned that it soon gained 50 additional pounds.

A Yosemite bear weighed by Beatty[90] tipped the scales at 680 pounds. One killed in Oklahoma[94] is stated to have weighed 720 pounds, and another killed in Louisiana[95] 671 pounds. The latter measured 9 feet, 2.5 inches from the "pad of hind foot to tip of nose" and 7 feet, 7.5 inches from "nose to root of tail."

A black bear, reported to have weighed 900 pounds, was killed by M. E. Musgrave of the Biological Survey on the southern slope of Navajo Mountain, Arizona, in December, 1921.[96] H. H. T. Jackson, U. S. Fish and Wildlife Service, recently investigated this record with care. It appears that no weight or measurements were taken, but he is inclined to believe that the estimated weight was aproximately that given. He estimated from a photograph of the skin that the latter measured "about 8 feet from the tip of nose to tail."[97]

A bear killed at Randall, Morrison County, Minesota, in the late nineties, measured "seven feet one inch from the nose to the tip of the stub tail." Pederson[98] states that he could not weigh the animal since the maximum capacity of his scales was 350 pounds.

Data on some Wisconsin bears, where the weights and lengths (tip of nose to end of tail) seem to have been taken with care, are given in Table 3.

TABLE 3.
LARGE WISCONSIN BEARS

| YEAR | LOCALITY | WEIGHT Pound | LENGTH | REFERENCE |
|---|---|---|---|---|
| 1844 | Aztalan | 609 | — | 99 |
| 1847 | Fond du Lac | — | 6 ft. 2 in. | 100 |
| 1862 | Baraboo | — | 7 ft. 4 in. | 101 |
| 1863 | Rock Falls | 610d* | — | 102 |
| 1863 | La Crosse | 469d* | — | 103 |
| 1864 | Prescott | 600 | 7 ft. 6 in. | 104 |
| 1873 | Appleton | 460 | 6 ft. 2 in. | 105 |
| 1874 | Sturgeon Bay | 583 | — | 106 |
| 1881 | Prescott | — | 6 ft. 7.75 in. | 107 |
| 1882 | Elroy | 519 | — | 108 |
| 1883 | Wausau | 536 | — | 109 |
| 1885 | Brule | 515d* | — | 110 |
| 1885 | Stevens Point | 802½ | — | 111 |
| 1888 | Oconto | — | 7 ft. 4 in. | 112 |
| 1895 | Prentice | — | 6 ft. 8 in. | 113 |

*d, dressed

Some large bears still exist in the state. One weighing 436 pounds, with the entrails removed, was killed near Solon Springs by Kenneth Smith.[114] Another killed by Joseph Taber, Jr.,[115] in Ashland County weighed 538 pounds. Vilas County produced a bear, shot by Ben Ballering, that weighed "approximately 550 pounds."[116] George Ruegger[117] was employed by the Conservation Department to kill a bear that was destroying livestock in Douglas County. He has informed me that this bear was killed on September 29, 1941, about 1.5 miles east of Paterson Park. It was a male and weighed 445 pounds hog-dressed. The live weight would have been about 523 pounds, applying a 15 per cent correction for dressing.

## BREEDING

The *belle passion,* according to Charlevoix,[43a] arises in July. Gerstell[89] states that breeding occurs in late June and in July. Bears were observed mating in the Yosemite Valley on June 25.[118] As early as 1840, Emmons[119] gave the gestation period as seven months. It is now generally considered to be seven and a half months, though Brown[120] stated recently that in captivity it is about seven months and one week.

The growth of the embryo is remarkable for slowness. Gerstell[89] found that between November 10 and December 15, i.e., after 70 per cent of the period of development has passed, the embryo is only 0.7 of an inch in length. The cubs when born are 6 to 9 inches in length and weigh 9 to 12 ounces.[121] Wright[122] gives 8 to 18 ounces according to the number in the litter.

Most reference works state that the black bear normally produces young only every other year. The cubs den with their mother during their first winter and are set adrift the following summer. Doubt has been expressed as to the regularity of this breeding period. Wright[122a] thought that this bear in the wild usually bred every year and turned her cubs adrift before denning. He saw an old bear and cubs denning together but once, and a female followed by yearlings not more than a dozen times. Bailey[123] states that it is not positively known whether or not it breeds only in alternate years as is generally supposed. A case is mentioned by Grinnell[118] of an old bear and two cubs in a den while "a small bear, probably her cub of the previous year, was curled up asleep . . . about ten feet from the old bear."

There is sufficient information available to justify the belief that breeding every two years is the normal procedure. Owing to the antagonism of an adult male to cubs, it is wholly improbable that the female would accept him while the cubs were with her. Should the cubs be lost prior to July, she might well mate again.

O. J. Murie, Fish and Wildlife Service, has written to me of his observations as follows:

> "The question about the breeding intervals of bears is a hard one to answer. . . . During the cub's first summer the mother is very truculent toward strange bears, and there are indications, and it is believed by many, that a male bear will kill an unattended cub. This circumstance strongly suggests that the mother does not breed during the summer when she is attended by young cubs. I have not seen any sign of breeding under such circumstances, nor have I seen a mother with cubs tolerate a strange bear near her.
>
> "It is true, furthermore, that females are often seen accompanied by yearlings. I have at least one significant observation. In the summer of 1944, I believe it was, at Fishing Bridge in the Yellowstone, a female black bear was followed for a time by three yearlings. Then they left her for a while and she was seen for a number of days in company with a male. They were indulging in the affectionate scuffling play that takes place at the mating time. Later the three yearlings were back with the mother, at least for a time."

The following information was furnished by Clifford C. Presnall, Fish and Wildlife Service:

"We have kept very close observation of a number of females during a period of five years and to the best of my memory, we we noted only one case where litters were born in successive years, rather than every other year. This particular bear had a litter every alternate year, with the exception of the one case.

"The cubs almost invariably den up with the mother during the first year after birth. . . . One unusually large den which I visited, in fact it was a small cave in a talus slope, had a mother bear in one bed of leaves, and each of her 2 cubs in separate beds several feet away. Our experience in the Sierras led us to believe it was almost necessary for a cub to den up with its mother the first year, otherwise it might have a pretty tough time. We know of several orphans that wandered disconsolately late in the winter, after all the other bears had denned up, and in one case a poor misguided orphan spent a cold and fitful hibernation in the crotch of a tree."

A lone, captive cub seems to be thoroughly capable of taking care of itself on the approach of winter. Prof. Moore[86] had one that dug a den to which it carried cornstalks. A very interesting account it given by Wright[122b] of his cub digging a den and lining it with old clothes; and Johnson[124] mentions that a young bear stole an overcoat with which to plug the entrance to its den.

Bears reared in captivity did not breed until they were three and a half years of age.[125] It remains to be determined if this is the normal age in the wild. Some statements regarding Wisconsin bears indicate that the female may breed at a lower age or that she was exceptionally small. On September 23, 1883, a female and two cubs were killed in Waupaca County: "For the species the game was rather small, the old bear weighing but 146 pounds and the cubs respectively 31 and 26 pounds."[126] On September 17, 1897, there were killed near Wausau a female weighing 160 pounds and her cub weighing 60 pounds.[127] A female that had two cubs was killed in Barron County in September, 1905. She weighed 150 pounds.[128]

Cartwright[128.1] while in Labrador, on August 29, 1779, killed a female black bear having the remarkably low weight of 72 pounds. Her cub weighed only eight pounds, indicating that it was born much later than usual.

The age at which the bear ceases to breed in the wild is not known. The female of a pair 24 years old, in captivity, did not breed during the last three years.[129]

A pregnant female, when disturbed, will sometimes drop her young prematurely. This fact is not mentioned in the life histories of the species. Early in January, 1878, near Oconto, Wisconsin, John Hale

wounded a bear in a "delicate" condition. She escaped leaving behind a very small cub. He followed her two miles, fired a fatal shot and found three more cubs near her.[130] When Kurz was at Fort Union on the Upper Missouri in 1851, he wrote in his journal: "Bears, big with young, if frightened, smoked out or in any manner driven from their dens during their winter sleep, are said to bring forth their cubs prematurely."[131]

The Carrier Indians of British Columbia told Macfarlane that it was extremely rare to kill a hibernating bear with unborn young; and that, "Even when attacked in their winter shelters, they will almost invariably manage to abort their young, if not already in existence, immediately on becoming aware of the near presence of men with deadly intentions."[132]

The young are born in Wisconsin the latter part of January and early in February. The earliest date found was January 16 (1876), the weather being exceptionally mild. On this date, within three miles of Green Bay, a party of hunters "surprised a bear lying on the top of a hollow log. They killed her and on going up to her found two cubs lying beside the log with their eyes just open."[133] There must have been an error in observation for the eyes do not open for 30 to 40 days after birth. The eyes of a pair of cubs taken near Chilton[133.1] the end of February were still closed.

The number of cubs according to Richardson[134] varies from one to five, probably with the age of the mother. Seton[121] states that they are usually two in number, occasionally one, three are common, and four have been recorded several times. Recently Rowan[135] published a photograph of a female with four cubs in British Columbia and mentions a case of a female with five cubs. Quadruplets are recorded by During[135.1] and by Kinney.[135.2]

The records of 284 litters taken from Wisconsin newspapers are given below:

| No. of cubs in litter | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| No. of litters | 43 | 119 | 91 | 27 | 3 | 1 |
| Per cent | 15 | 42 | 32 | 10 | 1 | 0.35 |

The average number of cubs per litter is 2.4 This figure would be higher at birth since it does not take into account the losses that occurred. The three[136] cases of five cubs and one[137] of six appear to be reliable.

## Denning

A snug, dry den is usually selected in a standing or fallen hollow

tree, a cave; or one is prepared underneath a windfall, the base of an uprooted tree, or dug in the ground. Wintering in the open is not uncommon for an old bear. Morse,[138] the winter of 1935-36, even found an old bear and three yearlings hibernating in the open 32 miles north of Duluth.

While hunting with the Indians in Michigan, the winter of 1763-64, Henry[76b] was informed that the female dens in the upper parts of trees to secure the young from the attack of wolves and other animals. The male lodged in the ground. It should be borne in mind that the ground dens made by the females are usually well concealed and not easily found, while the den trees are located readily by the claw marks. Surface dens with cubs are not now uncommon in Wisconsin where there are few large hollow trees remaining to serve as dens. One was photographed recently in Ashland County.[139]

The timber wolf was the chief natural enemy of the bear. A trapped bear was killed and nearly devoured by wolves in Eau Claire County.[140] When wolves were plentiful a majority of the female bears with cubs may have denned in trees, but it is doubtful if all of the dens were ever so located. Examples of the location of Wisconsin dens containing a mother and cubs are given below:

1839. Hollow tree, Milwaukee County.[141]
1852. Hollow tree, Sheboygan County.[142]
1858. Upturned roots of a fallen tree in a cedar swamp, Calumet County.[133.1]
1866. Burrow, Pierce County.[143]
1866. Hole under the roots of a tree, St. Croix County.[144]
1872. Fallen hollow tree, Pierce County.[145]
1874. Hole under a tree, St. Croix County.[146]
1875. Standing hollow tree, Marathon County.[147]
1878. Under a cedar stump in a large swamp, Portage County.[148]
1880. Under a pine tree, Marathon County.[149]
1882. Standing hollow tree, Taylor County.[150]
1884. Hollow tree, Clark County.[151]
1886. Under a windfall, Wood County.[152]
1889. Hollow log, Outagamie County.[153]
1892. Hole under a pine tree, Price County.[154]
1897. "An old bear and three cubs were killed on the Oneida reservation. . . . The bears had been preparing winter quarters in a hole in the side of a hill, and were seen by the Indians carrying hay to their quarters. When all were snugly nested away for the winter, they were routed out and shot as they appeared above the ground."[155]
1897. Standing hollow tree, Marinette County.[156]
1898. Standing hollow tree, Marinette County.[157]
1900. Standing hollow tree, Marinette County.[158]

## Seasonal Movements

The early literature records the prevailing opinion that bears moved southward on the approach of winter. There is no convincing evidence that there was a consistent directional movement at any season except locally. Du Pratz[77] states that bears arrived on the lower Mississippi, usually the end of autumn, in a lean condition as they did not leave the north until the ground was entirely covered with snow. They had well-beaten paths on both banks of the river. Du Pratz may have generalized from the fact that during one severe winter spent at Natchez bears in a lean condition appeared in unusual numbers.

Sibley[9] obtained from hunters on the Red River information on which he based the statement that, "the immense droves of animals that, at the beginning of winter, descend from the mountains down southwardly into the timbered country, is almost incredible." Buffalo and bear "were in droves of many thousands together." Atkinson[44] mentions a former bear crossing on the Kanawha at Charleston, West Virginia, used by the bears "in their migrations northward every spring."

On the upper Mississippi the bears sometimes moved north in autumn. When Lanman[159] was at Crow Wing, Minnesota, he wrote: "Immediately on my arrival there, I heard something about a contemplated bear hunt. It happened to be the month when this animal performs its annual journey to the south, whence it returns in Octobber. A number of them had already been killed, and there was a crossing place on the Mississippi, where a good marksman might take one almost at any time."

A bear pass on the St. Croix River, near the mouth of the Yellow River, is mentioned by Kohl.[81a] The bears moved south to open country in spring, due to better food conditions, and returned in autumn to winter in the heavy timber. In October they crossed the river nearly every night over a period of three to four weeks.

According to Philip Tome, the famous Pennsylvania hunter, "In the month of August they were to be found traveling west, and crossing Pine Creek, twenty-four miles from the mouth, where they had a beaten road that might be followed fifteen or twenty miles. . . . I have noticed generally that every seventh year the bears travel west in August, and return about the middle of October, but scattering wide apart and paying no attention to the path."[160]

Regarding the fall movement Merriam wrote: "In Lewis County . . . is an uninhabited tract of evergreen forest. . . . In this forest dwell many bears, and in the fall they often cross over the intervening valley, a fertile farming country, and enter the Adirondacks."[161]

In autumn the bear settles down to the serious task of converting as much food as possible into fat in preparation for hibernation. It is therefore normal for the species to seek a region having an abundant supply of food. Kennicott wrote: "At times, it migrates a considerable distance in search of food, particularly in autumn, when the males travel southward in large numbers. In Michigan, it has been known to traverse many miles in order to reach a locality where white-oaks bear a full crop of acorns."[162]

Bunnell[163] found bears quite numerous in the La Crosse, Wisconsin, region about 1845. When food was scarce the bears would wander. They were known as "traveling bears," of which his brother killed three in one day on the Trempealeau River.

## Emigration and Its Cause

The appearance at intervals of black bears in unusual numbers has been noted throughout much of the range of this species. It is not always possible to distinguish clearly a migration from an emigration. In this paper any spring or fall movement over regular trails or passes, or a concentration due to abundance of food in certain localities, is considered a migration. An emigration may be defined as the passing of an unusual number of bears through a region without a return. There is no information indicating a return after these periodic irruptions. Hardy[164] mentions two westerly movements of bears in autumn in Main, one about 1827, the other about 1867, with no evidence of a return in spring.

Mass movements of bears have been mentioned frequently, but beyond the statement that they were caused by lack of food there is little information. Seton[121] remarks, "What the nature and extent of this migration are, or whether regular in time or direction, I have not been able to determine."

Felt relates that, "In Sept., Oct. and part of Nov. [1663] there came many bears out of the wilderness, soe that severall hundreds were killed in the severall parts of Colonie."[165] There was another invasion in 1699. Josselyn wrote in 1672: "About four years since,

acorns being very scarce up in the country, some numbers of them came down amongst the English plantations, which generally are by the sea-side. At one town called Georgiana, in the province of Meyn . . . they kill'd fourscore."[166]

In the fall of 1759, bears moved down the Hudson River in large numbers and caused great damage to corn and livestock. It is added, ". . . they are more numerous than has been known in the memory of man. And, particularly, he was at a tavern on the post-road, near Poughkeepsie, when the landlord counted to him thirty-six, that had been killed within three weeks of that time, in the compass of four or five miles."[167]

Belknap, writing of New Hampshire in 1792, said: "In the autumn of some years, the bears come down into the old settlements, and they have been seen in the maritime towns; but now, their appearance in these places, is extremely rare."[168] However, the exodus of bears continued for, "The season, this year [1794],was unpropitious to the husbandman. . . . On the 17th of May, there was a heavy frost, so thick as to resemble snow, and so severe, that . . . apples, nuts, acorns and berries, were entirely cut off. For want of these, the bears were forced to leave their woody retreats, and seek subsistence nearer the sea shore. . . . It was said, that more than 300 were slain or taken in the whole State . . . of Maine."[169]

In the fall of 1796, bears came down from the northern regions of Canada and were "most numerous in the neighborhood of Lakes Ontario and Erie, and along the upper parts of the River St. Lawrence. On arriving at the borders of these lakes, or of the river, if the opposite shore was in sight, they generally took to the water, and endeavored to reach it by swimming. Prodigious numbers of them were killed in crossing the St. Lawrence by the Indians, who had hunting encampments, at short distances from each other, the whole way along the banks of the river, from the island of St. Regis to Lake Ontario."[170]

Willey relates that in the White Mountains, "In the autumn of 1804, it required all the vigilance and courage of the inhabitants to preserve their cattle and hogs from the ferocious creatures. The nuts and berries, their usual food, had failed them, and driven on by hunger, the infuriated beasts would rush almost into the very homes of the settlers."[171]

By 1840, the bear was a "stranger" in most parts of Massachusetts; however, a few years earlier great numbers appeared in the Hoosic

Mountain Range and between twenty and thirty were taken in one autumn.[119]

It is mentioned by Copway[80] that the Indians take bears when they are crossing a body of water. His statement that, "Some years ago, they were thus captured at the head of Lake Superior," is indicative of an emigration. The fall of 1945, St. Louis County, Minnesota, was invaded by bears.[172] The surprising number of 157 adults and 77 cubs was presented for bounty. The influx was attributed to the absence of wild fruits.

Kohl has written: "Several years have become remarkable for enormous bear migrations. Thus, I heard much at Riviére au Désert [Vilas County, Wisconsin] of the year 1811, as a perfectly extraordinary bear year. . . . In the said year however, they migrated the whole summer through from the northward across the river [Sault St. Marie] to what is called the 'upper peninsula of Michigan'. Above six thousand are said to have been killed on the island and banks of this moderately long river. Many traders bought five hundred or six hundred skins in the course of a year, and several even more. A hundred bears were sometimes killed in a night, and many a clever hunter brought down as many to his own gun during the season. Young bears were even taken out of the water by hand."[81b]

There is another statement that formerly, once in about three years, the bears collected on the northern shore of Lake Huron and "pushed their course southwesterly across St. Mary's River in hundreds and even thousands."[173]

Climate was not a factor in producing emigration, for the movements took place also on the Lower Mississippi. Father Gravier while on this stream below the Maramec River, Missouri, wrote on October 15, 1700: "Today we saw over 50 bears, and of all that we killed we took only 4, in order to obtain some fat. Those that came down the Mississippi were lean, and Those that came from the direction of the river Ouabachei [St. Joseph] were fat. They were continually moving from the South to the North. It must be better there for them."[174] The reasons for a movement in two directions seem contradictory.

The southward movement of bears in Pennsylvania in the fall of 1834 was due to lack of food.[175] In the fall of 1877 there was an unusual concentration of bears in the Mississippi bottoms near Memphis. The animals were particularly destructive to corn in Coahoma and Tunica counties, Mississippi.[176]

It was commonly believed that the bear would not hibernate if

lean, but would wander in search of food. De Kay wrote: "Indeed this condition of fatness is so necessary, that when the supply of food is cut off, instead of retiring to winter quarters, they migrate southwardly to warmer regions. Hence great numbers are occasionally known to enter our territory from the north, composed entirely of lean males, or females not with young."[177]

In very severe winters, according to Richardson,[134] a great number of bears have been known to enter the United States from the north. These were lean and nearly all males. He states that in the northern regions the bears mate in September after fattening on berries. Becoming poor in flesh during the rutting season, they will travel south if an early winter prevents them from becoming sufficiently fat for hibernation. This explanation is scarcely tenable since to the best of our knowledge mating does not take place later than July in even the northernmost part of the bear's range.

Merriam[161] states that it is a rule that when a male bear can find sufficient food he will not den regardless of the severity of the weather. There are so many exceptions that this cannot be considered a rule. Hardy[164] says that, of the two migrations of which he was informed, "lack of food did not seem to be the reason for moving." When King[178] was at Niagara, a bear in very poor condition was brought into town. He remarked that scarcity of food causes the species to migrate.

The Canadian Indians could not give Macfarlane[132] a satisfactory explanation for the "recurring seasons of exceptional scarcity of bears in regularly occupied tracts." The simplest solution was to assume that a migration had taken place.

Emigrations of bears and gray squirrels have been recorded several times as occurring simultaneously. Statements can be found that emigration takes place when food is plentiful and when it is not. The fact that both species enter or pass through a region supplied with food does not prove that they left one where food was sufficient. Weld[170] mentions that the southward movement of bears in Canada in 1796 was accompanied by a northward emigration of gray squirrels. Since the latter, in some sections, destroyed two thirds of the corn, thre was presumably a shortage of food in the region left. The great migration of squirrels in Michigan in the fall of 1866 was followed by one of the bears. "The same reason accounts for both — a scarcity of mast."[179]

An emigration of gray squirrels in Pennsylvania was folowed by one of wild turkeys in droves, while "the rear was brought up by scores of very serious half-famished-looking bears."[179.1] The exodus of squirrels from Clinton County, Pennsylvania, in the fall of 1889 was also followed by one of bears.[180] Rich[181] states that the abundance of bears in the Rangely Lakes region of Maine in the fall of 1894 was due to "lack of beech nuts and berries." Gray squirrels were "unusually abundant." On the other hand Strickland[181.1] claimed that bears and squirels were numerous in Canada only when there was a good crop of mast.

Hough wrote in 1896: "I am told that the Delta country of Mississippi, where the black bears were so numerous last year, has this year almost no mast at all, in consequence of which no bears are to be found in that country. . . . It is supposed that the bears have gone to Arkansas or the hereafter."[182]

Only two logical reasons can be advanced for an emigration of bears, lack of food, or a population so high that it results in intraspecific intolerance. The weight of opinion rests on a shortage of food.

There were several clearly defined emigrations of bears in Wisconsin during the latter half of the past century. These are described in Table 3.

The information on which the various emigrations are based is given below.

1844

"We noticed last week the capture of three bears . . . and since that time it has been ascertained that the country is full of them. Nearly one hundred have been seen in this county [Dane] within a week, and some twenty-five or thirty have been killed. . . . We understand that they are in great numbers in the counties west of us."[183] Dr. W. H. Fox, town of Fitchburg, Dane County, wrote: "That same fall (1844) there were a great many bears prowling about."[23a] Some appeared in the town of Springfield.[183.1]

"Many of our contemporaries are noticing the emigration of bears from the northern regions of the Territory to more southern latitudes."[184]

The crew of the steamer Cleveland, in October, captured in Lake Michigan a large bear swimming off Long Point, Racine County.[184.1] One was killed in August in the town of Albany, Green County.[21]

In this year Judge Erwin held court at Prairie du Sac, then the county seat of Sauk County. "In the midst of the session some one

TABLE 3.

BEAR MOVEMENTS IN WISCONSIN

| YEARS BETWEEN EMIGRATIONS | YEAR OF EMIGRATION | REMARKS |
|---|---|---|
| — | 1844 | Heavy emigration to southern end of state. Squirrels abundant in Milwaukee County. |
| 5 | 1849 | Emigration southward. Squirrels abundant at Watertown.<br>1854. Plentiful in the Lake Winnebago area.<br>1855. Very few records. |
| 7 | 1856 | Emigration into southeastern section of the state. Squirrels abundant and migrating.<br>1857. Few records.<br>1858. Numerous in the north but no movement southward. |
| 3 | 1859 | Broad movement to southern boundary. Few data on squirrels but they were abundant at Oshkosh.<br>1860-63. Very few records.<br>1864. Numerous in Western Wisconsin and exceptionally so in eastern Minnesota.<br>1865. Very few records. |
| 7 | 1866 | Common. Emigrated to southern counties. Squirrels abundant and migrating.<br>1867-70. Comparatively few records. |
| 5 | 1871 | Common to abundant. Reach southern counties. Squirrels abundant and migrating.<br>1872. Common in the north. A few appeared in Adams and Columbia Counties.<br>1873. Numerous but no extensive movement southward. Squirrels abundant and migrating.<br>1874. Few records.<br>1875. Numerous but no movement southward.<br>1876. Very few records.<br>1877. More plentiful than in 1876. |
| 7 | 1878 | Abundant and reach southern counties. Squirrels abundant and migrating extensively.<br>1879. Few records.<br>1880-81. Quite numerous.<br>1882. More plentiful than in 1881. Squirrels abundant. |
| 5 | 1883 | Abundant and reach southern counties. Squirrels abundant and migrating extensively.<br>1884. Few records.<br>1885. Abundant. A few reached Sauk County.<br>1886-87. Less numerous and no movement. |
| 5 | 1888 | Abundant and reach southern counties. Squirrels were abundant throughout the state but no well defined migration.<br>1891. A few were killed in Sauk and Adams Counties. Squirrels numerous in western part of state.<br>1894. Numerous and a few reached Sauk County.<br>1895. Quite numerous. One killed in Sauk County. Squirrels plentiful and migrating.<br>1896. Few records. |

cried from the outside that there were three bears crossing the Wisconsin river. A general stampede ensued . . . without the formality of adjournment. The mother bear was caught and her throat cut. . . . The cubs were finally caught and killed. . . . During the sitting of this court there were seven bears killed in the vicinity of the Sauk villages."[185]

1849

Rev. Breck in the fall of this year walked from Nashotah to Green Bay. On November 21 he wrote from Appleton that he was afraid of encountering wild animals in the dense woods on the eastern side of Lake Winnebago for, "I knew this year to be noted for the many bears that had come down from the North, for they had come even as far down as Nashotah [Waukesha County]."[186] The hunting of bears in this county was one of the common sports this autumn.[187]

"From notices which we have seen in several of our exchanges, we draw the conclusion that the bear family are becoming quite familiar in Wisconsin. . . . Three of the shaggy gentlemen were taken a few days since on Blue River in Iowa County. . . ."[188]

1856

Bears were very numerous at Green Bay,[189] Oshkosh,[190] and Appleton.[191] One was killed in Dodge County,[192] and several were seen or killed in Jefferson,[193] Milwaukee,[194] and Waukesha[195] counties.

1859

"Report says that the people of the northern portions of the county [Iowa] have become alarmed within the present week, on account of the numerous Bears prowling about. As high as eight are reported to have been seen."[196]

Bears were killed in Rock,[197] Grant,[198] Crawford,[199] Iowa,[200] Dane,[201] Racine,[202] Milwaukee,[203] Green,[204] Richland,[205] Columbia,[206] and Dodge[207] counties.

1866

"Bears are getting to be very abundant in this section [Berlin, Green Lake County]. Several have been brought into town, and we hear of them being seen in every direction – almost – within a few miles. . . ."[208]

"Our exchanges from the northern and less thickly settled parts of the State have reported bears unusually plenty this fall and an unusually large number have fallen victims to the hunters, but we did not expect to hear of any of the varmints appearing in Dane county.

A very large one, however, was killed among the woody hills in the center of the town of Perry . . . on the 30th [October]."[209]

The killing of a bear at Waterloo, Jefferson County, "about 1865,"[210] probably took place in 1866. Bears were found also in Richland,[211] Adams,[212] and Rock[213] counties.

1871

"The bears are 'coming in' thicker and faster. On either side of us we get reports of the appearance of bruin. . . . Mauston has been invaded by them; Sparta has hunters in pursuit of them; Black River Falls is surrounded with them; the islands in the Mississippi river in close proximity to La Crosse, are inhabited by them. . . ."[214]

Bears reached Lafayette,[215] Richland,[216] Sauk[217] Crawford,[218] Adams,[219] Columbia,[220] and Green Lake[221] counties.

Bears were common in northern Wisconsin in the fall of 1872 and did considerable damage to domestic animals. The three recorded for Columbia,[222] and Adams[223] were too few to constitute an emigration. The bear seen near Darlington,[224] Lafayette County, on January 28, 1872, undoubtedly arrived during the emigration of 1871.

1878

Bears were abundant in the northern half of the state. Several were seen and killed in Richland County.[225] One appeared as far south as Spring Green, Sauk County, the only one that "has been heard of in this section in fifteen years."[226] One was seen at Prairie du Chien,[227] and three were killed in Adams County.[228]

1883

"Bears are uncommonly thick this fall. The number that have been seen and killed within a short distance from the city [Eau Claire] has seldom, if ever been paralled at so early a date."[229]

"Bears are unusually plenty this fall, or at least they exhibit themselves more than is their custom."[230]

"Bears are migrating from the pine woods to winter quarters further south."[231]

The emigration extended to Crawford,[232] Richland,[233] Adams,[234] and Sauk counties[235]

In 1885 bears were abundant; however, the number that moved southward in the center of the state to reach Adams,[236] Marquette,[237] Columbia,[238] and Sauk[239] counties, was too small to form a well-defined emigration.

1888

Bears were very numerous and this is the last year of unquestion-

able emigration. The exodus extended to Adams,[240] Columbia,[241] Sauk,[242] and Iowa[243] counties.

Local opinion was preponderately in favor of a shortage of food as the cause of emigration. Some weight was attached to forest fires. The prevalence of bears in 1871 was attributed in four cases to the extensive forest fires that occurred in the fall of that year; however, bears were equally numerous in the autumn of 1872 in northeastern Wisconsin when fire was not a factor. The influx of bears into Jackson County in the autumn of 1901 was discussed as follows: "In former years the usual reason advanced for the visits of these animals in this section has been the occurrence of forest fires in the northern woods. This year, however, there have been no extensive areas swept by fire. . . . It would seem that they are led in this direction by their migratory instinct, and their course followed up in a search for particular kinds of food [corn and acorns]which bears enjoy."[244]

The black bear is notorious for lack of discrimination in food. Schoolcraft was told by the Indians that it is fond of nuts, esculent roots, honey, corn, berries and other wild fruits; and that, "it is only in the utmost extremity that it takes hold of animal food, and in a region where its favourite fruits are plenty, it will pass by the carcass of a deer without touching it." Few bears show so much restraint.

When in northern Wisconsin, Kohl paid considerable attention to the food of the bear. He wrote: "Now and then Du Roy pointed out to me spots in the forest where the bears had been scratching for 'makopin'. This is a small tuber, which the Canadians call the bear's potato [*Arisaema triphyllum*], nearly a translation of the Indian term. We dug some, and I tasted them, but found them marvellously bitter."[81c]

There were at least a dozen plants to which the Indians had attached the bear's name, bear potatoes, bear roots, bear berries, etc. The latter is the serviceberry (*Amelanchier canadensis*) of which Kohl wrote: "At this time we found it covered with glistening red berries, and our Canadian told us that the bears bend down the whole tree with their paws, and then eat off the berries. . . ."

The fall feeding habits of the bear as related by Moore[86] for Kewaunee County may be considered normal: "First they ate raspberries, then they visited the numerous blackberry patches, then they went into the swamps and ate blueberries. After the blueberry

season came to a close, they sallied out of the swamps and into the white oak forests."

Acorns are a highly favored food. Cooke[40a] called the bur oak acorn the "bear acorn." It is doubtful if this acorn is preferred by bears. It is the first to fall in late summer and the first to disappear due to poor keeping quality. He mentions that bur oaks were plentiful in his region, hence it was known as "good bear hunting grounds."

There is much opinion as well as considerable data to support the view that the exodus of bears and squirels is due to lack of food. The importance of blackberries and other soft fruits for the production of fat for hibernation is questionable when it is considered that the bears emigrated in 1871 and 1878, years when blackberries were abundant; and that in Wisconsin about six weeks elapse between the disappearance of blackberries and the time for denning.

The hardwoods of the southern half of the state are largely oaks, principally red (*Quercus rubrum*), white (*Q. alba*), bur (*Q. macrocarpa*), black (*Q. velutina*), scarlet (*Q. coccinea*), and northern pin oak (*Q. ellipsoidalis*). The Central Plain region, and particularly the Glacial Lake Wisconsin area, was the most productive of bears. The principal oak here is *Quercus ellipsoidalis.* So many species of oaks were conducive to a large population of bears since a complete failure of acorns in any year would occur only at intervals. An attempt has been made in the Appendix to resurrect the food conditions in the state from about 1850 to 1900. The study covers the important fall foods, such as the blueberry, blackberry, wild plum, wild grape, and acorns. The bear ate hickory nuts[245] on occasion but they formed an unimportant item in its diet.

The nut-bearing trees, hickory, walnut, and butternut, were too few to be a factor in supporting the large population of gray squirrels, and the latter competed with the bears for acorns. Bailey[246] states that in Sherburne County, Minnesota, the gray squirrel subsists largely on acorns when corn is not available. This is equally true of Wisconsin.

The simultaneous exodus, in so many cases, of the black bear and the gray squirel is striking. However, there are exceptions. In 1873, e.g., gray squirrels were abundant and emigrated, but there was no extensive movement of bears southward. It is not to be expected that the emigrations of the two species would always occur simultaneously owing to the vast difference in reproductive power. With good food conditions the gray squirel has two litters, each of three to five

young, in a year. In contrast the bear, having only about 2.5 cubs every two years, would produce only a fraction over one cub per year.

The data on the annual yield of acorns are too incomplete to determine if each emigration of bears was due directly to a failure of the acorn crop. Acorns were exceptionally abundant in 1870 and therefore a failure may well have occurred in 1871 when the bears emigrated. They emigrated again in 1878 and 1883, years when there was a definite scarcity of acorns. No sweeping conclusion can be drawn. The available information indicates that in this state, Wisconsin, emigration resulted from the coincidence of a high bear population and a failure of acorn mast.

The age and physical condition of the bears that reached southern Wisconsin during the emigrations have a bearing on the reason for the exodus. Unfortunately the information is not extensive, but it is sufficient to state that the van consisted preponderately of non-breeders. Most of the bears were either old and in poor condition, or were yearlings and two-year-olds in good flesh. There were exceptions such as the bear weighing 380 pounds, killed near Beloit in 1859, that "was so fat that he was unable to run very fast."[247] Some of the bears must have fared well on corn after reaching the southern counties. No cubs were reported south of Prairie du Sac.

The direction of the emigrations was distinctly southward, though a few bears are known to have crossed the Mississippi River into Minnesota. The geographical position of the state, with Lake Michigan on the east, Lake Superior on the north, and the Mississippi River on the west, may have steered the emigrations southward. This is doubtful, however, since the bulk of the emigrants passed through the center of the state.

## APPENDIX

### LAST DATES OF APPEARANCE OF BEARS IN THE SOUTHERN COUNTIES

The dates given on the map (Fig. 1) are tentative. All dates later than those given were rejected, after careful examination, as erroneous or for equally valid reasons. Occurrences based on memory going back forty or fifty years were considered unreliable. Recent dates for the central counties were furnished by Walter E. Scott.

ADAMS. One was reported seen in the town of Monroe in 1945 and one in the town of Grand Marsh in 1946.

A large bear was killed by Theodore Hawkins, town of Richfield, on October 21, 1895.—Friendship *Press*, Oct. 26, 1895.

BROWN. G. Grosse of Suamico shot a bear weighing 200 pounds on November

27, 1899.—Green Bay *Gazette* Dec. 2, 1899, 3.

BUFFALO. On the night of October 25, 1909, a bear killed two hogs at Eleva.—Mondovi *Herald* Oct. 29, 1909.

The local warden thought in 1946 that there were still two bears in the county.

CALUMET. In the summer of 1890 one bear was seen at Dundas and another at Brillion.—Chilton *Times* July 5 and Aug. 16, 1890.

Three were shot by G. M. Beach, town of Brillion, in September, 1886.—Chilton *Times* Oct. 2, 1886.

COLUMBIA. A bear killed many sheep in the towns of Fort Winnebago and Buffalo in September, 1888.—Portage *Democrat* Sept. 28, 1888.

One was killed in the town of Marcellon by Loyal Husbrook on October 5, 1885. —Portage *Democrat* Oct. 9, 1885.

CRAWFORD. One was seen on the railroad track at Glendale on September 17, 1883.—Prairie du Chien *Union* Sept. 21, 1883.

DANE. A bear weighing "over 400 pounds" was killed in the town of Perry on October 30, 1866. The carcass was sold in Madison at 20 cents per pound.—Madison *State Journal* Nov. 1, 1866.

DODGE. One was killed in the town of Trenton early in September, 1859, and another seen on the 6th of this month.—Fox Lake *Gazette* Sept. 8, 1859.

DOOR. Two were seen near Forestville in September, 1901.—Sturgeon Bay *Advocate* Oct. 19, 1901; Algoma *Record* Oct. 11, 1901.

A bear was seen in the county in December, 1945, and another in June, 1946. These were probably not natural occurrences since cubs were liberated in the county by the Conservation Department three years previously.

FOND DU LAC. A bear was shot at Ripon in October, 1883.—Princeton *Republic* Oct. 11, 1883.

Cory[87] was informed that a bear was killed in the county in the summer of 1906, but he expressed doubt that it was a valid record.

GRANT. One was killed in the town of Muscoda in May, 1871.—Lancaster *Herald* May 9, 1871.

Bears were reported "roaming" at Boscobel in September, 1875.—Milwaukee Commercial *Times* Sept. 11, 1875.

GREEN. One bear was killed in the town of Sylvester in September and another in the town of Monroe in October, 1859.—Monroe *Sentinel* Sept. 21, 28, and Oct. 12, 1859.

GREEN LAKE. The Conservation Department has paid for damage made by a bear north of Princeton in October, 1945. Under date June 18, 1946, W. E. Scott wrote to me that he was informed by the local warden that "recent tracks show that the animal is still in the county." This bear probably drifted down from Waupaca County.

Apparently no bear has been killed in the county for about fifty years. Two were shot on the Goyno farm northwest of Berlin on September 22, 1897.—Berlin (w) *Journal* Sept. 23, 1897, 8.

IOWA. During the irruption of 1888, bears were seen near Pine Knob and one weighing 175 pounds was killed at Cobb.—Dodgeville *Chronicle* Sept. 21, 1888; Montford *Monitor* Sept. 20, 1888.

JACKSON. The local warden was informed by a farmer in the town of Portland that he saw a bear in 1944. Bears were liberated in the eastern part of the county in 1937 or 1938 but there has been no sign of them during the past two years.

However, George Hartman of the Conservation Department, was informed by an Indian, James Funmaker, that he saw a large bear along Morrison Creek, town of Komensky, in January, 1946.

No published account of bear being seen later than 1903 was found. In September of this year several were observed at Knapp.—Black River Falls *Banner* Sept. 17 and 24, 1903.

JEFFERSON. Four bears were killed in the county during the emigration in the fall of 1856.—Watertown *Democrat* Sept. 25, Oct. 9, 1856; Jefferson *Jeffersonian* Oct. 9, 1856; Milwaukee *Sentinel* Nov. 26, 1856.

JUNEAU. George Hartman, Game Manager of the Central Wisconsin Area, reported as follows: "On February 19, 1946, while in the field with Fred Jacobson and several of the Deer Research men, we saw the tracks of a small to medium sized bear in the north end of the Necedah Wildlife Refuge. The men stationed on this refuge informed me that Robley Hunt had seen a bear in this vicinity while he was superintendent of this refuge. The tracks were seen in the western part of the Town of Finley, Juneau County."

A large bear, apparently the last one killed, was shot in the town of Fountain on October 23, 1897.—Mauston *Star* Oct. 28; *Chronicle* Oct. 28, 1897.

KENOSHA. No satisfactory record for this county was found.

KEWAUNEE. In September, 1893, a bear remained for a week in the vicinity of the Strausky mill, west Kewaunee, and evaded all attempts at capture.—Kewaunee *Enterprise* Sept. 29, 1893.

Rumors of their presence in December, 1897, in the large swamp south of Ryan were recorded.—Kewaunee *Enterprise* Dec. 10, 1897.

LA CROSSE. A wild bear was killed in the county on November 25, 1944. Warden Elmer Lange wrote further: "I saw a bear in Garber Coulee about a month before this one was killed. This bear was killed near Gills Coulee about 7 to 8 miles from the city of La Crosse."

LAFAYETTE. A large bear was seen three miles east of Darlington on January 28, 1872; and on June 14, 1873, a bear and a cub raided a chicken coop near this town.—Darlington *Republican* Jan. 28, Feb. 3, 1872; June 21, 1873.

MANITOWOC. A farmer living a few miles north of Two Rivers attempted to trap a bear in August, 1896.—Two Rivers *Chronicle* Aug. 25, 1896.

No accounts of bears killed were found after 1890. In August of this year a bear with four cubs was seen in the town of Maple Grove and one of the cubs was captured. In November a female that had one cub was killed in the town of Rockland.—Manitowoc *Pilot* Aug. 21, Nov. 20, 1890.

MARQUETTE. Warden E. F. Evans reported in 1946 that at least one bear was using the bottoms of the White River in northeastern Marquette County and northwestern Green Lake County.

MILWAUKEE. In October, 1859, a bear was brought to Milwaukee that had been killed within 15 miles of the city.—Milwaukee (d) *News* Oct. 13, 1859.

MONROE. Warden John F. Adamski reported that in the summer of 1946 a bear and two cubs were seen between Sparta and Tomah (town of Adrian), the only ones reported for several years.

Fred Moses and Austin Wilson killed a bear weighing 280 pounds at Warrens in the fall of 1909.—Alma *Journal* Nov. 4, 1909.

OZAUKEE. A large bear was killed near Port Washington in September, 1858. —Port Washington *Advertiser*. In Madison (d) *Patriot* Sept. 15, 1858.

PEPIN. One was caught in the act of killing two sheep on Cady Creek in September, 1889.—Durand *Courier* Sept. 6, 1889.

PIERCE. A bear with a cub was seen in the town of Clifton the end of November, 1899.—River Falls *Journal* Nov. 30, 1899.

RACINE. The end of October, 1859, two bears were found in the town of Yorkville and one was killed.—Racine *Advocate,* Nov. 2, 1859.

RICHLAND. A bear weighing about 200 pounds, in poor condition, was shot by J. A. Roudebush in the town of Marshall on May 8, 1905. Richland Center *Republican Observer* May 11, 1905; *Rustic* May 12, 1905; J. A. Roudebush *in litt.*

ROCK. A large bear was killed between Beloit and Janesville on October 30, 1859.—Beloit *Journal* Nov. 2, 1859; Janesville *Gazette* Nov. 1, 1859.

All subsequent statements of occurrence are doubtful. There are circumstantial accounts of a bear being pursued by men with dogs in the town of Lima on February 11, 1881; however, the bear was not again reported seen in this section of the state.—Whitewater *Register* Feb. 17; Delavan *Republican* Feb. 18, 1881.

SAUK. Jessie Walker, Baraboo, informed the Conservation Department that he saw a large and two small bears west of Devils Lake State Park in October, 1946.

M. Gallagher, town of Dellona, killed a bear in December, 1898.—Kilbourn *Mirror-Gazette* Dec. 17, 1898, 1.

According to Cole,[248] the last bear seen in the Baraboo Hills was killed on Thanksgiving day, 1891, by the Farnsworth brothers.

SHEBOYGAN. One was reported to be in the cedar swamp, town of Mitchell, in November, 1897.—Plymouth *Reporter* Nov. 18, 1897.

One of the local wardens informed George Becker in 1940 that the last bear was taken in the early 1900's. No published account of a kill was found later than 1889. In October of this year, J. Couch and E. Dean killed a bear in the swamp near Glenbeulah.—Sheboygan Falls *News* Nov. 6, 1889, 8.

TREMPEALEAU. A bear was killed near Osseo on October 16, 1898, and one was seen near this place in September, 1900.—Independence *News-Wave,* Oct. 22, 1898; Sept. 15, 1900.

VERNON. One was seen in a tree near Hillsborough on October 10, 1888.—La Crosse (w) *Republican and Leader* Oct. 20, 1888, 3.

WALWORTH. Only one record for this county was found. Baker[20] states that one was killed in the town of Lafayette in 1836.

WASHINGTON. In May, 1856, a farmer in the town of Jackson killed three cubs in a hollow tree, the old bears escaping.—West Bend *Democrat.* In Horicon *Argus* May 14, 1856.

WAUKESHA. A large bear started in the town of Hebron, Jefferson County, was pursued into Waukesha County and finally killed on November 8, 1856, in the town of Concord, Jefferson County.—Milwaukee *Sentinel* Nov. 26, 1856.

WAUSHARA. The local warden reported that a bear was seen in the town of Rose in September, 1944, and another in the town of Deerfield in October, 1945.

As far as known, the last bear killed in the county was in 1897. On September 19, 1897, an old bear and four cubs were killed at Aurorahville.—Wautoma *Argus* Sept. 23, 1897; Berlin (w) *Journal* Oct. 7, 1897, 5.

WINNEBAGO. In October, 1885, a bear was seen at Lake Butte des Morts.—Appleton *Crescent* Oct. 10, 1885.

A correspondent from the town of Rushford reported that John Gaughan killed two bears at Black Creek. No place or creek of this name could be found for the vicinity, so that it may refer to Black Creek in Outagamie County.—Oshkosh *Northwestern* Oct. 8, 1885, 8.

The drift of bears southward in the state in recent years is pronounced.

## FOOD CONDITIONS IN WISCONSIN

### Acorns (*Quercus*)

In attempting to determine the annual status of the acorn crop, so many gaps remained that an indirect approach to the investigation was also made. The passenger pigeon depended largely on acorns for nesting, so that a nesting in any one spring is presumptive evidence of a good crop of acorns the previous autumn. This would not hold necessarily for the eastern edge of the state where the beech occupied a narrow range along the shores of Lake Michigan and Green Bay.

1847. Mast abundant in Grant County.

1852. Mast reported scarce north of the lower Wisconsin River.

1854. Abundant in Jefferson and Outagamie Counties. There was a large nesting of pigeons in Waupaca County in 1855.

1857. The pigeons nested in Outagamie and Oconto Counties in 1858.

1858. Abundant in Iowa County.

1859. 'Shack' scarce north of Green Lake County but reported good at Tomah.

1860. Heavy crop in Dane County. The pigeons nested in Green County in 1861.

1861. The pigeons nested in Green County in 1862.

1863. There was a large nesting of pigeons along the Kickapoo River, Vernon County, and in southwestern Monroe County in 1864.

1864. Pigeons nested in Fond du Lac County in 1865.

1866. 'Shack' was abundant in Adams County. The pigeons nested in Fond du Lac County in 1867.

1867. The pigeons nested in Outagamie County in 1868.

1868. There were large nestings of pigeons in Green, Monroe, and Fond du Lac Counties in 1869.

1870. Acorns were abundant in Dane and Fond du Lac counties, and in the center of the state. There was a large pigeon nesting in 1871 that extended from Kilbourn to Sparta.

1871. Plentiful in Winnebago County.

1872. A professional pigeon trapper stated that few pigeons nested in the state in 1873 due to the great scarcity of mast.

1873. Deer were reported to be feeding on black oak acorns in Dunn County.

1874. Plentiful in Portage County. The pigeons nested in Pierce and Wood counties in 1875.

1875. The pigeons nested in La Crosse County in 1876.

1876. Plentiful in Dunn and abundant in Rock County. The pigeons nested in Monroe County in 1877.

1877. There was a bountiful crop of red oak acorns in St. Croix County. Acorns were plentiful in Dunn and unusually abundant in Eau Claire County. "Unusual quantities" were reported for the state. The pigeons nested in Adams County in 1878.

1878. Acorns were reported scarce in Dunn, Chippewa, Winnebago, and Oconto counties.

1879. Abundant in Walworth, Kenosha, Chippewa, and Pierce counties.

1880. Plentiful in Pierce and Barron counties.

1881. Plentiful in Trempealeau, Monroe, Adams, and Waushara counties; abundant in Chippewa; and "immense" in Winnebago County. There were large nestings of pigeons near Sparta, Tomah, and Kilbourn in 1882.

1883. Very scarce in Richland, Iowa, Juneau, and Dunn counties.

1884. Pigeons nested in the southeastern corner of Langlade County in 1885.

1885. Princeton, Green Lake County, reported that the "immense acorn crop" is bringing the bears down.

1886. Large crop in Waupaca County. Pigeons attempted to nest near Wautoma in 1887.

1887. Large crop in Sheboygan County.

1892. Abundant in Kewaunee County.

BLUEBERRIES (*Vaccinium*) AND HUCKLEBERRIES (*Gaylussacia*)

1853. Abundant in Outagamie County.

1856. Plentiful in Sauk County.

1858. Abundant in Marathon and Waushara counties.

1860. Abundant in Douglas County.

1861. Enormous crop in Waushara, Green Lake, Sauk, Portage, and Juneau counties.

1862. Plentiful in Juneau County.

1863. Plentiful in Waushara and Marquette counties.

1864. Crop fair to poor.

1865. Plentiful in Waushara, Portage, and Brown counties.

1866. Plentiful in Sauk, Waushara, and Juneau counties. The crop failed in Shawano and Portage counties.

1867. Abundant in Marathon, Chippewa, Douglas, Shawano, Portage, Eau Claire, and Monroe counties.

1868. Poor crop in most of the northern counties.

1869. Plentiful in Marathon, Chippewa, Polk, Sauk, Juneau, and Jackson counties.

1870. Abundant in Chippewa, Polk, Waushara, Marquette, Brown, Juneau, and Jackson counties.

1871. The crop was spotty being plentiful in Marathon, Chippewa, Polk, Juneau, Jackson, Portage, and Brown, and scarce in Outagamie, Winnebago, and Shawano counties.

1872. Plentiful in Juneau, Shawano, Adams, Eau Claire, Jackson, Waupaca, and Ashland counties.

1873. Abundant in Clark, Polk, Winnebago, Shawano, Juneau, Adams, Eau Claire, Jackson, Marinette, and Door counties.

1874. Plentiful in Portage, Wausau, Chippewa, Douglas, Shawano, Monroe, Jackson, and Marinette counties.

1875. The crop was exceptionally large in Oconto, Wood, Waushara, Monroe, Portage, Juneau, Adams, Eau Claire, and Jackson counties.

1876. Abundant in Adams, Monroe, Jackson, Barron, Door, Shawano, Mara-

thon, Pepin, Trempealeau, Dunn, Waupaca, and Portage, and medium in Marquette and Outagamie counties.

1877. The crop was fair in Juneau, Eau Claire, and Monroe, and very light in Wood, Douglas, Barron, Jackson, Portage, Door, and Shawano counties.

1878. The yield was small in Eau Claire, Oconto, Chippewa, Wood, and Juneau, and medium to large in Monroe, Jackson, Brown, Shawano, Pepin, and Marquette counties.

1879. Abundant in Jackson, Shawano, Barron, Wood, Waushara, Juneau, Eau Claire, Monroe, and Pierce, and scarce in Oconto and Marinette counties.

1880. Large crop reported by the blueberry counties.

1881. Again plentiful.

1882. The crop was good in Oconto; fair in Eau Claire; about one-third of "normal" in Monroe; and poor in Waupaca, Juneau, Jackson, Wood, Shawano, Chippewa, Burnette, and Waushara counties.

1883. Good crop in Juneau, Oconto, Brown, Shawano, Florence, Wood, Lincoln, St. Croix, Waushara, and Jackson; and poor in Eau Claire, Monroe, Trempealeau, Clark, Chippewa, and Price counties.

1884. The berries were abundant in Ashland, Douglas, and Juneau; plentiful in Wood, Monroe, Jackson, Clark, Waupaca, Shawano, and Florence; and few in St. Croix and Brown counties.

1885. Plentiful to abundant in all of the blueberry counties.

1886. Plentiful in Forrest, Bayfield, Burnett, Eau Claire, Jackson and Oconto; few in Barron, Waushara, Marquette, Adams, and Monroe counties.

1887. Abundant.

1888. The crop was poor in Monroe, Jackson, Marinette, Clark, Burnett, Waushara, Waupaca, and Eau Claire; good to plentiful in Oconto, Florence, Door, Wood, Iron, Forest, Douglas, Marquette, Juneau, and Adams counties.

1889. Poor crop.

1890. Abundant.

1891. Poor to fair. The Wisconsin Weather Bureau estimated the crop to be one fifth of average.

1892. The crop was light in Clark, Jackson, Trempealeau, Waupaca, Adams, Columbia, and Monroe; good in Chippewa, Eau Claire, Wood, Florence, and Shawano counties.

1893. Large crop throughout most of the blueberry counties.

1894. Very few to one third of last year's crop.

1895. Poor crop, smaller than that of the previous year.

1896. Abundant.

1897. Crop poor in Burnett and Price; fair in Monroe, Jackson, and Shawano; plentiful in Vilas, Brown, and Florence counties.

1898. Abundant.

1899. Abundant.

1900. Poor to one third of normal.

### Blackberries (*Rubus*)

1853. Abundant in Fond du Lac, Outagamie, and Jefferson counties.

1854. Abundant in Ozaukee County.

1855. Abundant in St. Croix County.

1856. Abundant in Portage County.

1857. Abundant in Marathon County.

1858. Abundant in Marathon, St. Croix, Monroe, Iowa, Outagamie, Winnebago, Portage, Richland, Brown, Sheboygan, and Manitowoc counties, and along the Wolf River. The crop was apparently heavy throughout the state.

1859. None in Washington (due to drought); "medium" in Waushara; plentiful in Monroe and Marathon; and abundant in Pierce, Green, Winnebago, Shawano, and Sheboygan counties.

1860. Unusually fine crop in Marathon County.

1861. Plentiful in Marathon, Outagamie, Portage, and Brown counties.

1862. Fair crop in Brown County.

1863. Abundant in Outagamie and Door counties.

1864. Poor crop in nearly all the counties.

1865. Abundant in Polk, Brown, Door, and Winnebago counties. Good crops of nearly all wild berries.

1866. The crop was practically a failure in Polk, St. Croix, Clark, and Waupaca counties. There was a fair crop in Shawano, Green Lake, and Outagamie; and a good one in Brown County. All wild berries were close to a failure in Waupaca County.

1867. Abundant in Marathon, Polk, St. Croix, Waupaca, Jackson, Shawano, Portage, Lafayette, Richland, Monroe, and Brown counties. Good year for most kinds of berries.

1868. Poor crop throughout most of the state.

1869. Scarce in St. Croix, but plentiful to abundant in Polk, Outagamie, Winnebago, Marathon, Crawford, Iowa, Sauk, Kewaunee, and Brown counties.

1870. Plentiful in Polk, Outagamie, Winnebago, Jackson, and Brown counties. Good year for all wild fruits.

1871. Abundant in Grant, Waupaca, Manitowoc, Marathon, Polk, Dunn, Outagamie, Shawano, Monroe, Jackson, Kewaunee, Brown, Door, St. Croix, and Portage counties.

1872. Scarce in Marathon, Dunn, Winnebago, Shawano, and Jackson counties due presumably to fire and drought. Plentiful in Portage County.

1873. Scarce in Marathon, Dunn, Shawano, Calumet, Jackson, Door, Wood, and Waupaca; quite plentiful in Clark and Eau Claire counties.

1874. The crop failed in Polk and St. Croix, but was abundant in Wood, Kewaunee, Marathon, Clark, Oconto, Marinette, Outagamie, Jackson, Winnebago, Calumet, Monroe, Vernon, Eau Claire, Brown, Door, and Wood counties.

1875. The crop failed in Oconto, Brown, Door, Outagamie, and Marinette counties, and was reported poor throughout the state.

1876. The berries were exceptionally abundant throughout the state.

1877. The crop was either light or a failure.

1878. Immense crop throughout the state.

1879. The crop was either small or a failure.

1880. Immense crop throughout the state. Berries of all kinds were in profusion.

1881. Practically a failure throughout the state.

1882. Huge crop.

1883. Plentiful in Eau Claire, Marathon, Chippewa, and St. Croix; quite plentiful in Trempealeau, Clark, and Monroe; and few in Oconto, Brown, Door, Outagamie, Waupaca, Juneau, Price, and Pierce counties.

1884. Plentiful in Chippewa, Marathon, Waushara, Adams, and Jackson; few in St. Croix, Dunn, Waupaca, Marinette, Brown, and Door counties.

1885. Plentiful in Marinette, Oconto, Door, Florence, Adams, and Monroe; quite plentiful in Outagamie; scarce in Wood, Marathon, Chippewa, Dunn, St. Croix, Waupaca, and Jackson counties.

1886. The berries were plentiful in Door, Shawano, Marathon, Iron, Price, St. Croix, Pierce, Waupaca, Marinette, and Oconto; quite plentiful in Florence and Barron; few in Clark and Jackson counties.

1887. The almost complete failure in the state was attributed to the dry weather.

1888. The crop was poor in Florence and Dunn; fair in Adams; but 17 counties reported it abundant.

1889. Scarce in Waupaca, Adams, Jackson, and Shawano; plentiful in Iowa, Crawford, La Crosse, Monroe, Florence, Marinette, and Door counties.

1890. The crop was unusually large in the northern half of the state.

1891. Poor crop except in Door County where it was stated to be immense.

1892. Large crop in the northern half of the state.

1893. Scarce in Oconto, Kewaunee, Vilas, Jackson, and Monroe; quite plentiful in Adams; plentiful in Crawford, Shawano, Langlade, and Florence counties.

1894. Poor crop.

1895. Poor crop. Poor year for all fruits.

1896. Abundant.

1897. Scarce in Florence, Vilas, Jackson, and Shawano; plentiful in Door, Brown, Marinette, Oconto, Marathon, Chippewa, and Brown counties.

1898. Abundant. All wild fruits were plentiful.

1899. Poor crop except in Marathon County where it was reported large.

1900. Unusually large crop.

WILD PLUMS (*Prunus*)

1852. Plentiful in the Milwaukee market.

1853. Abundant in Fond du Lac County.

1854. Plentiful in Grant, Dane, and Fond du Lac counties.

1856. Quite plentiful in Jefferson County.

1857. Plentiful in Dane and Dodge counties.

1859. Abundant in Pepin County.

1861. Plentiful in Dane and Rock counties.

1863. Plentiful in Outagamie County.

1865. Exceptionally large crop in Dodge and Vernon counties.

1866. Abundant in Vernon County.

1867. Scarce in Lafayette County.

1868. Abundant in Waukesha County.

1869. Plentiful in Marathon and Jackson counties.

1870. Heavy crop in Dane and Jackson counties.

1871. Abundant in Grant and Polk; scarce in Outagamie, Jackson, Juneau, and Manitowoc counties.

1872. Plentiful in Outagamie, Eau Claire, Polk, and Jackson counties.

1873. Scarce in Jackson County.

1874. Abundant in Lafayette, Marathon, and Polk counties.

1875. Plentiful in Outagamie and Jackson counties.

1876. Abundant in Pepin, Douglas, and Outagamie counties.

1877. The crop was "unusually large" in Brown; very light in Rock; and a failure in Chippewa County.
1878. Failed in Chippewa County.
1879. The crop was small in Sauk; good in Barron; large in Eau Claire, Buffalo, Chippewa, and Green counties.
1880. Large crop in Jackson, Chippewa, Buffalo, and Trempealeau counties.
1881. Scarce in Trempealeau and Door; quite plentiful in Marathon; plentiful in Iowa County.
1883. None in Douglas; plentiful in St. Croix County.
1885. Scarce in Douglas and Jackson; abundant in Door, Rock, Iowa, and Grant counties.
1886. Abundant in Vernon County.
1887. Scarce in Jackson; abundant in Chippewa, Eau Claire, and Kewaunee counties.
1888. Plentiful in Eau Claire County.
1891. Plentiful in Chippewa and Pierce counties.
1894. Plentiful in Vernon County.
1896. Very plentiful in Vernon County.
1897. Plentiful in Crawford County.
1898. Abundant in Chippewa County.

### Wild Grapes (*Vitis*)

1859. Abundant in Pepin County.
1870. Abundant in Fond du Lac County.
1871. Abundant in Marathon County.
1872. Plentiful in Outagamie County.
1879. Abundant in Richland County.
1881. None in Trempealeau; plentiful in Iowa County.
1882. Very abundant in St. Croix County.
1883. "Unusual abundance" in Door County.
1885. Abundant in Grant County.
1886. Abundant in Sauk and Vernon counties.
1889. Plentiful in Vernon County.
1890. Abundant on the islands in the Mississippi River.
1891. Plentiful in Vernon and Waupaca counties.
1892. Plentiful in Vernon County.
1893. Plentiful in Fond du Lac, Waupaca, Richland, Vernon, and Pepin counties.
1896. Very plentiful in Sheboygan and Vernon counties.
1897. Plentiful in Pierce County.
1899. Abundant along the Mississippi River.

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198. MADISON *State Journal* Sept. 27, 1859; Prairie du Chien *Leader* Sept. 29, 1859.
199. PRAIRIE DU CHIEN *Leader* Sept. 22 and 29, 1859; Milwaukee *Daily National* Oct. 5; Madison *State Journal* Sept. 17.
200. MADISON *State Journal* Sept. 30, 1859; Dodgeville *Advocate* Sept. 17; Mineral Point *Intelligencer* Oct. 3.
201. MADISON *State Journal* Sept. 23, Oct. 3 and 4, 1859; Madison *Daily Patriot* Oct. 1, 3, 5 and 6.
202. RACINE *Advocate* Nov. 2, 1859.
203. MILWAUKEE (d) *News* Oct. 13, 1859.
204. MONROE *Sentinel* Sept. 21 and 28, Oct. 12, 1859.
205. RICHLAND CENTER *Observer* Sept. 13, 1859; Milwaukee *Sentinel* Sept. 26.
206. COLUMBUS *Journal* Sept. 21, 1859; Portage *Record* Sept. 7, 14, 21 and 28; Madison *State Journal* Sept. 6; Portage *Badger State* Sept. 17.
207. BEAVER DAM *Democrat* Oct. 15, 1859; Fox Lake *Gazette* Sept. 8.
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209. MADISON *State Journal* Nov. 1, 1866.
210. A. S. HAWKINS. *Trans. Wis. Acad. Sci.* 32 (1940) 58.
211. RICHLAND CENTER *Republican* Jan. 3, 1867.
212. FRIENDSHIP *Press* Oct. 12, 1866.
213. EDGERTON *Union.* In Madison *State Journal* Dec. 30, 1866.
214. LA CROSSE *Republican and Leader* Nov. 4, 1871, 4.
215. DARLINGTON *Democrat* Dec. 22, 1871.
216. RICHLAND CENTER *Republican* Sept. 28, Oct. 12 and 26, 1871.
217. BARABOO *Republic* Sept. 20 and 27, 1871.
218. MILWAUKEE *Daily News* Nov. 5, 1871.
219. FRIENDSHIP *Press* Oct. 7, 1871; Kilbourn *Mirror* Sept. 29.
220. PORTAGE *Enterprise* Sept. 23, 1871.
221. BERLIN *Courant* Oct. 5, 1871.

222. LODI *Journal* Sept. 25, Oct. 9, 1872.
223. FRIENDSHIP *Press* Oct. 5 and 12, 1872.
224. DARLINGTON *Republican* Feb. 3, 1872.
225. RICHLAND CENTER *Republican* Sept. 19, Oct. 3, 10, and 31, 1878.
226. SPRING GREEN DOLLAR *Times* Sept. 17, Oct. 1, 1878.
227. PRAIRIE DU CHIEN *Union* Sept. 12 and 20, 1878.
228. FRIENDSHIP *Press* Sept. 14 Oct. 5 and 19, 1878.
229. EAU CLAIRE (d) *Leader* Sept. 30, 1883.
230. MENOMONIE *Times* Oct. 5, 1883.
231. ARCADIA *Republican and Leader* Oct. 11, 1883.
232. PRAIRIE DU CHIEN *Union* Sept. 21, 1883.
233. RICHLAND CENTER *Republican and Observer* Oct. 11, 1883, 1; Dodgeville *Sun* Oct. 5, 1883.
234. FRIENDSHIP *Press* Sept. 15, 1883.
235. BARABOO *Republic* Oct. 24, 1883, 1.
236. FRIENDSHIP *Press* Nov. 7, 1885.
237. *Ibid.* Oct. 17, 1885.
238. PORTAGE *Democrat* Oct. 9, 1885; *Register* Oct. 10.
239. BARABOO *Republic* Sept. 16, 23, Oct. 14, 28 and Nov. 4, 1885; Prairie du Sac *News* Sept. 19.
240. FRIENDSHIP *Press* Sept. 22, Oct. 13 and 20, 1888.
241. PORTAGE *Democrat* Sept. 28, 1888.
242. BARABOO *Republic* Sept. 12, Oct. 17, 1888.
243. DODGEVILLE *Chronicle* Sept. 21, 1888; Montfort *Monitor* Sept. 20.
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245. PRAIRIE DU CHIEN *Courier* Oct. 20, 1852; M. Birkbeck. Notes of a journey in America from the coast of Virginia to the territory of Illinois. Philadelphia. (1817) p. 169.
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# SQUIRRELS IN EARLY WISCONSIN

A. W. SCHORGER

The tree squirrels are set apart from most rodents by their beauty and food value. East of the Mississippi River they were the staple game animals in pioneer times and continued in this role long after deer had become scarce, or disappeared. The observant knew when the gray squirrel was being served, for on cooking, its bones acquire a pink color.[1] When the Indian did not possess a rifle, or chose to be economical, he used the bow. Bullock[2] while at Tuscarora, New York, in 1827, met an Indian and his boy laden with nearly a hundred squirrels that had been killed with a short and simple bow. Some of the New York Indians hunted squirrels with the blowgun,[3] a weapon undoubtedly brought in by the Tuscaroras when they migrated from the Carolinas.

White and Indian youth alike acquired skill in shooting by hunting squirrels. It was a point of pride with the hunter to kill his game by shooting it through the head or by "barking." The best marksmen in our armies through the Civil War were the men who had hunted squirrels since boyhood. The threat to southern Ohio by the Confederates in 1862 resulted in the call to arms of the "Squirrel Hunters" of that state.

Squirrels were a great problem to the early settlers due to their destructiveness to crops. The following statement is typical of conditions. "At that time [1823] it was an easy matter to raise grain and vegetables where the land was clear, but the great trouble was to save them. Squirrels, chipmunks and other vermin were so abundant that they would devour a field of corn almost entirely. . . . We used to have dead-falls for every fence corner, and some one of the family had to go around the field with a gun nearly all the time at certain seasons. I remember well that during warm weather, such was the stench from the carcasses of dead vermin, that it became nearly unbearable."[4]

The gray squirrel, due to its abundance, was particularly obnoxious. Massachusetts in 1740 voted a bounty of four pence on these animals.[5] In 1741, 4,762 gray and "ground" squirrels were presented for bounty in the Town of Westford, Middlesex County, Massachusetts.[6] The provincial government of Pennsylvania offered three pence per head for gray and black squirrels. After paying out 8,000 pounds, Pennsylvania currency, during the year 1749, the province retrenched to the extent of cutting the bounty in half.[7] An act passed in 1807 gave a one and one-half cent bounty on squirrels in Western Pennsylvania. Eight additional counties were included in 1811.[8] Most of the northern states at one time or another offered similar bounties.

A partial answer to the problem was the side hunt during which great numbers of squirrels were slain. During a two-day hunt in Madison County, Kentucky, 5,589 squirrels were killed.[9] Thirty hunters, on Christmas day, 1833, killed 1,200 gray squirrels at Fulton, Missouri. The hunt was an annual affair to reduce the destruction of crops.[10] Hall[11] mentions several side hunts in New York in which as many as 5,300 squirrels were killed; and one at Berlin, Vermont (?), that yielded 12,400. Other examples are given below.

Wisconsin had its side hunts but the numbers of squirrels killed were smaller than in some of the other states. There was the same problem of protecting the crops. As late as the fall of 1892, two men killed 188 squirrels in a cornfield of about ten acres near Viola, Richland County.[12]

Squirrels formed an item of importance in the game markets of Wisconsin. In the fall of 1876 the price ranged from $.90 to $1.25 per dozen in the Milwaukee market.[13] They were so plentiful in 1882 that the price dropped from $1.00 to as low as $.25 per dozen.[14] In 1890 they sold at two cents apiece in La Crosse.[15] There appears to have been occasional demands from furriers. There was an offer at Grantsburg in 1901 to buy 150 gray squirrels, those having large, bushy tails bringing the highest price.[16]

Squirrel hunting remains an important sport as is shown by the recent annual kills in Wisconsin and Michigan given below.

| | WISCONSIN | | |
|---|---|---|---|
| Year | Gray Squirrel | Fox Squirrel | Total |
| 1940 | 606,372 | 399,104 | 1,005,476 |
| 1941 | 409,626 | 258,756 | 668,382 |
| 1942 | 445,283 | 316,817 | 762,100 |
| 1943 | 348,572 | 240,800 | 589,372 |
| 1944 | 433,420 | 262,275 | 695,695 |
| 1945 | 422,543 | 245,726 | 668,269 |

MICHIGAN

| Year | Gray Squirrel | Fox Squirrel | Total |
|---|---|---|---|
| 1939 | 29,570 | 619,421 | 648,991 |
| 1940 | 34,980 | 725,565 | 760,545 |
| 1941 | 29,632 | 539,308 | 568,940 |
| 1942 | 44,602 | 644,825 | 689,427 |
| 1943 | 33,118 | 579,235 | 612,353 |
| 1944 | 48,315 | 700,330 | 748,645 |
| 1945 | 56,884 | 722,628 | 779,512 |

It will be noted that the gray is more abundant than the fox squirrel in Wisconsin, while the fox is far more plentiful than the gray squirrel in Michigan.

## THE RED SQUIRREL

The red squirrel appears to have ranged formerly throughout most of the state. I have never seen it in Dane County and there are no satisfactory records from Rock County west to the Mississippi River. It was common in Jefferson County[17] in 1856; however, the killing of one at Palmyra in 1887 evoked the comment that it was a rare species.[18] In July, 1866, this squirrel invaded Green Bay[19] and it was not uncommon to find half a dozen on one tree. It was very plentiful at Sturgeon Bay,[20] Stevens Point,[21] and Black River Falls[22] during the emigration of 1878; and at Marshfield[23] in 1883. In March of the latter year it was reported plentiful at Manitowoc.[24]

The red squirrel emigrates but the movement is not often spectacular. An extensive emigration took place in Essex County, New York, in the autumn of 1851. Watson states: "It is well authenticated, that the red squirrel was constantly seen in the widest parts of the lake [Lake Champlain], far out from land, swimming towards the shore, as if familiar with the service."[25] This squirrel is a better swimmer than the fox or the gray. Watson adds: "Reaching land, they stopped for a moment, and relieving their active and vigorous little bodies from the water, by an energetic shake or two, they bounded into the woods as light and free as if they had made no extraordinary effort." Cole[26] remarks on the ease with which it swims.

Further information on the movements of this squirrel in the Adirondacks is given by Merriam. He says: "James Higby tells me that in June, 1877, he saw as many as fifty crossing Big Moose Lake, and they were all headed the same way — to the north. I am informed by Dr. A. K. Fisher that at the southern end of Lake George, in early autumn, it is sometimes an every-day occurrence to see Red Squirrels swimming across the lake from west to east — never in the opposite

direction. The chestnut grows abundantly on the eastern side of the lake, but is comparatively scarce on the western, and these extensive migrations always take place in years when the yield of chestnuts is large."[27]

This species was frequently seen by Hardy[28] in emigration in Maine, swimming from east to west. Cole,[26] on September 18, 1921, found a red squirrel swimming southward across White Sand Lake, Vilas County, Wisconsin from a point where the lake was an eighth of a mile wide. The same autumn one was taken from the stomach of a great northern pike (*Lucius lucius*) at Lake Fanny Hoe, Keweenaw County, Michigan, where this squirrel was frequently seen to swim the lake.

The red squirrel has been losing ground gradually in the southern part of the state. The extent of its distribution southward was determined from information received from nearly one hundred residents within the vicinity of the present boundary (Fig. 1). Its persistence in southeastern Wisconsin appears to be due to the remnants of tamarack swamps. *Tamiasciurus hudsonicus loquax* occupies the state except in the northwest where it is replaced by an intergrade with *T. h. minnesotae.*

### The Fox Squirrel

The fox squirrel (*Sciurus niger rufiventer*) was not common in early Wisconsin but increased with settlement. "Atticus,"[29] writing in 1844, stated that gray and black squirrels were so common at Racine that a hunter could kill twenty of them in an afternoon. The fox squirrel was seen only occasionally, but he had killed several of them. During a hunting match that took place at Racine early in the winter of 1836, the red squirrel counted five, and black, gray and fox squirrels ten points.[30] Buck[31] states that in 1836 the northern slopes of the bluffs on Oregon Street, Milwaukee, were covered with "a growth of poplar and hazel, a great resort for black, gray, and fox squirrels."

In 1850 Moses Barret[32] settled on the Indian lands at Wautoma where he found red, gray, black, and fox squirrels. An occasional fox squirrel was to be found at Oshkosh[33] in 1859. Ficker[34] mentions only the gray and black squirrels as occurring in the town of Mequon, Ozaukee County, the winter of 1848–49. His "chipmunk" was evidently the red squirrel as it is described as very similar in coloration, but smaller than the German red squirrel. During a side hunt at Watertown in the fall of 1849, 235 black and gray, and 305 red

squirrels were killed by 20 hunters. The fox squirrel was not mentioned.[35] However, in 1856, the woods at Jefferson "are alive with squirrels — black, gray, fox and red that are committing sad havoc with our farmers' corn."[17] A side hunt at this place in 1866 yielded "over 350 black, gray and fox squirrels, about 200 red . . ."[36] The red squirrel counted five and the other species ten points each, indicating that the fox squirrel was not sufficiently rare to secure a premium.

The fox squirrel was the most numerous species at Brodhead,

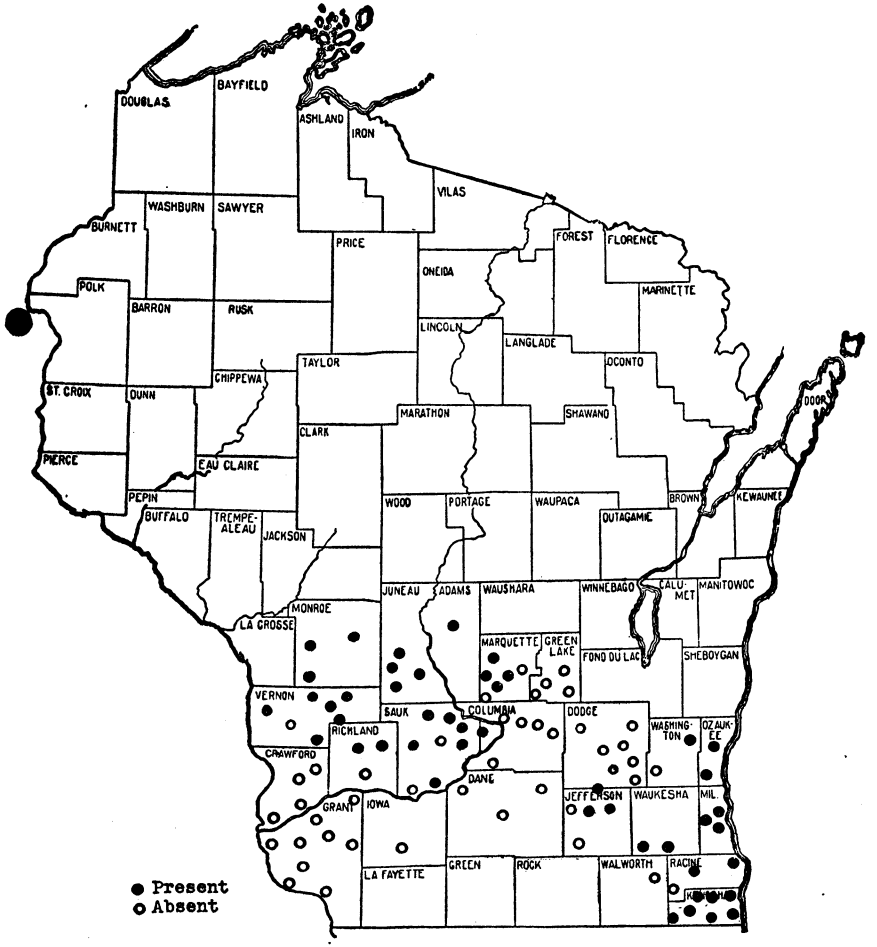


FIG. 1. Southern range of the red squirrel in Wisconsin.

Green County, in 1869.[37] Fox and gray squirrels were abundant, red few, and black rare, at Waukesha in 1879.[38] At this time Strong[39] limited the fox squirrel to the southern and eastern parts of the state. An opinion on the relative abundance of the various species in Richland County in 1882 may be formed from the points set for a side hunt: red 10, gray 25, black and fox squirrels 50 points.[40] In 1899 a hunter in this county is reported to have found 17 fox squirrels in one tree and to have killed 13 of them.[41] During a side hunt at Plymouth, Sheboygan County, in 1890, 3 fox, 2 black, and 33 gray squirrels were killed.[42]

Fox, gray and black squirrels occurred at Trempealeau in 1883, the gray predominating.[43] Kessinger,[44] in 1888, reported the status of the squirrels in Buffalo County as follows: fox, "not numerous"; gray, "more numerous"; black, occasional; and red, abundant. Fox, gray, and black squirrels occurred near Montello, Marquette County, in 1877.[45] In 1886 there were fox, gray, and red squirrels at Tustin, Waushara County.[46]

A fox squirrel was shot in Outagamie County in 1904.[47] Komarek[48] in 1932 listed the fox, gray, and a few black squirrels for the Menominee Indian Reservation, northeastern Shawano County. I was told by Edward Puchner in 1942 that fox squirrels appeared near Wausau three or four years previously. A few black squirrels were to be found but the gray predominated.

There is at intervals a considerable variation in the ratio of fox to gray squirrel populations. During a residence of 40 years in Dane County, I have found that the fox squirrel has always been the more numerous, taking the county as a whole. The gray squirrel was uncommon in the city of Madison up to 1934. Since that time it has increased to the point of being about as plentiful as the fox squirrel. Joseph Henderson, who was born near Riley, Dane County, in 1884, informed me that when he was a boy nearly all the squirrels were gray, a fox squirrel being considered a "prize." A similar situation in Dodge County is reported by Snyder.[49] In 1888 the fox squirrel was rare and the gray common at Beaver Dam. By 1902 this condition was reversed.

The fox squirrel is less numerous than the gray in the state. There were 245,700 fox squirrels killed in 1945. There was one fox squirrel killed to 1.7 gray squirrels. The fox squirrel was decidedly superior numerically to the gray in Calumet, Fond du Lac, Green, Richland,

and Rock counties, less so in Brown, Dane, Outagamie, and Winnebago counties.

The upper range of the fox squirrel, Green Bay to the northern end of Lake Pepin, as given by Hamilton[50] in 1943, is too conservative. The movement of squirrels in northwestern Wisconsin in the fall of 1946 showed that the fox squirrel was common at Hudson and that a few were resident at Osceola, Polk County.[51] Prof. J. R. Jacobson, Central High School, Superior, informed me that this species

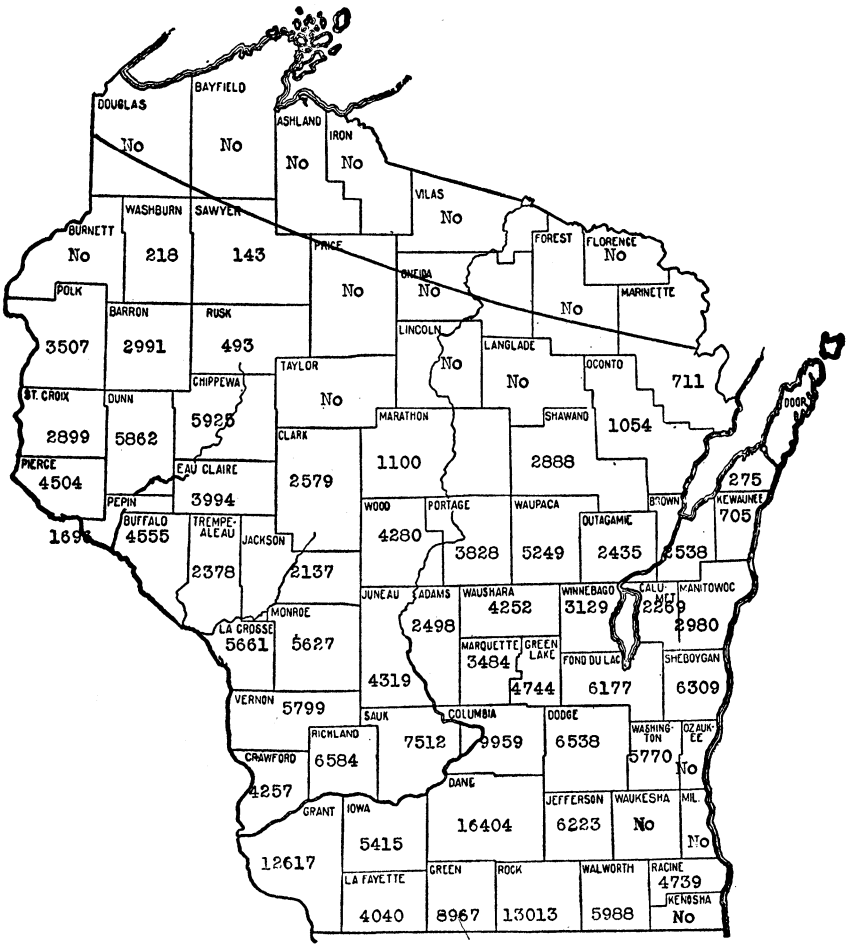


FIG. 2. Range of the fox squirrel in Wisconsin and the kill by counties in 1946. "No" shows no open season.

now occurs 20 miles south of Superior. It is fairly common in southern Marinette County, though Allen[52] reported it absent in Menominee County, Michigan. C. H. Richter wrote me that it has been at Oconto for at least 20 years. The present range is given in Fig. 2.

A fox squirrel with black markings is now comparatively rare in the state. A century ago fox squirrels with black bellies seem to have been fairly common. When Dr. P. R. Hoy[53] was in St. Louis in 1854 he noticed in the window of a barber-shop a black-bellied fox squirrel such as was found in the vicinity of Racine, Wisconsin. On inquiry he learned that it was obtained on the Wisconsin River.

Kennicott wrote: "A variety of this species is occasionally met with in which the tail and upper parts are of the usual colors, but with the entire under parts of the body perfectly black. It has only been observed in Southern Wisconsin and Northern Illinois."[54] Mrs. H. A. Main, Fort Atkinson, has a memo left by Thure Kumlien listing a male black-bellied fox squirrel, taken at Busseyville, August 26, 1880, as of possible interest to the University of Wisconsin. He valued it at $2.00. Snyder[49] had in his collection three specimens with the underparts black and states that three examples of complete melanism have been found in Dodge County. H. E. Reed, Ashippun, told me that about November 1, 1944, while hunting at Auroraville, Waushara County, with his son, the latter killed a black-bellied fox squirrel. He had never seen one before.

It has been generally assumed that the fox squirrel does not emigrate even when the gray squirrels are moving en masse. Porter[55] states that during an immense emigration of gray squirrels in Butler County, Pennsylvania, the fox squirrel, though common in eastern Pennsylvania, was not seen. Kennicott[54] remarked that this species will migrate singly but not in large companies; and that it has been known to cross "a prairie in summer four or five miles in width, to reach timber upon the other side." Brown and Yeager[56] found no evidence of an emigration of this squirrel in Illinois.

Authentic cases of emigration are rare in the literature. Britton,[57] when a boy, mentions seeing about 100 fox squirrels moving southward on the ground and along rail fences. Bennitt and Nagle[58] record small but very definite emigrations in Missouri in recent years.

On October 1, 1946, Harry Strobe gave to Aldo Leopold information obtained from his father on a movement of squirrels in the 1880's (probably 1883). The observations were made on Strobe's Island, an area of 90 acres situated in the Fox River three miles

south of Appleton, Wisconsin. Squirrels also crossed the river four or five years after this date. The movements, starting in August and continuing into September, lasted over a period of three to four weeks. The crossing, always westward, took place during the entire day, and 25 to 30 squirrels could be seen swimming at one time. "About 80 to 90 percent of the squirrels were grays and the rest were black and fox squirrels. Sometime after 1890 the fox squirrels replaced the gray squirrels and the numbers of squirrels declined."

Under date of October 19, 1938, Aldo Leopold sent me some information, furnished by Earl Schultz, Oregon, Wisconsin, on an emigration of fox squirrels at Reed's Landing at the lower end of Lake Pepin in September, 1903. The movement lasted for two weeks and no gray squirrels took part. The squirrels crossed daily from noon to 3:00 P. M. The direction was westward. When a squirrel was pushed off the eastern side of a boat, it invariably oriented itself and continued westward. On September 3, 1944, Cyril Kabat observed a movement of fox squirrels in the Puckaway Marsh, at the eastern end of Lake Puckaway, Green County, Wisconsin. "As many as 20 fox squirrels were observed attempting to swim across the Fox River and adjoining marsh waters . . . The movement was from west to east. The water area was about half a mile wide at this point." The distance from the timber from which the squirrels apparently started to the next hardwoods in the line of march was at least two miles.

The fox squirrels moved en masse during the squirrel emigration in northwestern Wisconsin in the fall of 1946.[51] In western Jackson County, where the direction of the movement was southwesternly, Warden Werner Radke saw "approximately fifty fox squirrels while traveling a mile of road in the towns of Albion and Springfield."

## The Gray Squirrel

*Range.* It is not possible to determine accurately how far north the gray squirrel occurred a century ago. While at Lac du Flambeau in 1804, Malhiot[59] wrote in his journal that the squirrels were doing much damage in the corn fields. This probably refers to the red squirrel. Kennicott[54a] in 1856, stated on the authority of Dr. Hoy that it did not occur in northern Wisconsin but was abundant in the southern part of the state. It was very abundant at Appleton[60] in 1854 and at Green Bay[61] in 1856, so that it must have occurred in this latitude prior to settlement. It is reasonable to assume that it was indigenous to all the northern counties. Richardson[26] stated in

1829 that the black squirrel was not uncommon on the northern shores of Lakes Huron and Superior, the gray never being seen. He mentions a specimen secured at Fort William, northeast of the present Minnesota boundary.

The increase northward has been induced by agriculture and the replacement of conifers by hardwoods. It was in Lincoln County by 1893. Through the felling of a tree a litter of six young was taken near Merrill[63] in August. The shooting of a gray squirrel at Florence in 1886, and again in 1895, in both instances induced the remark that this species was very rare in Florence County.[64] In October, 1895, a hunter killed 8 gray squirrels at High Ridge, 15 miles south of Ashland. They were supposed to be the first killed in that part of the state.[65] Chief Justice Marvin Rosenberry informed me in 1939 that about 25 years previously, while hunting deer at Star Lake, Vilas County, he shot a black squirrel and brought it into camp since it was a rarity. It has been reported from Duluth,[66] and in the fall of 1946 a few grays appeared in the city of Superior. Today it is found in all of the northern counties, but is rare in the immediate neighborhood of Lake Superior. (Fig. 3).

Most of the state is occupied by *Sciurus c. leucostis.* The status of the races in northern Wisconsin has not been worked out. The planting of *leucostis* in Vilas County in the years 1934-36 complicates the problem.[67] Burt[68] refers all the gray squirrels of the Northern Peninsula to *S. c. hypophaeus,* but in an earlier paper he thought that this race might be only a color phase.[69] The occurrence of *hypophaeus* in Dodge County, as reported by Snyder,[49] is open to question since no specimens appear to have been taken. Presumably the squirrels of northernmost Wisconsin are *hypophaeus.* On September 13, 1839, Bachman wrote to Audubon:". . . the ever varying Squirrels seem sent by Satan himself to puzzle the Naturalists." The latter have advanced to the stage where they seek bedevilment.

*White Phase.* Albinism appears to occur most frequently in regions where there is melanism. I am indebted to Prof. Leon J. Cole for some correspondence on the two color phases in the state. About the year 1913, three white squirrels were captured at Westfield, Wisconsin.* In the fall of 1940, Warden Hartwell Hope, Westfield, reported the presence of about 17 black squirrels in one locality and 7 black and one white in the town of Lincoln, Adams County. The same fall Carl L. Brosius, Acting Commandant, reported 30 to 35 black and 4 white squirrels on the grounds of the Grand Army

Home for Veterans, at Waupaca. On March 13, 1947, Gordon L. Paeske wrote to me that there were two white squirrels near the campus of Northwestern College, Watertown. There has been for many years a large colony of white squirrels at Olney, Illinois. Harvey D. Hays informed me that the present population of about 500 albinos stems from a pair introduced in 1902.

*Black Phase.* While predominating formerly in certain regions,

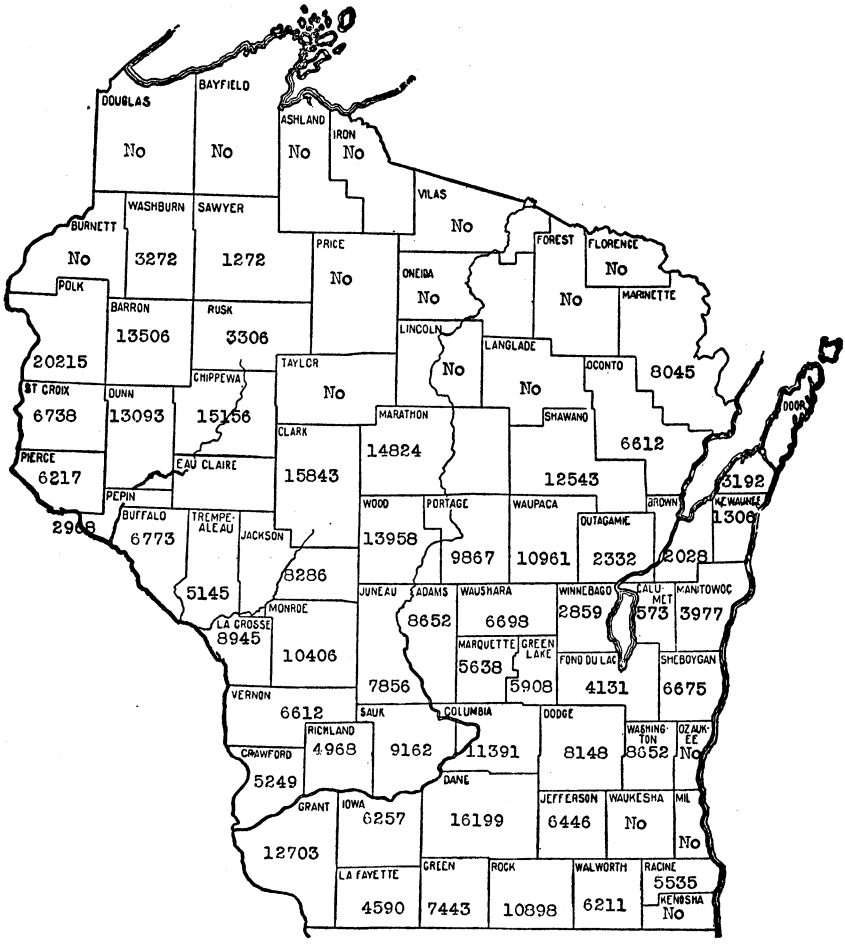


FIG. 3. Kill of gray squirrels in Wisconsin by counties in 1946. "No" shows no open season.

the black phase of the gray squirrel, for some unknown reason, becomes rare or disappears with the advance of civilization. It may be stated that in general the black phase increases as the northern limit of the species is approached. On October 15, 1749, Kalm wrote: "Yesterday and today we saw black squirrels in the woods. This squirrel is quite common about Fort St. Frédéric, but north of Montreal it is rather scarce and hard to find. They have these instead of the gray squirrel."[70]

Weeks writing of Salisbury, Vermont, said: "Grey-squirrels were rarely met with before the commencement of the present century, though they are now quite numerous; while black-squirrels, though now nearly if not quite extinct, were then found in quite large numbers."[71] The same trend at Weare, New Hampshire, was noted by Little.[72]

The black squirrel was very destructive to crops in New York, the gray arriving with settlement.[73] In the Genesee River region, black and red squirrels were common in 1804 but the gray was rare.[74] Some information on the disappearance of the black squirrel at Le Roy, New York, is given by Comstock.[75] This phase declined from about 90 percent to 2.5 percent from about 1850 to the period 1884-90. Dr. L. F. Hawley informed me that the ratio of black to gray was three to one at his home, Salamanca, New York, in 1900 and that on going to Ithaca only the gray was to be found.

The black squirrel, about 1800, was abundant in Crawford County, Pennsylvania, the gray arriving with settlement.[76] According to Beck,[77] the black squirrel, known locally as the "stump-ear", has been replaced almost entirely by the gray in Lancaster County, Pennsylvania.

The black squirrel was the dominant form in southwestern Michigan.[78] According to Evermann and Clark,[79] a large proportion of the squirrels in southern Michigan were black, while in middle Indiana a black squirrel was seldom seen. Kennicott[54a] mentions that of a lot of nearly fifty squirrels shot near the Rock River, Illinois, all were black. As late as 1872 black and gray squirrels were reported plentiful in the woods north of Freeport, Illinois.[80]

The cause of melanism has been discussed by Rhoads. He suggests that, "the original status of the black squirrel is dependent on an environment combining the climate and flora of the Upper Transition and lower Canadian life zones, in which coniferous and nut-

bearing trees were normally in the proportion of about ten to one. As these conditions through human agency revert to those of the Lower Transition and Upper Austral zones, with a corresponding increase in population, the ratio of blacks to grays decreases."[81] Rhoads' theory seems entirely inadequate since the black squirrel was once abundant in regions where conifers were entirely absent. The gray squirrel is characteristic of deciduous rather than coniferous forest. In this connection it is of interest that Spärck[82] in Denmark found a direct correlation between the dark phase of *Sciurus vulgaris* and deciduous forest.

The black phase was at one time the sole or prevailing form in the northern part of the range of the gray squirrel and pioneered in the extension of territory.[83] Seton states that, "melanism increases in frequency northward, until in Canada, the black is the rule; there, at most, 5 percent are gray."[84] Bachman[85] noted that both grays and blacks were to be found in the same litter. Black is a recessive character and tends to disappear. The gray form carries the genes producing black, so that when the proper combination of genes is produced in the mating of grays, the black phase may appear after several generations of grays. The heterozygous nature of the gray squirrel has been discussed recently by Shorten.[86] Gray squirrels were introduced at Woburn, England, in 1890, the black phase being introduced later. Shorten found that in a litter of four young produced by a pair of grays one was black; and a black female was found suckling a single black young.

The disappearance of the black phase is an intrigueing problem. The cause is possibly climatic. I believe that it is logical to assume that melanism developed on the borders of the glaciers during the Pleistocene when the climate was cold and moist. The line of maximum glaciation runs approximately from New York to St. Louis. Pleistocene remains are of little assistance since only a few of *Sciurus carolinensis* have been found, and these in Pennsylvania and Maryland.[87] The southern range of the northern gray squirrel at the time of the appearance of white explorers in the Ohio Valley is not determinable. In fact the first acceptable approximation of its range is that given by Allen[88] in 1877. He stated that it extended south to about isotherm 50° F., where the two forms were not readily distinguishable. Presumably he used the isotherm of Schott.[89] Allen gave but two definite localities, Washington and St. Louis, for the southern limits of *leucostis*. In Illinois and Indiana the line of maximum gla-

ciation and the above isotherm coincide roughly but in the other states there is considerable deviation. This is due largely to the Appalachian range. As is well known, increase in altitude has the same effect as increase in latitude on faunal distribution.

The southern form of the gray squirrel, according to Hamilton,[50a] extends at the present time to central Illinois, Indiana, and Ohio. On the other hand Lyon[90] states that except for the two northern tiers of counties all the gray squirrels of Indiana are referable to the southern form. He makes the following pertinent comment: "The frequency with which black squirrels were reported in the early days from comparatively southern portions of the state leads to the belief that the Northern Gray Squirrel extended farther south than recent writers indicate."

The black squirrel was rather uncommon directly along the Ohio River during the early 1800's. Of the squirrels crossing the Ohio in 1803, "many" were black.[91] There were also black squirrels in the emigration of 1817;[92] however, Blane informs us that these were considered invaders from the north. He wrote that, "they knew from seeing the black or Canadian squirrel, that they were to expect vast multitudes; since the animals of this species do not make their appearance, unless in times of the failure of the mast . . . in the Northwestern forests."[93] This statement loses significance since the distances travelled in the migrations are unknown.

Palmer,[94] in 1817, found the black squirrel near Cincinnati. No migration is recorded for this year. Maximilian[95] spent the winter of 1832-33 at New Harmony, Posey County, Indiana. He was informed by Le Seur that during several years residence he had seen but one example. On the other hand Haymond wrote in 1869: "The black squirrels were common — forming about one-third of the total number of squirrels in southeastern Indiana [Franklin County] at the period of its first settlement. Now they have completely disappeared."[96] When the Kanawha Valley was first settled, gray and black squirrels were very numerous and every few years they migrated from west to east in countless numbers.[97]

*Black Squirrel in Wisconsin.* The first highway surveyed in southern Wisconsin, according to John Trumbell,[98] ran from Racine to Janesville. In August, 1839, he travelled this road in a light wagon "shooting black squirrels by the way." He remarked that Walworth County, in comparison with Racine, was "a little better timbered."

At that time the road from Racine to Milwaukee ran through a strip of heavy timber about 15 miles wide. Black squirrels emigrated from Dane County in 1856.[99] One was shot in this county in November, 1899.[100] Bade[101] relates that during the early days at Plymouth he and a companion killed 67 gray and black squirrels in the town of Mosel, Sheboygan County, in a day's hunt. The black phase was not plentiful. Black and gray squirrels were reported abundant in Sheboygan County in 1894.[102]

When Featherstonhaugh was near the foot of Lake Pepin in September, 1835, he observed a great many gray squirrels, "but no black ones, which I have seen abound so much in Upper Canada."[103] This is curious since the black phase occurred throughout western Wisconsin. A party hunting 15 miles north of La Crosse in 1863 killed 13 gray and 9 black squirrels.[104] By 1888 only a few black squirrels were to be found in Buffalo County,[44] but they are not yet extinct.[105]

Black squirrels were abundant at Prescott[106] in 1868, at Hudson[107] in 1878, and at New Richmond[108] in 1895. Theye were quite plentiful at Rice Lake, Barron County, in 1880.[109] At this time Strong[39] reported it as occurring rarely throughout the range of the gray squirrel. A black squirrel with the terminal half of the tail white was killed at Friendship,[110] Adams County, in 1871.

This squirrel was common at Grand (Wisconsin) Rapids[111] in 1883. At this place on the afternoon of September 25, 1895, two hunters killed two black and 18 gray squirrels. Black and other squirrels were common at Stevens Point[113] in 1878 and at Marshfield[114] in 1883. In the fall of 1886 the woods near Neenah were "full of black squirrels."[115] Hamilton [116] mentions the killing of 19 black and gray squirrels at Sturgeon Bay in 1894. By 1901 the shooting of a black at this place was worthy of note.[117]

Today the black squirrel is very rare south of Baraboo and Reedsburg. North of the latitude of these places it is nowhere abundant, but may be considered fairly common locally.

*Emigration.* The early emigrations* of the gray squirrel were so impressive as to be recorded frequently by travelers. Kalm devoted several pages to this animal and said that, "it is peculiar that in some years a greater number of squirrels come down from the higher countries into Pennsylvania and other English colonies. They commonly come in autumn . . ."[7a] An emigration occurred in the autumn of 1749 while he was in America.

Col. Joseph Barker, one of the founders of Marietta, Ohio, in

1788, wrote: "The migration of the gray squirrel is a very curious phenomenon, and not easily accounted for. In the autumn of certain years they become itinerant, traveling simultaneously in millions from north to south; destroying whole fields of corn in a few days, if not immediately gathered . . . traveling forward without stopping long in any place; swimming large rivers; and perhaps before winter, returning again by the same route toward the north."[118]

Notable emigrations occurred on the Canadian border. Weld wrote in September, 1796: "The squirrels this year, contrary to the bears, migrated from the south, from the territory of the United States. Like the bears, they took to the water on arriving at it, but as if conscious of their inability to cross a very wide piece of water, they bent their course towards Niagara River, above the falls, and at its narrowest and most tranquil part crossed over into British territory. It was calculated that upwards of fifty thousand of them crossed the river in the course of two or three days, and such great depredations did they commit on arriving at the settlements on the opposite side, that in one part of the country the farmers deemed themselves very fortunate where they got in as much as one third of their crops of corn. These squirrels were all of the black kind said to be peculiar to the continent of America."[3a]

There seems to have been a general movement of animals in 1796. Rev. Zeisberger wrote at Fairfield, on the Thames, Canada: "With game too it has been unusual. Raccoons, squirrels, bears, wolves, and wild turkeys came in great number, and did great harm to the fields . . . Besides all sorts of vermin came from the south, tried to get over the river, and were drowned, whole heaps of which could be seen."

Another extensive emigration took place in 1807. Featherstonhaugh, in Upper Canada, "met the most surprising quantities of fine glossy black-skinned squirrels . . . : they had spread over an immense district of country, and were evidently advancing from Lake Huron to the south."[103a] This year Schultz found black squirrels astonishingly numerous on the north shore of Lake Erie. On August 16, 1807, he wrote that, "they were literally in small flocks upon the trees; on some we found ten, twelve and fifteen, and L. even killed five of them at one shot. Indeed, it was hardly necessary to shoot them, as you would frequently find three or four upon a little bush not more than twelve or fifteen feet in height. We shot one hundred and eighty-seven in less than three hours. They were exceedingly fat . . . It is somewhat singular that on the American side, you may range a day through

the woods, and scarcely pick up half a dozen of these animals, while there are such innumerable flocks on the opposite shore; an evident sign, I think, that the present multitudes . . . have migrated from the interior of the north-west, until their further progress south-eastwardly was arrested by the broad and rapid stream of Niagara."[92a]

Beardsley describes an emigration that took place at Niagara Falls in the fall of 1815: "All along the river, the trees and fences were covered with black squirrels, and thousands were swimming from the Canadian to the other side. I never saw them so plenty, anywhere before; and have never seen them in such numbers in our own state [New York] as they were that year."[120] During the early 1800's there were huge movements in the opposite direction. The squirrels were killed with sticks as they landed on the Canadian shore.[121] Talbot[122] states that in the summer of 1820 squirrels were so numerous as to destroy about one thousand acres of corn in the township of London, Ontario.

An emigration of gray squirrels took place in eastern New York in 1808 or 1809. Judging from the descriptions of Bachman[123] of some of the squirrels, the grays were accompanied by chipmunks. They crossed the Hudson between Waterford and Saratoga, and stopped in the mountains of Vermont. Many remained in Rensselaer County, east of the Hudson, where they were numerous for several years. There was no evidence of a return.

A French officer stationed at Fort Duquesne (Pittsburg) wrote that in August, 1755, black and gray squirrels were crossing the rivers. They crossed two and three times daily, and as many as 700 to 800 being seen at one time. He stated that they took to the water due to an itching on the head and added: "We had to throw the heads away because they had worms in their brains, which caused them to blacken and make the animals somewhat crazy."[124] When Schoepf[125] was at Pittsburg in early September, 1783, unbelievable numbers of gray and black squirrels were emigrating from the frontiers toward the coast. Vast numbers were killed. Two boys at Wheeling shot 219 in three days.

Emigrations of the greatest magnitude took place in the north central states where the preponderance of mast-bearing trees led to high populations. Rev. Cutler[126] on September 10, 1788, caught a a great number of squirrels that were swimming the Ohio below the mouth of the Little Muskingum. On September 11, 1803, at Sunfish Creek, about 117 miles below Pittsburg, Captain Lewis recorded

in his journal that squirrels were crossing the Ohio, "universally passing from the W. to the East shore they appear to be making to the south."[91] On the 13-15th the squirrels were swimming from the northwest to the southeast, only one being observed to swim in the opposite direction. On the 15th they camped 201 miles below Pittsburgh so that the migration covered a front of 84 miles.

Another emigration occurred in 1807, only four years later. Schultz wrote on October 6: "This country appears to be completely overrun with innumerable quantities of black and grey squirrels. The river (Ohio), since we left Marietta, has afforded us an abundant supply of these animals, without any trouble on our part, as our boat had continually five or six of them on board . . . I have counted no less than forty-seven at one time swimming across the river in different directions. The shores on each side of the river are literally lined with drowned squirrels; and I suppose that one third at least of those who take to the river perish in the water. They all appear to be migrating to the southward. Higher up the river we found them very fat . . . but they have now become too poor to be eatable."[92b] The Ohio was polluted by the thousands of dead squirrels on its surface and its banks. Cuming[127] was in Adams County, Ohio, near the Ohio River on August 8, 1807, when he found the woods "alive" with squirrels. This shows that the movement extended over a period of at least two months.

The emigration of 1807 is mentioned by Hildreth. In a paper dated January 17, 1809, he states that "last" year crops were injured by myriads of gray squirrels. They appeared to be "migrating from the north to the south — hundreds could be seen crossing the Ohio, where it was nearly a mile wide; in this attempt thousands were drowned."[128] This undoubtedly refers to 1807 for in a later paper he mentions the years 1807, 1822, and 1843 as memorable for the emigrations and depredations of this squirrel.[129]

Scott[130] quotes Col. Keys as stating that the squirrels began to appear in Highland County early in the spring of 1807 and that by the first of May the whole of southern Ohio was inundated. The planted corn was taken up almost entirely. Jones[131] also states that the squirrels emigrated in 1807 directly after corn-planting and that the crop was a failure over a large part of the country. Spring emigrations were unusual. As mentioned above there was an emigration in Ontario this year. The emigration of 1807 is accordingly remarkable for duration and extent of territory.

The next huge emigration took place in 1822. Blane has given us the following graphic description: "I could scarcely believe my eyes, when I saw the immense number of these animals, who were busily employed in destroying a field of Indian corn, and who, on our approach, took refuge in the neighboring thicket. We shot eleven out of one tree; from which also several others, alarmed at the noise of the rifles, jumped out and escaped. These little animals had that year done incalculable mischief to the Indian corn, throughout the States of Ohio and Indiana. They also swam the Ohio river by myriads, and ravaged the shores of Virginia and Kentucky. I found that this host of squirrels had in many places destroyed the whole crop, and that the little fellows were sometimes seen, three or four upon a stalk, fighting for the ear. In parts of Ohio, the people attempted to destroy them by means of guns, dogs, and clubs. One party of hunters, in the course of a week, killed upwards of 19,000. In most places, however, there were such multitudes of them, that the inhabitants quite despaired of being able to rid themselves of this plague. Whole legions of these animals when crossing the river were killed by boys and dogs; but their numbers did not appear to be sensibly diminished, until they came to the open and cultivated parts of Kentucky, where, as they had no longer the trees to take shelter in, they were easily destroyed. The farmers with whom I conversed, told me that the oldest settlers had never recollected seeing so many. But about fifteen years before [1807] they were almost equally plagued."[93] The effect of the destruction of the crops was acutely felt at Chillicothe, Ohio, in the spring of 1823, where the farm animals, particularly hogs, were starving to death. This shows that there was no mast left in the woods.

The naturalist, Godman, also witnessed the emigration in Ohio in the fall of 1822. He states: "Fortunately for the farmers these animals are not at the same time equally numerous in different parts of the country. We found the squirrels in 1822, most numerous throughout the country lying between the Great and Little Miami rivers; they became evidently fewer as we advanced towards Chillicothe, and beyond that place were so rare as to be seldom seen."[132] Blane's account shows that Godman arrived at Chillicothe after the emigration had passed. It extended beyond Columbus where squirrels were so numerous that a county-wide hunt was organized.[133] This took place early in September and 19,900 scalps were produced.

This was not the total kill since a great many hunters did not report.

The direction of the emigrations in Ohio was usually southeast or south. The irregular emigrations passing through Dayton, Ohio, originated in the northwest.[134] Bushnell,[135] in his annals under the year 1816, mentions a large emigration of squirrels towards the southeast in Licking County, Ohio. The movement across the Ohio River was not always southward. Jacob Hoffner informed Dury[136] that in the autumn of 1816 great numbers crossed the river from Kentucky below Covington.

An emigration lasting about 20 days took place in Miami County, Ohio, "about the year 1828-29", and passed from west to east.[137] One of the last large emigrations in Ohio took place in 1843. Hildreth states: "In addition to the other calamities which befell us . . . the gray squirrels commenced their depredations on the corn as soon as it was fairly in the milk, and continued them till it was gathered. They were most numerous in September and October, migrating from the woods in the interior in countless hosts; one man could kill a hundred and more in a day. . . . Thousands of them swam across the Ohio River."[129]

Indiana was as well populated with gray squirrels as Ohio. Flint relates that in the emigration of 1811, "they emigrated from the north towards the south by thousands, and with a front of some regularity, along the lower part of the state of Ohio, and the whole of Indiana."[138] This emigration is mentioned briefly by Latrobe.[139]

While on a collecting trip in 1819, Audubon observed large numbers of gray squirrels swimming the Ohio. The emigration began 100 miles below Cincinnati and extended to within 100 miles of the mouth of the Ohio; accordingly on a front of about 125 miles. "At times they were strewed, as it were, over the surface of the water."[85]

Hamilton County was over-run in 1826. The squirrels passed from west to east for a period of two weeks.[140] The year 1834 was remarkable for the number of squirrels throughout Indiana. Hahn[141] states that in Wabash County they emigrated northward, crossing the Wabash River in countless numbers. The woods and prairies near Crawfordsville, Montgomery County, swarmed with them for a period of two to three weeks.[142] According to Banta[143] this was an exceptionally bad year for squirrel depredations in Johnson County. Hahn mentions that in a great squirrel hunt in Bartholomew County the champion killed 900 squirrels in three days. The next largest score was 783. He also stated on the authority of E. J. Chansler that

the squirrels emigrated from Knox County this year and again in 1836 and 1837.

It is stated that Kentucky was invaded by squirrels in great numbers early in the spring of 1850. The great southward emigration across the Ohio into Kentucky in 1822 is also mentioned.[144] In September, 1877, Harrison and adjoining counties in Indiana were overrun by squirrels. The movement was northward.[145] A much larger emigration was said to have taken place in 1833.

Large emigrations have occurred west of the Mississippi and south of the Missouri. Galland, writing of Iowa in 1840, stated: "The common grey squirrels are found plentifully in the woods, with a few scattering fox squirrels, but no black ones . . . neither have I discovered the singular phenomenon of migration and emigration, profusion and scarcity, of these little animals, which are so remarkable in the early settlement of the Ohio valley."[146]

The middle of September, 1859, "hundreds of thousands" of gray squirrels appeared along the Merrimac River, Missouri, crossed the Mississippi, worked their way down the river, then crossed to Cape Giradeau in "countless myriads".[147] The old French settlers said that similar hordes were encountered in 1834 and 1852. It was the year 1834 that Townsend[10] found the gray squirrel so numerous in Missouri.

There has been a great number of comparatively small emigrations of the gray squirrel during the past 100 years. A few of these movements will be mentioned subsequently to emphasize a particular point.

*Nature and Cause of Emigration.* One of the most striking features of the movement of gray squirrels was the persistance with which these animals adhered to a course when it became set. They would not be turned aside by prairies, rivers, lakes of moderate size, or even villages. Before entering the water, they were said to climb trees to view the hazard ahead. Attempts to cross a stretch of water more than a couple of miles wide were rarely made. No instances were found where they blindly entered the Great Lakes. Crossings between Ontario and New York were made at the Niagara River. A hunter told Comstock[148] that in September, 1848, he saw "two acres" of black and gray squirrels crossing Seneca Lake, New York, at a place where it was five miles wide. They crossed from east to west. The next year these animals were plentiful on the west side and absent on the east.

A good account of the crossing of a lake is given by De Voe. He states: "It is said that they always travel to the east, often hundreds of miles, and when necessary to cross a river or lake they enter the water like dogs, if it is quite smooth. In the month of September, 1851, I arrived at Lake George [N. Y.] where I found the gray and black squirrels had been travelling for several days and were still moving. Early one morning I discovered three or four at several distances, swimming from the western to the eastern shore of the lake, which at that time was as smooth as glass. I watched them as long as I could see the ripples which they made, and supposed they succeeded in crossing the lake, which at this point was more than a mile wide. They will not enter the water when there is a ripple, as they swim very deep and of course drown easily; sometimes they are caught out in the rivers or lakes with a sudden breeze, just enough to agitate the water, when it drowns them, without they are lucky enough to catch a floating piece of bark or wood to mount upon, and with their tails curled up they are blown or wafted ashore. (People finding them in this situation are led to believe that they started with a float)."[149]

One writer remarks that he had frequently seen black squirrels crossing the Niagara River and that they "swam across, when the morning first began to dawn. On reaching the opposite shore they would appear greatly fatigued, and if unmolested would take a pretty long rest preparatory to their setting off for the neighboring woods."[150] There seems, however, to be no particular time of day chosen to cross water. Schultz,[92b] while floating down the Ohio, encountered them throughout the day.

The gray squirrel was considered by Bachman[123] to be a clumsy swimmer. Those that crossed the Hudson swam deeply and awkwardly, their bodies and tails being wholly submerged. On the other hand Lewis wrote that, "they swim very light on the water and make pretty good speed."[91] Weld[3a] states that no animal swims better and that when pursued he has seen them take to the water voluntarily. On reaching shore the first task is the drying and dressing of the fur.[85]

The fanciful assertion that in crossing a body of water each squirrel provides itself with a piece of wood or bark in which it sets sail is alluded to by many writers. I have traced this tale back as far as 1728, when William Byrd[151] had it from an Indian. When Linnaeus[152] was on the island of Gottland in 1741, he was told by

the inhabitants that the squirrels crossed lakes on chips and pieces of bark. This is an interesting case of the same folklore having independent origins.

The direction of the emigrations was seldom, if ever, the same in any region. There is little specific information on the size of the area involved in the movements and the distances travelled by individual squirrels. During the emigration of 1807, Featherstonhaugh[103a] thought that the squirrels that he encountered were advancing from Lake Huron. Since, at the same time, great numbers were crossing the Ohio into Kentucky, it is possible that they were moving in a line 400 miles in length from north to south.

Kennicott[54a] states that he has never known them to migrate "except when exceedingly abundant" and adds: "After one of these grand migrations, very few of the species are found in the localities from which they have moved, and these, as if alarmed at the unusual solitude, are silent and shy." The term abundant is scarcely applicable to the emigrations of the present day and there is serious doubt that mere numbers caused the exodus.

The squirrels as a rule were in good condition at the outset of emigration. Mass hysteria pushed them onward to die of exhaustion, disease, or starvation. At times they were heavily infested with the larvae of *Cuterebra emasculator,* that may have set them in frenzied motion. About one-half of the 50 chipmunks collected by Merriam[153] at Lake Champlain in October, 1885, contained this parasite. The last stage of an emigration in southern Ohio is described by Hildreth. He states that, "they were much emaciated, and most of them covered with running ulcers, made by worms of the *grub* kind. By the first of January they mostly disappeared; after that, and to this time, it was observed that on cutting hollow trees, their usual habitations, they were found in a manner filled with the bones and hair of squirrels; some trees containing as many as 40 or 50. By this it would seem they had died of some disease; for had they died of famine, they would have been found in the fields instead of hollow trees."[128]

The great scarcity of squirrels in Vermont in 1811 was attributed by Gallop[154] to destruction by "pestilence".

There was a southward emigration of black squirrels in Clinton County, Pennsylvania, in October, 1865. Seton[84] was informed that less than 40 percent of the animals shot were free from warbles. Chapman[155] found that an average of 12 percent of the gray squirrels

in southeastern Ohio in the years 1935-37 were infested by *Cuterebra*, the percentage being highest when squirrels were abundant. Only one squirrel out of 326 was infested with mange mites. During the emigration of 1883, the squirrels shot at Eau Claire, Wisconsin, were reported to be "wormy."[156]

Some of the gray squirrels in August, 1933, at the beginning of the emigration from Connecticut, showed bare patches on the body, and hairless tails.[157] Dr. Erwin Jungherr, pathologist of the Connecticut State College found that the skin lesions resembled papilloma. The symptoms strongly suggest infestation by the mange mite (*Sarcoptes*). Errington[158] found that a high percentage of the *Sciuridae* taken by the red-tailed hawk in southern Wisconsin in April and May, 1930, had mange. A fox squirrel found dead in the woods was completely hairless. Mange is common in the squirrels in Madison and is more prevalent in the city than in the country. Allen[52a] found mange to occur mostly in winter and spring, and it seemed to be closely associated with malnutrition. There is no evidence that any parasite is the direct cause of emigration.

The stimulus for emigration has long engrossed the attention of travelers and naturalists. In 1838 Hall wrote: "At the commencement of their march they are very fat; but towards its conclusion they become poor and sickly. After such an event they are scarce for several years, then multiply, emigrate, and perish as before. The cause of this phenomenon has never been explained. It cannot be want of food, for the districts they leave are often as fruitful as those to which they direct their course, and the healthy condition in which they set out, leaves no room to suppose that the danger of starvation has driven them from their home."[159]

Half a century later Merriam wrote in a similar vein: "Scarcity of food very probably gives rise to the disquieting impulse that prompts them to leave their homes, but the true motives that operate in drawing them together, and in determining the direction and distance of their journeys, are as little understood to-day as they were before the discovery of the continent on which they dwell."[27a]

Early opinion is preponderately in favor of a shortage of food as the cause of emigration. Kalm states that nuts were extremely plentiful in Pennsylvania in the fall of 1748. The following autumn great numbers of squirrels moved into southeastern Pennsylvania and "it appeared that their migration was occasioned by the scarcity

of nuts and acorns, which happened that year in the higher parts of the country, and obliged them to come hither for their food."[7a] The emigration of 1783 in western Pennsylvania,[125] and that across the Ohio from Kentucky in 1816,[136] was also ascribed to the absence of mast.

A few writers believed that the exodus was not due necessarily to lack of food. Schultz[92] gave no information on mast during the migration of 1807. He found the squirrels very fat in Ontario and on the upper Ohio, but very poor lower down the river. Lewis,[91] who witnessed the emigration across the Ohio in 1803, concluded that they were not traveling in search of food since walnuts and hickory nuts were abundant on both banks. It is obviously incorrect to assume that because squirrels are found traveling in a region where mast is abundant that the movement began in one equally well supplied with food. Dr. Hoy informed Kennicott[54a] and Wheaton[160] that the squirrels emigrated at Racine in the years 1842, 1847, 1852, and 1857. Mast was stated to have been abundant in these years and the squirrels in excellent condition. If many squirrels took part in these emigrations, it seems strange that none of the latter are mentioned in the Racine newspapers.

Regarding the emigration in southern Ohio in 1822, Blane[93] states that the black squirrels do not appear unless there is a failure of mast in the northwestern forests. Beardsley[120] ascribed the exodus of squirrels from Canada to New York in the fall of 1815 to the unusually large crop of mast in this state.

It has been mentioned that in 1834 Indiana and Ohio were overrun with squirrels. A satisfactory cause has been found. This year was noted for late frosts in the north central states. Maximilian,[161] writing in June, stated that all the mast had been destroyed at Princeton, Indiana. In Seneca County, Ohio, the woods had the appearance of winter on the first of June and Staib added: "In the summer of 1834 we were pestered greatly with squirrels, the woods were literally filled with them."[4a] Forest fruits were "annihilated" by the frost at Marrietta, Ohio.[162]

In southern Ohio, in the autumn of 1843, "the forests produced no nuts or acorns, and the poor squirrels were forced to travel in quest of food or perish."[129] Fortunately it is possible to substantiate the statements of Blane and Hildreth that there was no mast in Ohio in the years 1822 and 1843. Jackson[163] kept a nearly complete record

of mast at Cincinnati during the years 1814-48 and states that there was none in 1822 and 1843.

Seton[84] was strongly of the opinion that the large emigrations were due to overpopulation and likened them to those of the lemming (*Lemmus lemmus*). The food problem must be considered. Elton makes the following remarks on the lemming cycle: "The danger-signals are not long delayed in a community dependent upon the exiguous supplies of a northern land. Vegetation is denuded of the reserves built up in the previous time of lemming scarcity." And again: "The three factors that spring at once to the mind — food shortage, epidemic, and emigration — probably all play a part in the lemming crash."[164]

The emigrations of recent years are attributed to lack of food. In 1933 the squirrels traveled westward from Connecticut into New York. More than a thousand swam the Connecticut River between Hartford and Essex, a front of about 35 miles, on September 24; and hundreds crossed the Bear Mountain Bridge over the Hudson. Anthony[165] offered no explanation for this movement, but suggests overcrowding and mentions the coincidence of the rise and fall of animal populations with the periods of sun-spot maxima and minima.

This emigration has been described in considerable detail by Goodwin. After crossing the Connecticut on September 24, the main body did not reach the Bear Mountain Bridge until about December 10. Since 75 days were taken to cover a distance of approximately 85 miles, the rate of travel was slightly more than a mile a day. He states: "A general census of available data indicates that lack of suitable food in some places, correlated with a fairly large squirrel population started the migration. Neighboring districts with a sufficient supply of food to support their own squirrel population were not able to stand the added burden of greatly increased numbers, and the intruders were either driven out or more likely, all were forced to join the advancing army when the food supply was exhausted. Once a stampede was started, it would not be long before the recruits numbered several thousands, and of necessity the rate of travel would be accelerated."[157]

There was a westward movement of gray squirrels in the fall of 1936 that extended over most of Vermont.[166] A late frost in the spring destroyed the potential crop of nuts. Gray squirrels were abundant in western Massachusetts in 1934 and 1935, and were reported to have migrated in the latter year.[167] The direction was

westward. Jackson[168] stated that 2000 were found dead on the western shore of the Hudson between Albany and the Rip van Winkle Bridge. Food conditions in New England in the fall of 1935 were investigated by Hoover,[169] who found that there was a very light crop of acorns, beechnuts, and other nuts. Since there was a light mast in New England in 1935, and again in Vermont in 1936, the emigration in the latter state could not have been induced by mere numbers.

Gray squirrels, according to Hamilton,[50b] were unusually plentiful in central New York prior to the influx from New England. The second brood of young had appeared by early July, 1935. A third brood was produced that year, and possibly also in the year preceeding. The number of young in a brood was also "noticeably increased." He suggests that the New England squirrels were equally productive and that the emigration was caused by over-population. No information on food conditions is given by Hamilton; however, I have been informed by Robert W. Damer,[170] that 1935 was a poor mast year, particularly for beechnuts. He added that while most of the squirrels were traveling westward, many were moving in the opposite direction at the same times and places. The observations were made principally at Lake Champlain, the Hudson River below Albany, and the Gilboa Reservoir on Schoharie Creek.

It is obvious that a high squirrel population will cause a rapid depletion of food even in a good mast year. Hahn[171] states that at the University Farm, Mitchell, Indiana, 80 acres were heavily wooded with white oaks and that an additional 100 acres had a considerable stand of this species. The acorn crop was very large in the fall of 1906, and he estimated that each of the large oaks produced from 2000 to 8000 acorns. This immense crop was harvested so completely by the gray squirrels by the first of November that only an occasional acorn could be found by searching. Unfortunately we do not know how many acorns were consumed by the squirrels and how many were buried for winter consumption.

The movements of the red squirrel, like that of the other squirrels, seems to be governed largely by the food supply. In the fall of 1881 there was a good yield of beechnuts in the Adirondacks. The following fall the beechnut crop failed and scarcely a red squirrel was to be found.[27b] Hatt, from his study of the red squirrel, concludes: "It is probable that such migrations occur only in times of maximum population and of food shortage, for certainly there are no regular

seasonal movements of all the red squirrels. The migrations appear to be overflow movements due to an urge of hunger."[172]

Recent emigrations of the gray and fox squirrel in Missouri have been recorded by Bennitt and Nagel.[58] The year 1934 was very dry and there was a shortage of food. They suggest that the emigration of the gray squirrel is cyclic. There was a shortage of young of this species that year but not a "commensurate shortage of food." However, regarding the movements of the fox squirrel, they state "We believe they were due only secondarily to population pressure, through failure of the food or water supply. . . . Their movements seem to have followed exhaustion of the food supply."

Late frosts destroyed the mast on the Bankhead National Forest, Alabama, both in 1939 and 1940. Gray squirrels remained abundant the winter of 1939-40. About October 1, 1940, they began moving northward only to return about two months later. The southward movement was so complete that not a squirrel was left in the forest. The very limited food supply seemed to Moore[173] to be the cause of the emigration. In the fall of 1944, hundreds of fox squirrels, and a few gray squirrels crossed the Lake of the Ozarks, Missouri, moving in all directions.[174] The mast had failed. The extensive movement of squirrels in northwestern Wisconsin in the fall of 1946 was very plainly due to lack of acorns.[51]

Three abstracts from the Russian literature, kindly furnished by Dr. Charles Elton, Oxford University, show that the emigrations of the European squirrel (*Sciurus vulgaris* L.) are due to failure of the food supply. They are sufficiently important to be given in full.

"Squirrel migrations are widespread in the northern taiga zone of the U.S.S.R. but their effect on population dynamics is only large in certain years. When food is abundant in typical nesting stations only small changes of place are affected by young leaving the nest and when food is abundant everywhere dispersal of young takes place to a rather greater extent. Only when there is a shortage of food do mass migrations, accompanied by mass destruction, take place in the second half of the summer."[175]

"After the period of nesting and of family life is over, first the young squirrels, and then the adult ones, scatter through the stations not occupied before. This is due to the fact that the conditions of safety presented by the former stations cease to be of the same importance as during the reproduction and shedding seasons. In the

period of dispersion and of the redistribution of the squirrels among the different stations, the question of food resources is the principal factor. In years when the crop of staple food — the seeds of conifers (cedar, fir, spruce, and pine) — is a bad one this redistribution of the squirrels takes the form of mass migrations. Such migrations occurred during the investigations. They found their reflection in the numerical fluctuations of the squirrels, especially at the stations not characterized as belonging to the period of the sedentary existence of these rodents."[176]

"Hunting publications of the 19th and early 20th centuries are strewn with complaints from places in which the squirrel has 'suddenly' disappeared and with news of a mass appearance the animal has made in other areas. A. Cherkasov (1867) writes in 'Journal of a hunter in East Siberia': 'The number of squirrels in these parts is extremely variable . . . since it depends on the food crop the squirrel is not a settled animal: it wanders every year from one place to another. . . .'

"Wanderings occur in all areas occupied by the squirrel and in some parts they recur regularly every so many years. The migrations take place mainly at the end of the summer and during the autumn. They may be caused by drought and forest fires (central and eastern Siberia) but in the majority of cases are due to a bad crop of the squirrels' main foods. . . . The squirrel has been known to make journeys of 250-300 kilometers when migrating, venturing into forest-tundra, crossing the bare parts of mountains, steppes and ploughland, passing through villages and even large towns. It undertakes the crossing of wide rivers such as the Northern Dvina, the Ob, Yenesi, and Amur and starts to swim across the Tatar Strait, Lake Baikal, Tazor Bay, the Gulf of Finland and Mezen Bay. In these crossings and in the unfavourable conditions of the districts in which they find themselves during the winter, thousands of squirrels die."[177]

In a previous paper[178] I have cited references to the literature showing that emigrations of bears, gray squirrels, and even turkeys, have occurred simultaneously. The coincidence of the emigrations of bears and squirrels in Wisconsin is impressive. Since the two species compete for mast, it is improbable that they would emigrate simultaneously for any reason other than lack of food. It will be shown later that there are considerable data for Wisconsin to support this contention.

It should be mentioned in connection with emigration that there

is a far greater shifting of squirrel populations than is generally supposed. Unless there is a mass exodus, this phenomenon readily escapes notice. A forest near Cleveland studied by Williams[179] had a large yield of beechnuts and seeds of the sugar maple in the autumns of 1930 and 1931. About 50 gray squirrels occupied the area the winter of 1931-32. The fall of 1932 all but one squirrel left the nearly foodless tract. Edminster[180] found that on the Pharsalia Refuge, Chenango County, New York, the gray squirrels decreased from a population of 1,172 in 1935 to 371 in 1936, and to 107 in 1937. During the three years the populations of the refuge and of a public shooting area five miles distant both declined 91 percent.

Allen[52b] found a high population turn-over of fox squirrels in Michigan. In fact shifting seems to have been a continuous process. Fox and gray squirrels were equally abundant in the summer of 1936 on an area in Oklahoma studied by Blair.[181] In June, 1937, both species were equally scarce. Goodrum[182] paid particular attention to the food supply and found that the gray squirrel population in Texas was directly related to it. The squirrels shifted from one locality to another where their favored food was abundant.

The fall dispersal of fox squirrels in Ohio is attributed by Baumgartner[183] to intra-specific intolerance since it occurs at a time when food is most abundant. It is doubtful if intolerance is an adequate reason. The fall dispersal is a phenomenon secondary to emigration. It occurs regardless of the size of the squirrel population and the abundance of food. The autumn kill of squirrels by motor cars is higher than at any other season.

There are many cases where squirrels have shown a remarkable tolerance to dense populations as long as the food lasted. Browning and his uncle were hired to shoot the squirrels destroying corn in a field at Uniontown, Pennsylvania, in the autumn of 1798. He states: "The next day we started off before day-light, and as soon as we could see, found ourselves surrounded by the greatest number of squirrels I ever saw, which were running by the hundreds in all directions."[184] The uncle left on the fifth day and Browning continued shooting for nine and one-half days before the animals were exterminated.

While traveling in southwestern Ohio in July, 1817, Palmer[94] sometimes saw 50 or 60 squirrels at a time dash out of fields of grain. Porter says: "The myriads of squirrels that are to be found on a few

acres of favorable feeding-ground during the season of plenty is almost incredible to those who have not witnessed it."[55]

*Food Supply and Squirrel Populations.* The breeding potential of the northern gray squirrel is very high. Normally it produces two litters a year, in March-April and September, of two to six young each. A pair, allowing eight young annually, could lead to a population of 6250 squirrels at the end of five years, if there were no casualties. Kennicott[54a] mentions the probability of three litters annually; and Seton[84] cites a case of a captive squirrel in Toronto that had three litters in one year. However, Hamilton[50b] appears to be the only observer to determine that three litters are sometimes produced in the wild.

It was pointed out by Thompson[185] that a high squirrel population resulted from a mild winter preceded by a summer productive of food. The beech in New York, between 1871-1883, showed a bearing cycle of two years. Gray squirrels were most numerous in a year when there were no nuts. This was attributed to the influx of squirrels from distant parts during a good nut year, and they remained to breed the following spring. Merriam continues: "During the summer and early autumn a multitude of young, now nearly full grown, mingle with the parent stock. Hence the species attains at this time, its maximum in numbers. But this is the year when the next crop is a failure. Therefore, as the fall advances and they find that there is a scarcity of provision for the winter, many of them migrate — we know not where."[27a] The biannual exodus would not necessarily take place in regions where the mast is diversified.

It is obvious that a high squirrel population is dependent upon an adequate supply of food, but it is not always simple to show that the rise and the fall of populations are related unquestionally to the food supply. Linnaeus,[152] while in Gottland in 1741, was informed that the squirrels had a seven year cycle of abundance. Blomquist[186] thought that there was a 6 to 7 year cycle in the production of seed by pine and spruce in Finland. He found that seed was produced heavily in the years 1839, 1846, 1854, 1860, 1871, and 1875, spruce seeding a year prior to the pine. The abundance of seeds paralleled closely that of the squirrels. In Russia the number of squirrels shot annually follows seed production so closely that it has been suggested as a method for evaluating seed years.[187] The Siberian "cedar"(*Pinus cembra sibirica*) bears seeds very irregularly, but when there is a good seed year, the squirrel population rises rapidly.[188]

No cycle of approximately constant duration has been established for the gray squirrel. Hoy found a cycle of exactly five years for four migrations at Racine. Chapman[155] gives data for the years 1901-1935 showing that this species in the middle west probably reaches peak populations every five years. The extensive emigrations of the early days show no such regularity. The movements in Wisconsin show a 5 to 7 year cycle.

The breeding rate of squirrels rises when food is plentiful and falls rapidly when it is scarce. The white and black oaks in Michigan failed to bear during the summer of 1940, so that the fox squirrels suffered from malnutrition during the following winter. Of 52 females handled by Allen[52c] between March and June, 1941, only one was pregnant. Following the failure of mast in Missouri in 1944, the female squirrels did not have the usual spring litter in 1945.[189]

Several factors may govern the rise and fall of animal populations. McAtee[190] has shown how difficult it is to prove that a population is limited by the means of subsistence. Space, or intolerance, may be equally important. Errington writes: "There are scant grounds for challenging the reality of the subnormal food supplies, the heavy infestation by parasites, the mortality from predators or disease, the losses of the immature during adverse weather, the miscellaneous factors to which competent investigators have ascribed the declines of wild vertebrates in 1936 and 1937. . . ."[191]

It will suffice to point to a few clear and spectacular cases of the decline of population through failure of the food supply. Approximately every four years the population of lemmings and related rodents crashes, resulting in the reduction of the numbers of the arctic fox and snowy owl through migration and death. The cycle of the lynx is a striking example. Elton and Nicholson state: "This cycle is a real one in lynx populations, which are dependent upon the snowshoe rabbit (*Lepus americanus*) for food, and which starve when the rabbits disappear periodically."[192]

The opinion is expressed by Elton and Nicholson that climate may be partially responsible for controlling the ten-year cycle in the lynx. It had been previously suggested by Weaver and Clements[193] that the ten-year cycle of some mammals was dependent upon rainfall, that in turn is influenced by sun spots. The rainfall influences the amount of food and cover, hence the animal population. If climate is the factor determining the long cycle as well as the shorter and differing cycles of the various rodents, it would seem to lose para-

mount significance. The effect of climate upon the food supply is beyond question.

No known disease seems to be responsible for the die-off of the snowshoe hare. Green makes this impressive suggestion: "Dense populations may 'seed' something into the ground, the extent of which builds up with increasing populations, or the increasing population may eradicate certain plants that contain food elements essential for the maintenance of healthy populations."[194] Dennis Chitty told me recently that if, during a die-off or *Microtus* in England, some of the animals are trapped and given succulent foods, they survive. It appears therefore that a nutritional deficiency may be directly responsible for the die-off of certain species of mammals. Also, Wald and Jackson[195] have shown that nutritional deprivation in rats stimulates activity in the form of running. They suggest that this represents the behavioral basis of mammalian emigration and that, "This is recognized to be motivated primarily by nutritional need."

The data available support strongly the belief that squirrel populations and movements are governed by the food supply.

### Emigrations in Wisconsin

#### 1842

Gray squirrels emigrated at Racine, according to Hoy, though mast was "exceedingly abundant." They moved southward in large numbers for about a month.

The population north of Racine was not depleted greatly or it recovered quickly. Two years later, 1844, a man shot 84 black and gray squirrels in the town of Oak Creek, Milwaukee County, during a hunt, the duration of which was not stated.[1]

1. Milwaukee *Courier*. In Lancaster *Herald,* Dec. 7, 1844.

#### 1847

They again emigrated at Racine, according to Hoy.

Squirrels were very plentiful at Watertown in 1849.[1]

1. Watertown *Chronicle* Sept. 5, 1849.

#### 1852

There was an emigration at Racine.

Black and gray squirrels were very abundant at Appleton the autumns of 1853 and 1854.[1]

1. Appleton *Crescent* Oct. 22, 1853; Sept. 16 and 23, 1854.

#### 1855

Thousands of gray and black squirrels moved eastward, following the old rail fences. Unfortunately Trigg[1] does not give the locality.

In October of this year, during a large-scale hunt in the town of Greenville, Outagamie County, about 500 squirrels were killed.[2]

1. J. S. Trigg, *Madison State Journal,* July 23, 1900, 7.

2. W. A. Goodspeed, *et al.* History of Outagamie County, Wisconsin. [1911] p. 1299.

1856

Black squirrels emigrated from Dane County.[99]

Thousands of squirrels visited the cornfields at Jefferson[1] and Green Bay[2] where nuts were scarce. The woods at Milwaukee[3] and at Neenah[4] were "full" of squirrels.

1. Jefferson *Jeffersonian* Sept. 11, 1856. 2. Green Bay *Advocate* Aug. 28, 1856. 3. Milwaukee (w) *Wisconsin* Oct. 15, 1856. 4. Neenah and Menasha *Conservator* Sept. 4, 1856.

1857.

Squirrels emigrated at Racine for the last time, according to Hoy.

They were abundant at Oshkosh[1] in 1859; and in 1863 black squirrels were "swarming in the woods" at Appleton.[2]

1. Oshkosh *Courier* Sept. 16, 1859. Appleton *Crescent* Aug. 22, 1863.

1866

There were movements in the eastern portion of the state. Grays were abundant at Sturgeon Bay the middle of July and swam across the bay.[1] At the same time an unusual number of red squirrels appeared in the city of Green Bay.[2] Squirrels of all species were "never more abundant" at Appleton[3] where the red squirrel and chipmunk were reported moving northward.

Squirrels were abundant around Lake Winnebago, especially on the eastern side, where four men shot 198 in one day.[4] A boy at Wautoma[5] shot 10 gray and black, and 2 red squirrels with an hour. West Bend[6] reported gray squirrels "thick as hops." During a side hunt, 350 black, gray, and fox, and about 200 red squirrels were killed at Jefferson.[7]

In 1868 black and gray squirrels appeared in great numbers at Prescott;[8] and at Richland Center[9] they were never "so abundant". In 1870, though no definite migration was reported, black and gray squirrels swarmed at Sturgeon Bay.[10] A hunter at Mishicott killed 83 in one day.[11] They were very abundant at Appleton.[12] Prairie du Chien[13] reported the greatest gray squirrel season ever known; and at La Crosse[14] two men killed 45 in three and one-half hours.

1. Sturgeon Bay *Advocate* July 19, 1866. 2. Green Bay *Advocate* July 12, 1866. 3. Appleton *Crescent* Aug. 11, Sept. 22, 1866. 4. Fond du Lac *Reporter* Sept. 1, 1866. 5. Wautoma *Argus* Sept. 27, 1866. 6. West Bend *Post* Sept. 1, 1866. 7. Jefferson *Banner* Oct. 10, 1866. 8. Prescott *Journal* Sept. 25, 1868. 9. Richland Center *Sentinel.* In Madison *State Journal* Oct. 17, 1868. 10. Sturgeon Bay *Advocate* Sept. 15, 1870. 11. Manitowoc *Tribune* Nov. 24, 1870. 12. Appleton *Crescent* Sept. 3, Oct. 1, 1870. 13. Prairie du Chien *Courier.* In Madison *State Journal* Oct. 14, 1870. 14. La Crosse *Leader* Dec. 3, 1870.

1871

Gray squirrels in large numbers attempted the crossing of the Mississippi near La Crosse. The captain of the ferry-boat reported that, "the river is full of them swimming to the Minnesota shore."[1] The exodus was attributed to the shortage of nuts in Wisconsin. They were very plentiful at Osceola.[2] Near Oshkosh black and gray squirrels were moving northward, swimming the Wolf River, where acorns and nuts were reported plentiful.[3] They were again reported abundant at Appleton.[4]

1. La Crosse *Democrat* Sept. 19; Milwaukee *Daily News* Sept. 23, 1871. 2. Osceola *Press,* Sept. 15, 1871. 3. Oshkosh *Times* Sept. 6, 1871. 4. Appleton *Post* Oct. 5 and 26, 1871.

1873

A westward emigration was reported at Beaver Dam,[1] where squirrels were unusually plentiful the autumn of 1872.[2] Black River Falls,[3] in June, had more squirrels than ever known previously. In October they congregated in large numbers at Prescott.[4]

Gray squirrels "abounded" at Princeton,[5] and at Sheboygan[6] a man shot 55 in one day in the beech woods. A side hunt by 28 men at Oshkosh[7] produced 88 gray and 63 red squirrels. They were not plentiful at Lancaster.[8]

In 1875 four men shot 555 gray squirrels in one afternoon in Crawford County.[9] A hunter at Reedsburg[10] killed 26 in one day. They were unusually numerous at De Pere,[11] and Richland Center;[12] and "swarmed" at Sheboygan.[13]

Squirrels were very plentiful in 1876 at De Pere,[14] Green Bay[15] Hartford,[16] and Sheboygan.[17] At the latter place they entered the town. They were scarce at Oshkosh.[18]

1. *Forest and Stream* 1 (Nov. 27, 1873) 243. 2. Beaver Dam *Citizen* Oct. 31, 1872. 3. Black River Falls *Banner* June 14, 1873. 4. Ellsworth *Herald* Oct. 8, 1873. 5. Princeton *Republic* Sept. 6, 1873. 6. Sheboygan *Herald* Oct. 31, 1873. 7. Oshkosh *Times* Oct. 15, 1873. 8. Lancaster *Herald* Nov. 6, 1873. 9. Boscobel *Dial* Nov. 5, 1875; *cf.* Aug. 25, 1876. 10. Reedsburg *Free Press* Nov. 11, 1875. 11. De Pere *News* Oct. 16, 1875. 12. Richland Center *Republican* Oct. 14, 1875. 13. Sheboygan *Herald* Oct. 8 and 22, 1875. 14. De Pere *News* Sept. 16, 1876. 15. Green Bay *Advocate* Aug. 31, Dec. 7, 1876. 16. Hartford *Republican* Sept. 28, 1876. 17. Sheboygan *Herald* Aug. 18, Sept. 1, 1876. 18. Oshkosh *Northwestern* Oct. 28, 1876.

1878

In view of the abundance of squirrels in certain localities in 1875 and 1876, and the very high populations of 1878, it seems strange that squirrels were reported numerous in only four localities in 1877.[1] Movements took place over much of the state in 1878. This was the banner for squirrels and none like it has occurred since. It was a very poor year for mast.

In the eastern portion of the state, squirrels were unusually plentiful at Green Bay,[2] Two Rivers,[3] Sheboygan,[4] Oconto,[5] Menasha,[6] Sturgeon Bay,[7] Manitowoc,[8] Oshkosh,[9] Appleton,[10] Montello,[11] Grand Rapids,[12] and West Bend.[13] Due to the scarcity of acorns, they were crossing open country at Winneconne,[14] and "over-running" the region about Stevens Point.[15]

Damage to corn was especially heavy in the western counties where squirrels were very numerous. Exceptional numbers were reported at Richland Center,[16] Dodgeville,[17] Arcadia,[18] Durand,[19] Whitehall,[20] Baldwin,[21] River Falls,[22] Menomonie,[23] and Mondovi.[24] The three latter places stated that there was nothing in the woods for the animals to eat. Both Black River Falls[25] and Hudson[26] claimed that gray, black, and red squirrels were never more numerous. The town of Spring Lake thought that it had the highest population of red squirrels and chipmunks in Pierce County.[27]

Hunters at Alma[28] brought in about 1000 squirrels in a period of a week. Side hunts at Tomah[29] and Viroqua[30] resulted in the killing of 280 and 485 squirrels respectively. They were killed by the "thousands" at Dodgeville.[31] Madison[32] had them in abundance.

Squirrels emigrated at Sparta,[33] Prairie du Chien,[34] and La Crosse.[35] Nor-

beck[36] reported that at La Crosse squirrels "can be had by the barrel." No squirrels were observed to cross Lake St. Croix, but it was presumed that they did so since they were very plentiful in St. Croix and the surrounding groves.[37] Crossing of the Mississippi, however, began in Pierce County and extended down the river through Vernon County, a distance of about 130 miles.

It is probable that only a small portion of the army of squirrels that attempted to cross Lake Pepin from Pierce and Pepin Counties reached the Minnesota shore. A statement from Lake City reads: "We are informed that there are thousands of black and gray squirrels over on the Wisconsin shore of the Lake—all the squirrels in Wisconsin seeming to have determined to 'go west' and take a tree claim. Scores of them have been seen swimming the lake to this side, a distance of two and a half miles, and Captain Murray, of the steamer Pepin, says there is certainly a general emigration going on among them, from Wisconsin to Minnesota. Many of them are found drowned along the shore, the big fish get many more, and doubtless many survive the perilous voyage and arrive safely at the shore of our Gopher State."[38]

They were "very numerous" at Winona,[39] Minnesota, about a hundred being killed within the city. Bunnell[40] mentions that several times within his memory squirrels arrived at Winona after a long swim across the Mississippi, but he gives no dates.

Squirrels in "immense numbers" were swimming westward across the La Crosse River at West Salem during the third week in August.[41] Although the woods near La Crosse "have for some weeks past been literally full of gray squirrels", only a small number were moving here in comparison with Vernon County where men in boats scooped them in by the dozen as they were crossing the Mississippi westward.[42]

By 1882 the squirrel population had become exceptionally high again at Oshkosh,[43] Richland Center,[44] Boscobel,[45] Sparta,[46] Chippewa Falls,[47] Galesville,[48] Chetek,[49] and Durand.[50] Three men at Prairie du Sac[51] shot 41 squirrels in one day; and at Elroy[52] eleven men killed 145.

1. Appleton *Crescent* Oct. 13; Montello *Express* May 17, Sept. 22; West Bend *Democrat* Oct. 17 and 24; Darlington *Republican* Oct. 26, 1877. 2. Green Bay *Gazette* Oct. 5; Fort Howard *Review* Oct. 8, 1878. 3. Two Rivers *Chronicle* Sept. 3, 1878. 4. Sheboygan *Herald* Sept. 27, 1878. 5. Oconto *Reporter* Aug. 10, 1878. 6. Menasha *Press* Sept. 19, 1878. 7. Sturgeon Bay *Advocate* Sept. 26, 1878. 8. Manitowoc *Pilot* Sept. 12, 1878. 9. Oshkosh *Times* Sept. 28, 1878. 10. Appleton *Post* Sept. 5, Oct. 3; *Crescent* Aug. 17, Sept. 14, Oct. 12, 1878. 11. Montello *Express* Aug. 31, 1878. 12. Grand Rapids *Reporter* Sept. 12, 1878. 13. West Bend *Democrat* Sept. 11 and 18, Oct. 9, 1876. 14. Winneconne *Item* Sept. 21, 1878. 15. Stevens Point *Gazette* Sept. 4; *Journal* Sept. 7, 1878. 16. Richland Center *Republican* Sept. 5 and 19, 1878. 17. Dodgeville *Chronicle* Sept. 20, 1878. 18. Arcadia *Republican and Leader* Sept. 15, 1878. 19. Durand *Times* Oct. 4; *Courier* Nov. 2, 1878. 20. Whitehall *Messenger* Sept. 18, 1878. 21. Baldwin *Bulletin* Sept. 14, 1878. 22. River Falls *Press* Aug. 22 and 29, Sept. 19, Oct. 3; *Journal* Aug. 22 and 29, Sept. 12, Oct. 3 and 10, 1878. 23. Menomonie *News* Aug. 31, Sept. 7 and 28, Oct. 5 and 12, 1878. 24. Mondovi *Herald* Sept. 21, 1878. 25. Black River Falls *Banner* Sept. 6, 1878. 26. Hudson *Star and Times* Aug. 30, 1878. 27. River Falls *Journal* Aug. 29, 1878. 28. Alma *Express* Aug. 29, 1878. 29. Tomah *Democrat* Nov. 30, 1878. 30. Viroqua *Censor* Sept. 18,

1878. 31. Dodgeville *Chronicle* Sept. 3, 1878. 32. Chicago *Field* 10 (Nov. 2, 1878) 186. 33. Sparta *Herald* Sept. 3, 1878. 34. Prairie du Chien *Union* Sept. 12, 1878. 35. La Crosse *Republican and Leader* Aug. 24, 1878. 36. C. Norbeck. Chicago *Field* 10 (Sept. 28, 1878) 97. 37. Hudson *Star and Times* Aug. 30, 1878. 38. Squirrels coming by thousands. Lake City (Minn.) *Leader* Aug. 24, 1878. 39. Winona (Minn.) *Herald* Sept. 20, 1878. 40. L. A. Bunnell. Winona and its environs. Winona (1897) p. 332. 41. La Crosse (w) *Republican and Leader* Aug. 24, 1878. 42. *Ibid.* Sept. 21, 1878. 43. Oshkosh *Times* Sept. 23, 1882; *American Field* 18 (1882) 198. 44. Richland Center *Republican and Observer* Sept. 14, 1882. 45. Boscobel *Dial* Oct. 27, 1882. 46. Sparta *Herald* Oct. 17; La Crosse (w) *Republican and Leader* Sept. 23, 1882. 47. Chippewa Falls *Herald* Oct. 13, 1882. 48. Galesville *Independent* Sept. 28, Oct. 5, 1882. 49. Chetek *Alert* Oct. 27, 1882. 50. Durand *Courier* Oct. 20, 1882. 51. Prairie du Sac *News* Oct. 14, 1882. 52. Elroy *Tribune* Nov. 17, 1882.

1883

This was the last year of great abundance and extensive movement of squirrels. It was also a year of great scarcity of mast. In the eastern part of the state squirrels were very plentiful at Peshtigo,[1] De Pere,[2] Appleton,[3] Oshkosh,[4] Stevens Point,[5] Grand Rapids,[6] and Manitowoc.[7] Three men at Green Bay[8] shot 30 squirrels in a day's hunt; and near Racine[9] two men shot 56 in 7 hours.

The western part of the state again showed the highest population. Squirrels were abundant at Richland Center[10] and entered the town. Due to the "great scarcity of acorns" they were feeding on corn at Richland Center and Spring Green. Food was so scarce in the woods at Prairie du Chien[11] that they invaded the cornfields in the country and the gardens in the city. The same condition prevailed at Elroy.[12]

Squirrels were abundant at Eau Claire,[13] Chippewa Falls,[14] Montfort,[15] Ellsworth,[16] Phillips,[17] New Richmond,[18] Durand,[19] Hudson,[20] and River Falls.[21] They were very plentiful at Soldiers Grove[22] where a man is reported to have shot 76 in an afternoon. Three men at Dodgeville[23] killed over 50 in a day's hunt; and four hunters at Mauston[24] shot 101. A hunter at Alma[25] brought in 18.

These animals were abundant and emigrating at Lancaster,[26] Mineral Point,[27] and Trempealeau.[28] At the latter place the squirrels were gray, black and fox, the former predominating. Some crossed the Mississippi from the Minnesota side. The direction of the movement at Menomonie,[29] Whitehall,[30] and Potosi[31] was southward. A year later, 1884, squirrels were very scarce at Potosi[32] and Richland Center.[33]

In the fall of 1887, squirrels were plentiful at Necedah,[34] Racine,[35] Richland Center,[36] Prairie du Chien,[37] and New Richmond.[38]

1. Marinette and Peshtigo *Eagle* Oct. 13, 1883. 2. De Pere *News* Sept. 15, 1883. 3. Appleton *Post* Sept. 20 and 27, 1883. 4. C. M. B. *American Field* 20 (Sept. 29, 1883) 294. 5. Stevens Point *Journal* Sept. 15, 1883. 6. Grand Rapids *Tribune* Sept. 15, 1883. 7. Manitowoc *Pilot* March 8, Sept. 13, 1883. 8. Green Bay *Gazette* Sept. 29, 1883. 9. Racine *Journal* Dec. 12; *Post* Dec. 13, 1883. 10. Richland Center *Republican and Observer* Aug. 30, Sept. 20, 1883. 11. Prairie du Chien *Union* Sept. 14; *Courier* Sept. 4 and 11, 1883. 12. Elroy *Tribune* Sept. 14, 1883. 13. Eau Claire (w) *Free Press* Oct. 4 and 25; (d) *Leader* Oct. 20, 1883. 14. Chippewa Falls *Independent* Sept. 20, 1883. 15. Montfort *Monitor*

Sept. 6, 1883. 16. Ellsworth *Herald* Oct. 3, 1883. 17. Phillips *Badger* Sept. 5, 1883. 18. New Richmond *Republican* Sept. 26, 1883. 19. Durand *Courier* Sept. 28, 1883. 20. Hudson *Star and Times* Sept. 14, 1883. 21. River Falls *Journal* Sept. 27, 1883. 22. Soldiers Grove *Journal* Sept. 5, 1883. 23. Dodgeville *Chronicle* Sept. 28, 1883. 24. Mauston *Star* Nov. 22, 1883. 25. Alma *Journal* Nov. 22, 1883. 26. Lancaster *Teller* Sept. 6, 1883. 27. Mineral Point *Tribune* Sept. 13, 1883. 28. Arcadia *Republican and Leader* Sept. 27; Whitehall *Times* Oct. 4, 1883. 29. S. J. B. *American Field* 20 (Oct. 20, 1883) 366. 30. Whitehall *Times* Sept. 20, 1883. 31. Lancaster *Herald* Sept. 20, 1883. 32. *Ibid.* Sept. 25, 1884. 33. Richland Center *Rustic* Oct. 18, 1884. 34. Necedah *Republican* Oct. 7, 1887. 35. Racine *Journal* Dec. 21, 1887. 36. Richland Center *Rustic* Sept. 17, 1887. 37. Prairie du Chien *Courier* Oct. 4, 1887. 38. New Richmond *Republican* Sept. 14, 1887.

1888

An emigration for this year was not well defined; however, 1888 was outstandingly the best squirrel year between 1883 and 1895. In the fall of 1888 the bears moved southward.

Squirrels were numerous at De Pere,[1] Appleton,[2] Baraboo,[3] Richland Center,[4] Boscobel,[5] and Neillsville.[6]. Racine[7] reported that the autumn "crop" was the best ever known. Hunters commonly killed 20 to 30 daily, but two hunters killed 83 in one day.[8]

1. De Pere *News* Oct. 13, 1888. 2. Appleton *Crescent* Nov. 10, 1888. 3. Baraboo *Republic* Oct. 17, 1888. 4. Richland Center *Rustic* Oct. 13, Nov. 24, 1888. 5. Boscobel *Dial* Sept. 27, Dec. 6, 1888. 6. Neillsville *Republican and Press* Sept. 27, 1888. 7. Racine *Journal* Nov. 7, 1888. 8. Racine *Daily Times* Oct. 29, 1888.

1895

There were unusual numbers of squirrels at Green Bay[1] and Manitowoc,[2] at which places they were traveling southward. The black and gray squirrels arrived from the north at Green Bay where the dock swarmed with them. After several years of scarcity at Chilton,[3] squirrels came from "the north in droves." Gray and black squirrels "were never so thick" at Oconto.[4] They were abundant at Two Rivers[5] where a man shot 22 gray squirrels within two hours. A hunter at Shawano[6] killed 36 in a day's hunt; and a man at Sheboygan Falls[7] shot 23 in one day. There were squirrels in abundance in the beech woods at Kewaunee[8] in the fall of 1894; and in the fall of 1895 the hunting was "excellent."

Squirrels were very plentiful at Viroqua,[9] Trempealeau,[10] and New Lisbon.[11] New Richmond[12] had a big influx of gray and black squirrels, and Prairie du Chien[13] received gray squirrels from the north in "droves."

1. Green Bay *Advocate* Sept. 5, 1895. 2. Manitowoc *Pilot* Sept. 12, 1895. 3. Chilton *Times* Sept. 14, 1895. 4. Oconto *Reporter* Oct. 11, 1895. 5. Two Rivers *Chronicle* Sept. 3, Oct. 8, 1895. 6. Shawano *Advocate* Aug. 15, 1895. 7. Sheboygan Falls *News* Oct. 30, 1895. 8. Kewaunee *Enterprise* Nov. 3, 1894; Sept. 20, 1895. 9. Viroqua *Censor* Oct. 9, 1895. 10. Trempealeau *Herald* Sept. 27, Oct. 4, 1895. 11. New Lisbon *Press* Aug. 29, 1895. 12. New Richmond *Republican* Sept. 5, 1895. 13. Prairie du Chien *Courier* Sept. 24, 1895.

1897

A southward emigration of gray squirrels took place at Baraboo[1] in September. The fox squirrels did not participate. The rate of travel was stated to be one-

half mile per day. The last exodus was said to have been eight years previous. Hough,[2] referring to the movement of 1897, remarked that to his personal knowledge, the past two seasons had been very good squirrel years in southern Wisconsin.

1. Baraboo *News* Sept. 25, 1897. 2. E. Hough. *Forest and Stream* 49 (Oct. 9, 1897) 288; *cf.* A. H. Gouraud, *ibid.* 60 (Feb. 14, 1903) 125.

1903

The crossing of the Mississippi at Reed's Landing by fox squirrels was mentioned previously.

1905

In the autumn of this year gray and black squirrels crossed the Mississippi, some remaining in Winona, Minnesota. Jackson[1] states that the direct cause of the emigration was a shortage of nuts on the Wisconsin side. A crossing to Minnesota also took place this year in the vicinity of La Crosse.[2]

1. H. H. T. Jackson, *Bull. Wis. Nat. Hist. Soc.* 8 (1910) 87. 2. La Crosse *Press-Leader* Sept. 17, 1907, 8.

1907

In September hundreds of squirrels crossed the Mississippi from Minnesota due to the scarcity of nuts in the latter state.[1] Warden G. L. Kingsley stated that they rested on French Island, near La Crosse, before proceeding to the Wisconsin shore.

1. La Crosse (d) *Chronicle* Sept. 18; (w) *Argus* Sept. 21, 1907.

1914

Owing to the shortage of acorns in Wisconsin, "hundreds" of squirrels crossed the Mississippi to Minnesota from the neighborhood of La Crosse[1] in the autumn of 1914. Jackson[2] records an emigration of gray squirrels from Pepin westward across Lake Pepin in the early fall of 1914 or 1915. Since he was informed that acorns, nuts, and corn were abundant on the Wisconsin side, we have a contradiction on the food supply, granted that both accounts refer to the same year.

1. La Crosse (d) *Leader-Press* Sept. 4, 1914, 9. 2. H. H. T. Jackson. A recent migration of the gray squirrel in Wisconsin. *J. Mamm.* 2 (1921) 113-4.

1925

Thousands of squirrels crossed the Mississippi to Iowa, in the vicinity of Prairie du Chien according to a press item from Prairie du Chien dated October 16, 1925. This was quoted by Fryxell.[1] I have been unable to find any mention in the Prairie du Chien papers of an emigration of squirrels in the fall of 1925, nor could I find any inhabitant who had heard of it.

1. F. M. Fryxell. Squirrels migrate from Wisconsin to Iowa. *J. Mamm* 7 (1926) 60.

1946

There was an extensive movement of gray and fox squirrels extending along the Mississippi for about 180 miles and eastward for about 60 miles. The general direction was westward across the Mississippi.[1] Statements obtained from wardens and other sources[2] agree that an exceptional shortage of acorns caused the emigration.

1. A. W. Schorger, *J. Mam.* 28(1947)401. 2. Milwaukee *Journal* Oct. 3, 5, and 27, 1946.

Lack of food may cause an emigration at any season. In March, 1876, hundreds

of gray and black squirrels were observed moving southward near the Eau Galle woods, Dunn County.[196] They were in poor flesh. Near Montello[197] in February, 1882, sixty squirrels were counted in the distance of a mile.

A severe winter depletes the population. The winter of 1874-75 was marked by deep snow and extreme cold. During this winter squirrels practically disappeared from the vicinity of the Red River near Green Bay.[198] Two squirrels were found frozen to death in a hollow tree near Montello.[199] The following statement illustrates the effect of a severe winter: "Forest, Richland County, August 7, 1870. Squirrels are getting very plenty in the woods. Last winter they were the most numerous ever known. Fields of unhusked corn were literally alive with them. Mr. Benj. Starkey, of Sylvan, killed 23 at one time on one tree, and enough more on two other trees to make 33 in all . . . Toward spring their feed became scarce, some starved, and others became so poor they could be easily caught by boys and dogs. Many were killed that way."[200]

## Food Conditions in Wisconsin

Oaks of various species form so large a portion of the trees of southern Wisconsin that acorns are by far the most important squirrel food. Beech is limited to a narrow strip along Lake Michigan. The butternut, walnut and hickories were widely but sparsely distributed and their nuts were of little influence on the food supply except in a few localities. Years when the passenger pigeon nested are given since it is a reasonable assumption that the nestings were based on a crop of acorns or beechnuts the previous autumn.

The data on mast are too few to give a satisfactory picture of food conditions during the nineteenth century, but there are some definite cases of large migrations of squirrels resulting from lack of forest foods.

### 1836

Hogs lived in the woods at Kenosha the winter of 1836-37 without being fed.[201]

### 1837

"In July of '37, Ephraim Perkins . . . drove two hundred hogs from Illinois into Sugar Creek woods, in Spring Prairie (Walworth County), and left them to fatten on acorns."[202]

### 1841

Squirrels were cutting acorns and beechnuts at Racine.[203]

### 1842

According to Hoy, "mast was exceedingly abundant" at Racine.[54a]

### 1844

"The cold season at the north blasted the mast . . ."[204]

### 1847

Mast was "very abundant" in Grant County and at Racine, but

scarce north of the lower end of the Wisconsin River. Hazelnuts were quite plentiful in Jefferson County.

1848

Hazelnuts plentiful in Jefferson County.

1852

Mast abundant at Racine.

1853

Beechnuts plentiful in Manitowoc County.

1854

Deer were very fat in Jefferson County due to the abundance of "shack". Acorns were more abundant than usual in Outagamie County. There was a large nesting of pigeons in Waupaca County in 1855.

1856

"Scarcity of most kinds of nuts" at Green Bay.

1857

Butternuts were plentiful in Dodge County, and hazelnuts very abundant in Dane County. Pigeons nested in Outagamie and Oconto Counties in 1858.

1858

Hickory nuts abundant in La Crosse County, acorns exceptionally abundant in Iowa County, and a large crop of beechnuts in Door County.

1859

Acorns were reported scarce north of Berlin, but plentiful at Tomah. Hickory nuts were offered in large amounts in the Milwaukee market. Cravath[205] states that at Whitewater there was frost during every month of the summer and that very little corn matured.

1860

Acorns abundant in Dane County. The pigeons nested in Green County in 1861.

1861

Large crop of butternuts and hazelnuts in Richland County. The pigeons nested in Green County in 1862.

1862

Butternuts plentiful in Dane County.

1863

There was a large nesting of pigeons along the Kickapoo River, Vernon County, and in southwestern Monroe County in 1864.

1864

The pigeons nested in Fond du Lac County in 1865.

1865

Hickory nuts and hazelnuts were unusually plentiful in Dodge County, and nearly all kinds of nuts were plentiful in Fond du Lac County. The crop of beechnuts in Door County was exceptionally heavy.

1866

There was an abundance of "shack" in Adams County. The pigeons nested in Fond du Lac County in 1867 and flew westward for food.

1867

Hickory nuts were abundant in Outagamie County and hazelnuts in Polk County. The pigeons nested in Outagamie County in 1868.

1868

There were large nestings of pigeons in Green, Monroe, and Fond du Lac Counties in 1869.

1869

Walnuts were plentiful in Rock County. In Jackson County the crop of hazelnuts was abundant, but that of butternuts was spotty. Butternuts were unusually plentiful in Jefferson and Fond du Lac Counties. All kinds of nuts were reported plentiful in the latter county. Shawano County had beechnuts.

1870

There were no butternuts in Outagamie County. Acorns were abundant in Dane and Fond du Lac Counties and in the center of the state. The large pigeon nesting extending from Kilbourn to Sparta in 1871 was due to the abundance of acorns in the fall of 1870.

1871

Butternuts were abundant in St. Croix, Polk, Dunn, Jackson, Richland, and Fond du Lac Counties; black walnuts in Fond du Lac, Dane, and Richland Counties; hickory nuts in Brown and Fond du Lac Counties; and hazelnuts in Door County. Acorns and nuts were plentiful in Winnebago County. The squirrel migration at La Crosse was attributed to a shortage of nuts.

1872

There was a good crop of butternuts at Racine, but other kinds of nuts were a failure. Hickory nuts were scarce over most of the state; however in Outagamie County butternuts, hickory nuts, and hazelnuts were reported plentiful.

A professional pigeon trapper stated that few pigeons nested in the state in the spring of 1873 due to the great scarcity of mast.

1873

There were a few walnuts in Walworth County. Hickory nuts were abundant in Walworth, Green Lake, Winnebago, and Brown Counties; butternuts in Walworth and Calumet Counties; and hazelnuts in Walworth County. Butternuts were selling at 25 cents a bushel at Lake Geneva in the spring of 1874. Nuts were reported plentiful at De Pere and the woods alive with squirrels.

Deer were stated to be eating the acorns of the black oak in Dunn County. So few pigeons appeared in 1874 that a small crop of acorns in 1873 is indicated.

1874

Butternuts were abundant in Marathon County. The woods in Portage County were full of acorns. The pigeons nested in Pierce and Wood Counties in 1875.

1875

This was a remarkable year for nuts. Walnuts, hickory nuts, butternuts, beechnuts, and hazelnuts were all abundant.

There was a nesting of pigeons in La Crosse County in 1876.

1876

Hickory nuts were abundant in Dodge, Outagamie, and Columbia Counties; and acorns in Rock and Dunn Counties. The pigeons nested in Monroe County in 1877.

1877

This was another year in which the hazel, walnut, hickory, butternut, and beech yielded abundantly.

There was a bountiful crop of red oak acorns in St. Croix County. Acorns were plentiful in Dunn and unusually abundant in Eau Claire County. "Unusual quantities" were reported for the state. The pigeons nested in Adams County in 1878.

1878

This was a very poor year for mast. There were but few hickory nuts in Rock County, and in Oconto County acorns and beechnuts were scarce. Winnebago, Chippewa, Buffalo, Dunn, and Pierce Counties reported a great scarcity of nuts and acorns. There were no hazelnuts in Wood County.

1879

There was a large crop of beechnuts in Door County. It was an excellent season for all kinds of nuts throughout the state. Acorns were abundant in Pierce, Chippewa, Walworth, and Kenosha Coun-

ties. Some oak trees in the latter county yielded three to five bushels of acorns.

1880

There were no beechnuts in Door County. It is unusual to have two successive years in which the nut trees bear heavily, but this was another year in which walnuts, butternuts, hickory nuts, and hazelnuts were plentiful. Acorns were plentiful in Barron and Pierce Counties.

1881

Hickory nuts were abundant in Kenosha, Racine, Green Lake, Fond du Lac, and Waushara Counties. "Nuts" were also abundant in Iowa County. Squirrels were reported plentiful in Waushara County due to the "large crop of nuts and acorns". The butternut crop in Trempealeau County was about one-fourth that of 1880. Hazelnuts were plentiful.

This year was marked by the abundance of acorns throughout the state, in the central portion of which the crop was described as "immense" and as yielding "thousands of bushels". There were large nestings of pigeons near Sparta, Tomah, and Kilbourn in the spring of 1882.

1882

Beechnuts were plentiful in Sheboygan County. Hickory nuts were abundant in Rock, Walworth, Green Lake, Outagamie, Winnebago, and Trempealeau Counties. The crop in the latter county was exceptionally large. "Nuts" were quite plentiful in Brown County. Butternuts and walnuts were abundant in Rock County, and hazelnuts in St. Croix and Richland Counties. No information on acorns was found.

1883

This year was one of great scarcity of mast. Hickory nuts, walnuts, and butternuts were scarce in Walworth County; and hickory nuts were scarce in Kenosha and Waupaca Counties. A man at Reedsburg is stated to have gathered 50 bushels of black walnuts from a grove planted 24 years previously. The acorn crop was a failure in Richland, Iowa, Juneau, and Dunn Counties.

1884

Walnuts, butternuts, hickory nuts, and hazelnuts were plentiful to abundant. Though nuts were very plentiful at Potosi, squirrels were scarce. The pigeons nested in the southeastern corner of Langlade County in 1885.

1885

Hickory nuts were abundant but in Racine, Walworth, Green Lake, and Sheboygan Counties only a few nuts had meats in them. The crop of walnuts and butternuts was good to fair. Hazelnuts were plentiful in Iowa and Buffalo Counties. Green Lake reported an "immense acorn crop".

1886

All sections of the state reported unusually large yields of walnuts, butternuts, hazelnuts, and hickory nuts, especially the latter. There was a large crop of acorns in Waupaca County. In the spring of 1887, the pigeons attempted to nest near Wautoma.

1887

There was an immense yield of beechnuts in Oconto, Kewaunee, Manitowoc, and Sheboygan Counties. Butternuts were plentiful in Sauk, Juneau, and Jackson Counties. The crop of hazelnuts was enormous throughout the state. Nuts were not as plentiful in Rock County as the previous season and many of them did not fill. Acorns were reported abundant in Sheboygan County.

1888

Hickory nuts, walnuts, butternuts, and hazelnuts were abundant. No information on the yield of acorns was found.

1889

Shawano County reported beechnuts plentiful while Manitowoc County had none. Butternuts were plentiful in Rock County. There were no hazelnuts in St. Croix County.

1890

Hickory nuts were plentiful in Walworth and Juneau Counties. Nuts of all kinds were exceptionally scarce in Iowa County. No reports on the yield of acorns in Wisconsin were found. Near Chicago acorns were abundant on the species of oaks fruiting biennially.[206]

1891

There was a large crop of beechnuts in Sheboygan, Manitowoc, Brown, Oconto, and Shawano Counties. Hickory nuts were plentiful in La Crosse and Sheboygan Counties; butternuts in Pierce, Crawford, Richland, Jackson, Kewaunee, and Brown Counties; walnuts in Crawford County; and hazelnuts in St. Croix and Richland Counties.

No information on the acorn crop in the state was found. There was a medium yield near Chicago, but from 50 to 75 per cent of some species were destroyed by weevils.[206]

1892

The yield of hickory nuts in Dane County was poor. This was also true of beechnuts and hazelnuts in Oconto and Kewaunee Counties. Kewaunee reported that squirrels were visiting the farmyards, and even the city, for food, and on the other hand that acorns were plentiful in the woods.

1893

Beechnuts were plentiful in Manitowoc County. Walnuts, butternuts, hickory nuts, and hazelnuts were abundant in most regions. The hazelnuts in Juneau County were heavily parasitized.

1894

A heavy crop of beechnuts was reported from Manitowoc, Kewaunee, and Brown Counties. Butternuts were plentiful in Waupaca County.

1895

Walnuts were abundant in Vernon and Dane Counties. Hickory nuts were scarce in Trempealeau, plentiful in Calumet, and a drug on the market in Florence County. Hazelnuts were a large crop. Only a few were parasitized in Juneau County.

## ADDENDA

I. A. Lapham lists the gray squirrel for Ashland in his Diary (Library Wis. Hist. Soc.) under date September 6, 1858.

There is the following additional information for the emigration of 1834 for southern Illinois: "The gray squirrel (some individuals black) was very plentiful in early day . . . In the fall of 1834 there was a great immigration of squirrels from Kentucky, which crossed the Ohio River by swimming, and made their way northward through Gallatin and White counties, over-running the country and doing immense damage to the corn crop." Near Phillipstown in September, during a hunt of ten men on a side, each side killed 4,000 to 5,000 squirrels. Near Christmas they produced nearly 30,000 scalps on each side. — Anon. History of White County, Illinois. Chicago (1883) pp. 209-10.

"In Sept., 1801, an astonishing emigration of squirrels took place, from Kentucky across the Ohio river. As many as 500 per day were killed as they crossed the river." — L. Collins, History of Kentucky. Covington, Vol. 2 (1874) 468.

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* The correspondent wrote: "We think it is caused by the white weasel chasing the mother and frightening her." ?Quien sabe?

* Emigration is more correct than the customary term, migration.