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The *Transactions* welcomes sound original articles in the various fields of science and scholarship by members of the Wisconsin Academy of Sciences, Arts and Letters. With this volume, the task of editing passes from the hands of the Academy secretary-treasurer into those of an editor, and manuscripts should be addressed to James A. Larsen, Observatory Hill Office Building, University of Wisconsin, Madison 6, Wisconsin. Manuscripts should be double-spaced throughout, and should have the address to which proofs are to be sent in the upper left hand corner of the first page. In general, bibliographical style to be followed in scientific papers is that on pages 56 and 76 of this issue. Deviations from that style in the current volume exist, in most instances, for reasons of consistency with previous papers in a series. Manuscripts for consideration should be in the hands of the editor by June to permit publication of the *Transactions* within the year.

THE MOOSE IN EARLY WISCONSIN

A. W. SCHORGER
Department of Forestry and Wildlife Management,
University of Wisconsin

The moose *(Alces alces)* was the largest mammal, with the exception of the bison, indigenous to Wisconsin. A specimen shot in Bayfield County is stated to have weighed a trifle less than 1,000 pounds. The French-Canadian name was *orignal, oriniack,* or a variant. The first mention of moose in the state was by Radisson. While at Chequamegon Bay, near Ashland, about 1661, he shot one, and could have killed more, but stated, "we liked the fowles better."[1] On July 22, 1738, La Ronde[2] wrote from Chequamegon Bay that in March he sent his men to bring in a moose killed 15 leagues from the fort.

Range. The southernmost plausible record for the moose in Wisconsin was the one shot by Indians in the town of Dellona, Sauk County, latitude 43° 30′, in 1845.[3] This is below the normal range, and probably represents the phenomenon common to the species of individual wandering. Burt[4] gives an authentic record of a moose in Michigan as far south as Oakland County, latitude 42° 30′. Dart[5] stated that in 1840 moose were occasionally found at Green Lake, Green Lake County, latitude 43° 45′, and that shed antlers were often found. Some of them weighed 60 to 70 pounds. These weights appear high. There is paucity of information in the literature on the weight of the antlers alone. Merrill[6] gives the weights of antlers with skull attached of three record Alaskan moose as 77, 92, and 101.5 pounds respectively. Of the four races of moose, the Alaskan is the largest. The antlers with dried skull of a New Brunswick specimen weighed but 56 pounds.

Schoolcraft,[7] when at Rice Lake, Baron County, in 1831, wrote that the tracks of moose and elk were numerous on the sandy shores of the Red Cedar River. Subsequently the Indians told him that some of their party had been near the mill, and thought that the Sioux were about as the moose had been driven up. The sawmill was located on the Red Cedar River about 20 miles above its junction with the Chippewa River in approximately the center of Dunn County. This is the southernmost point recorded for the moose in the western part of the state.

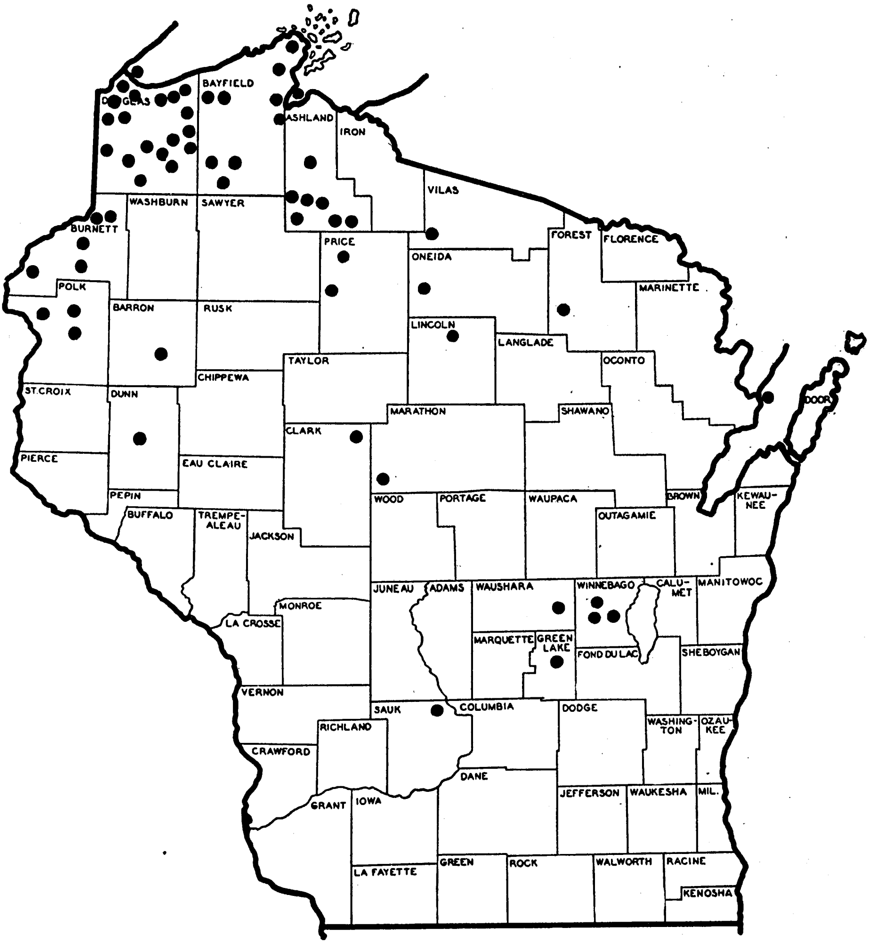

Fig. 1. Records of Moose in Wisconsin.

The reliable records for moose are shown on the accompanying map which shows that the best habitat was in the northwestern part of the state.

ABUNDANCE

Moose were most numerous in Douglas County followed by Bayfield and Burnett Counties. The moose is notorious for shifting its range, hence it is difficult to determine from published accounts just how plentiful it was. It is certain, however, that with the exception of the caribou, it was the least numerous of the deer family. When Schoolcraft[8] was at Kabamappa's village, near modern Gordon, Douglas County, in 1832, he was informed by the chief that though moose were once plentiful in the region, it was then necessary to go to the remote branches of the Brule River to hunt them. The only valuable information on abundance is given by Rev. Ely.[9] While enroute from Fond du Lac (Superior) to Yellow Lake, Burnett County, he stopped at an Indian lodge on March 7, 1835. One of the Indians told him that two or three lodges containing five hunters had killed, between November 15 and January 15, 13 moose, 9 bears, 2 deer, and various small game. Aside from the above entry, his diary records moose on only a few occasions.

Curot[10] had charge of a trading post on the Yellow River, the winter of 1803–04. He records trading for only three moose hides. The translation of his journal has elk skins, but in the French manuscript the word is *orignal.* At the post on Lac du Flambeau, Vilas County, the winter of 1804–05, Malhiot[11] traded for the hides, and the meat, or muzzles, of nine moose.

The statement was made by Brunson[12] in 1843, that moose, elk, deer, etc. were more plentiful in the regions adjacent to the Black and Chippewa Rivers than in any other part of the country. As far as the moose is concerned, this would apply only to the upper Chippewa. Lapham[13] merely listed the moose as a Wisconsin mammal in 1853. Evidently a moose was not easily obtainable at this time for Charles J. Sprague,[14] Curator of the Boston Society of Natural History, wrote to Lapham on July 22, 1853, that the Madison Natural History Society [Association] had made a request for a moose but did not state whether a skin, a skeleton, or both, was desired. Hoy[15] mentions that a cow moose was killed along the line of the Wisconsin Central Railway in December, 1877. About this time Strong wrote that it was rapidly becoming extinct.[16]

A letter to Seton from Charles H. Baker, a surveyor, reads as follows: "In answer, first, to your query as to the occurrence of moose in Wisconsin, I can state positively that in 1870, this animal was comparatively numerous east and southeast of Superior . . . , in the counties of Douglas of Bayfield, between Poplar River and the head of White River [Bayfield County], at a distance of from 15 to 20 miles or more south of Lake Superior."[17] Merrill[6a] wrote in 1916 that recent reports on moose in extreme northern Wisconsin lacked authenticity and that this species had not been numerous in northern Wisconsin and Michigan within the memory of any living person.

The year 1900 may be considered as approximately the time of the near extinction of the moose in Wisconsin. The last moose to arrive unaided in Wisconsin was drowned near Superior in 1921. There is little doubt that this individual was of Minnesota origin.

Carlton and Pine Counties, Minnesota, bordering northwestern Wisconsin are at present considered occasional moose counties.[18] Formerly they were excellent moose territory.

Of the four proposed races of the moose, the Minnesota populations falls within the range of *Alces a. andersoni.*[19] It is logical to assume that most of the Wisconsin moose belonged to this race, but there is insufficient material to prove it. The Isle Royale, Michigan, specimens belong to this race. As long ago as 1853, Andrews[20] wrote that in severe winters both moose and caribou cross on the ice from the mainland to this island. The moose that once occurred in the northern peninsula of Michigan may have been *Alces a. americana.*

There are some statements on the killing of moose that are very indefinite as to locality. One was reported killed in June, 1867, on the South Fork of the Chippewa River.[21] There is an east and west fork, but I am unable to find any tributary formerly known as the South Fork. A moose was killed on the St. Croix River in July, 1879;[22] and a Trempealeau paper states that Arthur Gibbs shot one in the northern part of the state in November, 1899.[23]

A large moose shot in northern Wisconsin and consigned to the Drummond Brothers, Eau Claire, arrived at its destination on December 23, 1884, reputedly the first ever to be brought to the city.[24] The heads of two moose were expected within the week and would be placed on exhibition. A week later another moose, killed at Drummond, Bayfield County, arrived in the city, so that both moose may have been killed in this county. The first moose is stated to have weighed a trifle less than 1,000 pounds. If "hog dressed," this weight would be high. Breckenridge[25] gives the total live weight of a male moose, five to six years of age, killed in Minnesota, as 1065 pounds. The heart and viscera weighed 239 pounds, and the blood lost, 26 pounds. Peterson[19a] gives the weight of a male taken in Manitoba as 1060 pounds without the blood lost.

In October, 1885, a party of Indiana and Ohio hunters was reported to have killed 8 deer and a large moose.[26] The locality is not stated. At this time most of the "foreigners" hunted in Florence County.

There are Moose rivers or creeks in Barron, Douglas, and Sawyer Counties; and Moose lakes in Bayfield, Douglas, Iron, Langlade, Marinette, and Sawyer Counties.

RECORDS BY COUNTIES

Ashland. Lapham[1] in 1858 listed the moose among the mammals of the Penokee Range. A female moose seen near Butternut on November 8, 1877, was killed by Joseph Harper on the 12th.[2]

Another account gives the date of the killing as November 9, and that the head was on exhibition in the office of the Ashland Press.[3] A drove of 13 moose was reported in the vicinity of Butternut in the spring of 1878.[4] In December, 1884, E. Gordon killed a cow moose on Torch River, which is in the southwestern part of the county.[5] In March, 1887, moose were reported quite numerous 20 miles west of Glidden; and in September of this year, a bull moose and numerous tracks were reported seen in T42, R2W.[6] The same fall two men while cruising on the West Fork of the Chippewa reported tracks and other sign of moose in T42, R4W.[7]

1. Lapham, I. A. Diary Aug. 24–Sept. 23, 1858. Wis. Hist. Soc. Library; Trans. Wis. State Agr. Soc. 1858–59, 5 (1860) 399. 2. Phillips *Times,* Nov. 10, 17, 1877. 3. Ashland *Press,* Nov. 17, 24, 1877. 4. Shawano *Journal,* Feb. 2, 1878. 5. Glidden *Pioneer,* Dec. 18, 1884. 6. Glidden *Pioneer,* March 24 and Sept. 22, 1887. 7. Chippewa Falls *Herald,* Dec. 9, 1887.

Barron. Schoolcraft[1] reported moose tracks numerous along the Red Cedar River below Rice Lake in 1831.

1. Schoolcraft, H. R. Summary narrative . . . (1855), p. 543.

Bayfield. The fresh tracks of a moose were seen by Rev. Ely in the northwestern corner of the county on January 6, 1836. Armstrong[1] states that about 1843, the Indians tried to capture a moose swimming across Chequamegon Bay. Peet wrote from Bayfield, on January 5, 1858: "One of my neighbors shot 2 Moose out in the woods a few days since."[2] A moose weighing about 750 pounds, shot near Drummond in December, 1884, was shipped to Eau Claire.[3] A large moose was reported using the Raspberry Bay area in the summer of 1886.[4] In connection with the report of Art Boyer that he had seen a bull moose in the Town of Barnes in the fall of 1936, it is stated that about 20 years previously P. C. Knapp of Iron River killed a moose in the town of Orienta.[5] Cory[6] was informed by M. Berg that a moose was killed at Cable "about 25 years ago" (c. 1885). A Bayfield paper states that a large moose was killed at Clear (Eau Claire) Lake early in November, 1882.[7]

1. Armstrong, B. G. 1892. Early life among the Indians. pp. 166, 172. 2. Peet, J. Diary. Typed copy in Wis. Hist. Soc. Library. 3. Eau Claire (d) *Leader,* Dec. 31, 1884. 4. Bayfield *Press,* Aug. 7, 1886. 5. Wis. Cons. Bull. 1 (11) (Nov., 1936) 12. 6. Cory, C. B. 1912. The mammals of Illinois and Wisconsin. p. 77. 7. Bayfield *Press,* Nov. 11, 1882.

Buffalo. It has been stated that Joseph V. Jones came to Mondovi in 1856, at which time moose were "very common."[1] Undoubtedly, elk was intended as this animal was once common. Moose is not given by Kessinger[2] in his brief list of the mammals of the county; and Bunnell,[3] who came to La Crosse in 1842, and was thoroughly familiar with the game mammals of the Upper Mississippi, does not mention it.

1. Durand *News,* March 15, 1905. 2. Kessinger, L. 1888. History of Buffalo County, Wisconsin, pp. 42–43. 3. Bunnell, L. H. 1897. Winona and its environs on the Mississippi.

Burnett. Curot,[1] the winter of 1803–04, obtained a few moose skins at his trading post on the Yellow River. In the spring of 1877 a moose was killed at a logging camp about 40 miles above St. Croix Falls, which would place it in Burnett County.[2] One was killed at Clam Lake in November, 1882;[3] and another at the ferry on the Yellow River, on June 13, 1889.[4]

1. Curot, M. 1911. Wis. Hist. Colls., 20:420, 421, 425. 2. Montello *Express,* March 3, 1877. 3. St. Croix Falls *Dalles of Saint Croix,* Nov. 17, 1882; Madison *State Jour.,* Nov. 9, 1882. 4. Grantsburg *Sentinel,* June 21, 1889.

Clark. A moose weighing 900 pounds was killed at Abbotsford in September, 1883, by John O'Connor.[1]

1. Eau Claire (d) *Leader,* Sept. 28, 1883.

Douglas. Doty[1] mentions moose as one of the principal game animals of the Indians in the Fond du Lac (Superior) area in 1820. In August, 1826, McKenney[2] measured a large moose killed in the neighborhood. Aside from the height, six feet and nine inches, the remaining measurements are not standard. Rev. Ely *(l.c.)* recorded moose in his diary on January 21, 22, and 28, 1835, and January 25, 1836. The moose was mentioned in 1855 as one of the game animals to attract tourists to Superior.[3] A large bull moose was seen within two miles of Superior on September 19, 1860; and tracks were reported to be plentiful on the road to the Douglas Copper Range.[4] In the spring of 1873, John O'Sagie and brother killed five moose in one week on the Poplar River; and A. Tourville two on the Amnicon, both streams emptying into Lake Superior a few miles east of Superior.[5] Eight moose were brought into Superior the spring of 1874, the crust on the deep snow rendering it impossible for the animals to travel.[6] In January, 1875, a cow and calf were seen near the headwaters of the St. Croix River;[7] and in the fall of this year moose were reported plentiful a few miles from Superior.[8] Frank La Suisse, living on Wisconsin Point, shot a bull moose in September, 1877.[9] The summer of 1884, one was seen by J. A. McGilvray on the bank of the St. Louis River near Duluth.[10]

A hunter who came to Bayfield to make a homestead entry on land in Douglas County, stated that the winter of 1884–85, up to the middle of January, he had killed five moose in addition to other large game.[11] A large moose was killed at Nebagamon Lake on July 1, 1886, by J. Gehen.[12] A moose was killed at Brule in November, 1894.[13] M. J. Bell shot a bull moose between the village of Brule and Lake Superior about 1896, the head of which was on display in the Knight Hotel in Ashland.[14]

Cory[15] corresponded with several residents of the county and learned that three moose were killed in the town of Brule in 1886, and one on the St. Croix in 1900. One was killed about 1907 in T45, R15W (town of Summit), and another at Charlie Brook in the fall of 1909. A moose swimming in Allouez Bay, at Superior on September 11, 1921, drowned after being roped and towed by a launch.[16]

1. Doty, J. D. 1876. Northern Wisconsin in 1820. Wis. Hist. Colls., 7:201. 2. McKenney, T. L. 1827. Sketches of a tour to the lakes. pp. 281–82. 3. Superior *Chronicle,* Sept. 4, 1855. 4. Superior *Chronicle,* Sept. 22 and 29, 1860. 5. Superior *Times:* Brandon *Times,* April 18, 1873. 6. Milwaukee (d) *Sentinel,* April 7, 1874. 7. Eau Claire *Free Press,* Jan. 21, 1875. 8. Superior *Times,* Oct. 7, 1875. 9. Superior *Times,* Sept. 29, 1877. 10. Chippewa Falls *Herald,* Dec. 26, 1884. 11. Bayfield *Press,* Jan. 17, 1885. 12. Superior *Times,* July 3, 1886. 13. Hurley *Miner,* Dec. 1, 1894. 14. Wis. Cons. Bull., 1 (11) (Nov., 1936) 12. 15. Cory, C. B. The mammals of Illinois and Wisconsin. (1912) p. 77. 16. McNaughton, J. W. Wis. Conservationist, 3 (6) (Jan., 1922) 12.

Dunn. When Schoolcraft[1] was at Lake Sapin (Balsam) in 1831, he was informed that the moose had been "driven up" from the vicinity of the sawmill on the Red Cedar River.

1. Schoolcraft, H. R. Summary narrative . . . (1855) p. 553.

Florence. There is no authentic record of a native moose. One was reported, in January, 1887, to be in the vicinity of Florence.[1] A moose, shot by a hunter during the deer season of 1937, was found near Pine River, south of Florence. This moose was trapped on Isle Royale and liberated near Escanaba, Michigan.[2]

1. Milwaukee *Journal,* Jan. 4, 1887. 2. Wis. Cons. Bull., 2 (10) (Oct., 1937) 25; 2 (12) and 3 (1) (Dec.–Jan., 1937–38) 54; 3 (2) (March, 1938) 40.

Forest. A bull moose, that was supposed to have wandered down from Lake Superior, was killed at Rice Lake by Indians on March 18, 1873. William Gumaer partook of it at "Johnson's Station".[2] The above information shows that the moose was killed at Rice Lake, town of Crandon, Forest County. The military road from Shawano to Lake Superior ran close to this lake.[2]

1. Shawano *Journal,* March 22, 1873. 2. Historical Atlas of Wisconsin. (1878) p. 99.

Green Lake. This county was the southern limit of its range. Gillespy,[1] in 1860, mentioned its former occurrence. Dart came to the county in 1840 and stated: "Elk and moose were found upon Willow River, and occasionally around Green Lake. Shed elk and moose horns were then often found here.[2]

1. Gillespy, J. C. The history of Green Lake County. (1860) p. 19. 2. Dart, R. Settlement of Green Lake County. Proc. Wis. Hist. Soc. for 1909. (1910) p. 260.

Jefferson. It is extremely doubtful if moose occurred in this county. Somers[1] in 1888 collected bones at the ancient village site of Aztalan and reported those of the moose without giving any basis for the identification. Subsequent extensive investigations of refuse pits have failed to establish the presence of moose.

1. Somers, A. N. 1892. Prehistoric cannibalism in America. Pop. Science Monthly, 42:204. *Cf.* S. A. Barrett, 1933. Ancient Aztalan. Mil. Pub. Mus., Bull. 13:356.

Lincoln. Moose were mentioned as present in the northern part of the county in 1878.[1]

1. Prairie du Chien *Courier,* July 9, 1878.

Marathon. A moose was reported seen in the fall of 1885 near Spencer, in the southwestern corner of the county.[1]

1. Spencer *Tribune,* Nov. 6, 1885.

Marinette. It is highly probable that moose once ranged back and forth across the Wisconsin–Michigan line. About the first of December, 1877, a Mr. Hummel of Green Bay shot a large moose near Spalding, Menominee County, Michigan, and returned with the antlers.[1] In November, 1885, a moose weighing 450 pounds dressed, was killed in Green Bay near Menominee.[2]

1. Green Bay *Advocate,* Dec. 6, 1877. 2. Menominee *Herald:* Green Bay (w) *Advocate,* Nov. 12, 1885:3.

Oneida. Arthur A. Oehmcke, Coordinator, Area II, Wisconsin Conservation Department, wrote to me on March 8, 1954, that Charles Talbot, proprietor of a resort on Willow River, has fragments of moose antlers. These were found at the edge of a cedar swamp northwest of Willow Lake between 1914 and 1915 by a trapper, Ed Wilson.

Polk. In October 1866, Thomas Rodgers, town of Sterling, killed a moose seven feet in height.[1] It was stated to have been the first moose killed in the county. In May, 1885, John Buck, an Indian, killed a moose, thought to have been three years of age, in the town of Luck.[2] Two Indians, in October, 1903, killed a moose, "the largest one known to have been killed in the county for the last 15 years."[3]

1. Osceola *Press,* Nov. 17, 1866. 2. New Richmond *Republican,* May 20, 1885. 3. St. Croix Falls *Standard,* Oct. 30, 1903.

Price. A herd of moose was reported as occurring in the vicinity of Butternut Lake in the spring of 1878 and two were killed there in the autumn of this year.[1] A moose was killed on the South Fork of the Flambeau in January, 1882, and was considered very rare.[2] About 1910 W. J. Webster, Superintendent of Schools at Park Falls, wrote to Cory[3] that he had heard of moose being killed in the county some years previously.

1. "Wildwood, Will" (Fred Pond). Chicago Field, 9 (April 20, 1878) 155; Turf, Field and Farm, 27 (Oct. 25, 1878) 257. 2. Phillips *Times,* Jan. 7, 1882; Chippewa Falls *Times,* Jan. 11, 1882. 3. Cory, C. B. The mammals of Illinois and Wisconsin. (1912) p. 77.

Richland. There is a questionable record for the county. Some large ribs found in an Indian mound at Eagle Corners were supposed to have been from a moose.[1]

1. Brown, C. E. Wis. Arch., 5 (1) (Oct., 1905) 217.

Sauk. Cole was informed by Theodore Conkey, government surveyor, that a party of Indians killed a moose in 1845 in the town of Dellona. I examined the original field notes in the State Land Office, Madison, and found that Conkey did survey the town in 1845. There is, however, not one mention of a bird or mammal, a failure common to all the government surveys in the state. It is to be expected that a moose would occasionally wander this far southward.

1. Cole, H. E. A standard history of Sauk County, Wisconsin. 1 (1918) p. 103.

Vilas. Malhiot[1] traded for the skins and meat of several moose at his post on Lac du Flambeau the winter of 1804–05.

1. Malhiot, F. V. Wis. Hist. Soc. Colls., 19 (1910) 187–231.

Waushara. Dart[1] has stated that when he came to Green Lake County, moose were to be found along the Willow River. Since there is no Willow River in this county he must have had in mind Willow Creek which empties into Lake Poygan in eastern Waushara County. The Lake Poygan area was once fairly good moose territory.

1. Dart, R. Proc. Wis. Hist. Soc. for 1909. (1910) p. 260.

Winnebago. The late George Overton, Butte des Morts, informed me on May 27, 1939, that a few years previously his wife found part of a moose antler in a creek on his farm. This specimen is still in possession of the family. Remains of moose have been found at the Lasley Point archeological sites, Lake Winneconne, town of Winneconne. Buckstaff[1] has reported five scapulae, and Bullock[2] a badly decomposed antler found here.

1. Buckstaff, R. N. Indian bone implements in the Oshkosh Public Museum. Wis. Archeol. 23 (2) (June, 1942) 25. 2. Bullock, H. R. Lasley Point mound excavations. *Ibid.*, p. 40.

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PLANT SUCCESSION ON A SAND PLAIN, NORTHWEST WISCONSIN[1]

IRVEN O. BUSS[2]
Department of Wildlife Management, State College of Washington

An area of about 120 sections located primarily on the north side and adjacent to the Chippewa River in southeastern Dunn County (Figure 1) near the prairie-forest border (Curtis, 1955, p. 559) was studied to: (1) determine the succession of plants on a sand plain, and (2) record some of the principal plants occurring on sites undisturbed for 35 years or longer. Field work was done mainly during June, July, and August, 1940, although numerous trips were made to the area subsequently.

The climate, geology, formation of alluvial terraces, and the soils of the south part of northwestern Wisconsin have been described by Weidman, Hall and Musback (1911). These authors tell that some time during the periods of glacial activity the streams were unable to carry away the land-wash brought down from the upland slopes and were forced to deposit large amounts of sand along their courses. In this manner, broad sand plains developed along the rivers of this area. The plain in southeastern Dunn County, where this study was centered, is probably the largest alluvial sand plain in the entire south part of northwestern Wisconsin. It is known locally as the Meridean Prairie.

After filling its valley with such a deposition, a river may change its action and entrench its course in the built-up flood plain. The part of the plain remaining above the new valley floor is called a terrace. The Chippewa valley below Chippewa Falls is characterized by five terraces which are well developed and consist of an exceptionally deep deposition. Well drillers below Eau Claire can not tell the depth of the deposition, for the difference between deposited sand and sandstone is rendered indistinguishable by pressure at depths of 200 feet or more.

Plainfield Sand is the soil type characterizing Meridean Prairie and the terraces of the Chippewa River. According to Weidman, Hall and Musback (1911, map) it is a "light sandy soil; level valley

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[1] Dedicated to Norman C. Fassett, Godfather of this study, who suggested the techniques used for studying plant succession and provided other technical help during the course of the field work.

[2] Professor of Wildlife Management, State College of Washington, Pullman; formerly Chief of Wildlife Research, Wisconsin Conservation Department, Madison, Wisconsin.

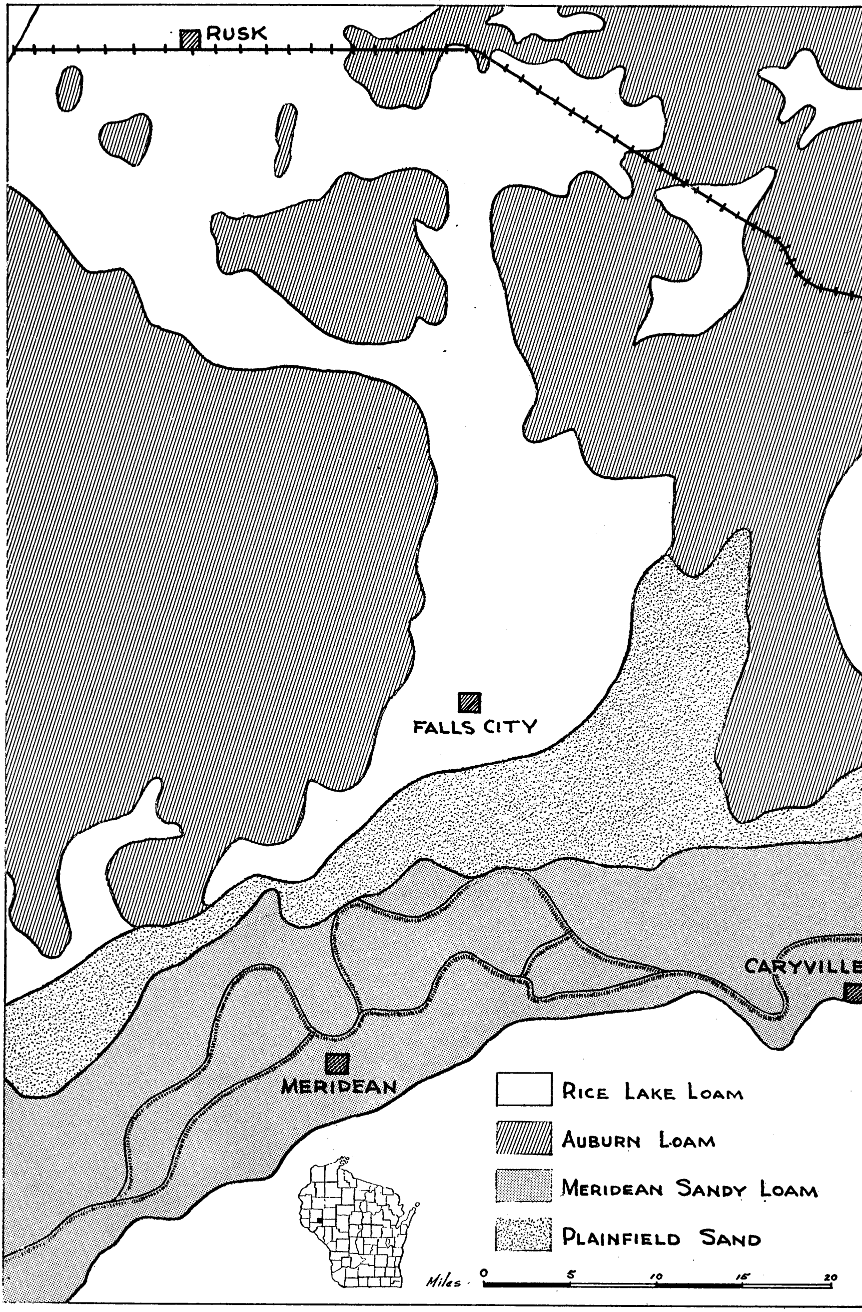

FIGURE 1. Soils Map of Study Area near Chippewa River in Southeastern Dunn County.

bottom land; forest trees mainly jack pine." Rusk Prairie immediately to the north consists of Rice Lake Loam which, according to the above authors (p. 58), is a fine sandy loam with sandy or gravelly subsoil, uniformly level, and in Dunn County "the native vegetation consisted largely of a slight stand of scrub oak, poplar, some birch and pine." Auburn Loam is a sandy or silt loam, generally with an undulating surface, and it was ". . . originally wooded with hardwoods, mainly red oak, black oak, burr oak, some birch, poplar and scattering maple" (Weidman, Hall and Musback, 1911, p. 79). The bottomlands of the Chippewa River consist of Meridean Sandy Loam which is a sandy loam containing considerable coarse and fine sand with a small amount of clay material; it is nearly level, and the above authors report (p. 65) that the forest growth was elm, maple, ash, a few oak, and some pine.

The taxonomic nomenclature is that of Gleason (1952).

PLANT SUCCESSION

On three sections of Meridean Prairie immediately north of the Chippewa River, uncultivated fields were studied to determine the succession of plants. The fields were used for raising rye, corn, and soybeans on a rotation basis after leaving the fields abandoned for several years or more (Buss and Mattison, 1955, p. 245). The duration of abandonment of these fields was variable and was ascertained from the landowner who knew when he had last cultivated each field. Those fields that could not be dated in this manner, were either dated by counting growth rings of trees planted in them by homesteaders, or they were excluded from observation.

Since all fields in which plant succession was studied were in three contiguous sections located on Plainfield Sand at the same elevation, their physical environment was the same, or at least very similar. Figure 2 presents graphically the direct observations for plants of 25 species which occurred on fields not cultivated for from one to 35 years. Abundance was designated by four categories (abundant to dominant, common or numerous, occasional or scattered, and few to rare) as shown in the Key of Figure 2. In estimating abundance both density (number of stems per unit area) and coverage (actual area covered by a plant) were taken into consideration; a few plants of one species might give great coverage and many small plants of another species result in little coverage. Miller and Egler (1950, p. 156) indicate that such a system has certain disadvantages but that it also has many advantages for simple rapid survey. Each vertical line in Figure 2 represents abundance of one species for one field. For example, there are 15 vertical lines representing abundance of flowering spurge,

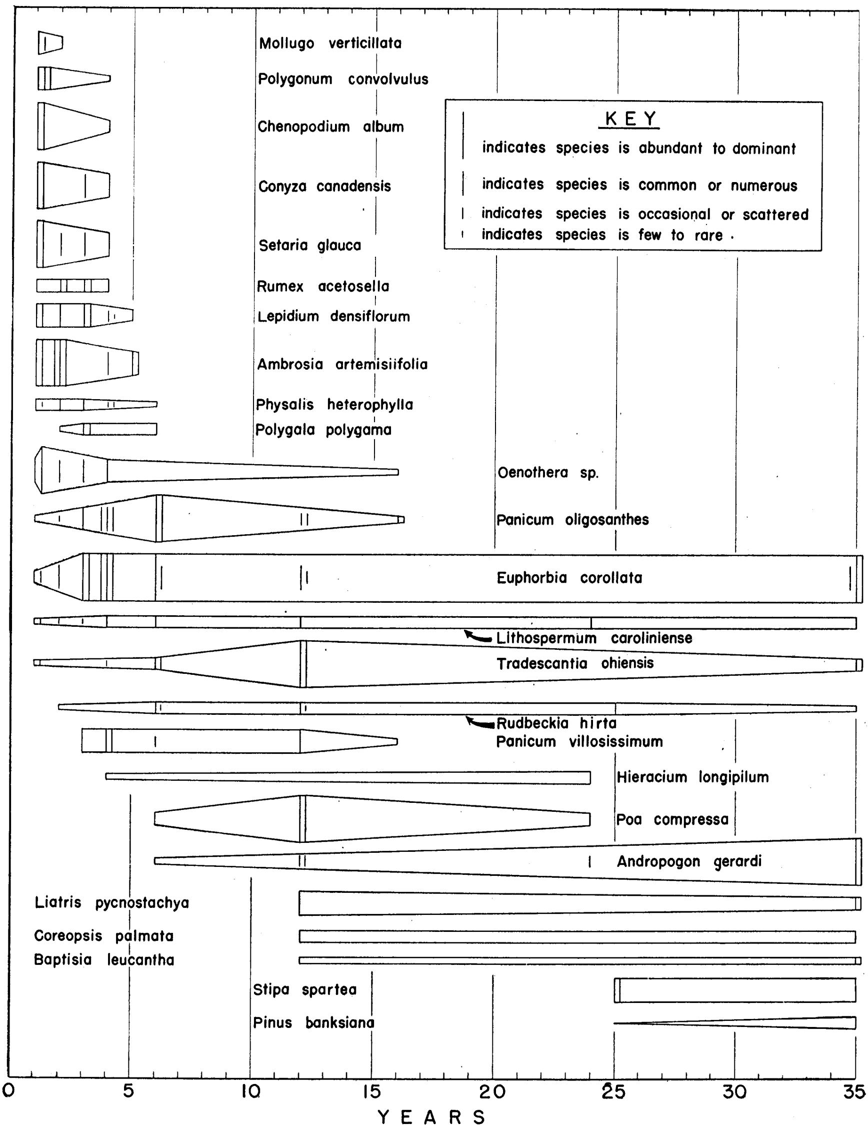

FIGURE 2. Occurrence of Plants on Fields not Cultivated for Various Times up to 35 Years.

Euphorbia corollata, for each of the 15 fields in which it was observed. By connecting the vertical lines a figure is developed which shows: (1) at what time or stage after cultivation the different plants became conspicuous and when some of them disappeared, (2) how long after cultivation each species occurred most frequently, and (3) which plants remained in the oldest observed stages. Since the length of any vertical line depends on abundance assigned to it by direct estimate, the records for any plant might vary directly with the observer. Nevertheless, the results of this study are strikingly similar to those obtained by Thomson (1939) who described and used this technique in studying plant succession on abandoned fields in the central Wisconsin sand plain area.

Some plants, such as sandbur, *Cenchrus pauciflorus,* invade so rapidly following slight disturbances that they have been eliminated from the figure. Pocket gophers, *Geomys bursarius,* Franklin ground squirrels, *Citellus franklini,* skunks, *Mephitis* sp., farm implements crossing from one field to another, and automobiles crossing the fields, caused disturbances which permitted the plants to become established. In most cases the time of the disturbance was unknown.

The first nine species in Figure 2 occurred in the first plant stage following cessation of cultivation. They may be considered weedy plants which disappeared and were replaced by other plants within five or six years postcultivation. Horseweed, *Conyza canadensis,* probably occurred on older fields than those shown in the figure, but it was not found on fields uncultivated for 12 years. Red sorrel, *Rumex acetosella,* occurred so locally that observations concerning this species were very difficult to obtain. Scattered patches usually grew so densely that no other species grew within its boundaries. Some fields had from four to 10 patches, whereas others abandoned for the same time had none. It is likely that this species occurs in fields not cultivated for 15 or more years.

Evening primrose, *Oenothera* sp., also occurred in early stages, but it persisted in later stages than the other plants of weedy nature.

Panic grass, *Panicum oligosanthes,* more nearly approached a monotype in a six-year field than any other species growing in any known-aged field.

The next four plants, *E. corollata,* puccoon, *Lithospermum caroliniense,* spiderwort, *Tradescantia ohiensis,* and black-eyed Susan, *Rudbeckia hirta,* may be considered dominants since they occurred in fields of all ages. *E. corollata* was found growing in practically every field studied. Its occurrence may be regarded as weedy, and it should not be considered as a valid species for determining plant stage of any field. After *L. caroliniense* reached a four-year stage, it did not appear to increase or decrease and persisted as scattered or occasional wherever it was observed.

Canada blue grass, *Poa compressa,* grew very dominantly in two 12-year fields.

Tickseed, *Coreopsis palmata,* displayed behavior similar to that for *L. caroliniense* but did not occur as soon after cultivation ceased.

Wild indigo, *Baptisia leucantha,* occurred rarely and only in late stages. Many original sites along the terraces were lacking in this species.

Porcupine grass, *Stipa spartea,* appeared to be the most conservative of all species shown in this figure. Where it was undisturbed on original or virgin sites, it was found growing abundantly. I was informed by several reliable old homesteaders that *S. spartea* and turkey-foot grass, *Andropogon gerardi,* were by far the most abundant plants that occurred originally on Meridean Prairie. Eighty-year-old hunters told me that these grasses waved against their horse's bellies as they drove across the prairie hunting pinnated grouse (Buss and Mattison, 1955, p. 90).

Although the oldest plant stage studied on these fields was herbacious and of prairie type, jackpine, *Pinus banksiana,* encroached on the edges of a few of the older fields. In each case the field adjoined a solid stand of *P. banksiana* and black oak, *Quercus* sp., which bordered two sides of the sand plain. There was no natural reproduction of woody species in fields not adjacent to these woodlots regardless of the age of the fields. Thomson (1943) studied plant succession on a sand plain in central Wisconsin and shows in a figure that the frequency of various species in abandoned fields was very similar to those studied in Dunn County. On page 38 Thomson (1943) states that "The dominance of the prairie species persists in the fields from fifteen to twenty-two years abandoned but in the older fields . . . the shrubby and woody plants, *Myrica asplenifolia, Rubus* sp., *Rhus glabra,* and *Pinus banksiana* become more prominent." The prominence of shrubby and woody plants in fields abandoned from 22 to 35 years was not conspicuous in Dunn County.

Observations were secured on a few fields, and some of the terraces, which had never been cultivated. Although no apparent differences were observed between these fields or terraces and the fields not cultivated for 35 years, numerous rare species were probably missing from the abandoned fields.

PLANTS ON UNDISTURBED SITES

On the entire area of about 120 sections, sites undisturbed for at least 35 years were studied to: (1) determine some of the principal plants which occurred on these sites, and (2) show the similarity or dissimilarity of these species to those observed on the oldest abandoned fields of the sand plain. The sites occurred at roadsides, in cemeteries, along a railroad right-of-way that crosses the northern part of the area, and on small inaccessible areas that were not farmed. Many county and town roadsides were undisturbed since they were constructed over 50 years previous to this study. The railroad right-of-way has been undisturbed for over 40 years with the exception of annual fires set to the dead vegetation each spring or fall. The section foreman for this line informed me that late fall burnings were the general rule, but early winters and lack of manpower made spring burning necessary during some years. Despite the annual firing, numerous prairie species occurring during late stages on other areas of the same soil type were found along the right-of-way. Some of the plants were conservative species.

Each site was studied once, and the following observations were recorded: (1) abundance—employing the same technique used in the study of plant succession on abandoned fields, and (2) the soil type on which each species was observed. Specimens of practically all plants studied were collected and placed in the University of Wisconsin herbarium.

These observations are summarized and presented in Table 1. All of the plants listed in the table were observed on three soil types, Rice Lake Loam, Auburn Loam, and Plainfield Sand, unless a notation following the plant name indicates otherwise. Although some plants were observed on only one soil type, this is believed to have very little significance in most cases. Observing sites only once and at various times of summer undoubtedly resulted in some plants being missed. However, certain plants like umbrella-wort, *Oxybaphus hirsutus,* white sage, *Artemisia ludoviciana,* and wood lily, *Lilium philadelphicum* var. *andinum,* probably were limited to one soil type. A few plants showed a higher abundance on one soil type even though they occurred on all three types. Little bluestem, *Andropogon scoparius,* occurred most abundantly on Rice Lake Loam, *S. spartea* was observed growing less abundantly on Auburn Loam than on Rice Lake Loam and Plainfield Sand, tick trefoil, *Desmodium canadense,* appeared to grow most abundantly on Auburn Loam, and *L. caroliniense* grew markedly more abundant on Plainfield Sand than on the other two soil types.

TABLE 1

PLANTS OCCURRING ON SITES UNDISTURBED FOR AT LEAST 35 YEARS

Abundant to dominant:
- *Andropogon gerardi* (Big Bluestem or Turkey-foot Grass)
- *Tradescantia ohiensis* (Spiderwort)
- *Euphorbia corollata* (Flowering Spurge)

Common or numerous:
- *Stipa spartea* (Porcupine Grass)
- *Phlox pilosa* (Prairie Phlox), found on Rice Lake Loam only
- *Artemisia ludoviciana* (White Sage), found on Plainfield Sand only
- *Solidago rigida* (Prairie Goldenrod)
- *Liatris scariosa* (Blazing Star)
- *Liatris pycnostachya* (Blazing Star)

Occasional or scattered:
- *Eragrostis spectabilis* (Love Grass), found on Rice Lake Loam only
- *Eragrostis cilianensis* (Stink Grass), found on Rice Lake Loam only
- *Sporobolus heterolepis* (Prairie Dropseed), found on Rice Lake Loam only
- *Andropogon scoparius* (Little Bluestem)
- *Sorghastrum nutans* (Indian Grass)
- *Cyperus schweinitzii* (Sedge), found on Rice Lake Loam only
- *Carex lasiocarpa* (Sedge), found on Rice Lake Loam only
- *Smilacina stellata* (False Solomon Seal)
- *Polygonatum biflorum* (Solomon Seal)
- *Sisyrinchium campestre* (Blue-eyed Grass), found on Rice Lake Loam only
- *Oxybaphus hirsutus* (Umbrella-wort), found on Auburn Loam only
- *Amorpha canescens* (Lead-plant)
- *Petalostemum purpureum* (Purple Prairie Clover), few found on Auburn Loam
- *Petalostemum candidum* (White Prairie Clover), none found on Auburn Loam
- *Tephrosia virginiana* (Goat Rue), found on Plainfield Sand only
- *Desmodium canadense* (Tick Trefoil)
- *Linum sulcatum* (Prairie Flax), found on Rice Lake Loam only
- *Euphorbia glyptosperma* (Spurge), found on Rice Lake Loam only
- *Helianthemum bicknellii* (Frostweed), found on Rice Lake Loam only
- *Cicuta maculata* (Water Hemlock)
- *Asclepias tuberosa* (Butterfly-weed), found on Rice Lake Loam only
- *Lithospermum canescens* (Hoary Puccoon)
- *Lithospermum carolinense* (Puccoon)
- *Campanula rotundifolia* (Harebell)
- *Lobelia spicata* (Lobelia), found on Rice Lake Loam only
- *Rudbeckia hirta* (Black-eyed Susan)
- *Coreopsis palmata* (Tickseed)
- *Hieracium longipilum* (Prairie Hawkweed)

Few to rare:
- *Lilium philadelphicum* var. *andinum* (Wood Lily), found on Rice Lake Loam only
- *Myrica asplenifolia* (Sweet Fern), found on Rice Lake Loam only
- *Oxybaphus nyctagineus* (Umbrella-wort), found on Rice Lake Loam only
- *Baptisia leucophaea* (Wild Indigo), found on Plainfield Sand only
- *Baptisia leucantha* (Wild Indigo), found on Plainfield Sand only
- *Astragalus canadensis* (Milk Vetch), found on Plainfield Sand only
- *Lathyrus venosus* var. *intonsus* (Vetchling), found on Rice Lake Loam only
- *Polygala sanguinea* (Milkwort)
- *Aster falcatus* (Wild Aster), found on Plainfield Sand only

In general, the plants observed on sites undisturbed for at least 35 years included the plants which were observed during the study of succession on the sand plain in fields abandoned for 35 years.

By 1956, intensification of agricultural practices on the fields of Meridean Prairie and the surrounding area reduced the prairie flora to a very few relics on the Chippewa River terraces, in several old cemeteries, and along part of the railroad right-of-way crossing the area. All of the fields formerly left abandoned for periods of time up to 35 years are now plowed and planted on an annual rotation basis. The roadside vegetation has been drastically reduced by disturbance and improvement of the roads. Thomson (1940, p. 708) concluded that the prairie flora was rapidly being exterminated in central Wisconsin by the encroachment of the forest and by the activity of man. In Dunn County the activity of man greatly overshadows the effects of the forest in eliminating the prairie flora.

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CHARACTERISTICS OF TROUT ANGLING AT LAWRENCE CREEK, WISCONSIN

JAMES T. MCFADDEN
Wisconsin Conservation Department, Westfield, Wisconsin

INTRODUCTION

As part of a research program designed to evaluate the effects of different angling regulations on a wild brook trout population, a complete creel census was conducted at Lawrence Creek during the 1955 fishing season. The information obtained provides the first complete assessment of angling pressure on a Wisconsin trout stream.

METHODS

Each angler was required to secure a permit at a permanent checking station before fishing. Separate permits were issued for each of the sections into which the stream is divided. Before leaving the project area, anglers were required to return their permits and present their catches for examination.

All trout caught were weighed and measured. Scale samples were taken for age determination. The amount of time spent in fishing and methods employed were recorded for each angler. Successful fishing trips were considered to be those during which at least one legal trout was creeled.

The 1955 trout season opened on April 30 and closed on September 7. The minimum size limit was six inches, and the daily bag limit was 10 trout. The only departure from statewide regulations was the limitation of angling to the period 5 a.m. till 9 p.m. each day.

DESCRIPTION OF AREA AND STREAM

Lawrence Creek is located in Adams and Marquette Counties, Wisconsin, approximately 40 miles south–southeast of the geographical center of the state. The average length of the growing season in this locality is 145 days.

The soil of the entire watershed is the relatively infertile Coloma Sand. Much of the original forest cover of mixed oaks has been replaced by pine plantations and now abandoned farms. Streamside cover includes marsh-meadow, alders, and mixed oaks.

The Lawrence Creek Project Area includes 3.3 miles of stream from the headwaters to the upper end of Lawrence Millpond. The average width of the stream is approximately 23.5 feet, and the total surface area 9.4 acres. The volume of flow increases from approximately 12 cubic feet per second one mile below the headwaters, to 25 cubic feet per second at the downstream extremity of the project area. The gradient is moderate.

Non-game fishes occurring in Lawrence Creek include the common sucker *(Catostomus commersonni)*, blacknose dace *(Rhinichthys atratulus)*, brook stickleback *(Eucalia inconstans)*, muddler *(Cottus sp.)*, and creek chub *(Semotilus atromaculatus)*. Of these, only the muddler is abundant.

The bluegill *(Lepomis macrochirus)*, largemouth bass *(Micropterus salmoides)*, and green sunfish *(Lepomis cyanellus)* move into the lower part of Lawrence Creek from Lawrence Millpond during the warmer months, but apparently are not year-around residents. These species are occasionally taken by anglers.

Lawrence Creek was last stocked with rainbow trout *(Salmo gairdneri)* in 1945 and with brook trout *(Salvelinus fontinalis)* in 1948. The stream presently supports a small wild rainbow trout population, and a large wild brook trout population. No brown trout are present.

ANGLING STATISTICS

During the 19-week angling season, 3,040 legal brook trout were caught on 1,712 angling trips totaling 4,653 man hours of effort. Under a fishing intensity of 495 hours per acre, Lawrence Creek yielded 323.4 legal brook trout per acre, or 57.2 pounds per acre.

One hundred and seventy-seven legal rainbow trout were also caught, constituting an additional 18.8 fish per acre or 4.7 pounds per acre.

Anglers caught an average of 0.67 legal trout per man-hour over the entire season.

PERIODICITY OF ANGLING PRESSURE AND CATCH

Fishing pressure was extremely heavy during the first week, but decreased rapidly thereafter (Figure 1). Pressure and anglers' catch followed similar trends through the season. A noticeable increase in the number of angling trips occurred during the fifth week, which included Memorial Day. No such increase in angling pressure took place during the tenth week, which included the Fourth of July. Although the number of trips per week increased after the thirteenth week, at no time did it approach the level of the opening week of the season.

On the opening day (April 30), 16.8 per cent of the season's total catch and 8.6 per cent of the total trips were recorded. During the first week, 27.1 per cent of the total catch and 18.9 per cent of the

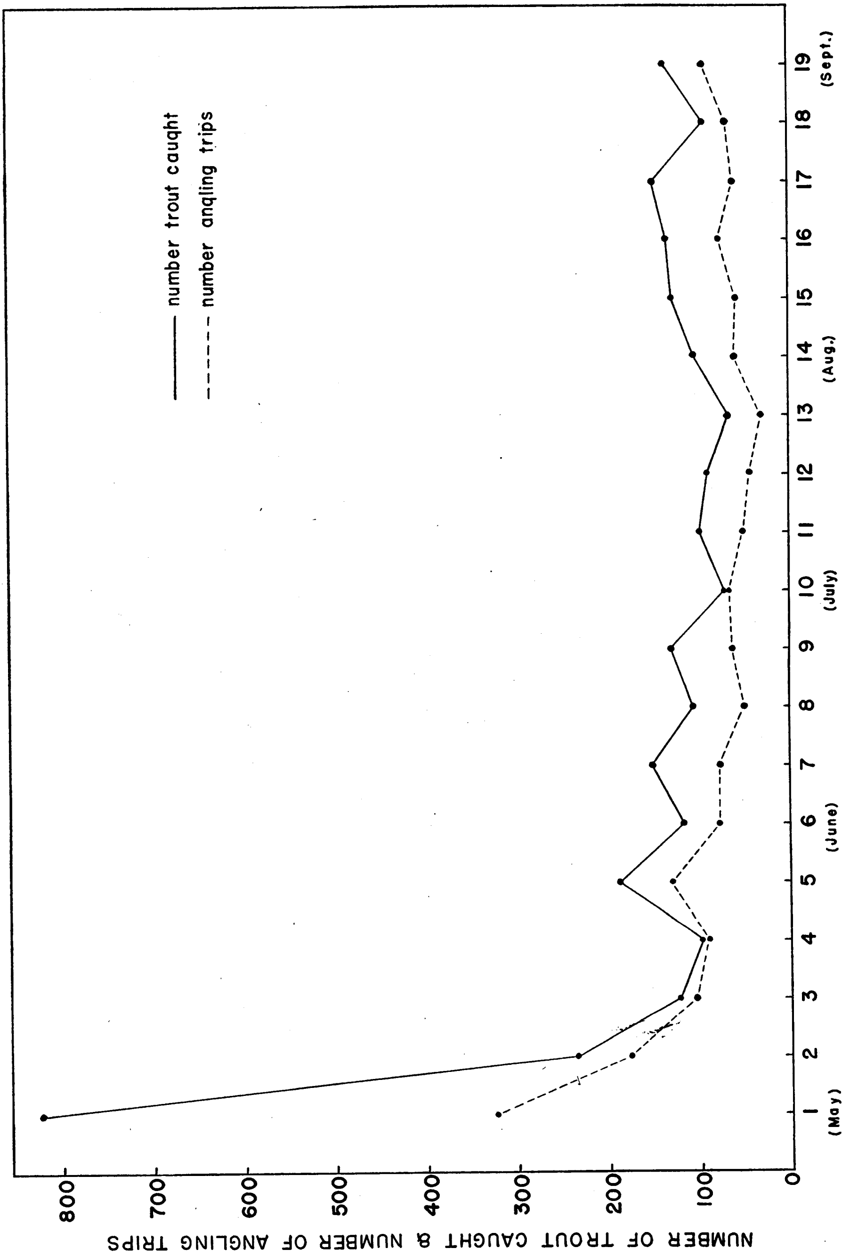

FIGURE 1.—Distribution of angling pressure and catch of legal brook trout through the 1955 angling season at Lawrence Creek.

total trips were accounted for. By the fifth week, 48 per cent of the season's total catch and angling trips had been taken.

Fishing pressure was generally heavier on weekends. Sixty-two per cent of the angling trips were recorded on Saturdays and Sundays, which constituted only 29 per cent of the days of trout season.

ANGLING INTENSITY

Angling intensity varied from 350 man hours per acre on Section D to 662 man hours per acre on Section C. The average for the entire stream of 495 hours per acre is very high when compared with data recorded for other trout streams (Table 1).

TABLE 1

COMPARISON OF ANGLING INTENSITY ON VARIOUS TROUT STREAMS IN THE UNITED STATES

Man Hours Per Acre	Water	State	Year	Authority
670	Sunkhaze Stream	Maine	1949	Rupp 1955
662	Lawrence Creek (Sec. C)	Wis.	1955	This paper
495	Lawrence Creek (entire stream)	Wis.	1955	This paper
429	Ipswich River	Mass.	?	Mullan 1955
395	Sunkhaze Stream	Maine	1951	Rupp 1955
381	Shawsheen River	Mass.	?	Mullan 1955
296	White River	Mich.	1939	Shetter 1944
250	Pigeon River	Mich.	1950	Cooper 1952
189	Hunt Creek	Mich.	1940	Shetter 1944
129	North Br. Au Sable R.	Mich.	1939	Shetter 1944
84	Deerfield River	Mass.	?	Mullan 1955
46	Swift River	N. H.	1955	Newell 1956
29	Swift River	N. H.	1953	Newell 1953

TABLE 2

COMPARISON OF MAXIMUM RECORDED ANGLING INTENSITY ON WISCONSIN WATERS

Man Hours Per Acre	Water	Year	Authority
495	Lawrence Creek	1955	This paper
123	Escanaba Lake	1950	Churchill
62	Murphy Flowage	1955	Dunham
37	Spruce Lake	1954	Churchill
31	Nebish Lake	1951	Churchill
29	Pallette Lake	1951	Churchill
24	Mystery Lake	1955	Churchill

Angling intensity on Lawrence Creek greatly exceeded that recorded on other Wisconsin waters for which data are available (Table 2). Escanaba Lake, Murphy Flowage, Spruce Lake, Nebish Lake, and Mystery Lake contain warm water fish populations. Pallette Lake contains both warm water species and trout. The hours of angling on these lakes were accumulated during 12-month seasons, in contrast to the 19-week season for Lawrence Creek.

DISTRIBUTION OF CATCH

The most successful 11 per cent of the angling trips accounted for 51 per cent of the season's total catch (Figure 2). Ninety-four per cent of the catch was accounted for by 36 per cent of the trips. No legal trout were taken on 53 per cent of the angling trips.

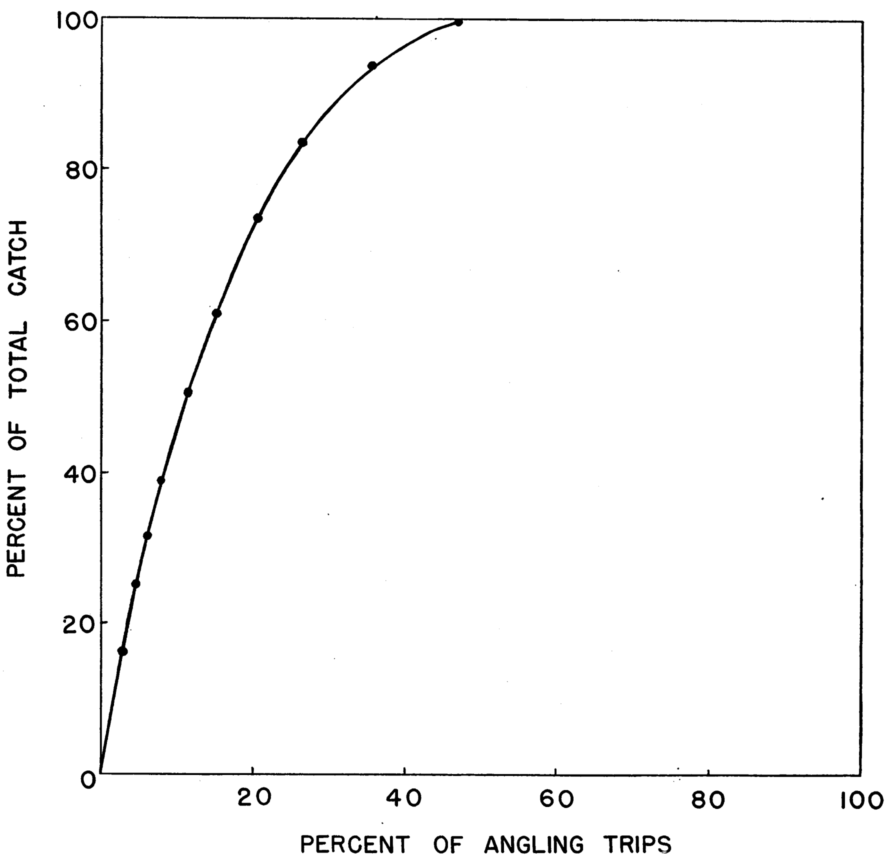

FIGURE 2.—Distribution of the catch of legal-sized brook trout among angling trips during the 1955 season at Lawrence Creek.

Certain individuals consistently made good catches. For example, three of the most successful anglers made a total of 39 trips to Lawrence Creek during 1955. Altogether they accounted for 9 per cent of the season's total catch. Fishing the same average number of times, 34 anglers of this proficiency could have taken the entire season's catch of 3,040 brook trout in 442 trips, instead of the 1,712 recorded in 1955.

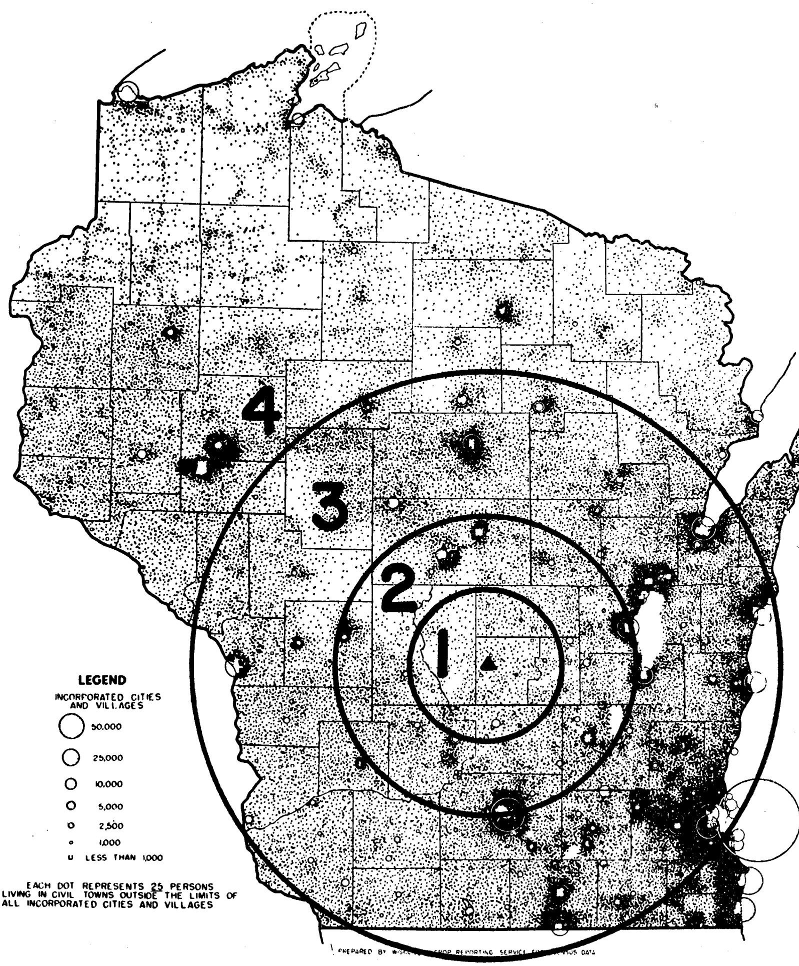

FIGURE 3.—Relationship of zones of residence of Wisconsin anglers fishing Lawrence Creek during 1955 to population density of the state.

RESIDENCE OF ANGLERS

In order to compare the number of trips made by resident anglers from various localities, the state was divided into four zones of successively greater radial distance from Lawrence Creek (Figure 3). Nineteen per cent of the trips were made by anglers residing within a 25-mile radius of Lawrence Creek (Zone 1); 20 per cent by anglers residing within a radius of 25 to 50 miles (Zone 2); 47 per cent by anglers residing within a radius of 50 to 100 miles (Zone 3); and 3 per cent by those residing more than 100 miles away (Zone 4) (Table 3).

TABLE 3

RESIDENCE OF ANGLERS FISHING LAWRENCE CREEK DURING THE 1955 TROUT SEASON

Zone (as Indicated in Figure 3)	Approximate Area in Square Miles	Radial Distance from Lawrence Creek in Miles	Percent of 1955 Angling Trips
1	1,963	0–25	19
2	5,891	25–50	20
3	21,700	50–100	47
4	25,200	over 100	3
Non-residents			11

Non-resident anglers accounted for an additional 11 per cent of the angling trips. Ninety-three per cent of these were made by residents of Illinois. Other states from which fishermen came were Indiana, New Jersey, California, Minnesota, Texas, Iowa, Ohio, Michigan, and Missouri.

ANGLING METHODS

Natural baits, including worms, minnows, and insects, were used exclusively on 61 per cent of the angling trips. Artificial lures, including flies, spinners, and plugs, were used exclusively on 28 per cent of the trips. On 11 per cent of the trips both natural and artificial baits were used. Bait fishing and fly fishing were both effective methods when employed by proficient anglers.

DISCUSSION

Recruitment of smaller fish to the legal-size group was such that the number of brook trout in the stream at the close of the season nearly equalled the number present when the season opened. The abrupt decrease in angling pressure after the first two weeks of the season cannot be attributed solely to depletion of the stock of trout. Rather, it seems to characterize the psychology of a large segment of the angling public. The close parallel in the trends of angling pressure and catch through the season (Figure 1) suggests that an increase in pressure would have resulted in a corresponding increase in the catch.

The extremely heavy angling pressure indicates that the trout fishery of Lawrence Creek is extensively utilized as a recreational resource. Many trout streams in more densely populated areas of the United States are not fished as heavily. Unfortunately, comparative data from other Wisconsin streams are not available.

None of the lakes of Wisconsin so far studied have been fished as intensively as Lawrence Creek. While not comprehensive, the data available suggest that a relatively higher angling intensity is characteristic of Wisconsin's trout stream fisheries when compared with lake fisheries.

The fact that angling intensiy may be extremely high on Wisconsin trout streams (eg. 662 man hours per acre on Section C, Lawrence Creek) emphasizes the possibility that wild brook trout populations are being overexploited.

The consistency with which certain fishermen made good catches of brook trout, while 53 per cent of the angling trips were unsuccessful, indicates that the skill of the individual is the most important factor in determining angling success. The relatively few anglers of exceptional ability accounted for a disproportionately large share of the total catch. The data also indicate that a substantial increase in "effective fishing pressure" could be achieved without an increase in the number of anglers, if the present angling public increased in proficiency.

Since over 60 per cent of the angling trips were made by persons living more than 50 miles from Lawrence Creek, it is evident that trout fishermen are a mobile group. The heavily populated southeastern part of Wisconsin furnished a major portion of the angling pressure. Very few Wisconsin anglers living more than 100 miles away fished Lawrence Creek. This area includes mainly the northeastern and northwestern counties, characterized by low population densities and abundant fishery resources. Residents of Illinois contributed substantially to the angling pressure, but all other nonresidents combined accounted for less than one per cent of the angling trips.

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A NINE-YEAR STUDY OF FALL WATERFOWL MIGRATION[1] ON UNIVERSITY BAY, MADISON, WISCONSIN
PART I

S. TENISON DILLON

Department of Forestry and Wildlife Management, University of Wisconsin, Madison

This paper presents a consolidation and analysis of nine years' observations on the fall waterfowl migration through University Bay. The purpose is an evaluation of the area as a local waterfowl refuge.

The data were gathered by students carrying out a project assignment for a course in Wildlife Management Techniques directed by Dr. Robert A. McCabe of the Department of Forestry and Wildlife Management of the University of Wisconsin. The students and the periods of their participation (dates inclusive) are as follows:

Paul F. Springer	September 28–December 22, 1946
Frederick Greeley	October 1–December 3, 1947
William H. Kiel, Jr.	October 6–December 24, 1948
Laurence R. Jahn	September 23–December 23, 1949
Keith L. White	September 25–December 11, 1950
Robert S. Dorney and H. Jay Hosford	September 28–December 10, 1951
S. T. Dillon	September 24–December 12, 1952
Alexander Dzubin	October 5–December 21, 1953
George V. Burger	October 2–December 23, 1954

The average annual observation period covers eighty days and extends from September 29 through December 17.

Common and scientific names of waterfowl used throughout this paper are given in Appendix A. Scientific names follow Delacour and Mayr (1945) and the fourth edition of the AOU check list of North American birds (1931). Common names follow local usage.

Invertebrate animal nomenclature (Appendix B) is after Pennak (1953). The identification of invertebrates was carried to varying levels of classification by the authorities cited. Thus a single common name might refer to anything from a genus to a phylum depending upon the extent to which the taxonomy of the animal was worked out. In those instances where such confusion was possible, the common name is followed in text by the appropriate scientific designation.

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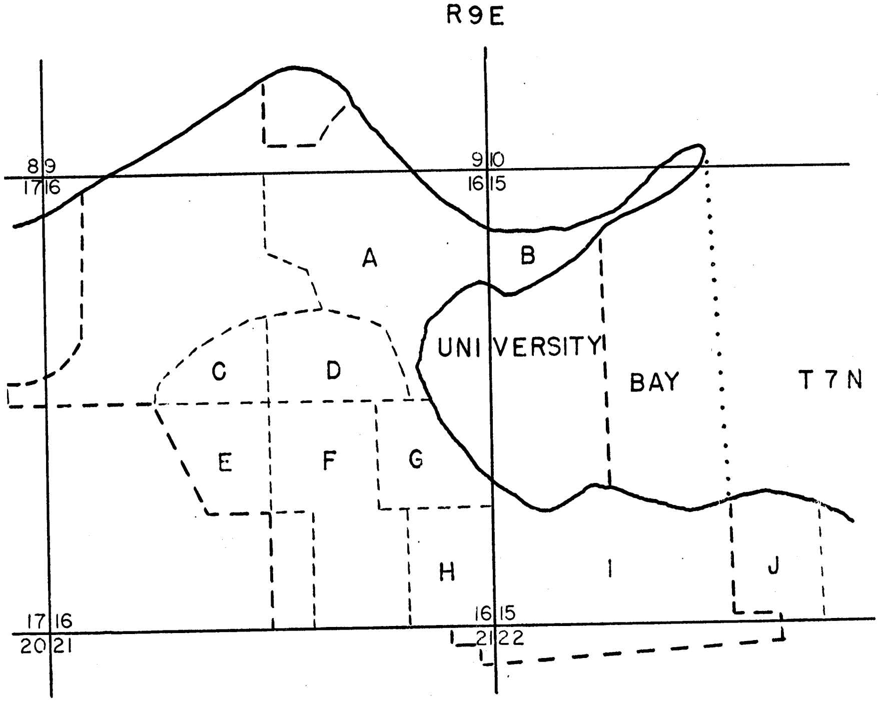
[1] Journal Paper No. 33, University of Wisconsin Arboretum.



- - - - BOUNDARY UNIVERSITY BAY GAME REFUGE

. . . . EASTERN BOUNDARY BAY STUDY AREA

A ALICE YOUNG, 1941
B ALICE YOUNG, 1939
C JOHN OLIN, 1909
D STEVENS and FULLER, 1909
E JOHN and CHRISTINA BREITENBACH, 1909
F THOMAS ISOM, 1908
G UNIVERSITY HEIGHTS CO., 1895
H WILLIAM ALBERS, 1905
I ROBY and STEVENS, 1866
J ELIZABETH HAIGHT, 1866

FIGURE 1. Acquisition map of the land adjacent to University Bay showing the areas purchased, person(s) selling and the date of the deed transferring ownership to the University of Wisconsin. The boundaries of the University Bay Game Refuge and the University Bay study area are also shown.

Plant nomenclature, given in Appendix C, follows Fernald (1950). Where no common name was given, the plant is referred to in text by its scientific name.

THE AREA

University Bay, situated within the metropolitan area of Madison (a city of 96,000 people according to the 1950 census), is close to the center of considerable human activity. It is approximately one and one-half miles from the State Capitol building and is slightly less than one-half mile from the Forest Products Laboratory and a Veterans Hospital capable of holding 486 patients. It is bounded on the north by a projection of land approximately one-half mile long known as Picnic Point, on the east by the open water of Lake Mendota, on the south by University Bay Drive and the athletic fields of the University of Wisconsin and on the west by the Drive and an eighty-acre reclaimed marsh (known as University Marsh), now a part of the University Experimental Farm.

For the purposes of this study, University Bay includes that body of water lying west of a line extending almost due south from the tip of Picnic Point to the University Residence Halls for men

HISTORY

Land Acquisition, Development and Use. The land forming three sides of University Bay and including University Marsh was acquired by the University in a series of purchases from 1866 to 1941. The individual purchases, the person(s) from whom the land was purchased and the date of the deed transferring title to the University are shown in Figure 1. The purchase of Picnic Point in two sections is of particular interest since it had a direct bearing on the use of the Bay by hunters, as will be described later. The outer Point and an easement for access were purchased in 1939. It was not until 1941 that the University acquired the land at the base of the Point.

In the late 1800's and early 1900's, the land in the vicinity of University Bay was farmed except for those areas too marshy to support livestock or machinery. At that time the land produced primarily hay and feed grains. Since its purchase by the University, the area has been developed largely as an experimental farm but it is used by many departments other than those in the College of Agriculture.

One of the more difficult phases of this development was the drainage of University Marsh. In 1910, when drainage was first considered, the surface water of this marsh was level with that of Lake Mendota and rose and fell with it. The surface stratum con-

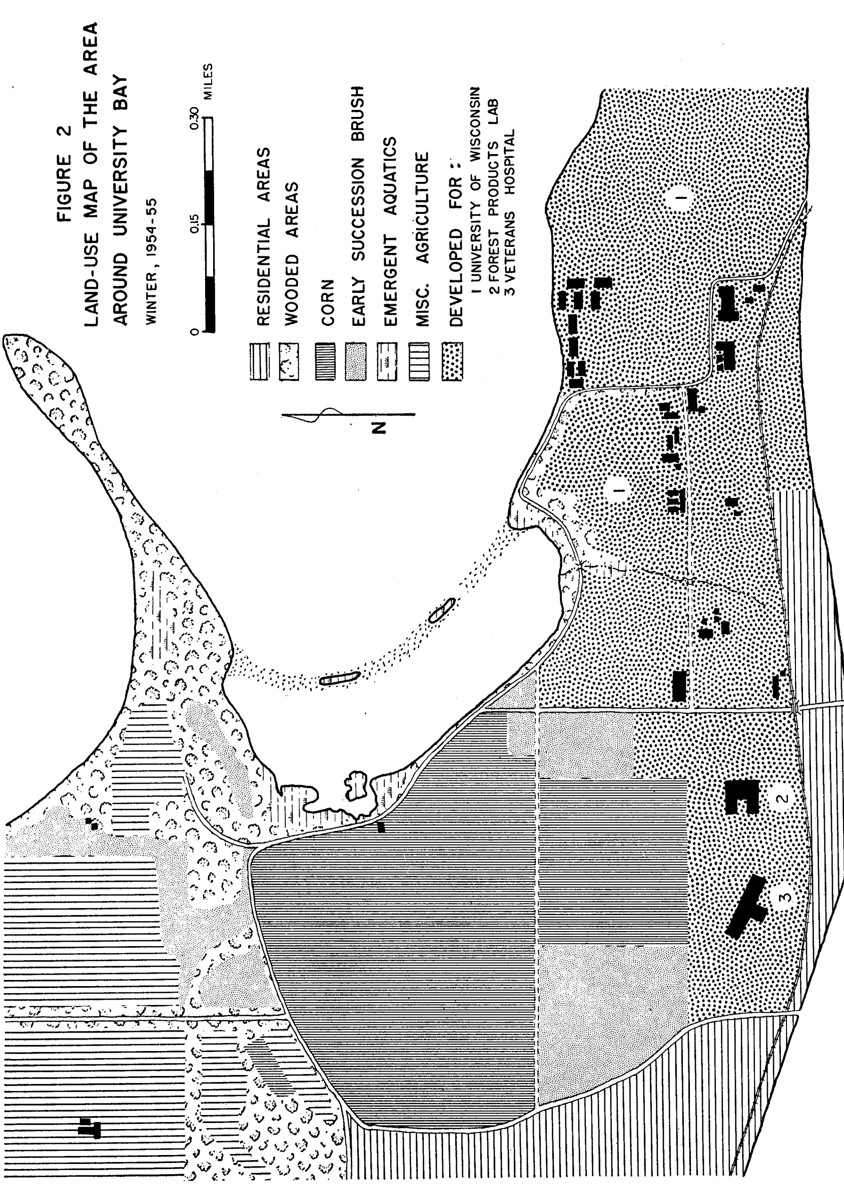


FIGURE 2
LAND-USE MAP OF THE AREA AROUND UNIVERSITY BAY
WINTER, 1954-55

sisted of a layer of peat from one to six feet deep. This was underlain by a thin marl bed blending in places into silt or clay beneath which was water-bearing sand with artesian pressures so great that water would stand in a pipe two feet above the marsh surface (Elliott, Jones and Zeasman, 1921). The vegetation at this time consisted of cattail, willow, wiregrass and bluejoint.

The first attempts to drain the area consisted of open ditches which conducted the water to a central reservoir. The water was then pumped under University Bay Drive, which acts as a levee, into the lake. This method proved ineffective as did a briefly-installed, geared windmill which operated a water-bucket elevator.

In 1914 experiments in tiling and pumping with an electric motor were begun and proved so effective that on May 8 of that year the first plowing was done on a portion of the Bay-level marsh. Tiling was completed in 1921 and remains as part of the drainage system in use today.

Corn is grown on most of this drained land for economic reasons but timothy, buckwheat and various truck crops can be and have been raised on small areas. Most of the corn is cut as silage and, with proper fertilization, yields of sixteen to twenty-two tons per acre may be obtained. The fertilizer used is almost entirely manure from the University dairy barns. A superabundance is available for use on University lands, consequently it is spread periodically throughout the year. In addition to its value as fertilizer, it is a fall and winter food source for wildlife on the area. This includes flights of Mallards and Black Ducks from the Bay.

The general land-use pattern in the immediate vicinity of University Bay as of the winter of 1954–55 is shown in Figure 2. The two beds of emergent vegetation (hard-stem bulrush) shown along the gravel bar in the Bay are not visible in the winter but I include them on this map because of their prominence during the fall waterfowl migration.

Hunting and Trapping. Much of the following information concerning hunting and trapping on and around University Bay was contributed by A. C. Breitenbach of 1218 University Bay Drive. Mr. Breitenbach spent his boyhood on a farm just west of University Marsh and hunted the Bay consistently until its incorporation into a refuge.

Although better shooting was to be had elsewhere on Lake Mendota, Picnic Point and University Bay were long considered excellent wildfowling spots. The Point offered good pass shooting and the secluded Bay, with its abundance of plant foods, provided exceptional decoy shooting. Gunning pressure on the Bay during the early 1900's, however, was light when compared with today's standards. Usually the local residents were occupied with the serious business of farming and hunted only on week-ends. Probably no more than ten or twelve persons, representing some four families, hunted the Bay regularly. They took their ducks from four more or less permanent blinds situated in the bulrush beds along the bar and from a number of temporary blinds at the pump-house inlet and along the south shore of Picnic Point. Occasionally hunters from town would converge on the Point to take advantage of a heavy flight and, on such days, as many as twenty-five to thirty gunners would take stands along its length.

Lesser Scaup and Ring-necked Ducks were shot in greatest numbers. Other diving ducks such as the Canvas-back, Redhead, Buffle-head and American Golden-eye were taken in smaller numbers. Among the dabbling ducks, Mallards, Baldpate, Blue-winged Teal, Black Ducks and a rare Pintail were bagged. I have no data on the actual numbers of waterfowl taken on the Bay, but I assume they were large as Wisconsin waterfowl seasons were then long (3–4 months) and bag limits generous (15–20 ducks per man per day).

Gunning ceased on University Bay when it was included in a game refuge established by the Wisconsin Conservation Department at the request of the University of Wisconsin Regents. This, however, was not accomplished in one step. First action was taken around 1927 but, since the University was not in possession of all the land around the Bay, hunting continued. Five years later the commission order was renewed, but hunting went on as Picnic Point was yet privately owned. In 1942, after the acquisition of the lower Point, this order was rescinded and replaced by Wisconsin Conservation Commission Order GR–520 which provided for the inclusion of Picnic Point and University Bay in the refuge. Since that time two revisions of the order have appeared, the last of which (GR–520, Rev. 2) became effective September 22, 1944, and provided for the setting aside of some 692 acres to be known as "the University Bay Game Refuge" established ". . . for the purpose of providing safe retreats for game and game birds in which they may rest and replenish adjacent hunting grounds, thereby promoting a successful wildlife program and insuring to the citizens of this state better opportunities for hunting and recreation through an adequate supply of game. . . ."

The approximate boundaries of the refuge, legally described in Wisconsin Conservation Commission Order GR–520 (Rev. 2), are shown in Figure 1.

Trapping before University Marsh was drained must have been profitable for the marsh was apparently quite productive. Mr. Breitenbach tells me that Indians used to camp in the area during the winters of the late 1800's and take muskrats *(Ondatra zibethica)* with spears. In the early 1900's, I am told, two men harvested some 600 muskrats from the area in one season, and often Mr. Breitenbach and his son have taken 100 or more during a season's trapping. A few individuals still practice limited trapping around the shores of Lake Mendota, but this does not interfere with its use by waterfowl.

An additional activity which does influence the use of the Bay by waterfowl is fishing. This sport is extremely popular during the fall months and the passage of boats through the Bay is often a source of considerable disturbance. The west shore of the Bay is one of the few remaining points of public access to the lake, consequently use is heavy. As many as eighty-six boats are kept over winter along this shore and many more enter and leave the water here during the height of the fall season.

Physical Description. University Bay, as delineated by Figure 1, covers approximately 180 acres (0.28 square miles). The area of Lake Mendota is 15.2 square miles.

Hydrographic maps of Lake Mendota for the years 1900 and 1953, obtained from the University of Wisconsin Geology Library, show the greatest water depth in the bay to be between forty-five and fifty feet. The maximum depth of Lake Mendota is about eighty feet. These maps also show some changes in bottom configuration that have taken place in the fifty-three years represented. The gradient along the south shore of Picnic Point is apparently becoming steeper while that east of the gravel bar is becoming more gentle. There have been some shifts in the deep-water zones also but these are, for the most part, outside of the Bay. One would expect wave action and lake currents gradually to steepen the shoreline along the Point. The decrease in the gradient along the bar is probably due to the deposition of silt entering the Bay at the southwest corner from University Creek. This creek drains some 1900 residential acres north and west of the Bay. The per cent of the total bottom area of the Bay found within each contour interval (Table 1) indicates a general trend toward increasing shallowness.

The map of 1900 also provides topographic coverage of the land immediately adjacent to Lake Mendota. It shows ten-foot contour intervals and is based upon a lake-level datum plane of 846 feet above sea level. This map shows two heights with a lowland marsh bordering the Bay between. Southeast of the Bay the "college hills" rise 110 and 120 feet above the lake. To the northwest, at the base of Picnic Point, the land rises eighty feet above the lake. The marsh between (University Marsh) lies entirely within the ten-foot contour interval. Another smaller marsh, the "Indian Pond", is shown at the base of the Point. Picnic Point is only a few feet above lake level at its narrowest but rises to twenty feet at each extremity.

TABLE 1

BOTTOM AREA BETWEEN WATER-DEPTH CONTOURS IN UNIVERSITY BAY FOR 1900 AND 1953

Water Depth (feet)	Total Bottom Area			
	1900		1953	
	Acres	%	Acres	%
0– 5	40	22.3	68	37.9
5–10	29	16.2	32	17.8
10–15	27	15.0	10	5.5
15–20	4	2.2	9	5.0
20–25	8	4.4	18	10.0
25–30	12	6.6	8	4.4
30–35	12	6.6	5	2.8
35–40	15	8.3	10	5.5
40–45	22	12.3	11	6.1
45–50	11	6.1	9	5.0
50–55	TR	....	....	....
Total	180	100.0	180	100.0

Aquatic Vegetation. In general the species and distribution of submerged and floating-leaved aquatic plants in any body of water depends upon the bottom characteristics, water depth and fertility and light transmission. In the case of University Bay, another factor is operating. This is the leeching of nutrients from the heavily-fertilized University Marsh cornfield and their subsequent deposition into the Bay via the drainage pump. This has undoubtedly affected the density and distribution of aquatic plant growth in the Bay, but how and to what extent is not known.

The bottom of University Bay west of the gravel bar is filling with silt and plant detritus. To the east the bottom changes from coarse gravel on the bar to sandy-mud and finally to debris-filled mud. Along the south side of Picnic Point a rocky, gravelly shore slopes to depths of eight to ten meters (Andrews, 1946).

Water depth and light transmission combine to limit plant growth to a zone above the "compensation point" indicated by Ruttner (1953, p. 127) to be that depth at which light intensity is approximately one per cent of the light intensity at the surface. It is at this depth that photo-synthesis during the day just balances or slightly exceeds respiration at night. This is, of course, a fluctuating zone since it is a function of light intensity and transmission properties of the water. In Lake Mendota this zone is usually placed at depths of about five to six meters (Muttkowski, 1918; Denniston, 1921; Rickett, 1921). Muttkowski termed the bottom area included between the water depths of zero and six meters the "eulittoral zone" and Table 1 shows that in 1953 about 62% of the bottom area of the Bay fell within this zone.

Early work by Muttkowski *(op. cit.)* indicated no definite zonation of submergent or floating-leaved aquatic plants in Lake Mendota with the exception of one area located ". . . along the western end of the bar in University Bay. Here a zone of pure *Chara* is followed by submerged hummocks of *Lemna,* this in turn by *Myriophyllum* and *Ceratophyllum,* and finally by *Potamogeton amplifolium.*" He also noted a "secondary zonation" involving "upright plants" such as pondweed and wild celery, the leaves of which reached the surface of the water but did not emerge and "recumbent plants" that remained submerged such as coontail and water milfoil.

These earlier works have shown the following plants to be characteristic of Lake Mendota:

Shoreline—filamentous algae *(Cladophora* and *Spirogyra).*
Eulittoral zone—bushy pondweed, various other pondweeds, wild celery, muskgrass, coontail and water milfoil.
Marsh, pond, river and creek mouth—duckweed, hard-stem bulrush, cattail, bladderwort, crowfoot and water lily.

The most recent intensive study of the macroscopic flora and fauna of University Bay was done in the summers of 1939, 1940, 1941 and 1946 by Andrews *(op. cit.).* Much of the following information concerning plant species and distribution on the Bay is from his work. It should be noted that Andrews considered the "eulittoral zone" of Muttkowski to extend only to a depth of four meters, which included about 56% of the bottom area of the Bay in 1953 (Table 1).

Plants characteristic of the marshes at the two inlets to the Bay and the shallows nearby include cattail, bur reed, white water lily, curly-leafed pondweed and duckweed. On the mucky bottoms inside the bar are found waterweed, water milfoil, *Potamogeton angustifolius,* floating brown-leaf, sago pondweed, clasping-leaf pondweed and horned pondweed. On the bar, among the beds of hardstem bulrush, grow bushy pondweed, muskgrass and *P. angustifolius.* In the deeper waters outside the bar and along the gravelly north shore of the Bay are found large-leaf pondweed, whitestem pondweed and flat-stem pondweed. Plants such as coontail, muskgrass, knotty pondweed, crowfoot and wild celery are found distributed throughout the "eulittoral zone" of the Bay. American lotus was introduced into the Bay in the early 1930's as one bed near the mouth of University Creek. This bed has spread considerably since the original planting.

White (1950) presented a figure drawn by Edward Koppe of the University of Wisconsin Botany Department depicting the distribution of aquatics in University Bay. This figure is apparently based on Andrews' work as three of his sample transects are shown.

During February and March of 1946, Andrews *(op. cit.)* sampled flora and fauna through the ice along six transects extending out into the Bay. At this time crowfoot and whitestem pondweed were green indicating active growth. Muskgrass was brown or black and coontail and large-leaf pondweed showed summer growth that had maintained itself over winter. Specialized overwintering structures included winter buds of curly-leafed pondweed, flat-stem pondweed and wild celery and turions of water milfoil. In April filamentous algae such as *Cladophora* and *Spirogyra* covered the shoreline and blanketed certain segments of the Bay. By May, turions of water milfoil began to grow, and this plant became dominant for a month. A month later, clasping-leaf pondweed, knotty pondweed, whitestem pondweed and coontail became conspicuous, mixed with the water milfoil beds. The muskgrass beds on both sides of the bar were thick by mid-June and the beds of hardstem bulrush flowered.

By July pondweeds were replacing water milfoil in the shallows but dense beds of the latter persisted in deep, cool waters indicating that summer succession may be delayed there. Mid-July found most of the pondweeds in flower. By August 1, wild celery was the dominant plant in the Bay, and a month later the Bay held its greatest densities of wild celery and pondweeds. The plants of wild celery had broken off by October and floated to the shore. The broad-leafed pondweeds were disintegrating such that by November only stems, debris and a few plants were left in water up to six feet deep. In deeper waters, water milfoil, clasping-leaf pondweed and whitestem pondweed were still vigorous. The muskgrass beds near the bar had been loosened and piled up by heavy winds but dense beds were still intact in deep water.

Ice usually covers the Bay during the first weeks of December.

Thus, the aquatics most prominent in the Bay from September to December are wild celery, various pondweeds, water milfoil and muskgrass. All of these plants are of considerable value as food for nearly all of the species of ducks involved in this study, as well as for Coots. Both fruiting and vegetative parts are eaten (Cottam, 1939; Martin and Uhler, 1939; Martin, Zim and Nelson, 1951). Among those species of ducks considered in this paper only the American Golden-eye and Buffle-head eat more animal than plant food in the fall and winter (Martin, Zim and Nelson, *ibid*). The fact that by November most of the plant beds have disintegrated or have been uprooted does not detract from their food value. The tubers and roots are still available on the bottom and the seeds and vegetative parts are present in windrows along the shore. An additional source of food, especially for the Mallards and Black Ducks, is the freshly spread manure and harvest-waste corn found just west of the Bay.

There appears to be no shortage of plant food for the fall flights of waterfowl on University Bay.

Aquatic Invertebrates. Muttkowski *(op. cit.)* in addition to his "eulittoral zone", defined a "sublittoral" and "aphytal zone." This differentiation indicates a diversity of environment that determines to a large extent the species and distribution of invertebrate animals within Lake Mendota. The "eulittoral" or zone of plant growth supports animal life different from that found in the "sublittoral zone" of accumulating refuse or the "aphytal zone" of decomposition and periodic anaerobic conditions. Muttkowski found the following animals to be characteristically associated with the "upright" and "recumbent" plants of the "eulittoral zone" of Lake Mendota: freshwater jellyfish, flatworms, aquatic earthworms (Class *Oligochaeta*), mayfly larvae and nymphs, caddis fly larvae (*Leptocella* sp.) and various midges. Scuds or sideswimmers (*Hyalella* sp.) and water mites (*Hydrachna* sp.) were especially numerous. In the "sublittoral zone" such tube builders and burrowers as caddis fly larvae (*Leptocerus* sp.) and aquatic earthworms (*Limnodrilus* and *Tubifex* sp.) were common. In the "aphytal zone" phantom midges and water mites (*Limnesia* sp.) were found as well as various oxygen storing midges (*Tendipes* sp.)

TABLE 2

PRODUCTIVITY RATINGS OF SOME AQUATIC PLANTS OF LAKE MENDOTA
(Data from Andrews and Hasler, 1943)

Rating	Plant	Invertebrate Animals/Kg. of Dry Plant Material
Most productive	Coontail	52,000
	Water milfoil	29,000
Moderately productive	Sago pondweed	21,000
	Muskgrass	17–20,000
Less productive	Clasping-leaf pondweed	18,000
	Knotty pondweed	10,000
	Large-leaf pondweed	5,000
Least productive	Wild celery	3,000

The "eulittoral zone" is by far the most productive of invertebrate animal life. Andrews and Hasler (1943), in sampling the flora and fauna of Lake Mendota in 1939, found certain aquatic plants to be more productive than others. Their findings are presented in Table 2.

These writers suggest that coontail and water milfoil are most productive because they possess the "most dissected surface area."

Considering total numbers alone, Andrews (*op. cit.*, Table 17) determined the order of importance among animals of the plant zone of University Bay to be:

1) sideswimmers (*Hyalella* sp.)
2) midge larvae (*Tendipes* sp.)
3) mayfly nymph
4) caddis fly larvae
5) aquatic earthworms (phylum *Annelida*)
6) leeches
7) water mites (*Hydrachna* sp.)
8) snails

Hundreds of thousands of animals per kilogram of dry plant material were found by Andrews.

Muttkowski *(op. cit.)* has presented a description of the seasonal succession of animal life in Lake Mendota. The close relation between the increase and decline of aquatic plant and invertebrate animal numbers should be noted.

According to United States Weather Bureau records at Truax Airport, Madison, the ninety-seven-year (1851–52 to 1954–55) average date of the ice break up on Lake Mendota is April 6. Soon after this occurs, midges (*Tendipes* sp.) emerge from the water. In early May the migration of the fishfly larvae begins and by mid-May the adults are extremely numerous on overhanging branches. Early in June the mayfly emergence begins and by mid-June the flights are largely over. The summer succession is characterized by periodic flights of the phantom midge. These flights, occurring at about ten-day intervals, reach their peak in mid-July but last until mid-September. In late June and early July the caddis fly larvae which pupated in late May and early June leave their cases and become conspicuous as adults.

The peak of the invertebrate faunal development comes in late August and early September when the caddis fly eggs laid in July hatch. These flies attain their full size in late August. At the same time many of the small aquatic earth worms (class *Oligochaeta*) become prominent. This population growth is of such magnitude that it seems as though every plant in the "eulittoral zone" of Lake Mendota must be covered with these animals. This increase in numbers is paralleled to a lesser extent in flatworms, leeches, and water mites (*Hydrachna* sp.). Mayflies also are especially numerous at this time as are certain species of the genus *Tendipes* which reach their larval maxima. By mid-September the autumnal decline in the invertebrate population begins. Some species within the "aphytal zone" are stimulated to new activity by the increased oxygen supply brought about by the recirculation of lake waters. Also certain midges (*Tendipes* sp.) pupate and fishflies migrate to the bottom. In general, however, autumn storms cause widespread destruction among the invertebrates. Waves deposit plants and animals alike in windrows along the shores such that by late November the entire plant zone is almost stripped clean. As the lake waters become colder, animal activity diminishes and the period of winter dormancy sets in.

The cycle of invertebrate animal activity is rapidly declining in University Bay when the heaviest flights of waterfowl arrive. This would apparently produce a lack of available animal food. Only two of the species of ducks involved in this study might be affected by this apparent shortage—the American Golden-eye and Buffle-head. These species feed largely upon sideswimmers (order *Amphipoda*), shrimp, snails, caddis fly larvae, dragonfly nymphs and mayflies during the fall and winter (Cottam, *op. cit.;* Martin, Zim and Nelson, *op cit.*). It may be that these ducks secure their animal foods from the shoreline windrows or from the bottom in an inactive state. They may, on the other hand, become predominantly plant feeders under local conditions where animal foods are not available.

Use by Waterfowl. Waterfowl-use patterns on University Bay have been discussed in reports by Burger (1954), Dillon (1952), Dzubin (1953) and White (1950) in relation to available plant food, weather conditions and the progressing season. Of these three factors the distribution of available aquatic food plants is probably the most important in determining the distribution of waterfowl on the Bay. As has already been pointed out, the aquatic plants most numerous in the Bay during the late fall are wild celery, various pondweeds, water milfoil and muskgrass. Of these, wild celery is the most abundant. All of these plants are well distributed west of the bar and along the south shore of Picnic Point. Some of the long-stem pondweeds grow profusely east of the bar up to water depths of five to seven meters.

The aforementioned reports suggest a close correlation between this plant distribution and the fall distribution of waterfowl on the Bay. Dabbling ducks generally restrict their activities to the bulrush beds along the bar, the marshy areas adjacent to the two inlets and to the shallows along the south shore of the Point. The diving ducks also frequent these areas but are often seen in the deeper water east of the bar and off the University Residence Halls for men. Coots associate with both diving and dabbling ducks.

Weather conditions, particularly strong winds, probably influence local waterfowl movements more than their actual distribution on the Bay. In any event winds become a factor only when blowing from the north, northeast or east. Since prevailing winds in this area are westerly, this does not happen too often (three out of thirty-five observation days in 1952). When such winds do blow strongly, waterfowl within the Bay tend to move more freely, particularly the diving ducks. Coots and dabbling ducks remain close to the bulrush beds on the bar or in the shelter of lee shores. Movement between these areas, however, is frequent. On very calm days waterfowl of all species present tend to gather on the open waters of the lake. This may reflect a preference on their part or it may be the result of disturbance by the generally increased boat traffic under such conditions.

The progressing season affects the distribution of waterfowl in as much as the formation of ice on the Bay forces the ducks out into the lake. Ice usually begins forming inside the bar during the last two weeks of November and, by the end of the first week in December, this area is usually closed except, possibly, for small openings around the two inlets. Ice formation then progresses out into the Bay and lake until Lake Mendota is entirely covered. The average date of closure is December 19 over the period from 1851–52 through 1954–55 according to United States Weather Bureau records at Truax Airport. This progressive freezing poses no special problem for the Coots and diving ducks but it deprives the dabbling ducks of much of their shallow-water feeding areas. As a result, the Mallards and Black Ducks apparently rely upon the manure and corn found immediately west of the Bay.

THE STUDY

Field Procedure. Materials used as census aids in this study were a twenty-power Bausch and Lomb spotting scope fitted for mounting either upon a portable tripod or the glass pane of an automobile window, a hand counter, binoculars and some type of notebook or tally sheet. Various field guides (Peterson, 1947; Kortright, 1942) were used for identification of waterfowl.

Counts were made either on foot or from an automobile using vantage points along University Bay Drive and Picnic Point. The observation posts varied little from year to year. Most counts were made between eight and ten A.M., although some afternoon counts were taken and, in a few instances, afternoon recounts were made as checks on the morning tallies. The observers maintained an average of one count every 2.6 days over the average annual observation period of eighty days.

Each observer attempted to record the total number of waterfowl of each sex (where possible) of each species. Each duck was counted separately when possible, but estimates became necessary when large flocks or groups of actively feeding diving ducks were encountered. In addition, records were kept on waterfowl-use and flight patterns and duck reaction to local weather conditions and disturbance. Notes were also taken describing a number of other items such as courtship behavior and feeding habits, which I shall not enlarge upon in this paper.

Field difficulties were encountered which, no doubt, reduce the accuracy of the data obtained. For example, it is difficult to distinguish by sight the sexes of early migrants of such species as the Blue-winged Teal and Baldpate. In such species as the American Golden-eye, Buffle-head, Hooded Merganser and American Merganser in which the young do not acquire their adult plumage until the fall or early winter of their second year of life (Kortright, *op. cit.*), sex ratios were recorded as the number of adult males to juvenile males plus females. No attempts were made to sex individual Black Ducks or Coots. Other field difficulties included disturbance through human activity in the area and factors which limited visibility such as thermal currents, wave action, fog and haze.

An additional source of error, affecting only the 1951 data, is the inconsistency of the description of the area comprising University Bay. In this year the observers considered the eastern boundary of the Bay to be a line extending from the south end of the gravel bar to the tip of Picnic Point. This reduced the area of the Bay by approximately 10–15 per cent and excluded an unknown number of ducks and Coots from that year's counts.

Data Used. The results of nine years of fall observations on University Bay are shown in Table 3. I have also drawn upon aerial survey data for the years 1951–54, inclusive, supplied me by Mr. L. R. Jahn of the Wisconsin Conservation Department. These data represent waterfowl counts on Lakes Mendota, Waubesa and Kegonsa (which I shall hereafter refer to as the "three lakes") and are presented as cumulative totals in Table 4. Madison lies along the south shore of Lake Mendota. Lake Waubesa is located some five miles southeast of Madison and Lake Kegonsa lies approximately ten miles southeast of the city. Aerial surveys were conducted on an average of once every 9.4 days over an average annual observation period of sixty-six days which extended from September 25 through November 29.

TABLE 3

TOTAL NUMBERS OF WATERFOWL RECORDED DURING FALL OBSERVATIONS ON UNIVERSITY BAY, 1946–1954

Species	Years			
	1946	1947	1948	1949
Mallard*	1,823	2,465	3,253	5,922
Black Duck*	1,456	2,338	4,325	6,608
Baldpate*	691	1,545	739	1,133
Pintail	78	69	160	180
Gadwall*	5	4	65	584
Shoveller*	18	117	64	248
Green-winged Teal	121	19	87	190
Blue-winged Teal	75	44	2	25
Wood Duck	45	1	31	4
Total dabbling ducks	4,312	6,602	8,726	14,894
Ring-necked Duck*	314	266	322	1,009
Redhead	15	73	48	40
Scaup sp.*	193	5	120	892
Canvas-back*	122	23	38	567
Buffle-head*	200	59	338	540
American Golden-eye*	736	255	757	309
Ruddy Duck	10	24	24	1
Hooded Merganser	82	41	119	357
Red-breasted Merganser	27	0	0	0
American Merganser	47	28	93	10
White-winged Scoter	0	0	0	3
Total diving ducks	1,746	774	1,859	3,728
Coot*	2,652	10,336	7,743	11,697
Whistling Swan	0	0	0	0
Canada Goose	0	0	0	8
Total waterfowl	8,710	17,712	18,328	30,327
Observation days	29	27	32	32
Observation period (days)	86	64	80	92
Starting date	9/28	10/1	10/6	9/23

*Species considered "common" on the Bay.

TABLE 3—Continued

Species	Years			
	1950	1951	1952	1953
Mallard*	2,463	2,931	6,575	9,786
Black Duck*	3,691	1,913	3,664	3,271
Baldpate*	681	516	1,854	465
Pintail	150	25	76	159
Gadwall*	283	125	102	220
Shoveller*	124	114	34	131
Green-winged Teal	27	10	147	369
Blue-winged Teal	1	7	79	20
Wood Duck	0	2	12	10
Total dabbling ducks	7,420	5,643	12,543	14,431
Ring-necked Duck*	400	458	444	1,548
Redhead	435	273	86	964
Scaup sp.*	121	220	350	1,966
Canvas-back*	76	121	73	359
Buffle-head*	581	170	888	1,385
American Golden-eye*	237	109	773	334
Ruddy Duck	13	24	4	39
Hooded Merganser	293	45	71	89
Red-breasted Merganser	1	1	0	0
American Merganser	28	60	15	1
White-winged Scoter	0	0	2	1
Total diving ducks	2,185	1,481	2,706	6,686
Coot*	21,013	10,389	29,974	21,244
Whistling Swan	1	1	1	0
Canada Goose	0	0	1	0
Total waterfowl	30,619	17,514	45,225	42,361
Observation days	34	20	34	33
Observation period (days)	78	74	80	79
Starting date	9/25	9/28	9/24	10/5

*Species considered "common" on the Bay.

TABLE 3—Continued

Species	Years 1954	Totals 1951–1954	Totals 1946–1954
Mallard*	3,480	22,772	38,698
Black Duck*	2,679	11,527	29,945
Baldpate*	971	3,806	8,595
Pintail	44	304	941
Gadwall*	448	895	1,836
Shoveller*	94	373	944
Green-winged Teal	17	543	987
Blue-winged Teal	2	108	255
Wood Duck	1	25	106
Total dabbling ducks	7,736	40,353	82,307
Ring-necked Duck*	3,002	5,452	7,763
Redhead	618	1,941	2,552
Scaup sp.*	1,394	3,930	5,261
Canvas-back*	2,832	3,385	4,211
Buffle-head*	1,774	4,217	5,935
American Golden-eye*	518	1,734	4,028
Ruddy Duck	50	117	189
Hooded Merganser	50	255	1,147
Red-breasted Merganser	6	7	35
American Merganser	11	87	293
White-winged Scoter	2	5	8
Total diving ducks	10,257	21,130	31,422
Coot*	29,717	91,324	144,765
Whistling Swan	0	2	3
Canada Goose	0	1	9
Total waterfowl	47,710	152,810	258,506
Observation days	32	119	272
Observation period (days)	83	316	716
Starting date	10/2		

*Species considered "common" on the Bay.

TABLE 4

TOTAL NUMBERS OF WATERFOWL RECORDED DURING FALL AERIAL SURVEYS OVER LAKES MENDOTA, WAUBESA AND KEGONSA, DANE COUNTY, WISCONSIN, 1951–1954

(Data Contributed by L. R. Jahn, Wisconsin Conservation Department)

Species	Year				Total
	1951	1952	1953	1954	
Mallard	1,886	15,337	11,106	14,174	42,503
Black Duck	1,213	6,182	4,815	6,716	18,926
Baldpate	653	231	71	458	1,413
Pintail	40	83	20	12	155
Gadwall	0	4	135	22	161
Shoveller	0	0	0	0	0
Green-winged Teal	0	0	0	0	0
Blue-winged Teal	30	255	0	1,019	1,304
Wood Duck	78	10	0	0	88
Unidentified dabbling ducks	768	1,666	66	935	3,435
Total dabbling ducks	4,668	23,768	16,213	23,336	67,985
Ring-necked Duck	4,729	8,842	814	5,754	20,139
Redhead	525	2,172	1,274	455	4,426
Scaup sp.	6,577	10,626	9,645	28,157	55,005
Canvas-back	7,785	30,715	24,048	142,355	204,903
Buffle-head	0	1	0	230	231
American Golden-eye	562	359	4,099	5,793	10,813
Ruddy Duck	0	0	14	0	14
Hooded Merganser	0	6	0	0	6
Red-breasted Merganser	1	0	0	0	1
American Merganser	0	4	0	0	4
Old-squaw	0	0	0	2	2
Unidentified diving ducks	367	3,813	453	1,416	6,049
Total diving ducks	20,546	56,538	40,347	184,160	301,591
Coot	61,298	220,677	39,954	84,792	406,721
Whistling Swan	0	0	0	2	2
Snow and Blue Goose	0	0	35	3	38
Canada Goose	2	24	221	126	373
Total waterfowl	86,514	301,007	96,770	292,424	776,715
Observation days	5	8	6	9	28
Observation period (days)	47	64	80	72	263
Starting date	9/24	9/22	10/1	9/24	

A far greater percentage of the total number of waterfowl using the "three lakes" during the falls of 1951–54 appeared on Lake Mendota than on either of the others. This relation (Table 5) holds in general for each species as well.

TABLE 5

PER CENT OF WATERFOWL APPEARING ON EACH OF THE "THREE LAKES", 1951–1954

Lake	Year			
	1951	1952	1953	1954
Mendota	97.5	94.5	81.5	89.5
Waubesa	1.2	2.1	11.2	3.6
Kegonsa	1.3	3.4	7.3	6.9

I present these Conservation Department data as a natural complement to the University Bay material which alone does not provide a complete picture of the fall waterfowl flight through the Madison area. I do not intend to compare or contrast these data since the areas on which they were gathered are ecologically different as waterfowl habitat; rather I shall use them to supplement one another in attempting to show how waterfowl use the University Bay Refuge.

Species Present. Twenty-three species of waterfowl (ducks, geese, swans and coot) were seen on the Bay at some time during the field periods of this study. Of these, only eleven species are what I shall call "common." As used here, this designation means that any one of these eleven species of waterfowl was seen on approximately one-half or more of the total number of observation days during at least four of the eight years involved (1946 is omitted for lack of sufficient data). It also means that each of these species was represented by a cumulative total of at least 100 individuals during the observation periods of at least five of the complete series of nine years. The eleven "common" species are designated in Table 3 by an asterisk.

The adoption of these criteria eliminates from our serious consideration a number of species which may be seen each fall on the Bay and, on occasion, in relatively large numbers. The Blue-winged Teal, for example, is fairly abundant in fall migration but arrives so early (mid-September) that much of the flight was past each year by the time field observations got well underway. Species such as the Pintail and Green-winged Teal may be seen on the Bay over a period of several weeks but usually in small numbers. The Hooded

Merganser and Redhead, particularly the latter, almost qualify as "common" species. The remaining "uncommon" species visit the Bay only occasionally in small numbers.

Canada Geese and occasionally Blue Geese, Snow Geese and Whistling Swans alight on the "three lakes" in the fall, but they are seldom seen on the Bay (Tables 3 and 4). One Whistling Swan was seen on the Bay on five successive occasions. A swan was first seen in the fall of 1950 at which time it was in the grey juvenile plumage described by Kortright *(op. cit.)*. J. J. Hickey and R. A. McCabe of the Department of Forestry and Wildlife Management, University of Wisconsin saw a Whistling Swan in similar plumage on the Bay in the spring of 1951. The following fall a swan again appeared, this time in somewhat whiter plumage. This lighter plumage was similar to that of the Whistling Swan reported on the Bay by Hickey and McCabe in the spring of 1952. I saw a swan in adult plumage on the Bay the following fall. This sequence led to considerable speculation among observers that this might be the same individual returning and that a tradition might be in the making. To my knowledge, however, no swans have been observed on the Bay since the fall of 1952.

Excluding geese and swans, a cumulative total of 258,506 waterfowl was recorded on the Bay during this study (Table 3). This is undoubtedly a maximum estimate as it was impossible to distinguish ducks and coots which has been counted on a previous visit from those which had not. In any event, this cumulative total represents a rate of use of this 180-acre body of water of approximately 360 ducks and coots for each day of the eighty-day average annual observation period during each of the nine years covered by this study. Actually the average length of time that waterfowl are present on the Bay each fall probably approaches 100 days since the first Blue-winged Teal and Wood Ducks usually arrive in the state by mid-September (Barger, *et al*, 1942).

Other species of ducks which find their way to Wisconsin's inland lakes, but which have not been reported on University Bay by observers participating in this study are the Old-squaw, Common (American) Scoter and the Surf Scoter. These ducks frequent the open waters of Lake Michigan some seventy-five miles east of Madison and are occasionally seen on the larger inland waters where they are apparently becoming more common (Kumlien and Hollister, revised, 1951). As evidence of this, Nero (1950) and Nero and Hunt (1954) report Dane County and Madison-area Surf and American Scoter records. Also the Wisconsin Conservation Department aerial survey team recorded two Old-squaw on Lake Kegonsa on December 4, 1954.

Another species, the Greater Scaup, is a regular migrant on the larger, inland lakes of Wisconsin but is much less numerous than the Lesser Scaup. Sight and bag records indicate that the ratio is about 50:1 (Schorger, 1929). I am informed by Mrs. R. A. Walker, president of the Madison Audubon Society (personal conversation), that Greater Scaup are identified each year on the Bay. On only one occasion, however, have observers participating in this study made any distinction between these two species (Dorney and Hosford, 1951).

Population Trends. An examination of Tables 3 and 4 provides an overall picture of waterfowl population trends on University Bay and the "three lakes" and enables one to make some ecological as well as numerical observations. It must be remembered, however, that these tables present cumulative totals which do not allow for the annual discrepancies in the number of observation days. These totals must be converted to a per-observation-day level before comparisons can be made.

One of the more obvious trends in the University Bay data is the tendency toward an annual increase in the total number of waterfowl. This represents an average annual rate of increase of 29 per cent. The "three lakes" data, although covering only four years (1951–1954), also conform to this trend, the rate of increase in this case being 54 per cent. The average annual rate of increase on the Bay for the corresponding period of time is 22 per cent. A further examination of Table 3 shows that, with the exception of the Mallard, diving ducks—more specifically Scaup sp., Canvas-back, Ring-necked Duck and Buffle-head—and Coot are largely responsible for the increases on the Bay. This is interesting in view of the fact that University Bay is apparently better dabbling than diving duck habitat, as is indicated by the relative total numbers of each group using the Bay each fall (Table 3). Furthermore, this trend toward an annual increase in these species was sharply accentuated on the Bay in the last two or, in the case of the Coot, three years of the study.

There are two probable explanations for this:

(1) Ecological changes in the Bay such that it has gradually become more attractive to diving ducks. This should also include the corollary hypothesis that ecological changes might also have occurred in the preferred, open-water habitat of these ducks such that it has gradually become less attractive to them, thereby encouraging their use of marginal habitat as represented by the Bay.

Ecological changes have taken place in the Bay, but in such a way that would seem to favor dabbling rather than diving ducks. For example, the progressive lessening of water depths as a result of the deposition of silt entering primarily through University Creek (Table 1). It may be that nutrients draining into the Bay from the heavily fertilized field immediately to the west have stimulated production of plant and animal foods preferred by diving ducks, but I do not know this to be true. There is some evidence that temporary conditions may exist on Lake Mendota that might increase diving-duck use of its bays. This will be discussed as a "food-relation" hypothesis later.

(2) Gradually increasing Mississippi Flyway populations of the species concerned with 1953 and 1954 (also 1952 in the case of the Coot) being particularly favorable nesting and/or rearing seasons.

We may assess this possibility to some degree by referring to the fall migration issues of Audubon Field Notes (January, 1947 and 1948; February, 1949–1954) and to U. S. Fish and Wildlife Service data compiled by Williams (1952 and 1953) and Crissey (1954).

Observations contributed to Audubon Field Notes from the "Western Great Lakes Region" ("Middle-western Region" prior to 1949), which includes Wisconsin, indicate a generally increasing fall waterfowl flight from 1947–1948 to 1952–1954. Zimmerman (1947) has also shown that the 1946 fall waterfowl flight through Wisconsin was not heavy. Specifically, increases were noted in the Mallard and Baldpate in 1949; Green-winged Teal in 1950 (an early flight, however); Blue-winged Teal, Gadwall and Baldpate in 1952 and Canvas-back in 1953. At Seney Refuge, Germfask, Michigan, Black Ducks and Ring-necked Ducks increased in 1951 while Buffle-head and Common Golden-eyes were "scarce." In general these trends were also apparent on University Bay (Table 3).

The Fish and Wildlife Service data concern the status of the continental waterfowl populations for 1952, 1953 and 1954. Separate discussions are presented for each flyway combining kill data, mid-winter inventories (January) and breeding-ground surveys (May to July). The data compiled by Williams (1953) and Crissey *(op. cit.)* have not been officially published and are included in this paper by permission of Mr. J. P. Linduska, U. S. Fish and Wildlife Service, Washington, D. C. The data have not been edited and are subject to correction.

There are two alternatives in handling this information. One is to consider the breeding-ground surveys as a forecast of the fall flight for the same year and the other is to consider these surveys plus the mid-winter inventories as an index of the fall flight of the preceding year less hunting season mortality. The second alternative seems the more desirable since the breeding-ground surveys usually present an incomplete picture of the juvenile segment of the population which will form an important part of the fall flight for that year. Therefore, in the following tables and discussion, the

1952, 1953 and 1954 Fish and Wildlife Service data will be presented under the years 1951, 1952 and 1953, respectively.

Considering all species of ducks together, Fish and Wildlife Service surveys indicate a general increase in the Mississippi Flyway population during the course of this study. The flyway population of Coots, however, did not conform to this pattern and was apparently suffering a decline in 1952 and 1953. These relationships are shown in Table 6 where changes in Mississippi Flyway population indices relative to the average indices for the preceding five years are given for ducks and the Coot. The five-year time interval includes the year shown and the four years preceding it.

TABLE 6

FLUCTUATIONS IN MISSISSIPPI FLYWAY POPULATION INDICES OF DUCKS AND COOTS FOR 1951, 1952 AND 1953 RELATIVE TO AVERAGE INDICES FOR THE PRECEDING FIVE YEARS

(U. S. Fish and Wildlife Service Data)

Species	Per Cent Change		
	1951	1952	1953
All Ducks	—2	+20	+17
Coot	+42	—59	—44

Duck populations per observation day on University Bay, when compared with the average populations of the preceding five years, show changes similar to those experienced in the flyway as a whole. The Coot population, however, was apparently increasing on the Bay while it was decreasing throughout the flyway. These trends on University Bay are shown in Table 7.

TABLE 7

FLUCTUATIONS IN UNIVERSITY BAY DUCK AND COOT POPULATIONS FOR 1951, 1952 AND 1953 RELATIVE TO POPULATION AVERAGES FOR THE PRECEDING FIVE YEARS

Species	Per Cent Change		
	1951	1952	1953
All Ducks	—2	+14	+39
Coot	+22	+68	+6

This apparent agreement between duck population trends in the Mississippi Flyway and on University Bay does not carry over with any consistency into a consideration of individual species.

During the fall of 1954, approximately five times as many Canvas-back were observed on University Bay as during any previous fall of this study (Table 3). Aerial surveys on Lake Mendota showed the Canvas-back population there to be approximately four times greater than that of any preceding year in which fall surveys were made (Table 4). This suggests the possible operation of a threshold phenomenon in which Canvas-back, once they exceed certain population levels in their normal habitat—the open waters of the lake—occupy the marginal habitat of the bays, at least for short periods of time. An examination of aerial survey data shows that Canvas-backs reached maximum fall numbers on Lake Mendota between November 3 and 15, 1954 (61,450 were tallied on November 8). On University Bay, maximum numbers were attained between December 7 and 16 (1,634 were recorded on December 12). Aerial surveys were terminated as of December 4 at which time 7,400 Canvas-back were on the lake. Only a few Canvas-back were seen on the Bay after December 12. The four-week time interval between the appearance of maximum Canvas-back numbers on Lake Mendota and University Bay (assuming no concentrations appeared on the Bay between observation periods) indicates that this is not a "threshold phenomenon" in the strict sense. It more likely involves a food relationship that might operate as follows.

The succession of plant and animal foods in Lake Mendota is rapidly declining in November and December. This dwindling supply was utilized for a month prior to December 4 by a Canvas-back population ranging from 7,000 to 60,000 ducks. It seems probable, then, that any late-season flights of Canvas-back might be forced to seek out the less heavily utilized food supplies of the bays. This might account for the appearance of 1,634 Canvas-back on University Bay on December 12. We must, however, not overlook the possibility that the coincidental appearance of an observer and a flock of 1,634 Canvas-back on University Bay could have taken place by merest chance. If, on the other hand, this "food-relation" hypothesis is correct, it might explain some of the apparent population increases on the Bay in recent years.

(To be concluded)

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AUTUMNAL MIGRATION OF DUCKS BANDED IN EASTERN WISCONSIN

JOSEPH J. HICKEY
Department of Forestry and Wildlife Management
University of Wisconsin

The object of this paper is to demonstrate the extent of autumnal migratory movement of ducks that have been banded in eastern Wisconsin. Five species will be discussed: black ducks *(Anas rubripes),* mallards *(A. platyrhynchos),* wood ducks *(Aix sponsa),* and blue-winged and green-winged teal *(Anas discors* and *A. carolinensis)*. These were banded by Frank A. Schader under the direction of L. H. Barkhausen at Suamico, near Green Bay, Wisconsin, from 1929 to 1940 and at the Moon Lake Wildlife Refuge, Campbellsport, 59 miles farther south, by Frank Hopkins from 1927 to 1935 inclusive.

Banding data have certain limitations which make them only crude indices of the routes used by migrating waterfowl (Hickey 1951). On the one hand, the ducks banded at a given location are more likely to be shot in that general region in subsequent years than they will in other regions. In this respect, they are not adequately randomized samples of large populations. And on the other hand, the recoveries sent in by hunters are indicative of birds that have come into contact with gunfire and not, of course, representative of nonstop flights at moderately high altitudes. Other limitations involve clerical errors which in the past have marred the data set up in a centralized banding file by the United States Fish and Wildlife Service (Hickey 1952:20). About 12 per cent of the localities mapped in the present paper probably refer to the residence of the hunter and not to places where ducks were actually shot. In approximately 10 per cent of records, the date of recovery actually represents the date on which the hunter wrote or mailed his report.

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TABLE 1

DISTRIBUTION OF INDIRECT RECOVERIES OF MALLARDS BANDED IN THE LAKE STATES

WHERE BANDED	MINNESOTA	NORTH-EASTERN ILLINOIS	EASTERN WISCONSIN	SOUTH-WESTERN MICHIGAN
NUMBER RECOVERED	112	1718	394	134
Where recovered	Percentage Recovered			
Alaska	...	0.1	...	...
Alberta	0.9	0.9	0.5	1.5
Saskatchewan	0.9	2.2	1.0	1.5
Manitoba	1.8	4.7	4.3	11.2
Ontario	...	0.7	2.3	8.2
Quebec	...	...	0.5	0.8
Misc. Canada	...	0.2	...	...
Subtotal	3.6	8.8	8.6	23.2
Pacific Flyway				
Idaho	...	0.2	0.3	...
Nevada	...	0.1	...	...
Central Flyway				
Montana	...	0.1	0.3	...
North Dakota	5.4	3.7	...	6.0
South Dakota	1.8	3.3	0.5	1.5
Nebraska	2.7	0.9	...	...
Kansas	0.9	0.7	...	...
Oklahoma	3.6	0.4	...	...
Texas	4.5	1.4	0.5	0.8
Subtotal	18.9	10.5	1.3	8.3
Mississippi Flyway				
Minnesota	25.9	15.2	15.0	9.0
Iowa	1.8	4.9	2.8	...
Missouri	5.4	2.2	2.3	...
Arkansas	11.6	8.6	4.3	0.8
Louisiana	6.2	5.3	6.3	...
Wisconsin	3.6	6.9	26.9	11.9
Illinois	13.4	25.0	17.3	8.2
Kentucky	0.9	0.7	0.5	...
Tennessee	0.9	3.1	1.0	1.5
Mississippi	2.7	3.1	2.8	0.8
Alabama	...	0.6	1.3	...
Michigan	...	1.7	3.8	29.8
Indiana	...	1.9	2.0	0.8
Ohio	0.9	0.5	1.5	4.5
Subtotal	73.3	79.7	87.8	67.3
Atlantic Flyway				
Pennsylvania	...	0.1	...	0.8
New York	...	...	...	0.8
New Jersey	...	0.1	...	...
North Carolina	...	0.1	...	...
South Carolina	0.9	0.2	1.0	...
Georgia	...	0.4	1.0	...
Subtotal	0.9	0.9	2.0	1.6
Reference	Hickey 1951	Mann *et al.* 1947	This Paper	Pirnie 1941

The term "direct recovery" as used in this paper involves a bird recaptured in the same migratory period in which it was banded (Aldrich 1949a). An "indirect recovery" involves a bird banded in one migratory period, here usually the fall, and recaptured in some subsequent migratory period, usually some subsequent year *(ibid.)*.

MALLARD MOVEMENT

Previous Work. Hawkins (1949), in mapping 1,785 direct recoveries of mallards banded in the Prairie Provinces, has shown the main flight of these birds in the interior of the continent. For the most part, the direction appears to be a southeasterly one. Wisconsin recoveries made up 0.5 per cent of the reports of birds banded in Alberta, 0.5 per cent of those banded in Saskatchewan, and 2.5 per cent of those banded in Manitoba. Hickey (1951) has tabulated 5,932 indirect recoveries of mallards banded in 12 states and provinces. Ninety-nine of these recoveries refer to Wisconsin-banded birds, the main flight apparently proceeding down the Mississippi Valley and a few birds crossing the Appalachians to Virgina, South Carolina and Florida.

Indirect Recoveries. The reported movement of 394 Wisconsin-banded mallards is tabulated in Table 1 and compared to similar data for birds banded in this general region. Judging from the numbers recorded in the Central Flyway, the Minnesota, northeastern Illinois and eastern Wisconsin birds represent progressively more easterly segments of the mallard population. The percentage distribution of the birds banded in southwestern Michigan is peculiarly distorted by the high fraction of the population reported shot in Canada. The explanation must be ecological rather than statistical, and it may have to await the actual mapping of the Canadian recoveries of these Michigan birds. The progress of Wisconsin-banded birds across Minnesota and Wisconsin and thence south on the eastern side of the Mississippi River is fairly similar to Pirnie's (1941) map of his recoveries in the United States.

Indirect recoveries of Wisconsin-banded mallards are mapped in Figures 1, 2, 3, and 4. The birds in spring are as far west as the Grand Prairie region in Alberta close to the British Columbia line and as far east as the southern tip of Lake Huron and the western tip of Lake Erie. The records are few and may well be subject to geographic differences in the manner in which birds are recaptured. They are not proof that most of these birds nested in Ontario rather than Manitoba. The aberrant March 4 report from Wichita County, Kansas, was not verified by checking the correspondence files in the banding office of the Fish and Wildlife Service.

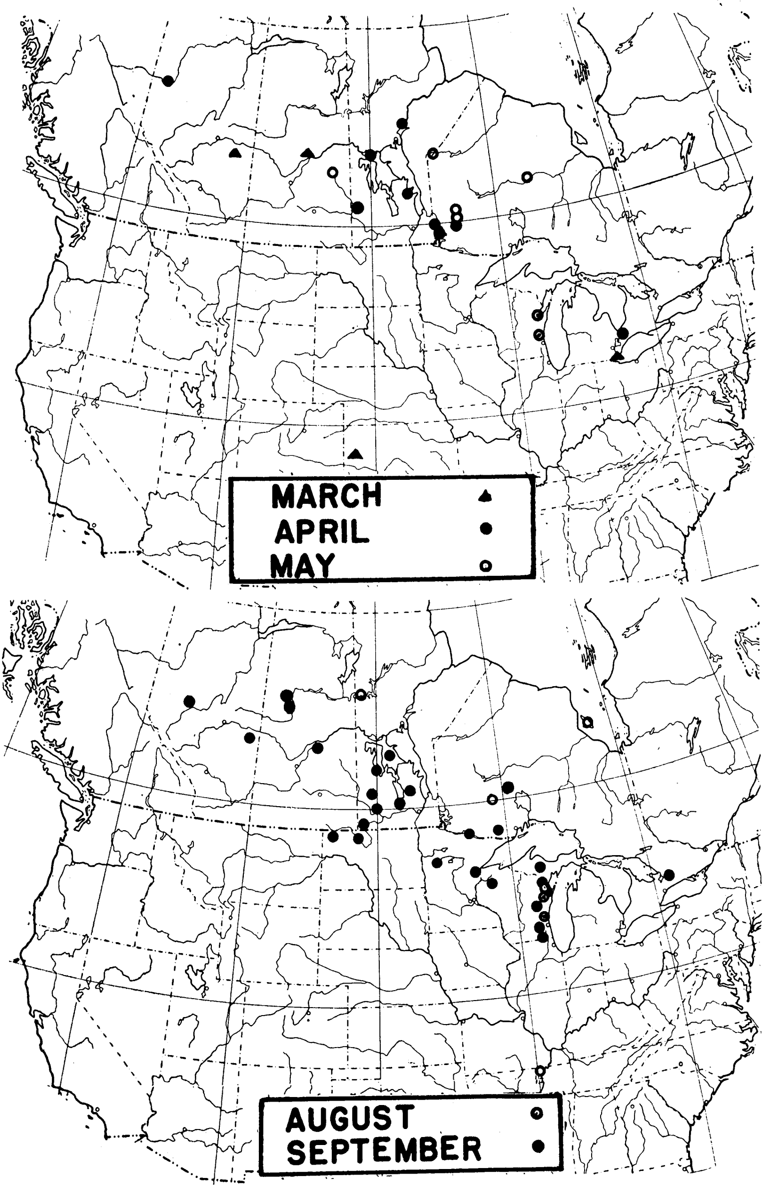
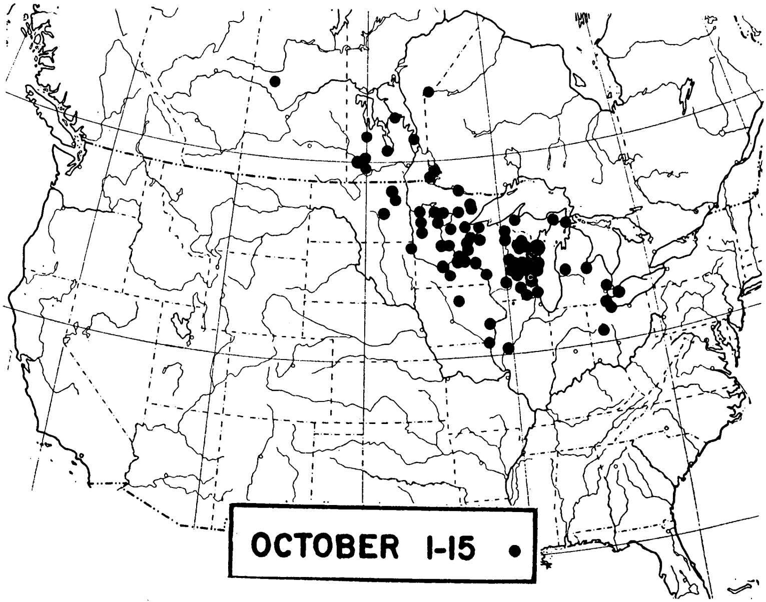


FIGURE 1. Indirect recoveries of mallards banded in eastern Wisconsin. Distribution of reports secured in some migratory period in which the birds were banded. In the upper map, the two circles in Wisconsin show the location of the banding stations.



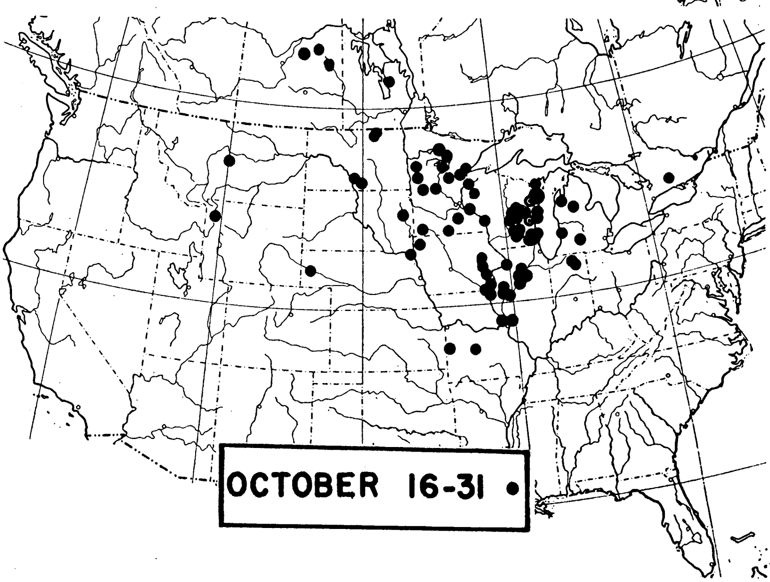


FIGURE 2. Indirect recoveries of mallards banded in eastern Wisconsin (continued).

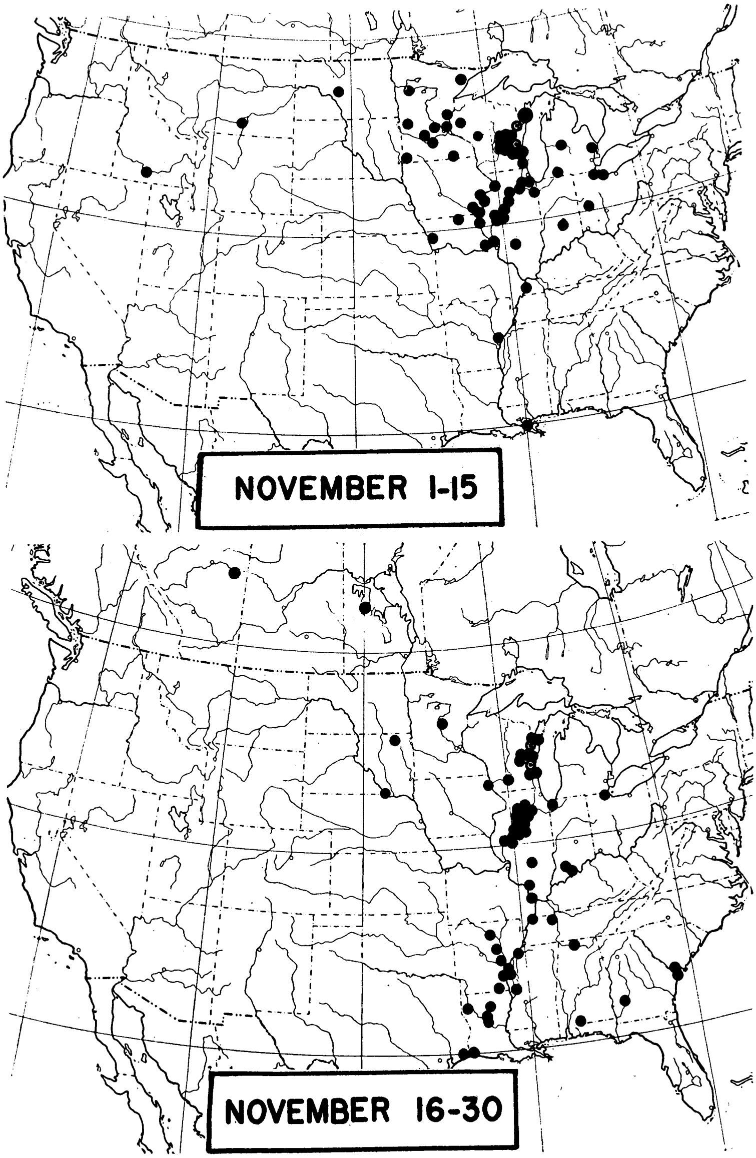


FIGURE 3. Indirect recoveries of mallards banded in eastern Wisconsin (continued).

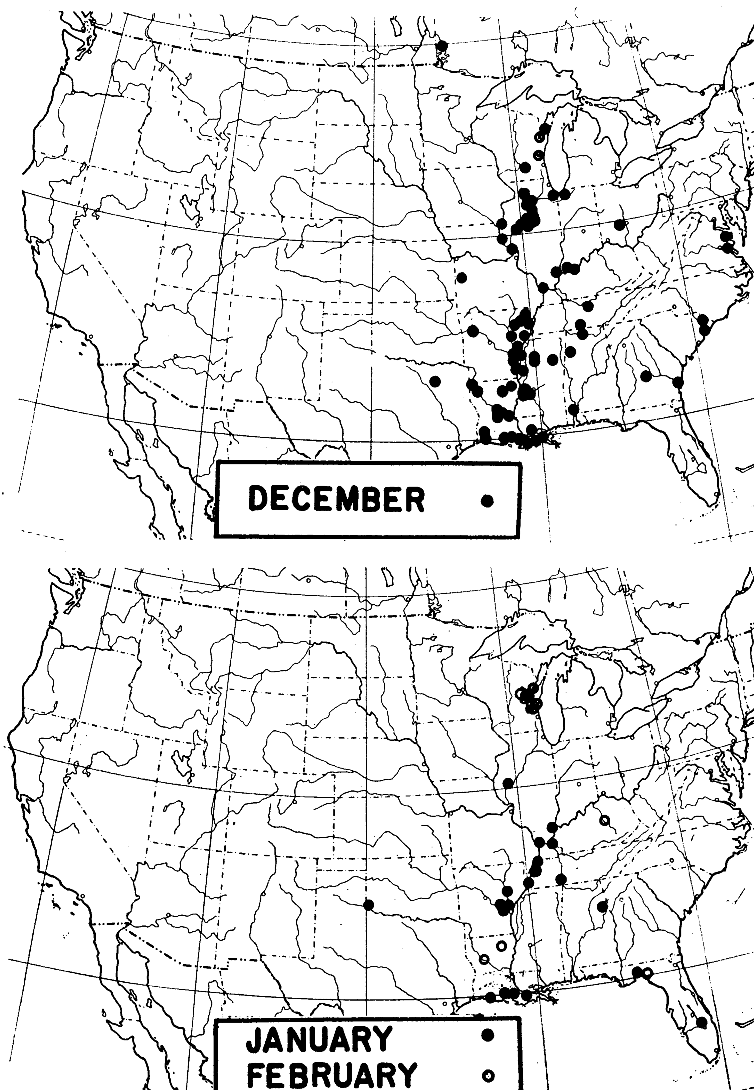


FIGURE 4. Indirect recoveries of mallards banded in eastern Wisconsin (concluded).

August records of mallards often refer to birds which have engaged in postbreeding-season flights. Apparently these birds may be as far north as Akimiski Island in James Bay on August 10 and as far south as Portageville, Missouri, in the same month. All but one of the September recoveries refer to the last 16 days of this month.

Hunters' reports of these birds in the first 15 days of October fairly blanket Minnesota and Wisconsin, with the greatest concentration being in the vicinity of the banding station. By late October the migratory movement has apparently widened. This picture is simply a composite one obtained by mapping birds banded over a number of years. It is, moreover, importantly affected by the dates of legal hunting in this region. During the period from 1931 to 1941, for instance, hunting began in Illinois once on October 6, 7 times on October 14–16, twice on October 21–22 and three times on November 1 (Bellrose 1944).

TABLE 2

RECAPITULATION OF INDIRECT RECOVERIES OF WISCONSIN-BANDED MALLARDS[1]

When Reported Recovered	Where Reported Recovered						
	Canada	Ida. to Minn.	Wis.	Ia., Ill., Ind., Ohio	Ky., Tenn., Ark.	Gulf States	Atlantic Coast
Sept. 1–10	1	....	....	....	....	....	....
11–20	5	....	3	....	....	....	....
21–30	8	3	3	....	....	....	....
Oct. 1–10	9	29	21	2	....	....	....
11–20	5	16	26	6	....	....	....
21–30	4	8	23	14	....	....	....
Nov. 1–10	....	7	16	18	1	1	....
11–20	1	5	8	6	3	6	2
21–30	....	1	4	20	6	5	1
Dec. 1–10	....	....	1	10	3	13	2
11–20	1	....	....	5	3	12	3
21–30	....	....	1	2	6	7	....

[1]Some birds were omitted from this table because the dates were not sufficiently definite. South Dakota and Michigan data were omitted for the sake of brevity.

On at least one occasion, a Wisconsin-banded mallard reached the Delta of the Mississippi River by the 2nd of November. The first report from Texas is dated November 16; the first from South Carolina, November 19. Late-November reports of birds in Alberta and Manitoba come well after freeze-up time; these may well in-

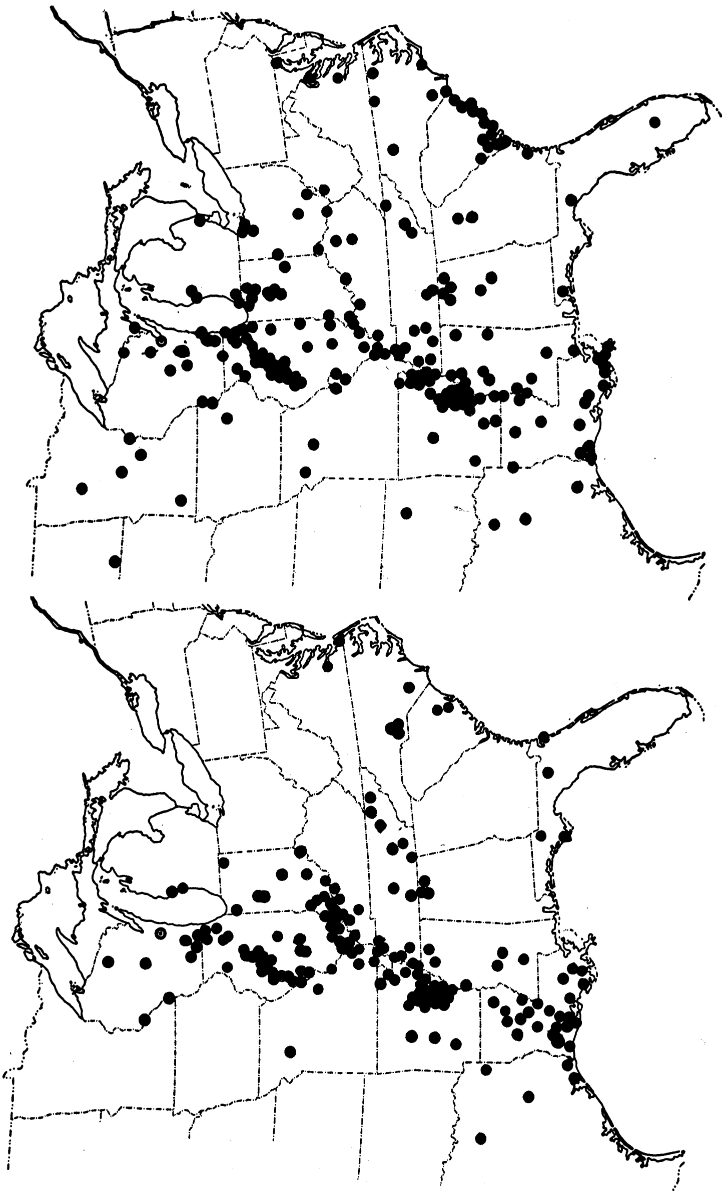


FIGURE 5. Direct recoveries of mallards: birds reported shot or found dead in the same autumnal migration in which they were banded. Left: birds banded at Campbellsport; not shown—61 reported within 50 miles of the banding station. Right: birds banded at Suamico; not shown—228 shot within 50 miles of the banding station. The stations are indicated by a dot within a circle.

volve dates on which hunters sent in their letters rather than dates on which the birds were shot. The November maps show not only concentrations of recoveries near the banding station but also a well-marked path of mallard mortality along the Illinois River.

Eastern-Wisconsin mallards evidently winter in numbers in Arkansas and Louisiana, with a sprinkling of birds reaching the Atlantic Seaboard from Virginia to Florida. A general picture of the autumnal distribution of mortality in these mallards is summed up in Table 2.

Direct Recoveries. Figure 5 shows the distribution of hunters' reports sent in during the same fall in which the mallards were banded. The geographic patterns of the Campbellsport and Suamico series are much the same. The autumnal movement of birds northward from the banding point has been noticed on numerous occasions on which duck records like these from the interior of the continent have been analyzed in the past (Lincoln 1932–33; Pirnie 1935, Warren 1945, Van den Akker and Wilson 1949). From Campbellsport, 4.9 per cent of Hopkins' 226 direct recoveries were distributed along the Atlantic. This is quite similar to 5.6 per cent of Barkhausen's 448 direct recoveries.

Twenty-seven per cent of the direct recoveries from Campbellsport emanated from within 50 miles of the banding station, while 51 per cent of the direct recoveries involving Suamico birds were reported within a similar radius. While the tendency for a refuge to increase hunting opportunities within its vicinity is now well known, this high proportion of local reports of the Suamico birds is, I think, rather unusual. So many of the Suamico-banded birds were shot nearby at Long Tail Point and in the immediate vicinity of the banding station as to preclude the possibility of mapping these particular records in this publication. The distribution of other recovery reports from Wisconsin is given in Figure 6.

As a general rule, ducks baited into banding traps cannot be considered as randomized samples of large regional populations: in years after the date of banding, more of them tend to be shot in the state or province in which they were banded than in any other state or province (Hickey 1951). This is also true of the samples considered here. A review of indirect recoveries for both black duck and the mallard (Figure 7) reveals, however, that the "homing" is by no means precise.

BLACK DUCK MOVEMENTS

Previous Work. As Addy (1949) has pointed out, the Appalachian Mountains apparently serve to some extent to divide easterly and westerly populations of the black duck as they migrate

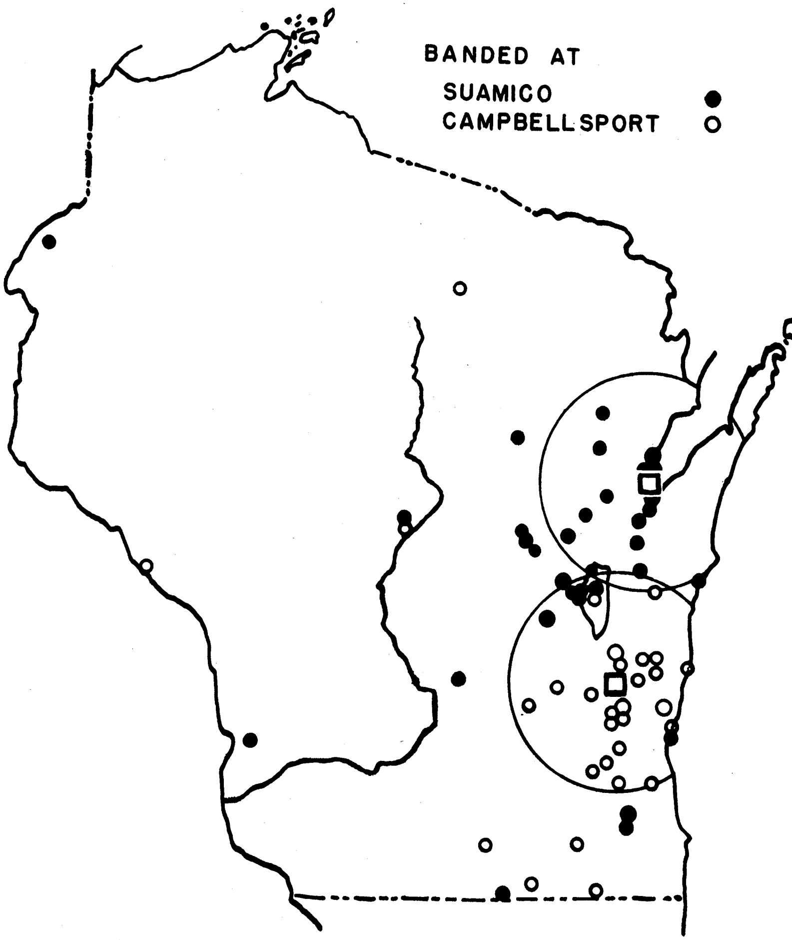


FIGURE 6. Direct recoveries of mallards: Wisconsin reports of birds shot or found dead in the same migratory period in which they were banded. The circles around each banding station have a 40-mile radius. The smaller circles or dots refer to 1 or 2 reports; the slightly larger circles or dots refer to 3 or more reports from the same locality.

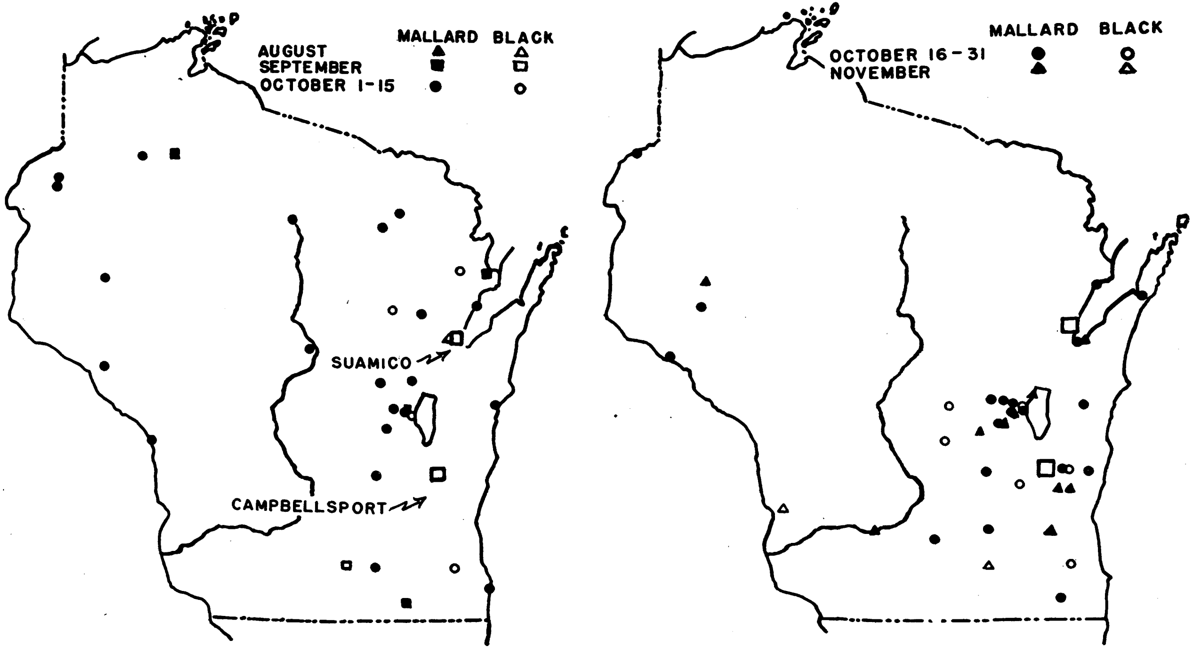


FIGURE 7. Indirect recoveries: Wisconsin reports of mallards and black ducks banded at Suamico and Campbellsport and reported in some subsequent year.

south each fall. Lake Scugog, just north of Lake Ontario, is almost on the dividing line. Of 298 direct recoveries tabulated by Lincoln (1927) for birds banded at this station, 55 per cent were in the Atlantic Flyway, 44 per cent in the Mississippi Flyway, and 1 per cent in the Central Flyway (specifically Kansas, Oklahoma, and Texas). Among 115 indirect recoveries, these percentages were 71, 26, and 2 per cent respectively. This shift is statistically significant and not easily explained. It seems to have been critically associated with the number of recoveries reported from Ohio: 13 per cent of the direct recoveries, 3 per cent of the indirect. When this essentially Canadian sample of birds first reached Ohio, it seems to have been particularly vulnerable to gunning. In later years when the entire sample consisted of adult birds, the greater experience of the birds may not have made them so vulnerable when they first came in contact with hunting pressure in the United States. Lincoln's tabulations of these Ontario-banded black ducks suggest to me that the Atlantic-bound birds made Maryland and Virginia their first stop after leaving Canada; the Mississippi-bound birds clearly stopped off in Ohio on the flight leaving the vicinity of the banding station.

Pirnie (1932, 1935) has mapped 331 direct recoveries of black ducks, banded at the Munuscong State Waterfowl Refuge in the eastern end of the Upper Peninsula of Michigan. Excluding Michigan and Ohio recoveries, 91 per cent of these reports were in the Mississippi Flyway, and 9 per cent were in the Atlantic Flyway. Among these records were 1 for Minnesota and 13 for Wisconsin.

Pirnie (1941) has also mapped the southward drift of black ducks banded near Battle Creek in southwestern Michigan. Recovery of 22 of these birds in northern Ontario in spring and early summer strongly pointed to this region as an important nesting home for many of the black ducks leg-banded at this station. Of the 83 birds reported in states other than Michigan, 78 per cent were recovered in the Mississippi Flyway. This figure includes both direct and indirect recoveries. I was surprised to observe that it is significantly different from the value mentioned above for birds banded on the Upper Peninsula. Twenty-five Wisconsin reports appear in these data.

Seasonal Movement of Wisconsin Black Ducks. A total of 190 recoveries of black ducks are available from the banding work of Barkhausen and Hopkins at Suamico and Campbellsport. Of these, 74 are reported from Wisconsin as direct recoveries, 22 from Wisconsin as indirect recoveries, 56 as direct recoveries in other states, and 38 as indirect recoveries elsewhere. Exclusive of the Wisconsin recoveries, 91 per cent of the reports (both direct and indirect) emanate from the Mississippi Flyway, 6 per cent from the Atlantic

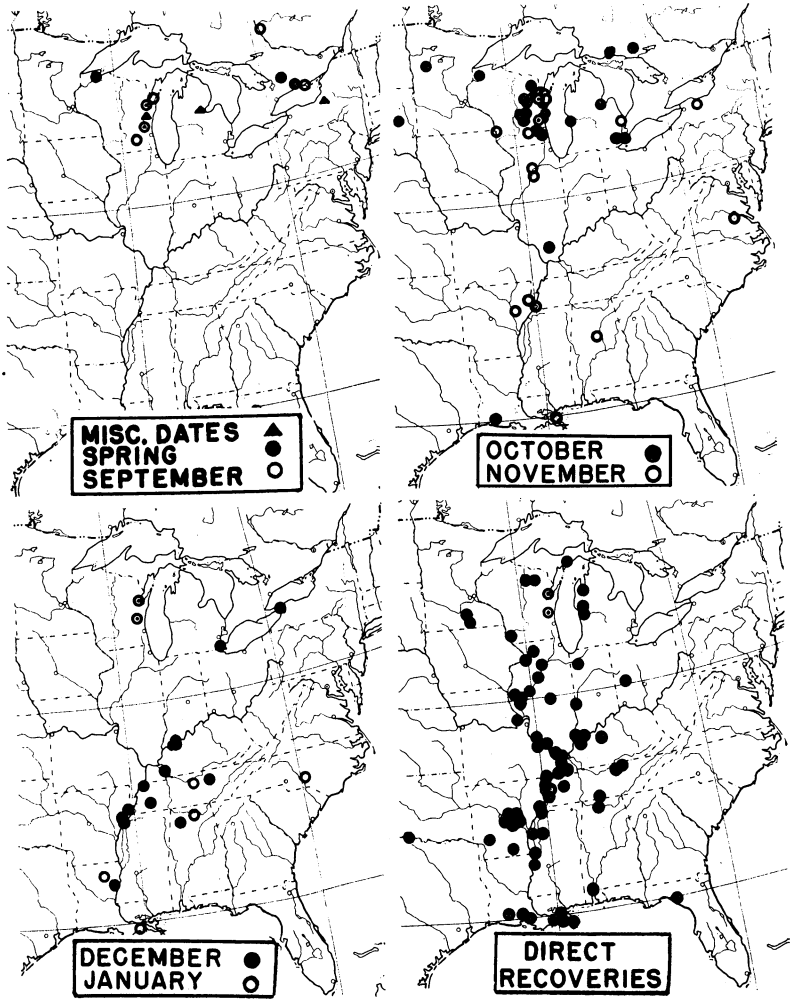


FIGURE 8. Recoveries of banded black ducks. Three maps show the approximate date of birds recovered in some migratory period after the one in which they were banded. At lower right: direct recoveries—birds recovered in the same autumnal migration period in which they were banded. Each banding station is shown as a dot within a circle. Not mapped: direct recoveries within 50 miles of each banding station.

and 2 per cent from the Central Flyway. In general the geographic distribution (shown in Figure 8) follows that of Pirnie's (1932) sample from the Upper Peninsula. It differs from Pirnie's (1941) sample from southwestern Michigan in having significantly less birds reported from the Atlantic Seaboard. Within the Mississippi Valley, however, the two sets of recoveries from eastern Wisconsin and southwestern Michigan are very much alike, although the Wisconsin-banded birds do not move into eastern Michigan as much as the Battle Creek birds do. It seems quite likely that black ducks which reach eastern Michigan during the fall migration increase the probability of their being later recorded in the Atlantic Flyway to the East.

MISCELLANEOUS WATERFOWL

Green-winged Teal. Low (1949) has mapped recoveries of green-winged teal banded in British Columbia, the Prairie Provinces, Utah, and the Maritime Provinces. The only one of these recovered in Wisconsin was a bird banded at the Bear River Migratory Bird Refuge in Utah and said to have been taken in the same autumn near Lake Winnebago. Unlike reports of Saskatchewan- and Manitoba-banded mallards, green-winged teal banded in these provinces appear to move almost due south. Low *(ibid.)* found no evidence of birds from the interior reaching the Atlantic Seaboard.

Direct and indirect recoveries of Wisconsin-banded birds (Figure 9) indicate that these birds go as far as east Texas on the Gulf Coast and to Georgia and Florida on the seaboard. One bird banded at Suamico on November 4 was reported at Titusville on the east coast of Florida 18 days later. Another banded at Suamico on November 4 was shot at Natchetoches Parish, in southwestern Louisiana five days later. It is not possible at this time to reach any definite conclusion about the breeding distribution of these Wisconsin-banded teal. The two southern Manitoba records were obtained in April, and the York Factory record could not be definitely dated. The James Bay reports involve a spring and an August date.

Blue-winged Teal. The light shooting pressure encountered by the blue-winged teal has long made it a poor subject for banding studies. Stoudt (1949) has examined nearly 3,000 recoveries in the files of the Fish and Wildlife Service, and mapped the spectacular distribution of reports to Central America, Colombia, and Venezuela. Direct recoveries of Wisconsin-banded birds are principally confined to Minnesota and Wisconsin. An appreciable movement to Minnesota is evident before the birds go south. One bird was recovered in Panama; another in Venezuela.

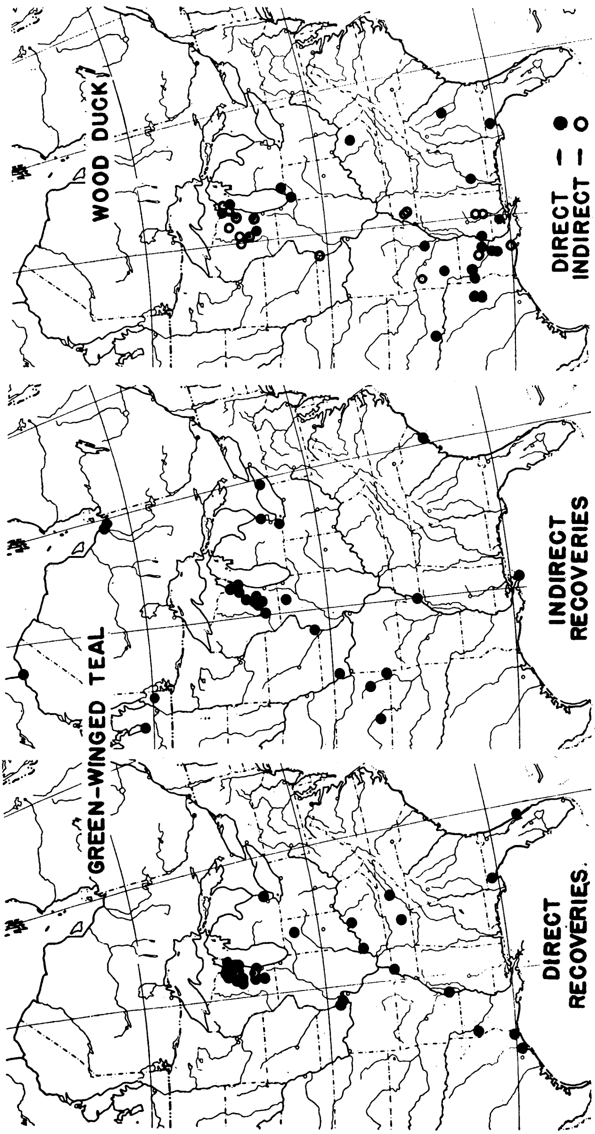


FIGURE 9. Recoveries of green-winged teal and wood ducks banded in eastern Wisconsin.

Wood Duck. Very little is known about the movement of banded wood ducks. Of the recoveries of Wisconsin-banded birds, 18 emanated from Hopkins' work at Campbellsport, 56 from the banding at Suamico, and 19 from operations carried out at the Necedah National Wildlife Refuge by B. J. Carter, C. V. Fermanich, and R. W. Hunt. As Figure 9 demonstrates, these birds move south to Texas, Louisiana, Mississippi, Alabama, Florida and Georgia. Although the sample is small, the geographic spread of these reports is considerable.

December to February reports of these wood ducks were confined to Alabama (1), Mississippi (3), Louisiana (3) and Texas (2).

Lesser Scaup. A female lesser scaup *(Aythya affinis)* reported by L. H. Barkhausen as banded at Big Suamico on October 22, 1930, was reported shot at Boston, Georgia, on December 10, 1931. Aldrich (1949b) has mapped a fairly conspicuous migration route of this species from the Prairie Provinces through Minnesota, Wisconsin, and southeastern Michigan to Chesapeake Bay. Birds banded in British Columbia, Alberta, Saskatchewan and Manitoba have all been recovered in Wisconsin in the same migratory period in which they were banded. The main numbers of Wisconsin birds probably come from Manitoba and Saskatchewan. As Lincoln (1932–33) and others have brought out, this flight to the Atlantic Coast is apparently characteristic of a number of other diving ducks like the canvas-back *(Aythya valisineria)*, the redhead *(A. americana)*, and probably the ruddy duck *(Erismatura jamaicensis)*.

SUMMARY AND CONCLUSIONS

This paper is an analysis of 1,064 recovery reports of mallards banded at Suamico and Campbellsport in eastern Wisconsin. Additional data on 207 black ducks, 57 green-winged teal, 37 wood ducks, 24 blue-winged teal and 1 lesser scaup are also considered.

The mallard recoveries were spread out during the spring from the Grand Prairie region of Alberta to the western tip of Lake Erie. By August, the birds were as far north as James Bay and as far south as Missouri. Hunters' reports blanketed Minnesota and Wisconsin during the first 15 days of October. By November, a well-marked path of mallard mortality was evident along the Illinois River, and some birds had reached Louisiana, Texas, and South Carolina. Eastern Wisconsin mallards appear to winter in Arkansas and Louisiana in numbers, with a sprinkling of birds reaching the Atlantic Seaboard from Virginia to Florida.

The black ducks banded in the same region had a migration confined pretty much to the Mississippi Valley. The green-winged teal migrated as far as eastern Texas on the Gulf Coast and to Georgia and Florida on the Atlantic Coast. The wood ducks appear to winter in much the same geographic area. The single report on a lesser scaup came from Georgia and appears to be in line with the well-marked southeasterly movement of diving ducks which other authors have mapped from the Praire Provinces to the Atlantic Coast.

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FUROR POETICUS AND MODERN POETRY*

HASKELL M. BLOCK
Department of Comparative Literature, University of Wisconsin

When we examine 20th century poetry from an international standpoint, we can see that the radical experimentation in structure and language that we find in such American poets as Ezra Pound and T. S. Eliot, E. E. Cummings and Hart Crane, to name only a few, is part of a wide-spread effort in our time to reconstruct the foundations of the poetic art. Often this reconstruction took the form of an organized protest. Almost always, the new poets of the day, whether in France or Spain, Russia or America, thought of themselves as consciously *avant-garde,* committed to the rejection of outworn themes and styles, and compelled to set forth justifications of their own efforts in grandiose and magniloquent terms. The manifestoes of the revolutionary poetic movements that flourished for a short time throughout Europe during and after World War I are interesting today largely for historical reasons,[1] but the mere fact that these documents exist suggests the importance of deliberate formulations of poetic theory to the young experimentalists. At over 30 years distance we can see the large gap that separates their ambitions from their accomplishments, and if we are careful, we do not read contemporary poetry as a mere exemplification of aims and doctrines. Yet sometimes, theory and practice cohere and mutually reinforce our understanding of the poet's work, and even when no such coherence can be found, the poet's aesthetic and critical theories can be of the highest interest as a clue to his poetic strategy and technique and to the impulses animating his work and that of his contemporaries.

The doctrine of *furor poeticus* is as old as the study of poetry, perhaps older, yet in recent years it has played a role of major importance in shaping the attitude of the poet toward his art. According to this view, the poet creates under the direct impulse of divine inspiration and in a momentary condition of delirium or frenzy which deprives him of his reason. The ancients described the poet's madness as a kind of demonic possession, in which the

* This essay is part of a larger study tentatively entitled *Surrealism and Modern Poetry.* I am grateful to the Graduate School of the University of Wisconsin for a grant which enabled me to complete the research on which this essay is based.

[1] The best over-all study of this phase of the history of modern poetry remains Guillermo de Torre, *Literaturas Europeans de Vanguardia* (Madrid, 1925). A continuation of this work is badly needed.

poetic utterance at once takes on the force of prophecy. We can readily understand why the earliest of western poets were regarded essentially as prophets. Poetry in pre-literary times was intimately allied, in some societies at least, with tribal ritual and with the welfare of the community. The poet's function was not simply to glorify in song the heroic deeds of the past or to inspire those of the present; he was called upon to predict the future as well, and he was able to do so because of his divinely inspired vision, the sign of the poet's kinship with the hidden spiritual forces held to govern nature and human destiny.[2]

From the beginnings of Greek literature, the nature and function of the poet were explained by the doctrine of prophetic inspiration. Well before Plato, philosophers such as Heraclitus, Empedocles and Democritus were particularly concerned with such psychological phenomena as the apparently irrational ecstacy that accompanied poetic composition. For Heraclitus, souls of the deepest intelligence possess intuitive powers of divination associated with premonitory dreams that signal supernatural revelations. For Empedocles, the condition and status of the individual depends on the daimon or genius that has entered into and possessed him; through the exaltation induced by delirium, the poet-prophet creates poetry and at the same time, purifies his soul. Democritus went even further in the fusion of madness and poetic genius, declaring, according to Cicero, that one cannot be a good poet "without an inflammation of the soul and without the presence of an overpowering impulse akin to delirium." This poetic power is not dependent on intelligence or knowledge, for it is wholly divine in origin. Dreams and visions are signs of supernatural visitation and the immediate source of poetic inspiration; without such inspiration no poetry worthy of the name can be produced.[3]

We can see at once how considerable was Plato's debt to his predecessors. Homer, Hesiod, Pindar and other ancient poets insisted on the same divine sanction of the poet's activity, and saw no conflict between the poet's madness and his concern with historical or even moral truth.[4] With the aid of the Muses, knowledge as well as power was assured the poet-seer; witness Homer's many appeals for information as well as for inspiration.[5] But as Plato insists, without the gift of inspiration, whatever knowledge and skill a would-be poet might possess is useless.

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[2] See N. K. Chadwick, *Poetry and Prophecy* (Cambridge, 1942).

[3] For a fuller discussion see A. Delatte, *Les Conceptions de l'Enthousiasme chez les Philosophes Présocratiques* (Paris, 1934).

[4] See Louis Meridier (ed.), Platon: *Oeuvres Complètes*, t. V, *Ion* (Paris, 1931), p. 14.

[5] A. Sperduti, "The Divine Nature of Poetry in Antiquity," *Transactions of the American Philological Association*, Vol. 81 (1950), p. 231.

It is of course owing to Plato far more than to his predecessors that subsequent poets could give renewed expression to the concept of *furor poeticus* by way of explaining and justifying their art. Poetic madness is described by Plato, after Democritus, as a kind of demonic possession which in a true poet deprives him wholly of his reason. This explanation of the poet's frenzy and his unique prophetic and oneiric power Plato sets forth most fully in an early dialogue, *Ion,* which offers the most representative illustration of the ancient point of view.[6] Similar descriptions can be found in *Phaedrus,* in *The Laws,* and in other dialogues. For Plato, the poet is often a person of little intellectual ability, but when the god is in him, he is exalted above all other mortals. Plato goes further than his predecessors in emphasizing the distinction between inspiration and art, but in all essential respects his view of the nature of poetic activity is that which was generally held in ancient Greece before his time and which through Plato was transmitted to modern literature. Thus despite the highly imperfect knowledge of virtually all ancient literature and philosophy possessed by the middle ages, sufficient expressions of the poet's divine madness were available in Horace, Ovid, Pliny and Claudian among others, so that the traditional view could reappear in Statius, Fulgentius, and in later anonymous compilations.[7] From the Renaissance to our own day, the concept of *furor poeticus* has received wide and varied restatement, especially by poets and critics who responded directly to the mystical and visionary allure of Platonic and Neo-Platonic thought. In English poetry Blake and Shelley are perhaps the most characteristic champions of the view that the poet is divinely inspired; post-Romantic poets, in England and on the continent, have from time to time reasserted the demonic and hallucinatory character of poetic vision.

When we approach the history of modern poetry we find that no single writer has been more influential in the dissemination of this view of the nature and function of the poet than Arthur Rimbaud. This is not the place to assess Rimbaud's astounding literary career, compressed between the ages of 16 and 19, and followed by the poet's repudiation not only of literature but of modern civilization, to die at 37 after spending the latter part of his life as an African trader and gun-runner. Rimbaud's aesthetic theory is even more fragmentary and frenetic in expression than the prose-poems of *Illuminations* and *Une Saison en Enfer* to which it is intimately related. Virtually the whole of Rimbaud's literary theory is con-

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6 An extended discussion is provided by Craig LaDrière, "The Problem of Plato's *Ion,*" *Journal of Aesthetics and Art Criticism,* X (1951), 26–34.

7 Cf. E. R. Curtius, *European Literature and the Latin Middle Ages* (London, 1953), p. 474.

tained in two letters of May, 1871, subsequently known as the "lettres du Voyant," perhaps the most dynamic expression of the interpenetration of poetry and prophecy that one can find anywhere in recent literature.

> I say it is necessary to be a *seer*, to make oneself a S E E R! The poet makes himself a *seer* by a long, immense, and reasoned *derangement* of *all the senses*. All the forms of love, suffering, folly, he searches in himself, he boils down in himself so as to keep nothing of them but the quintessences. Unspeakable torture, wherein he needs all constancy, all superhuman strength, wherein he becomes among all the great invalid, the great malefactor, the great outcast,—and the supreme Savant!—For he reaches the unknown! Because he has cultivated his soul, already rich, richer than any! He reaches the unknown; and when, gone mad, he ends by losing the comprehension of his visions, he has seen them! Let him die in his leap among things unheard of and without names: other horrible toilers will come; they will begin at the horizons where he went down. . . .[8]

We can see at once that Rimbaud here joins hands with an ancient poetic tradition, mingling echoes of Plato, of Baudelaire, Hugo, and also of the mystical and prophetic writings of Ballanche, Eliphas Lévi, and other students of occult magic.[9] For Rimbaud, as for his precursors, the poet is essentially a medium, or must become so through a wilful disorganization of his senses. Thus in expressing his wild and visionary thoughts and feelings, the poet-seer gives simultaneous expression to the unconscious spiritual power that pervades the universe. Hence the sanctity of the poet's mystical experience and the privacy of his inner vision, a vision that only he can have. Yet there is this important difference between Rimbaud's poetic of "*dérèglement*" and the ancient notion of *furor poeticus*. The bard or rhapsode of Homer's day acquired his divine gift through the operation of mysterious and external powers mediating between the poet and the supernatural. His poetry and the frenzy which accompanied it were wholly beyond his control. Rimbaud, on the other hand, insists on the recapture of the primitive character of the poet-seer through conscious effort. The poet must learn how to disorder his senses systematically, so that he can induce hallucinations at will.[10] Otherwise, presumably, he will be no more able to explore the realm of the unknown than ordinary men.

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[8] The translation is from W. C. Blum, "Some Remarks on Rimbaud as Magician," *The Dial*, Vol. 68 (1920), pp. 723–724.

[9] Cf. Enid Starkie, *Arthur Rimbaud* (New York, 1940).

[10] See the discussion of W. M. Frohock, "Rimbaud's Poetics: Hallucination and Epiphany," *The Romanic Review*, XLVI (1955), 194.

It may be true that Rimbaud's early poetry fails to support the cosmic aspirations of the letters of May, 1871, but it is difficult to separate his last work, *Une Saison en Enfer,* from the poetic of hallucination. This collection is made up of prose-poems which are at once autobiographical reminiscences and restatements of poetic theory. As is true in Rimbaud's earlier poems, the poet's representation of his distorted visionary experiences is logical and lucid, yet the poetic process which he describes in *Une Saison en Enfer* is at the same time a celebration of the disorder he invokes and which he ends by finding sacred. As the poet exclaims in "*Délires* II":

> I became an adept at simple hallucinations: in place of a factory I really saw a mosque, a school of drummers composed of angels, carriages on the highways of the sky, a drawing-room at the bottom of a lake; monsters, mysteries; the title of a melodrama would raise horrors before me.
>
> Then I would explain my magic sophisms with the hallucination of words!
>
> Finally I came to regard as sacred the disorder of my mind.

In a sense, "Alchimie du Verbe" is the poet's testament, a recipe for the conscious destruction of rational consciousness, a direct appeal to the cultivation of fantasy and nightmare expressed in a poetry of personal and private association, of metaphorical dislocation and cosmic disorder. It is easy to see why so many 20th century poets have claimed Rimbaud as their spiritual godfather and primal source of inspiration, for his theory as well as for his technique.

The emergence of Rimbaud as a major force in 20th century poetic thought and expression coincided with the rapid development of non-objective art in the years immediately preceding the first world war. The war itself, with its violent transformation of lived reality into chaos, also helped to encourage a poetry of fragmentation and disintegration, a deliberate rejection of the traditional sanctions of so-called civilized life and a reversion to primitive and instinctive roots of artistic expression. The surrealist poets in France, led by André Breton, did little more than codify a poetic that had developed at least a decade before the surrealist manifestoes of 1924, in the poetry of Apollinaire, Jacob, Cendrars, Reverdy, and other so-called cubist poets. In their poetic theory the surrealists insisted even more boldly than did Rimbaud on the necessary dislocation of objective reality, the explosive power of metaphor, the exploration of the total unconscious mind through free and violent association. Here too, however, we must be on guard against equating theory and practice. Automatic writing or the complete suppression of logical control and the abandonment of any process of revision is far more important in the manifestoes of 1924 than it is in the poetry which even the most extreme surrealist poets of the Paris school composed. In poetry written outside of France in response to the surrealist experiment, the role of automatic writing is reduced even more. Yet the emphasis on fluid associations and fragmentary, disjunct metaphors undoubtedly plays an important part in subsequent poetry wherever the surrealist influence was felt. With this influence there came a revival of the doctrine of *furor poeticus.*

When we examine the course of avant-garde poetry in Spain in the 1920's we can see that here the surrealist theories and techniques came to be assimilated to native and somewhat more moderate experimental tendencies. No better illustration of this development in its relation to the concept of *furor poeticus* can be found than the writings of Federico García Lorca.

Students of the poet-playwright, García Lorca, have emphasized both the traditional and the experimental character of his poetic expression. Certainly the political significance of the poet's tragic end—at the hands of a Franco firing squad in the terrible summer of 1936—has been thrust into the background. It is right that the poetry receive precedence, for García Lorca was one of the most unpolitical of writers, a poet consciously dedicated to his art rather than to social or political propaganda.

Perhaps no Spanish poet of his time was more eclectic than Lorca and more readily able to assimilate even the most contradictory attitudes and techniques. His early poetry, as we can see in the *Romancero Gitano,* is poetry close to the tradition of the popular *juglar;* it is poetry to be recited far more than to be read. Its themes of violence and sensuous brutality, mystery and death, derive from the passionate world of the gypsies of Andalusia, made vivid and intense by the poet's involvement in the wonder and suffering he recreates. Such poems as the "Romance Sonambulo" or the "Romance de la Guardia Civil Española" testify to the poet's fluidity of metaphor and free juxtaposition of the planes of fantasy and external reality. It is clear that from the time of Lorca's study at the Residencia de Estudiantes in Madrid and increasingly during the 1920's, he became familiar with the doctrines and techniques of contemporary experimental poetry, with its emphasis on fragmentation, speed, violence, syntactical distortion, the rejection of logical structure and linear description, and the exploration of the hidden recesses of the mind. The appearance in 1925 of Guillermo de Torre's critique, *Literaturas Europeas de Vanguardia,* undoubtedly played an important part in the diffusion of the new poetic techniques among Spaniards of Lorca's generation. Such poets as Rafael Alberti, Vicente Aleixandre, Gerardo Diego, Luis Cernuda, all responded warmly to the appeal of French surrealism,[11] assimilating its revolutionary doctrines and modifying them within the framework of traditional Spanish poetry. No doubt the visit of the French poet, Louis Aragon, to the Residencia de Estudiantes in 1925 also served to direct the attention of young Spanish writers of the day to the efforts of André Breton and his confreres in Paris. In the case of Lorca, some importance must also be placed on his close friendship with the painter, Salvador Dalí. Lorca's own attempts at painting were conspicuously in the manner of Spanish non-objective artists such as Juan Gris, Picasso, and Dalí. In the decade following 1925, Lorca's poetry was frequently marked by the same privacy of imagery and inwardness of vision which the surrealists in France claimed to derive from pure psychic automatism. This tendency reaches its climax in Lorca's development in the volume, *Poeta en Nueva York,* composed during the unhappy visit to the United States in 1929–30. Some readers have refused to see in this collection anything but a temprorary aberration of the poet's faculties. However, if we examine this phase of the poet's career in relation to changes in his poetic theory occurring in the years immediately preceding his American journey, we can see that this surrealist phase of Lorca's development is deliberate and in no way accidental.

The poet's first important critical pronouncement is his lecture delivered on the occasion of the tercentenary of the death of the Spanish poet, Góngora.[12] In the course of his speculations on the way in which poetry comes about, Lorca states expressly his view that the poet is divinely inspired, but almost in the same breath, emphasizes his belief that this supernatural inspiration precedes but does not accompany the act of poetic creation: "Conceptual vision must be calmed before it can be clarified."[13] This view of *furor poeticus* is on the whole the traditional view of poets since classical antiquity.[14] It is important to add, however, that it was a view which Lorca came to revise radically as his technique came to reflect the poet's obsession with the compelling power of demonic and primitive sources of inspiration and the consequent irrationality of poetic vision.

By 1928 we can see that the poet has advanced a considerable distance from the traditional view of divine inspiration of the Gón-

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[11] Cf. José Luis Cano, "Noticia Retrospectiva del Surrealismo Español," *Arbor* XVI (1950), 334–335.

[12] The text is reprinted in García Lorca's *Obras Completas* (Madrid, 1954), pp. 67–90. Subsequent references are to this edition.

[13] *Ibid.,* p. 80.

[14] Cf. C. M. Bowra, *Inspiration and Poetry* (London, 1955), pp. 2–3.

gora essay. In an interview with a journalist in June of that year, Lorca asserted that his present position in poetry was marked by a return to inspiration: "Inspiration, pure instinct, the poet's only reason. I find logical poetry intolerable. Here truly is the lesson of Góngora. For the present, I am instinctively impassioned."[15] We should view these remarks primarily as a justification of the poetry Lorca was then writing or contemplating, and not as a systematic aesthetic formulation. Yet in the same year, in a lecture entitled "Imagination, Inspiration, Evasion," he attempted to clarify his poetic theory and to set forth the foundations of a new and dynamic poetic freedom.[16] In this lecture Lorca makes a sharp distinction between the provinces of the poet's faculties. Imagination, he asserts, "always operates on data of the clearest and most precise reality. It is within the realm of our human logic, controlled by reason, from which it can not disconnect itself. Its special manner of creating requires order and limits." Inspiration, on the other hand, rises not from human logic but from a poetic logic. It imposes no order, no limits to the poet's activities. While imagination is a discovery that invokes the aid of acquired technique, inspiration is a gift which technique is incapable of bringing forth. Lorca places himself in a direct relationship with the poetics of Rimbaud and his successors when he declares: "The poetic act that inspiration discovers is an act with a life of its own, governed by unpublished laws, and which breaks with any sort of logical control." The result is what he defines as poetry of evasion, an escape from the confines of objective reality "by way of the dream, by way of the subconscious, by way of the dictation of an unusual fact that delights the inspiration."

We can see at once how the wild and hallucinatory imagery of "El Rey de Harlem" or the "Oda a Walt Whitman" of *Poeta en Nueva York* is an expression of this new aesthetic formulation. There is no doubt that the disordered and at times seemingly chaotic vision of the poems of 1929–30 coincided fully with the poet's view of the way his art comes into being. The most extreme assertion of the doctrine of *furor poeticus* in the critical writings of the Spanish poet comes in 1930, in a lecture presented at Havana shortly after his departure from New York, entitled characteristically, "Theory and Play of the Demon."[17] Here Lorca boldly proclaims that "tenir duende"—"to have the demon"—is the sign of

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[15] *La Gaceta Literaria,* 15 de junio, 1928. Cited by Guillermo Diaz-Plajo, *Federico García Lorca* (Buenos Aires, 1948), p. 15.

[16] "Imaginación, Inspiración, Evasión" was first presented in Granada in 1928 and then in Madrid in 1929. Newspaper accounts of the lecture, including substantial quotations from Lorca's text, may be found in "Federico García Lorca: Textes en prose tirés de l'oubli," edited by M. Laffranque, *Bulletin Hispanique,* LV (1953), 332–338.

[17] The text may be found in *Obras Completas,* pp. 36–48.

the greatest artists. What is unique and significant in art comes to us not from the poet, but from the demon through the poet. In figurative language appropriate to the nature of his subject, Lorca invokes not only Socrates, from whose "joyous demon" that of the poet is descended, but also Nietzsche, Rimbaud, Apollinaire, the Arabic bards of the Moors, the dancers of Cadiz, and the great bullfighters of contemporary Spain. Without the presence of demonic possession, no artist can achieve energy or passion and infuse vitality into his art. The demon is "a power and not an act, a struggle and not an idea." It has no relation whatsoever to scientific knowledge or to logical reason, but exists as the spiritual force of creation, residing both within and outside of the artist, in the world about him and in his blood. Its impact on the poet is revealed in "an almost religious enthusiasm" that gives rise to radical changes in the poet's sensations and his forms of expression. Through the struggle it arouses and the inward agitation of the poet within its sway, the demon inspires a creation that is at once magical and intense, and as the forms of demonic possession are endless, so the expression of the poet's inner conflict never takes the same form twice. Inspired poetry is endlessly unique. Each great artist, Lorca declares, is possessed by his own peculiar spirit, and in the act of creation, is overwhelmed by it, transported out of himself and impelled to seek out "new scenes and unknown accents" in the quest of an ineffable vision. The *furor poeticus* is thus the sign and cause of the poet's initiation into the secrets of his art and the mysteries of the universe he inhabits.

In many ways Lorca's poetic theory and practice offer one of the most extreme statements of the doctrine of *furor poeticus* that we may find in the work of a 20th century poet. Yet it is important to recognize that this attitude belongs primarily to a single phase of Lorca's career, frenzied in its intensity and necessarily brief in its duration. We know that by 1932 Lorca had veered sharply away from the poetic theory of demonic inspiration. By that time, indeed, he had become skeptical of any attempt to define poetry, but he insists as forcefully as in the early essay on Góngora on the consciousness of his effort: "If it is true that I am a poet by the grace of God—or of the demon—I am also so by the grace of technique and effort and of my absolute realization of what is a poem."[18] Perhaps this fusion of inspiration and effort represents the poet's final view, but we cannot be sure. By 1932 Lorca was immersed in the composition of plays that were to lead him more and more away from the bold metaphorical and personal style of his poetry toward a more chastened and subdued idiom closer to the language

[18] "Poética," in *Poesía Española*. Selección de Gerardo Diego (Madrid, 1932). The text is reproduced in *Obras Completas*, p. 93.

and experience of every-day reality. How long he would have persisted along this line of development, no one can say. This much, however, is clear: the doctrine of *furor poeticus* played a major role in the poet's assertion of his freedom to give full expression to an inner vision superior to the life of conscious and purposive acts, and in so doing, to explore the depths of his being with an intensity and passion shared by few poets of our time. There can be no doubt that some of the poems of García Lorca written in accordance with the ancient view of how poetry comes about are among the most significant compositions of an age of avant-garde experimentation in European poetry.

When we turn from the European scene to the America of the 1920's, we may observe the same attempt to enlarge the frontiers of poetry through the exploration of the unconscious and the irrational and through the elaboration of new techniques to express the intensity and range of poetic experience. Hart Crane is among the most representative of the American poets who participated in this enterprise. In both theory and practice, his work provides a striking illustration of the continuity and inter-relatedness of European and American poetry in our time.

We can readily understand why the doctrine of *furor poeticus* should have been congenial to Hart Crane at the beginning of his poetic development. A youth of unusual sensitivity and delicate balance, easily susceptible to external excitation, alienated in his environment, Crane seized on the tradition of the poet's divine inspiration as a way of justifying the uniqueness and sanctity of his poetic vision. In his copy of Plato's *Phaedrus* he underscored in heavy lines the assertion of Socrates that "the poetry of sense fades into obscurity before the poetry of madness."[19] We know that Crane was reading Plato in the spring of 1919;[20] the Platonic view of poetic inspiration was to affect his poetics and his poetry throughout the whole of his career.

Few poets have been as susceptible as Hart Crane to literary influences. From the very beginning of his discovery of his poetic vocation, Crane read avidly in the classics of ancient and modern literature, and especially in contemporary poetry. With other young writers of his time he shared an admiration of Ezra Pound and T. S. Eliot, and delighted in the paradoxical wit of Donne and the Metaphysical poets. At the same time, Crane selected his masters carefully, deliberately constructing a poetic tradition that he felt would respond to his aims and temperament and serve to guide his development. His principal models, in addition to those mentioned, were Blake, Whitman, Nietzsche and Rimbaud.

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[19] Philip Horton, *Hart Crane* (New York, 1937), p. 125.
[20] *Letters of Hart Crane* (New York, 1952), p. 17.

It was probably in the pages of *The Dial* for 1920, where some of Crane's first published poems appeared, that he came to know Rimbaud. In the summer of that year *The Dial* published a translation of the *"Lettre du Voyant,"*[21] and also versions of the poet's two collections, *Les Illuminations* and *Une Saison en Enfer.* At once, Crane wrote to a bookseller in Paris for a copy of Rimbaud's poems. He received them in the fall of 1920 and read them as well as he could with the aid of a dictionary.[22] Thereafter he frequently drew upon Rimbaud for guidance in his writing and in his evaluations of other poets.[23] Edgell Rickword's study of Rimbaud, published in 1924, furnished him with additional evidence of the French poet's significance. In a letter of June 20, 1926, Crane declares flatly that "Rimbaud was the last great poet that our civilization will see," and in almost the same breath he couples Rimbaud and Blake as the prime examples of the generative power of the poet's inner feelings and explorations.[24] In his demand for "a reasoned derangement of all the senses" so as to make of the poet a seer, Rimbaud provided the young American with a poetic credo fully in accord with his unusual excitability and with the demonic and irrational impulses animating his art. In its fundamentals, Hart Crane's poetic theory is a direct expression and enlargement of that of Rimbaud.

It is in some ways surprising to see Hart Crane attempting to provide a conscious rationalization of an art founded on the exploration of the unconscious and irrational. Yet Crane was far more concerned with questions of poetic theory than many more learned poets of the 1920's, and his aesthetic speculations provide at least some measure of the seriousness of his efforts to define his attitude toward his art. Perhaps his most important critical statement is the essay, "General Aims and Theories," written in 1925 by way of clarifying the poems in his first collection, *White Buildings.*[25] It is here that he sets forth most elaborately his theory of the "logic of metaphor" as the organizing principle of poetic expression:[26]

> As to technical considerations: the motivation of the poem must be derived from the implicit emotional dynamics of the materials used, and the terms of expression employed are often selected less for their logical (literal) significance than for their associational meanings. Via this and their metaphorical inter-relationships, the entire construction of the poem is

[21] See n. 8 above.
[22] Brom Weber, *Hart Crane* (New York, 1948), p. 107.
[23] An extended discussion is provided by Brom Weber, *ibid.*, pp. 144–150.
[24] *Letters*, p. 260.
[25] The essay is reprinted in Horton, *op. cit.*, pp. 323–328.
[26] *Ibid.*, p. 327.

> raised on the organic principle of a "logic of metaphor," which antedates our so-called pure logic, and which is the genetic basis of all speech, hence consciousness and thought-extension.

The reliance on emotional dynamics and on free association in the use of language points clearly to a technique of syntactical dislocation and metaphoric fragmentation, of wilfully induced hallucination very much in accord with the aims of Rimbaud and of his followers in the avant-garde movements of European poetry.

At the same time, there are significant differences, and it is especially important to recognize that at times, Crane's view of the role of acquired skill, of conscious art, in the creative process is altogether traditional. "There is little to be gained in any art so far as I can see, except with much *conscious* effort," he wrote in a letter of 1921.[27] Yet the aim of this effort as subsequently set forth came to be the total transformation of the realm of rationally ordered logic into a vision that will embody "the so-called illogical impingements of the connotations of words on the consciousness."[28] Rimbaud too had insisted on the deliberate as opposed to the unconscious source of poetic madness, but Crane goes further than his predecessor in asserting the primacy of intuitive vision, of ecstatic joy, of "the tremendous emotional excitations" that characterize for him the poetic act.[29] He is not as bold as the Lorca of *Poeta en Nueva York* who held that madness is the poet's divine right and the mark of his greatness, but Crane's impassioned cry, "New thresholds, new anatomies!" is not only an ecstatic outburst inspired by alcoholic intoxication; it is a plea for an enlargement of the poet's province, an affirmation of the power of vision and transformation that the true poet possesses. In this claim we can see once more an attempt to re-establish the sanctity of poetic inspiration through the invocation of the doctrine of *furor poeticus*.

This view of the poet's demonic possession and divine inspiration can be found in 19th century poetic thought in the United States as well as in Europe, and we should not overlook Crane's conscious affinities with his American forbearers in his poetic theory. Emerson had declared in his essay on "The Poet" (1844) that poetry is a response to an inner voice, the fruit of the poet's wonder and exaltation in discovering "what herds of daemons hem him in." The act of composition he held to be a systematic and deliberate process, the organization of "a metre-making argument," but he adds that the poetic impulse is a divine gift. It is altogether understandable that Emerson's greatest admirer among American poets, Walt Whitman, shared this view of the poet's supernatural origin

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[27] *Letters*, p. 52.
[28] See Horton, *op. cit.*, p. 330.
[29] Cited *ibid.*, p. 152.

and character. In "Song of Myself" the prophet-seer proclaims his divinity "inside and out": "Through me the afflatus surging and surging." Poetry for Whitman is the expression of a cosmic spirit that gives life and energy both to the poet and to the universe. The *furor poeticus* is not so much a description of the way poetry allegedly comes about, as a sign of the special function of poetic expression: the communication of the poet's unique insight into the divine poem of which he is a part.

From the beginning of Hart Crane's speculations on his epic poem, *The Bridge,* early in 1923, Whitman was foremost in the poet's mind.[30] His growing sense of personal identification with Whitman, that reached its culmination in the "Cape Hatteras" section of *The Bridge,* was in large part a response to his need for a "gigantic vision" as a means of ordering his inner turbulence. The glorification of the poet's conception of "the American myth" in his major effort flows directly from his interpretation of the spiritual message of Whitman's poetry. Crane came to see himself as Whitman's immediate successor and repeatedly urged the importance of Whitman's example for all American poets, present and future.[31] There can be no doubt that Crane's deliberate attempt to liberate poetry from the shackles of rational logic and scientific discourse owed at least as much to Whitman as it did to Rimbaud. In both instances, the doctrine of *furor poeticus* was available in a contemporary form that could be readily absorbed into the poet's aesthetic.

Hart Crane's poetry provides ample proof of the importance of his preoccupation with the roots of poetic expression. In his lyrics such as "Voyages" in *White Buildings* as well as in the poems that make up *The Bridge,* the poet's language is marked by an unusual reliance on associational values, a fluid expansion and amalgamation of metaphors and symbols. Often, his imagery is reduced to fragments, in which an extended series of acts or feelings may be rendered in a single word or phrase. The poet's radical individuality, his free employment of autobiographical reference and private allusion, further complicates his art. Yet the poems of Hart Crane, like those of Rimbaud or García Lorca, cannot be dismissed as unintelligible simply because they do not reveal all of their secrets at a single reading. The best of these poems are not so much the products of uncontrolled thoughts and feelings as the expression of an inner vision transcending literal statement in order to make known the hidden, underlying relationships and values of objects and events. For the poet, inspiration and its accompanying inner

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30 *Letters,* pp. 128–129.

31 See Hart Crane's essay, "Modern Poetry," reprinted in *Collected Poems of Hart Crane* (New York, 1946), p. 179.

turbulence is the source of poetic composition, but it does not exclude the operation of acquired technique; rather, it enhances what art the poet may possess and aids him in his deliberate quest for a fusion of chaos and order. Clearly, there is nothing in the poetic theory of Hart Crane that would exclude the most rigorous revision, but this too, he would hold, should be inspired by the poet's awareness of his secret and dynamic powers. It is this unique consciousness that directs and shapes the poet's language in accordance with the dictates of his inner vision. That Crane in his most ambitious poetry organized his vision into a harmony of parts and whole may be doubted, but the energy and power of his shorter poems as well as of sections of *The Bridge* are a lasting testimony of his poetic genius. His best poetry is in perpetual readiness for rediscovery and assimilation by all who would enlarge the resources of the poet's art.

It is not difficult to understand why poets committed to radical experimentation in language and to an intense and passionate exploration of their innermost feelings as the groundwork of poetic expression should find the doctrine of *furor poeticus* congenial to their art. Whether theory preceded or followed technique is not always clear; often the two develop hand in hand, interacting and mutually reinforcing one another. In the instances of Rimbaud, García Lorca, and Hart Crane, there can be no doubt that the age-old view of the poet as a being at once inspired and possessed, and thereby endowed with unique powers of intuition and devination, has been of vital importance in their poetic art. It has mattered both as strategy and tactics, justification and exploration, a means of evading common reality and of enlarging the poet's vision of a deeper, mysterious reality. From an objective and critical standpoint, *furor poeticus* can never provide a satisfactory account of the poet's ways and means, but this has not been its office. It has served in our time as a reassertion of the poet's primitive authority and spiritual power, a liberation of the ecstasy and wonder of the poet's universe.

NAVAL WARFARE IN THE RIO DE LA PLATA REGION, 1800–1861

CLIFTON B. KROEBER
*Department of History, University of Wisconsin**

Naval war is an important but little-known phase of the early national histories of Argentina, Paraguay, and Uruguay.[1] While the decisive battles of South American independence were fought by armies, in Chile, New Granada, and Peru, between 1818 and 1824, these battles occurred 10 years after the three colonies of the Río de la Plata region were free of Spanish rule. In their part of the world, Spanish power was shattered by a naval battle in 1814. Later, naval war was important in the turbulent civil and foreign wars that punctuated the history of the Plata region until 1861.

The three colonies of the Viceroyalty of the Río de la Plata shared with Brazil and Bolivia the great Plata-Paraná-Paraguay river basin, an area larger than the United States east of the Mississippi. In 1800, most of the colonists still lived close to the rivers. There were few cart roads anywhere in the region, and the rivers were the ordinary routes of travel. The colonists were old hands at running their little sailing ships among the channels and islands of the Paraná River and its great delta. Contraband trade was a long-established habit, and these sailors knew every tangled passage and channel that led through the delta from the Argentine to the present Uruguayan shore.

Deep-water sailing was quite unfamiliar to the colonists. For 300 years Spain had prevented her colonials from building sea-going ships or learning overseas navigation. When Spain's weakness encouraged foreign invasion of the Plata region in the early

* Now at Occidental College, Los Angeles.

[1] Some aspects of naval history of the Plata region have been thoroughly studied. See, among others: A. J. Carranza, *Campañas Navales de la república argentina* . . . (Buenos Aires, 1914–1918); Teodoro Caillet-Bois, *Historia naval argentina* (Buenos Aires, 1944), and *Los marinos durante la dictadura* . . . (Buenos Aires, 1935); Juan B. Otaño, *Origen, desarrollo y fin de la marina desaparecida en la guerra de 1864–1870* (Asunción, 1942); Lewis W. Bealer, *Los corsarios de Buenos Aires . . . 1815–1821* . . . (Buenos Aires, 1937); Agustín Beraza, *Los corsarios de Artigas* (Montevideo, 1949); and Charles C. Griffin, "Privateering from Baltimore during the Spanish-American Wars of Independence," *Maryland Historical Magazine,* XXIII (1940), pp. 1–25.

Abbreviations used in this article are: ANA—Archivo General de la Nación, Buenos Aires; ANU—Archivo General de la Nación, Montevideo, and, within that, ex-MHNU refers to papers formerly in the Museo Histórico Nacional, Montevideo; ANP—Archivo de la Nación, Asunción; CDBA—Consular Despatches, Buenos Aires, in The National Archives, Washington, D. C.; MHNU—Museo Histórico Nacional, Montevideo.

nineteenth century, there was only a handful of colonists who knew how to sail large ships or how to fight a naval battle.

Spain kept professional naval officers in America at that time so that the colonists need not learn the naval profession. Montevideo had been made one of six major naval bases Spain maintained in America. Warships for the base were scarce during the last years of the eighteenth century and in the early 1800's,[2] and the commander at Montevideo used such warships as came to the Río de la Plata on temporary duty like transatlantic convoy. He also had a number of river gunboats,[3] probably small ones, with one cannon, that used both sail and oars. Meanwhile, Buenos Aires could not be defended against amphibious attack, since the coast is so low and easy to approach in small boats; so the Spanish crown made no attempt to build more than a simple fort there. The Spaniards depended on their strategic strong point of Montevideo to guard all the back country against foreign attack.

In 1806, the Río de la Plata faced its first large foreign invasion, and the colonists learned their first naval lesson. No Spanish warships were present[4] when a British invasion fleet sailed into the estuary—quite unauthorized by the British government, as it happened—and the colonists had to defend themselves against some of the world's best soldiers and sailors. In a rapid enveloping movement, the British landed troops near by, and their ships blockaded Buenos Aires. The story of the ensuing fight in the city and the unexpected Argentine victory is well known, but the naval preliminaries of the colonists' victory were of key importance. A force of fighting men sailed across from the Uruguayan shore in small ships and boats, evading the British vessels and bringing to Buenos Aires leaders and soldiers who soon won the battle in the city.[5]

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[2] In 1797 there were six frigates, some meant for occasional convoy duty; ANA, Consulado, Expedientes, leg. 2, exp. 31. About 1800 only one frigate, two corvettes, 21 launches, and a few other small craft were there; H. Martínez Montero, *Marinas mercante y de pesca del Uruguay* (Montevideo, 1940), I, 37. One large vessel had been sold at Montevideo because of doubts it would ever survive the trip back to Spain; see Expediente obrado para la venta y remate dela Corbeta de Guerra S.ta Escolástica, ANU, ex-MHNU, caja 245, carpeta 31. This had been the only large ship at Montevideo.

[3] This force fluctuated in numbers, and other launches there were for nonmilitary purposes. See the record of one built at Buenos Aires, for a six-man crew: Consulado of Buenos Aires to its deputy at Montevideo, Buenos Aires, October 3, 1804, in MHNU, Consulado de Comercio, legajo 1802–1804.

[4] Martínez Montero, *op. cit.*, I, 37. When the English captured Montevideo in 1807, there were only a dozen launches there. Captain Juan Gutiérrez de la Concha had brought six larger ships from Spain with seven light gunboats, in 1806; but such small ships as these were hidden in the inner port at Buenos Aires to protect them while the British were present: see Carranza, *op. cit.*, I, 19–20.

[5] Even after the British had given up the invasion and were blockading the northern entrance channel and raiding into the estuary, there were no major war vessels on hand: Santiago de Liniers to the Consulado, Buenos Aires, December 17, 1807, ANA,

The British naval-blockaders meanwhile suffered from ignorance of the treacherous estuary's sailing conditions. Six of their gunboats went aground and had to be towed away. They then lost a major warship, probably one of the few British warships ever to surrender to cavalrymen, who were able to splash out from the shore when an unexpected change in the weather sent the water level so low that the warship was stranded, several miles from shore.[6] The British did not realize that the estuary is so shallow that heavy ships were always in danger of going aground during a slight change in weather and water level. The colonists learned another lesson during this fighting: that small river craft could do much, even in the face of large warships, by stealing back and forth in the shallows of the estuary and delta.

After this invasion and a further British attempt in 1807 had been repelled, Spain allotted a number of large warships to continuous duty at Montevideo.[7] This fleet was on hand when the colonists of Buenos Aires began their war of independence in 1810. In August,[8] the Spanish ships blockaded Buenos Aires, to cut the rebels off from foreign trade and thus from any independent source of revenue. The royalists took charge of ports on the Uruguayan shore, Colonia and Maldonado, and they soon dominated the Paraná River as far north as San Nicolás and the Río Uruguay all the way up to the head of navigation at Salto. In 1811, the Spanish viceroy Elío authorized privateering in the rivers, a common war measure in those days, and Spanish naval activity on the rivers was conducted chiefly by these privateers,[9] who ranged as far upriver as

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Consulado, Expedientes, leg. 4. He says there were three small schooners and some gunboats, two of them maintained by the consulado.

Liniers crossed from Colonia to Las Conchas (Tigre, now in the suburbs of Buenos Aires), using small ships, on August 3, 1806. The British had four ships of the line (50–64 guns each) and eight other vessels: Caillet-Bois, *Historia naval,* pp. 29–30.

[6] Alexander Gillespie, *Gleanings and Remarks, collected during many months of residence at Buenos Aires* . . . (Leeds, 1818), p. 35.

[7] At least nine sizeable warships were there by September, 1810: Carranza, *op. cit.,* I, 35.

[8] Communication between Buenos Aires and Montevideo was cut off August 13, 1810, and on September 10 the Spanish ships appeared off Buenos Aires; see Caillet-Bois, *Historia naval,* pp. 40–42. On the 16th and 17th ensued one of the strangest incidents in naval history. A storm wind from the southwest *(pampero)* had been blowing for a day and night, and the water level in the estuary had fallen many feet by the morning of the 17th. H.M.S. *Porcupine,* off the coast at Quilmes, was lying in only four feet of water. The Spanish blockaders, five to eight miles offshore, were in only twelve feet. The revolutionary Junta lost the opportunity of taking guns out into the estuary to bombard the blockaders, and by 5 A.M. on the 18th, the water rose again. See Carranza, *op. cit.,* I, 35–37, and Caillet-Bois, *Historia naval,* pp. 42–43. The latter believes the water must have fallen to 8–10 feet below mean low water (which was then reckoned at what we would call the average of lowest seasonal lows).

[9] Both Buenos Aires and the Spanish officials at Montevideo authorized privateering before 1816; see H. D. Barbagelata, *Artigas y la revolución americana* . . . (2nd ed., Paris, 1930), p. 34 (Elío's decree authorizing it, November 18, 1812); Carranza, *op. cit.,* I, 227 (three Buenos Aires privateers captured in 1811); and *Las presas marítimas en la república argentina* . . . (Buenos Aires, 1926), pp. 85–86 (Spanish privateers at Santa Fe, 1812), and pp. 94–95 (Battle between privateers, December 4, 1814). These early corsarios, like the earliest Artigas commissioned in Uruguay, evidently operated only in the estuary and rivers.

Paraguay. On the other hand, the Spaniards had few troops anywhere in the region, and the garrison of Montevideo was not strong enough to leave the walls of the city itself. For the time being, the Spaniards had no usable army and the revolutionists no navy; so the war dragged.

The revolutionists of Buenos Aires were slow to understand that they were engaged first of all in a naval war. They allowed a large number of Spanish naval officers to return freely to Montevideo when the fighting started,[10] and at first they did nothing to create a navy. In 1811, they had a small fleet but disbanded it when a temporary truce was made with Viceroy Elío.[11] When hostilities broke out again in 1812, the revolutionists on both the Argentine and Uruguayan sides of the estuary were so numerous that they put Montevideo to the siege, but there was no navy to seal up the port or to protect the passage of men and supplies from the Argentine to the Uruguayan shore.

With Spanish warships on hand, supplies could reach the army only by a very roundabout route. For almost two years, the Buenos Aires government had to cart supplies by land, north to San Nicolás or Santa Fe on the River Paraná, across the river to the town of Paraná, then across the whole province of Entre-Ríos to the River Uruguay, and overland again through Uruguay to the outskirts of Montevideo.[12] Meanwhile, Buenos Aires also had trouble keeping in touch with the towns along the River Paraná, because Spanish privateers were so active on the river. The Spanish ships managed to avoid the revolutionists' batteries on the riverbanks by using alternative river channels.[13]

Finally, in 1814 a group of foreign merchants influential in the Buenos Aires government prevailed on Supreme Director Gervasio Posadas to allow them to buy and arm private vessels for a war fleet.[14] They enlisted foreign sailors, found a Yankee trader to pay

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[10] Caillet-Bois, *Historia naval,* p. 40.

[11] *Ibid.,* p. 68. The blockade was lifted October 16, 1810, due to pressure brought by British naval officers. Viceroy Elío arrived at Montevideo in January, 1811, and re-imposed the blockade in March. He signed an armistice with Buenos Aires on October 20, 1811, at which time the quondam "warships" of Buenos Aires were returned to their owners (*ibid.,* pp. 45, 58, 67).

[12] *Ibid.,* pp. 80–81. General Rondeau put Montevideo to the siege October 20, 1812, in coöperation with Artigas and other Uruguayan leaders. The blockade of Buenos Aires was renewed by the Spaniards on March 4, 1812: see U. S. Consul W. G. Miller's despatch, March 25, 1812, CDBA, I, stating that the Spanish force numbered twelve sail.

[13] This, in spite of a carefully worded warning against just such a thing by the governing Junta at Asunción, Paraguay, January 29, 1812; see Benjamín Vargas Peña, ed., *Paraguay-Argentina, correspondencia diplomática,* . . . (Buenos Aires, 1945), pp. 116–117. The Junta also asked to have privateers sent to Paraguay, and their letter shows that river craft were being held in port as much as possible while the danger from Spanish privateers was still great.

[14] Caillet-Bois, *Historia naval,* pp. 84–86.

the bills, and proposed a tough old Irish sailing captain named William Brown as admiral.

Brown's force of converted merchant ships never did match the strength of the Spanish fleet and he had his work cut out for him in training local lads for the navy; but foreign sailors and shipmasters gave the necessary stiffening of experience. Brown himself proved to be a born commander. He had the rare ability of convincing governments that he was doing the best possible job despite small progress and frequent setbacks. His continuity in command is unique in the military annals of the period. Brown was also a fine sailor, and he made careful use of the peculiar features of the Plata estuary. He knew when to offer battle, when to fade away into a fog, and how to take refuge in waters where a stronger enemy could not follow. He was personally fearless. As commodore of a questionable little fleet, he repeatedly sailed his flagship into such danger that his captains would not follow. This aggressive posture impressed the government and the navy alike, and Brown soon found officers who dared to sail with him.

The Spanish advantage was in size of ships and in guns that could do damage at long range; but Brown would storm alongside to board or retreat safely into shallow water instead of anchoring his ships to indulge in suicidal cannonade. He found unexpected opportunities to cut out units of the Spanish fleet, striking with great daring when given the slightest chance.[15]

Brown's first objective was to drive the Spanish privateers out of the River Paraná and the delta. He won a small river battle and gained the strategic island of Martín García (March, 1814), thereby barring the Spanish naval forces from the River Paraná. Then he appeared off Montevideo with his whole force, blocking the Spanish warships from the upper estuary unless they cared to fight their way through his squadron. The strategic value of this move was that supplies could now be ferried from Buenos Aires directly to the Argentine forces besieging Monteviedo.[16]

The Spaniards, penned up in a besieged and dreary city, were hesitant to fight at sea; but one of them was finally persuaded to lead the ships out against Brown's armada. After a two-day battle punctuated by violent weather, Brown caught the Spaniards and ran them down or shot them to pieces (June 12–15, 1814). It was a

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[15] His small fights are described in Carranza and Caillet-Bois' works. He took the fleet out March 8, 1814, using ships bought in the port. One *balandra* and one *falucho* were already on hand.

The only previous fleet, in 1812, had been sent toward Paraguay to support General Manuel Belgrano's army in that direction. These three ships were caught in the delta region and beaten to pieces by Spanish forces: Caillet-Bois, *Historia naval*, pp. 52–56.

[16] After the Martín García battle, the Buenos Aires government sent 3,000 men across the estuary in 22 transports.

one-sided victory and practically the end of the Spanish fleet.[17] The evacuation of Montevideo by the Spaniards followed almost at once (June 23, 1814), dissolving an army of 6,000 men, the last Spanish force still occupying the Plata region. Where the land siege had not brought victory, the naval campaign helped to tip the balance against the Spaniards.

Now that the homeland was free of Spanish troops, the governments of Buenos Aires and Montevideo carried the war against Spain. Brown's converted merchantmen could not challenge the Spanish navy off the coasts of Europe; but large seagoing ships could. The story of the deep-water privateers of Buenos Aires and Montevideo, beginning in 1815, is a sequel to the North American sea war against Britain in 1812–1815. Many of the same Americans participated, sailing now under the flags of nations whose language most of them did not speak and whose shores some of them never saw.[18] These *corsarios* were usually financed by foreign merchants at Buenos Aires or Montevideo, and almost all of them were foreign ships with polyglot crews.[19]

Their war was disastrous to Spanish commerce. In 1817 they hung off Cádiz, cutting up the merchant shipping of Spain and taking contraband cargoes from neutral ships. Privateers commissioned by José Gervasio Artigas of Uruguay[20] did most of their fighting against Portuguese shipping,[21] since the Portuguese monarch, then in Brazil, wanted to annex Uruguay to his possessions. Artigas' privateers also added to the damage sustained by Spain. In 1818 and 1819, their attacks on Spain and Portgual were at their peak; but having captured most legitimate prizes, they turned more and more to piracy.[22] It was 1821 before Buenos Aires called an end to authorized privateering,[23] and both the British and Ameri-

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[17] Brown had seven ships, more than 1100 men, and 130 guns (captains Baxter, Clark, Russell, King, MacDougall, Lamarca, and Hubac). The Spaniards had 11 vessels, 1087 men, and 155 guns; see *ibid.*, pp. 97–100. The Spanish disadvantage was that the guns were divided among more ships and leadership was poor. Brown received one reinforcement during the battle. He captured four ships, burned two others, and chased the rest away.

[18] Bealer, *op. cit.*, Beraza, *op. cit.*, and Griffin, *op. cit.*, discuss this privateering. It is not necessarily true, as Bealer states (p. 10), that the major role in the creation of the Argentine navy was played by men from the United States. William P. White did finance the 1814 fleet out of his own pocket, and many of the first captains were United States citizens.

[19] Bealer, *op. cit.*, pp. 10–11; Beraza, *op. cit.*, p. 33; and Caillet-Bois, *Historia naval*, p. 96.

[20] Beraza, *op. cit.*, pp. 182–184, 186, for effects of this effort during 1817 and 1818.

[21] Bealer, *op. cit.*, p. 201, mentions how serious it was.

[22] The history of these privateers has been written mainly by historians partial to Buenos Aires; but the weight of evidence seems to show that Artigas' privateers were poorly controlled and often continued their activities into the period when privateering was becoming piracy. It should be remembered, however, that Artigas' position was much more desperate than that of Buenos Aires. He was considered a rebel by Buenos Aires and his homeland was invaded by a large Portuguese army.

[23] A copy of Governor Martín Rodríguez's decree, Buenos Aires, October 6, 1821, is included in CDBA, II.

can navies had to make full efforts to keep the sea lanes reasonably safe. As one port after another refused to receive their prizes, these modern corsairs fell back on the old haunt of American piracy, the Caribbean. What had become an international abuse by 1819, however, had been a legitimate[24] and effective arm of war for several years before. Buenos Aires and Montevideo had had seagoing ships that could even the score with Spain and Portugal.

In 1816, Buenos Aires had also equipped its own warships[25] for use against certain dissidents in the river provinces (Entre-Ríos, Santa Fe, Corrientes and Uruguay, then known as the Banda Oriental). Artigas of Uruguay had a fleet of small ships in the middle Paraná. After the Portuguese invaded his province and occupied the capital city of Montevideo (January 19, 1817), he created another small force in the Río Uruguay. His ships made damaging attacks on Buenos Aires war vessels in both rivers. These battles were not large but they were bloody, deadly-serious encounters affecting the political domination of the whole river region. The ships of the two major powers, Buenos Aires and the Portuguese, found that naval action in the rivers was tricky and hazardous. Danger lurked for any ship sailing in the rivers, where the navigable channels led the ship from shore to shore, often under the fire of concealed batteries. Launches could put out from the river banks to overwhelm any ship that grounded on a sandbank or was separated from its squadron.[26]

In 1818, the Portuguese finally gained control of the Rio Uruguay, storming Artigas' batteries on the western bank and capturing his small fleet. The meaning of this victory was that Artigas found it hard to move freely back and forth across the Río Uruguay as he had in the past. He now had to operate either west of the river, in Entre-Ríos Province, or east of it, in what is now Uruguay. The Portuguese also took Colonia, removing the last local base for Artigas' privateers who now had to use foreign ports exclusively.[27]

By contrast, the failure of Buenos Aires to control the River Paraná during late 1819 and early 1820 helped Francisco Ramírez of Entre-Ríos Province to organize a campaign along the river and finally to beat the forces of Buenos Aires. The naval success of Ramírez was probably a factor both in his victory in the land battle

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[24] War was war, and Spanish corsarios too broke the rules of polite privateering. By 1817, in any case, Artigas knew that his cause was failing; see Beraza, *op. cit.*, p. 345.

[25] U. S. Consul Halsey's despatch, July 19, 1815, CDBA, I, notes that four or five ships were to be put "in active service" as part of the measures against Artigas.

[26] Sometimes these incidents were as novel as they were inspired. One tiny ship of the Buenos Aires flotilla, retreating down the River Paraná in 1816, was lassoed as it passed close to the high river bank: Caillet-Bois, *Historia naval*, p. 155.

[27] *Ibid.*, pp. 155–159. Artigas had had twelve little ships in the Arroyo Perucho Verna, just above Colón on the west bank.

of Cepeda and in his brief domination of the city of Buenos Aires during early 1820. This was the first and almost the only campaign in which Buenos Aires altogether lost control of the river provinces. Later, Ramírez' squadron was beaten. His control of the river once broken, he was caught on the western bank of the Paraná among hostile armies that soon drove him to his doom.[28] Naval forces had played a secondary but very important role in the continuous fighting since 1815 that saw Artigas driven out of Uruguay (1820), Ramírez fail in an attempt to impose federalism on Buenos Aires, and both Buenos Aires and Portugal emerge as major powers in the Río de la Plata.

In the years that followed, Buenos Aires drifted into a war with the newly independent Empire of Brazil. The chief cause was rivalry over present-day Uruguay. In 1823, the Brazilians completed their war of independence by blockading Montevideo into submission, capturing it, and incorporating the whole province into the new Empire. Buenos Aires still claimed the Uruguayan territory, and in 1825 she encouraged a small group of Uruguayans who invaded their homeland in order to make it an Argentine province. In spite of the obvious danger of such a policy, Buenos Aires made no naval preparations while war was impending, or indeed until the war with Brazil was already a month old (January, 1826).[29] At that time, William Brown was again offered the command of a Buenos Aires navy that consisted of two old river craft and a dozen gunboats recently used only as rock barges. The old seadog took charge at once and sailed out the very next day to reconnoitre the Brazilian squadron blockading Buenos Aires.[30] For more than a year he fought against an ever increasing Brazilian force that finally numbered more than fifty warships.

Brown had luck at first. He frequently sought battle, engaging the enemy under almost preposterously dangerous conditions. By sheer aggression, he induced the Brazilians to withdraw their

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[28] *Ibid.*, pp. 199–206, for an account of this whole campaign that ended in July, 1821.

[29] A Brazilian fleet appeared off Buenos Aires in July, 1825, to inquire why the government appeared to be helping General Lavalleja and the rest of the Thirty-Three *Orientales* (Uruguayans) who invaded the Banda Oriental in that year; *Ibid.*, p. 214. By October 19, U. S. Consul Slacum reported that the Brazilian squadron was again lying off the port, and he expected war soon. See his despatch of November 5, 1825, CDBA, II.

[30] Caillet-Bois, *Historia naval*, p. 223. War was declared by Brazil on December 10, 1825, and on January 11 Brown was asked to serve. On the 12th, he made his first trip from the port. The Buenos Aires government authorized privateering, January 22, 1826.

As always, the navy had to be re-created. J. J. M. Blondel, *Almanaque político y de comercio de la ciudad de Buenos Aires . . . 1826* (Buenos Aires, 1825), pp. 45–47, lists the pre-war naval organization that furnished only two captains (Cerruti and Rosales) to Brown's fleet of 1826. The *Gaceta Mercantil*, Buenos Aires, February 17, 1826, reported that captains Clark, Parker, Espora, Cerruti, Rosales, and Handell were being appointed "while the conduct of the former captains is being reviewed." Brown, in short, ran his own show.

blockade so far down the estuary that Buenos Aires opened a direct supply line to the Uruguayans fighting to free their province.[31] This success did not last long. The Brazilians selected better commanders and sent in more warships, until the Buenos Aires navy could make only occasional hit-and-run attacks.[32] The imperial fleet divided into three units: heavy ships waited to catch the elusive Brown whenever he stood out of the inner roads of Buenos Aires; light craft in the Río Uruguay blocked the east–west supply line to the Uruguayan army; and a mixed force remained near Montevideo as a distant blockade of the approaches to Buenos Aires. The Brazilians finally overwhelmed Brown, and they reduced the foreign trade of Buenos Aires to almost nothing.

The Argentine commodore succeeded in crossing the estuary and cutting up the Brazilian gunboats in the Río Uruguay,[33] and on more than one occasion he held his own with the blockading squadron. The attrition of battle was too much for his few ships, however, and when in April, 1827, two of his vessels were caught and destroyed while aground on a sandbank,[34] his "fleet" action had to cease.

The Buenos Aires navy had fought bravely. Most of the leaders were foreigners, but Brown discovered a number of Argentines whose courage and skill fitted them for ship commands. Some of these same Argentines lent their experience to the establishment of

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[31] The Brazilians would not fight his leaky old tubs at that time. The blockade was withdrawn to Punta de Indio, far down the estuary. On February 9, Brown fought a drawn battle using ships captained by Parker, Seguf, Mason, Baisley, Cerruti, and Warner, and with Espora and Rosales commanding smaller *cañoneras*. After that, he had a bloody failure trying to take the port of Colonia, March 1, 1826—it was a land-sea operation with too little coördination of effort. The Portuguese nonetheless evacuated Martín García Island, near Colonia. Caillet-Bois, *Historia naval,* p. 242, believes they did it because Brown was expected to keep on trying until he took the island and the port.

[32] The blockade was tight after July, 1826, when Admiral Norton reorganized the Brazilian fleet. He led most of his thirty-one ships (266 guns, 2300 men) against the port of Buenos Aires in July, 1826, trying to wipe out Brown's force; but the affair ended without a casualty. Brown's four remaining vessels escaped into shallow water where Norton could not follow.

[33] The navy lists copied in J.A.B. Beaumont, *Travels in Buenos Ayres and the adjacent provinces . . .* (London, 1828), pp. 216 ff., show that he not only broke up this force of about twelve gunboats but also put some of them into his own fleet. As of April, 1827, Brown had thirty-one vessels ("merchant brigs, small schooners, and sailing barges"), and 186 guns, as against the thirty-six ships and 452 guns of the Brazilians.

[34] This was the so-called Battle of Monte Santiago, April 7, 1827. Some of the best officers and sailors were lost here, since two Argentine ships fought almost to the last man; Caillet-Bois, *Historia naval,* p. 318, and Beaumont, *op. cit.,* pp. 220–222. Some of Brown's captains not mentioned above were: Bathurst, Coe (his second in command on several occasions), Silva, Granville, Shannon, and Drummond. Captain Parker was one of many colonists who came out from England in August, 1825, in the Beaumonts' Río de la Plata Agricultural Association, and who then saw service in the cause of Buenos Aires. Beaumont, *op. cit.,* pp. 4–6, 122, 223, 246, assigns this as a prime cause for the failure of the immigration scheme, and he says that some of his peaceful agriculturists were even making fortunes as privateers.

Brown's last aggressive action was on July 29, 1827, when he sailed into the blockading force off Buenos Aires and fought almost alone until the next day. His captains finally rescued him.

the steam boat navy and the Argentine Naval Academy a generation later.

Privateering was harder to stop. Brown himself was one of the commanders who went out to sea to harry the Brazilian coasts after his fleet had stopped fighting in the estuary. The *corsarios* of Buenos Aires wreaked havoc along that shore[35] all during the war. On the other hand, naval victory in the estuary helped the Brazilians keep a tight blockade on the port of Buenos Aires.[36] Customs duties were the chief revenue of the Buenos Aires government, and the loss of this income led to unsound monetary policies, depreciation of money, and inflation.[37] Loss of prestige due to the failure to win this war was also a major factor in the overturn of government at Buenos Aires in 1827. The group that went out of power had been making an ambitious attempt to unify the nation, and the war helped bring that attempt to nothing.

After the war, the Buenos Aires fleet was disbanded again,[38] and there was no naval resistance to the French naval intervention in the estuary in 1838–1840.[39] The small fleet that did exist during that period[40] was insufficient even for the war against independent Uruguay that broke out as soon as the French warships were gone. The Buenos Aires dictator Juan Manuel de Rosas had to buy more ships[41] and go to much trouble finding experienced sailors before

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[35] Caillet-Bois, *Historia naval,* p. 218, copies the names of sixteen of them, evidently half of this list being estuary and river craft.

[36] César Díaz, *Memorias, 1842–1852* . . . (Buenos Aires, 1943), tells how they held close to Buenos Aires and also kept a close guard over the small but important estuary port of Salado, while he was there in 1827–1828. The blockade of Buenos Aires began December 21, 1825 and ended September 30, 1828; see *The British Packet and Argentine News,* Buenos Aires, August 31, 1833. This newspaper listed 106 foreign merchantmen as having broken the blockade; 16 in 1826, 38 in 1827, and the rest in 1828; but these figures are a total of ships arriving at Salado and Ensenada de Barragán as well as at Buenos Aires.

[37] The ratio of Buenos Aires paper money to silver rose steadily after the war but by 1840 had not yet regained its pre-war value. See Consul Edwards' despatch, April 12, 1842, CDBA, VI, showing that in 1840 the paper-silver ratio was still only half what it became in 1842 (it was then 18 to 1; i.e., the paper *peso* 5½ cents U .S.).

[38] Arsène Isabelle, *Voyage à Buénos Ayres . . . (de 1830 à 1834)* (Havre, 1835), pp. 31–32, explains that: the French naval commander in the estuary stole in and burned what was left of the fleet, evidently in 1829.

[39] The background and course of this intervention are well treated in Nestor S. Colli, *Rosas á través de la intervención francesa en el Río de la Plata (durante los años 1838 á 1840)* (Buenos Aires, 1948).

[40] In early 1838, they had the brigantine *Sarandí* (9 men), brigantine *Eloísa* (22 men), two little port launches, the bergantín-goleta *San Martín* (31 men), and the bombard *Porteña* (17 men), perhaps others; see Relación de las Cantidades de Dinero qᵉ con Caudal del Estado he Satisfecho á las Tripulaciones de los Buques de Grra del Estado . . . April, 1838, in ANA, Secretaría de Rosas.

[41] Caillet-Bois, *Los marinos,* pp. 16–18, 39, shows that both governments reinforced their flotillas after Rosas' decree of January 22, 1841 (closing the Paraná to other than Argentine shipping and refusing to allow his vessels to stop at the Uruguayan customs-house on the Río Uruguay at Higueritas). This customs-house had been established mainly because of an earlier decree of Rosas to the effect that all Uruguayan river craft must stop for inspection at Martín García Island, then held by Buenos Aires. The bergantín-goleta *Vigilante,* of five guns, was one of the last new ships Rosas acquired at this time; and the Uruguayans bought at least four mer-

attempting to blockade the port of Montevideo where President Fructuoso Rivera of Uruguay maintained his government. Argentines could be conscripted for the fleet, but few of them were good sailors; and most foreign sailors to be found at Buenos Aires were under protection of their consuls and had to be hired if they could be obtained at all.[42] William Brown was again called upon to lead the fleet, while the Uruguayans' ships were commanded by John H. Coe, a "North American adventurer," who had once captained a Buenos Aires ship in the war against Brazil.

In 1841–1842, the English and French naval commanders in the estuary refused to allow Brown's squadron to blockade Montevideo because of the predictable loss to neutral shipping, and Brown was only permitted to blockade the port in 1843.[43] The old leader's touch was still good, and, while he won few clear-cut victories, his ships stopped the foreign trade of Montevideo.[44] On February 16, 1843, this blockade became more threatening when Montevideo was cut off from the land side by the troops of Manuel Oribe, the Uruguayan leader friendly to Buenos Aires.[45] Not wanting to risk a naval battle in Montevideo Bay, Rivera's forces rested their defence in gunboats anchored at both ends of the bay, and they established many new shore batteries, using cannon taken from ships in the port.

In April, 1843, the blockade of Montevideo was tightened, ships being forbidden to bring food to the stricken city. This measure went beyond the usual practice of the time but it was recognized as legitimate, for instance, by United States authorities on the

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chantmen to go with their six war vessels and smaller *lanchones;* see *ibid.*, pp. 36–37, and *The British Packet*, May 15, 1841, which tells of the purchase of the U. S. merchantman *Kremlin* by the Buenos Aires government.

[42] As early as 1821, British merchants at Buenos Aires had persuaded the government to refrain from pressing their nationals into military service (*A Five Years' Residence in Buenos Aires . . . 1820 to 1825)* [London, 1827], p. 40). The Anglo-Argentine treaty of 1825 formulated this arrangement. In 1841, Comandante Alvaro Alzogaray wrote to Brown that among the 100 merchant ships in the Riachuelo port (Buenos Aires), all but *two men* in the crews were protected by foreign consuls (English, United States, French, Brazilian, or Sardinian). See his letter, Buenos Aires, July 1, 1841, in Francisco Sergi, *Historia de los italianos en la argentina* (Buenos Aires, 1940), p. 151.

The navies had to consist in great part of paid foreigners, since foreign naval commanders on the scene usually acted promptly to free their nationals from conscription.

[43] John F. Cady, *Foreign Intervention in the Rio de la Plata . . .* (Philadelphia, London, 1929), p. 114, terms this sort of blockade "almost worthless as measures of coercion. . . ." Martínez Montero, *op. cit.*, I, 11, concurs.

[44] Commercial shipping had great difficulty, but small raiding parties often sailed from Montevideo. The Italian Legion, led in part by Guiseppe Garibaldi, went on small forays against Oribe's makeshift port of Buceo (eastward around the point from Montevideo Bay), and as far away as Santa Fe on hit-and-run attacks. Once they captured a brigantine at Buceo, under the guns of Oribe's other ships; see the anonymous manuscript titled Historia de la Legión Italiana en Montevideo, entries for August and October, 1843, August 1844, and January and February, 1845, in MHNU.

Like so many naval expeditions in that region, the Legion's raid on Rosario, January 23, 1845, lost a ship when the water level fell unexpectedly. The other ships escaped just ahead of Rosas' cavalry by pitching their cannon into the river.

[45] Díaz, *op. cit.*, p. 94. It was formally declared March 17.

scene. The British and French representatives, however, forced Commodore Brown to pass any ships that came in from sea without knowing the blockade existed.[46]

Montevideo was sore beset but not quite starved out. Fishermen managed to bring in some food, and United States and other foreign merchant ships ran the blockade to bring fresh meat to the Uruguayans.[47] Real relief for Montevideo came only with the Anglo-French naval intervention in 1845. Before the English and French forces intervened, Brown had managed to eliminate most of the remaining Uruguayan warships. These vessels, it appears, were deliberately sacrificed by one of Rivera's officers, the Italian Guiseppe Garibaldi, as the necessary price of convoying a large number of Rivera's troops to Entre-Ríos Province in 1842.[48]

Meanwhile, Paraguay gained her independence (1811) and remained aloof from the Argentine and Uruguayan disturbances. The Paraguayans were good river sailors, and even during the late colonial period they were accustomed to river campaigns—engaging in frontier strife with the Portuguese, sending reinforcements against the English invasion of 1806, and running errands for the Spanish military officials in the colony.[49] This kind of small naval activity was familiar to the two strong, suspicious men who ruled Paraguay from 1811 to 1862 (José Gaspar Rodríguez de Francia, to 1841, Carlos Antonio López afterward). Both these dictators kept up the navy and used it for other than purely military tasks, as the Spaniards had done before them. Much of Paraguayan industry and commerce was in the hands of the state,[50] and these dictators used their sailing ships and canoes as public transportation everywhere in the republic.

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[46] *Ibid.*, pp. 149–151. See also Foreign Minister Felipe Arana to U. S. Consul Amory Edwards, Buenos Aires, March 19, 1843, and Edwards' correspondence with other figures, all in CDBA, VI.

[47] As mentioned in Arana's note cited in footnote 46, and in Consul Edwards' despatch of September 20, 1843, CDBA, VII, in which he notes that U. S. ships were being bought in the Río de la Plata to be used in this trade.

[48] Díaz, *op. cit.*, p. 43, refers to this incident which he blames on the principal minister of Rivera's government, Antonio Vidal.

[49] Libro Mayor de la Real Caxa del Paraguay . . . , 1803, in ANP, recording a variety of expenses of this naval activity. Some ships were owned by the crown, some leased or hired for specific purposes. The Libro Mayor de la R[l] Caxa del Paraguay, año de 1807, *ibid.*, shows expenses of hiring six ships to take troops to Buenos Aires during the English invasion, in 1806—more than 5,000 pesos' worth. Ships were also hired to carry troops north to Fort Borbón on the Paraguay River; see Libro Mayor . . . for 1808, *ibid.* The captain of the port of Asunción was ordered not to commandeer ships already loaded for river trade: Instrucciones al Capitán del Puerto, by the governing Junta, Asunción, January 9, 1812, ANP, tomo 216, no. 1.

[50] Some kind of official monopoly of yerba mate (Paraguayan tea) and wood existed from early independence days. By 1846, it was well established.

In 1845, López was using small ships to bring supplies from distant points for government projects; see his permits to travel, issued to Sgts. Andrés Carvallo (for twenty men and a *zumaca*) and Ignacio Robles (for sixteen men and a *buque*), Asunción, January 23 and July 27, 1845, ANP, tomo 272, no. 30.

Paraguay built up a sailing-ship navy before 1820,[51] and this force was increased by a variety of smaller craft in later years.[52] Carlos Antonio López, like Francia before him, anticipated dangers of all kinds and from all possible directions. He provided against such threats by buying and building a fleet of small steamers especially during the 1850's.[53] This was the strongest war fleet in the Plata region at the time, although it was put to no warlike use until the Paraguayan War of 1865–1870.

Meanwhile, Buenos Aires was once again in trouble with major naval powers. In July, 1845, United States Consul Graham at Buenos Aires was exasperated at the British and French refusal to allow Brown's navy to impose a complete blockade on Montevideo:

> "The English and French acknowledge the *right* of this Government [Buenos Aires] to blockade Montevideo . . . but they refuse to permit any *interference* with their [own] trade to Montevideo, therefore all Governor Rosas has the *power* to do, is to say that vessels having communication with that place, shall not enter this Port. . . ."[54]

Worse was yet to come. British and French traders in Montevideo were loudly protesting the stoppage of their trade, and Rivera's Uruguayan government sent out several missions to obtain British or French intervention against Buenos Aires. On August 1, 1845, the French and English naval units in the Río de la Plata put a blockade on Oribe's port of Buceo,[55] presumably to discourage his siege of Montevideo. The next day they captured the whole Buenos Aires fleet, removed their nationals from its crews, and sent the ships home to Argentina.[56] The blockaders soon captured the Uru-

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[51] Otaño, *op. cit.*, p. 3, records that Francia sent a squadron to demonstrate off the port of Corrientes in 1818. The Libro Man[al] de la Caxa de Haz[da] de la República del Paraguay [for 1816], ANP, lists the construction expense for several new warships and for repair of others. Wood was brought for ship repair in 1822, according to Juan José Zuloaga's declaration, Asunción, August 20, 1822, *ibid.*, tomo 235, no. 14.

[52] By 1845, government construction of canoas, lanchas, and other smallish vessels was too extensive to detail here. These craft were built and repaired near Villa Rica, at Concepción, Asunción, Pilar, Yuti, Tobatí, Paso de la Patria, Oliva, and probably elsewhere; see ANP, tomos 272, no. 30; 282, no. 13; 291, no. 13; and letters in tomo 1424. This activity continued into the 1850's, culminating in the establishment of a large number of guard posts along the rivers, all of them equipped with small vessels or canoes.

[53] There were a dozen of these vessels, if not more; see Otaño, *op. cit., passim.* The military repair, shipbuilding, and machinery shops built for this program are discussed in a progress report submitted by the English chief engineer, John W. K. Whitehead, during 1857 (ANP, tomo 323, no. 2). He states that it had taken eighteen months to put the first of the locally built steamers into the water, counting from the time they started to build not only the ships but the foundries, shops, and other works. He also discusses the building of a new pier which was being built so that heavy marine engines could more easily be moved into steamboats built in local yards.

[54] Despatch of July 5, 1845, CDBA, VIII.

[55] British Chargé Adolph Turner's notification to U. S. Consul Robert M. Hamilton, Montevideo, August 2, 1845, *ibid.*

[56] Consul Graham's despatch, August 11, 1845, *ibid.* He was almost if not quite speechless: "If it be a declaration of war, against which nation is it—The Banda Oriental or the Argentine Confederation?" Could these local commanders declare a

guayan port of Colonia from Oribe's army, took the island of Martín García from Rosas, and coursed up and down the Río Uruguay. The Argentine dictator reacted by denying British and French ships the right to anchor at Buenos Aires or to buy food or supplies there. Thus his open support of Oribe's Uruguayan faction provoked the Anglo-French forces to blockade the ports of Buenos Aires Province, on September 22, 1845.[57]

This was a very different sort of blockade than those of 1826–1828 or 1838–1840. As Consul Graham saw it:

> "The effect and apparent object of this new kind of blockade, is to make our Merchants as well as others doing business with Buenos Ayres, to pay duties on exports & imports *in Montevideo* as well as here; and besides the freight charged by the small vessels to and from Montevd.º is more than to & from the U. S. The proceeds of the Montevidean custom house belong to a company of English Mchts. who made advances to sustain the Govt. and the present object of the Blockaders appears to be to secure them from loss. Does not this subject merit the Attention of our Govt.? . . ."[58]

Historians are agreed that the blockade was so managed as to route foreign trade by Montevideo rather than to deny it the Buenos Aires market altogether. In other respects, too, this naval intervention failed to meet the proper definition of a blockade. For instance, there never was a consistent blockade of any port in the Argentine province save Buenos Aires itself.

The British forces withdrew from this intervention in mid-1847, probably because British merchants in Buenos Aires finally made their protests heard. Thereafter, the French had but a single warship stationed off Buenos Aires,[59] and this quasi-blockade ended in midwinter of 1848 without having caused any permanent damage to Oribe or to Juan Manuel de Rosas of Buenos Aires.

The importance of this long period of naval and military conflict between Argentina and Uruguay, which continued from 1838 to 1852, is not to be found in the two interventions by major Euro-

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war? If they would, as they said, blockade any Oriental port occupied by troops in the service of the Argentine government, then "What constitutes an occupation of a port of the Oriental Republic?"

[57] Graham's despatch, September 17, 1845, CDBA, VIII; see also British Chargé Francis L. Ball's note to Graham, Buenos Aires, September 22, 1845, and French Chargé Baron de Maueuil (?) to Graham, same place and date, *ibid.*

On September 1, there were 71 foreign vessels at Buenos Aires. At first they were given only fifteen days time in which to leave, but this limitation was extended to November 1, 1845, at which time those remaining were sent out of the port; see Graham's despatch, November 3, 1845, CDBA, VIII.

[58] Despatch of January 2, 1847, CDBA, VIII. I have not been able to verify these accusations: others say that the French dominated this group.

Our representatives at Buenos Aires were a mediocre set of men during the early and middle nineteenth century, and most of them automatically took at face value the official facts and interpretations handed them by governments of Buenos Aires.

[59] As Graham asserts in his despatch, July 3, 1847, CDBA, VIII.

pean powers. Its significance lies in the war between Rosas and Oribe on the one hand and Rivera on the other. From 1838 to 1847, this war was fought to decide whether Uruguay would continue to be an independent nation or whether it would become an Argentine province. Rosas and Oribe failed to win because the French and English twice intervened to protect Rivera and the port of Montevideo. After 1847, however, there was a change. When the English and French were gone, the war acquired a new dimension. Rosas and Oribe now threatened to overwhelm Montevideo where Rivera lay besieged; and if Montevideo fell, Rosas would control the trade of the whole river region and all its foreign and local shipping. It was this threat—that Rosas would finally gain a domination that he had sought for two decades—that provided new allies to Rivera's cause.

Even in 1847, Entre-Ríos Province had refused to follow Rosas and Oribe in their embargoes against shipping from the rivers Paraná and Uruguay to the port of Montevideo. In 1851, faced with the imminent capture of Montevideo by Rosas and Oribe, Governor Urquiza led Entre-Ríos into an alliance with Corrientes Province, Rivera's party in Uruguay, and the Empire of Brazil. The announced object of this alliance was to overthrow Oribe and to face Rosas, if necessary, in order to ensure freedom of trade and shipping in the river region.

In May, 1851, the promised Brazilian fleet appeared in the Río de la Plata to protect the gathering of troops planned by Urquiza. This force also shielded Montevideo until the land army could relieve it from Oribe's siege. Rosas meanwhile had been prevented by the French from reoccupying the island of Martín García, which he felt he must hold in order to oppose any such coalition as was now forming against him.[60] Brazil gathered troops along her Uruguayan border, and her steamers supported Urquiza by entering his ports along the western side of the Río Uruguay.

Near the end of 1851, this Brazilian fleet threw a protective shield along the Paraná and Uruguay rivers, while Urquiza's army advanced to raise the siege of Montevideo. When the city was free and Oribe's forces scattered, the ships ferried many of Urquiza's troops over into Entre-Ríos. In December, they steamed up the Paraná to protect his army once again as it made the westward crossing of the Paraná from Entre-Ríos Province into Santa Fe. Admiral Grenfell's Brazilian ships shot their way past Rosas' batteries at Tonelero on December 17, joining Urquiza near Diamante at the head of the Paraná delta.[61] There the six steamers, with

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[60] Graham's despatch of May 19, 1851, CDBA, VIII.

[61] I follow Díaz, *op. cit.*, pp. 158 ff., and William Hadfield, *Brazil, the River Plate and the Falkland Islands* . . . (London, 1854), p. 190, for these events.

dozens of sailboats and any number of improvised rafts, canoes, and other floating objects, spent sixteen days carrying men and equipment across the stream. General César Díaz relates that fifty thousand horses swam this crossing.

Urquiza and a few of the leading units went so rapidly south through Santa Fe Province by Christmas Day that the fleet began bringing men down river to Rosario to catch up with the general. Gathering the whole army, Urquiza dispensed with any further naval support and made a long, hard march out into the pampa and round about to approach Buenos Aires from the southwest. There he fought the victorious battle of Caseros, in early 1852, that broke the power of Rosas. After four decades of independence, Argentina was on the point of forming her first national government.

As it proved, the new leaders of Buenos Aires would not suffer Urquiza's temporary rule, nor would they agree to the national constitution written at Santa Fe in 1853. By the end of 1853, Urquiza moved on Buenos Aires once again to enforce submission to the national government. Both sides quickly organized little fleets, now for the first time including steamships. Urquiza's naval blockade of Buenos Aires (April 23–June 20, 1853) came to a bizarre end when his commander John Coe went over to the Buenos Aires government with all his ships.[62]

The British merchant Wilfrid Latham summed up the reasons for this strange turn of events in saying that the blockade "became a 'job'—a trading job of the commander of the blockading squadron. . . ."[63] Latham had been trying to mediate the disagreement between Urquiza and Buenos Aires, and his petition with the names of five thousand foreign residents of the city having gone in vain, another way to end the fighting was found, he says:

> ". . . the Buenos Ayrean government having offered a good price for Coe's defection, and deposited the gold ounces on board an American man of war lying in the river, the whole blockading squadron came into port, and anchored under the guns of the fort, with the Buenos Ayres flag flying. . . ."[64]

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[62] According to Wilfrid Latham, *The States of the River Plate* (2nd ed., London, 1868), pp. 276–280, and Alfred M. Du Graty, *La Confédération Argentine* (Paris, 1858), pp. 51 ff. Consul Graham's despatches also tell parts of the story. He states that Buenos Aires bought its vessels and enlisted as many Italian sailors as could be found at Buenos Aires or Montevideo (despatch of January 31, 1853, CDBA, VIII). He also dates Coe's defection on June 20; see the despatch of July 3, 1853, *ibid:* "There seems to be no doubt that the chiefs of the squadron were bribed. . . ." If so, this was the second round of bribing, since a few weeks earlier two ships that now rejoined the Buenos Aires fleet had deserted to the Confederation forces. Their commanders remained in service both times. See Latham, *op. cit.*, pp. 280–281, and Graham's despatch of May 9, 1853, CDBA, VIII.

[63] Latham, *op. cit.*, p. 285.

[64] *Ibid.*, p. 287.

After this incident, some of the Buenos Aires warships were sold and the few remaining in service were modernized.[65] When Buenos Aires and the Argentine Confederation again commenced hostilities in 1859, both governments had to buy and rent steamers and sailing ships. They contracted for the services of "foreign legions" of Italians and Spaniards on the pattern of Guiseppe Garibaldi's Legion at Montevideo a few years before.[66] This time the Buenos Aires force occupied Martín García Island, and the Confederation declared its ports closed to all "commerce or correspondence" with Buenos Aires.[67] The Confederation fleet made only occasional appearances off Buenos Aires, and no blockade of the port was recognized by foreign powers. The important fighting took place on land, the only naval action coming when the Confederation fleet retired up the Paraná, forced its way past the guns of Martín García, and dodged the Buenos Aires fleet altogether by using an unexpected channel. When Buenos Aires lost the decisive land battle on October 25, her fleet was able to fight off Urquiza's squadron and bring the troops safely home to Buenos Aires again.[68]

The final act in this decade of intermittent naval war among Argentine provinces came in 1861. Martín García was again occupied by the forces of Buenos Aires, and both sides collected navies as quickly as possible:

> "The principle was 'catch as catch can.' The Federals kept what they could at Parana, and the Buenos Ayreans seized all the vessels they could lay their hands on at their own end of the river. None were safe except those which sailed under a foreign flag. . . . When the Government took possession of a steamer, they set to work to strengthen and repair her as well as they could, to mount a few guns, and through the agency of crimps, to get sailors from foreign ships in the port. . . ."[69]

The fleets thus assembled were almost equal in force, Buenos Aires possessing six steamers and a brig, while President Santiago Derqui of the Confederation had nine steamers and some smaller craft.[70] These squadrons confronted each other but did not fight while the issue was being decided by the armies. Buenos Aires was the victor

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65 The governor's annual message to the legislature (printed at Buenos Aires, 1854) mentions selling some "unnecessary" and degenerate vessels; and the message of 1858 (printed at Buenos Aires, April 30, 1858) speaks of the navy as being "considerably reduced," but also mentions that the government of Buenos Aires had just had a small war steamer built in Europe. This was probably the first ship built abroad for either Argentina or Uruguay.

66 Consul Hudson's despatch of May 28, 1859, CDBA, IX.

67 Hudson's despatch, June 7, 1859, CDBA, IX. This decree went into effect on May 30, 1859.

68 Consul Hudson's despatches of August 20 and October 29, CDBA, IX, narrate these events.

69 Thomas W. Hinchliff, *South American Sketches* . . . (London, 1863), p. 88.

70 Hinchliff, *op. cit.*, pp. 329–331, and Consul Hudson's despatch of August 24, 1861, CDBA, X.

at the Battle of Pavón, September 17, 1861. After covering the retreat of Confederation troops across the River Paraná into Entre-Ríos, the national government's squadron retired to Paraná to be dismantled. In this disarmed state it was "captured" by the fleet of Buenos Aires, thus ending the river campaigns that had been such an important part of the wars since 1810.

During the period 1810–1861, the fleets of the Platine states wisely did not fight naval wars with the major naval powers that intervened in their affairs. Likewise, the governments that ruled Buenos Aires and Montevideo up to 1861 could not hope to meet the challenge of civil or foreign war by naval force alone. Fighting in ships was a new and uncertain experience to these former Spanish colonists, and the tiny budgets of their new republics had no place for peacetime navies save for a handful of ships in coast-guard and port duties.

In time of war, foreigners led the Argentine and Uruguayan war fleets, and many of the seamen were foreign born. This is not surprising, since foreigners dominated shipping in the Plata region more and more as time went by. Argentina and Uruguay never had seagoing merchant fleets during that period. The coastal trade with Brazil fell into other hands. As for the hundreds of small craft on the rivers and estuary, Italian and Spanish immigrants owned and manned so many of them as to rival the number of native-born sailors. But by 1861 the Argentines and Uruguayans had acquired a tradition that soon led them to build steam-driven fleets, to found naval academies, and, down to our own time, to maintain professional navies that render useful services to those peaceable republics.

Paraguay did emphasize naval affairs, mostly because her dictators were at once so all-powerful in Paraguay and so apprehensive of foreign attack. They spent a disproportionate amount of time and money on all aspects of national defence, including the navy. Still, it was true that the rivers were Paraguay's first line of defence, as it later proved when she launched a terrible war against other Platine powers in 1865.

Why was naval warfare so frequent and so serious in that period between 1800 and 1861? First of all, fleets were valuable in support of armies, as has been shown in the foregoing pages. Most generals were aware of this even before 1850. Secondly, warships were even more often used in the Plata region to block the enemy's trade, since so much commerce went by water and because shipping activity increased with each new decade. Also, the Platine economy was gradually becoming part of the Atlantic trading system. Commercial powers like England and France now showed an active, sometimes an aggressive interest in the Plata region. Argentina had her diplomatic difficulties with the United States government, as well.

Most important of all, naval warfare reflected a conflict of interests among the three Platine nations and also within Argentina and Uruguay. Before 1861 each of the three nations was constantly distracted by a particular problem of its own. For Paraguay, the problem was to obtain recognition of her independence gained in 1811, sustained thereafter, and formally declared in 1842. For Uruguay, the issue was first to gain her freedom (1828), and then somehow to force others to honor her independent status in day-to-day practice. For Argentina, the problem was unification under one government, which was finally achieved in 1861.

With these problems unsettled, the three riverine nations spent more than half a century in mutual suspicion, antagonism, and war, to say nothing of bitter civil wars in Argentina and Uruguay. The most frequent occasion for trouble was the use of the rivers for trade and travel. This long struggle is known as the issue of freedom of navigation—the attempts by Paraguay, Uruguay, and the Argentine river provinces to gain the right to regulate their own shipping, to have free access to the rivers and the sea, and to have foreign ships come directly to their own river ports. Naval warfare among those nations should be understood as merely a part of that larger issue of free navigation, which was of first importance during peace and war alike. Freedom of navigation was, in turn, but a locus of conflict over the basic issues of unification and independence which were disturbing domestic and international affairs everywhere in the region. To place naval warfare in this context is to go far toward explaining why it was so frequent, so serious, and so significant in the Río de la Plata region before 1861.

NOTES ON THE BIOLOGY OF THE CHERRY FRUIT WORM IN WISCONSIN[1]

D. A. DEVER
*Department of Entomology, University of Wisconsin**

This study was initiated in 1949 with the discovery of a new insect pest infesting sour cherries in Door County, Wisconsin, viz., the cherry fruit worm, *Grapholitha packardi* Zell. Larvae of this insect are found in the flesh of cherries at harvest time. Some of the infested fruits can be detected and removed at the canning factory by the sorting crew. Many of them, however, are not detected until the processed fruit is opened for inspection.

Such infestations constitute a serious threat to the cherry industry of Door County, as the presence of infested cherries in the processed fruit is sufficient reason to condemn the entire cherry pack. In view of this, investigations were initiated to determine effective control procedures for this pest. Concurrent records and observations were made on the biology and ecology of the cherry fruit worm.

DISTRIBUTION

Wisconsin ranks third nationally in sour cherry production. The main acreage of sour cherry trees is in Door County. A survey was made to determine the distribution and relative abundance of the cherry fruit worm. Twenty-three orchards in Door County and several of the larger orchards on Washington Island were surveyed. The results of the survey are presented in Table 1.

The cherry fruit worm was found to be quite generally distributed throughout the county. The infestations were quite heavy in the southern part of the county. In the northern areas they were sporadic and light in nature. The nature of the distribution and the occurrence of the cherry fruit worm on Washington Island indicates that this insect was present in Door County for a number of years prior to its discovery in 1949.

HISTORY

It seems probable that the cherry fruit worm was widely distributed in North America many years before it was first reported as occurring in Texas by Zeller in 1876. He described the cherry

[1] Approved for publication by the Director of the Wisconsin Experiment Station.
* Now Research Entomologist, California Spray-Chemical Corporation, Medina, N. Y.

fruit worm under the name *Grapholitha packardi.* Since Zeller's original description the species has been mentioned as a pest of apples in Missouri by Murtfeldt (1891) and as a pest of apples, peaches, and roses by Forbes (1923) in New York. Heinrich (1926) listed the distribution of the cherry fruit worm as Texas, Mississippi, Missouri, Arkansas, Illinois, Michigan, Maryland, West Virginia, New Jersey, Delaware, Massachusetts, and New Hampshire. Lipman (1936) and Martin (1939) reported this species as a pest of cultivated blueberries in New Jersey. However, the full importance of the cherry fruit worm as a pest of sour cherries was not realized for many years despite its early discovery and wide distribution.

TABLE 1

RESULTS OF A GENERAL SURVEY TO DETERMINE THE DISTRIBUTION OF THE CHERRY FRUIT WORM IN DOOR COUNTY, 1951

Orchard	Locality*	Cherry Fruit Worm
Smith	Sturgeon Bay	†
Wellhaven	Sturgeon Bay	†
Overbeck	Sturgeon Bay	†
Ullsperger	Sturgeon Bay	†
Palmer, Jr.	Sturgeon Bay	†
Babach	Sturgeon Bay	†
Goldman	Sturgeon Bay	†
Barnard	Experiment Station	†
Petusilka	Experiment Station	†
Bieri	Valmy	†
Eames	Egg Harbor	0
Moore	Egg Harbor	0
Chase	Juddville	0
Slobay	Juddville	0
Perry	Fish Creek	0
Clark	Fish Creek	0
Fiedler	Fish Creek	0
Erickson	North Bay	†
Urmeneta	Ephraim	†
Logerquist	Ephraim	0
Ebers	Sister Bay	†
Roen	Sister Bay	0
Carlson	Baileys Harbor	0
General Survey	Washington Island	†

*Orchards are located within five miles of town indicated.
†Indicates presence of insect in orchard.

In most areas the cherry fruit worm was infesting sour cherries many years before it reached high infestation levels. Downes (1929) reported that it was first found in British Columbia in 1917 but did not become serious until 1927. In that year the average infestation in sour cherries was from 36 to 45 per cent of the total crop. Hoerner and List (1952) indicated that the cherry fruit worm was present in Colorado as early as 1914. They stated that in 1915 and again in 1922 fruit had been refused by a processor on account of infestations by this species. Breakey and Webster (1938) reported cherry fruit worm as unusually abundant in sour cherry orchards in western Washington. The fruit was heavily infested and part of the crop was refused by the canneries. In 1949 this species was first noticed as destructive to sour cherry in Wisconsin (Dever and Fluke, 1951, Dever 1954 b).

The presence of cherry fruit worm larvae in harvested and processed fruit has caused considerable anxiety among the growers and processors of sour cherries.

According to Hoerner and List (1952) the armed forces refused the northern Colorado crop in 1945 because of worm infested cherries. In 1949 the Wisconsin cherry pack was jeopardized because of larval infested cherries in the processed fruit.

INJURY

The cherry fruit worms cause injury by boring into the fruit. They bore through the epidermis shortly after they hatch. In a few days this early injury can be detected by means of the entrance hole made by the young larvae as well as the small brown trails caused by their tunnelling. The larvae may feed extensively just below the surface, and is evidenced by sunken, rough, brownish colored areas (Figure 1). More than one fruit may be damaged as the larva matures. Mature fruits are roughened, blackish, and generally distorted. Larval frass may be present on the surface of the cherry. The inside of the cherry, next to the pit, is completely eaten away (Figure 2).

In Door County, worm infested cherries may be found from the middle of July through harvest time. The larvae may leave the fruit prior to harvest, but in some cases they may still be present in the harvested fruit. As a result, worm infested cherries may find their way into the processed fruit.

The injury caused by the cherry fruit worm may be confused with that caused by plum curculio larvae. In early stages the characteristic crescent shaped mark made on the fruit by the adult curculio will serve to distinguish curculio infested cherries. As the extent of the damage increases, however, it becomes more difficult to separate the two. Positive identification can be made using certain larval characteristics (Dever, 1954).

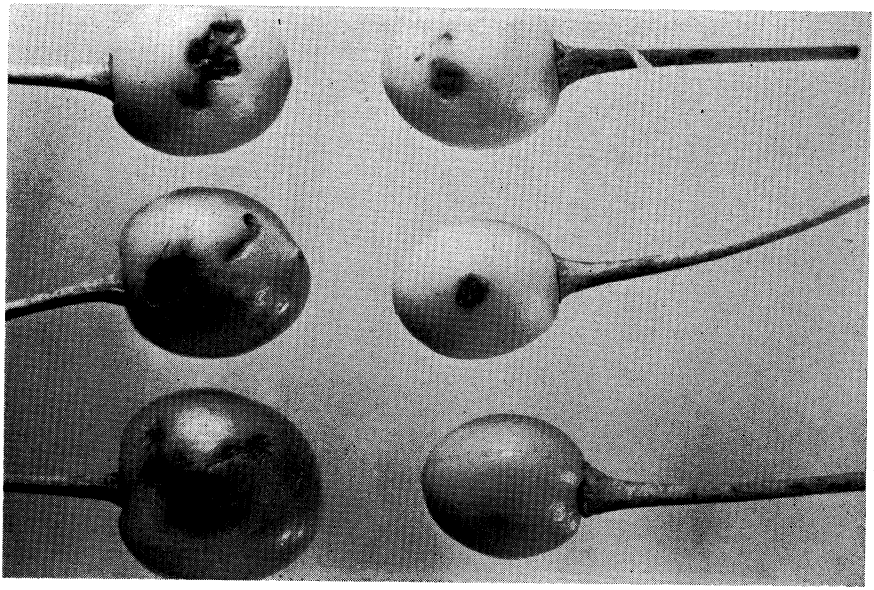

FIGURE 1. Various degrees of injury caused by larvae of the cherry fruit worm.

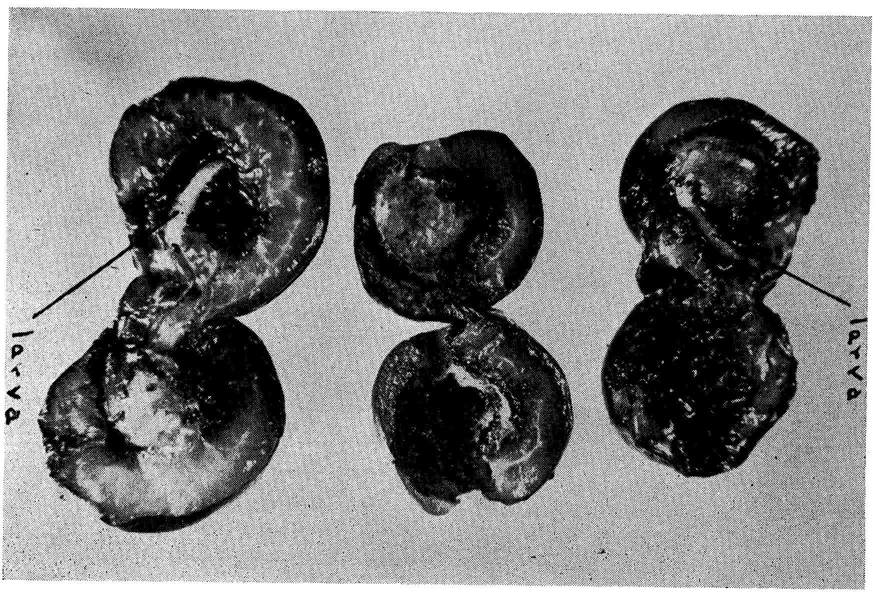

FIGURE 2. Internal damage caused to mature cherries by cherry fruit worm larvae.

TECHNICAL DESCRIPTION

The following description of the moth is that given by Forbes (1923).

"Dark fuscous, head and palpi dark; fore wing with several transverse lead-grey bars, parallel to outer margin, and also connected with oblique fasciae running down from the costa. A distinct series of black dots or short bars in the speculum, and between the speculum and the costa, extending most of the width of the wing. Basal line in fringe unbroken. Hind wing in male light gray, no darker at the margin, with a blackish sex-patch covering most of cell and extending a little beyond it; in female blackish. Fringe gray. 10 mm. Male usually smaller."

Heinrich (1926) makes the additional comment concerning the sex-scaling. "Its most striking character, however, is a strong patch of blackish sex-scaling upon the upper surface of the hind wing and a similar patch on the under surface of the fore wing of the male. This character, as far as I know, is shared by no other North American species of Grapholitha or Laspeyresia."

The following description of the full grown larva was made from specimens collected in the Door County area of Wisconsin.

Mature Larva—general color whitish-pink, ventral surface not so pink as dorsal; head, from mottled yellowish-brown to dark brown, shiny; mouth parts, pale gray, almost white; antenna, white at base, slightly darker towards tip; thoracic shield, shiny, pale yellow to light brown, divided in the middle by a longitudinal paler line; thoracic legs, white; prolegs white, crochets uniordinal, uniserial, and in a complete circle; crochets on anal prolegs uniordinal, uniserial, and in a transverse band; setae on grayish-white pinaculae; anal shield, mottled grayish-black; anal comb, dark brown with four to six prongs of irregular length. (For detailed setal pattern see reference cited: Dever 1954).

BIOLOGY AND ECOLOGY

The cherry fruit worm has one generation a year in Wisconsin. The adults (Figure 3) are small grayish-black moths with a wing spread of one-quarter inch. The adults lay (Figure 3) their oval, yellow eggs on the fruit at the time it begins to color. After an incubation period of approximately 10 days, the eggs hatch and the young larvae bore into the fruit. These larvae reach maturity in about three weeks and leave the fruit to construct their winter quarters. They may spin a nest under a piece of loose bark, in a roughened stub of a broken branch or twig, or, they may bore into

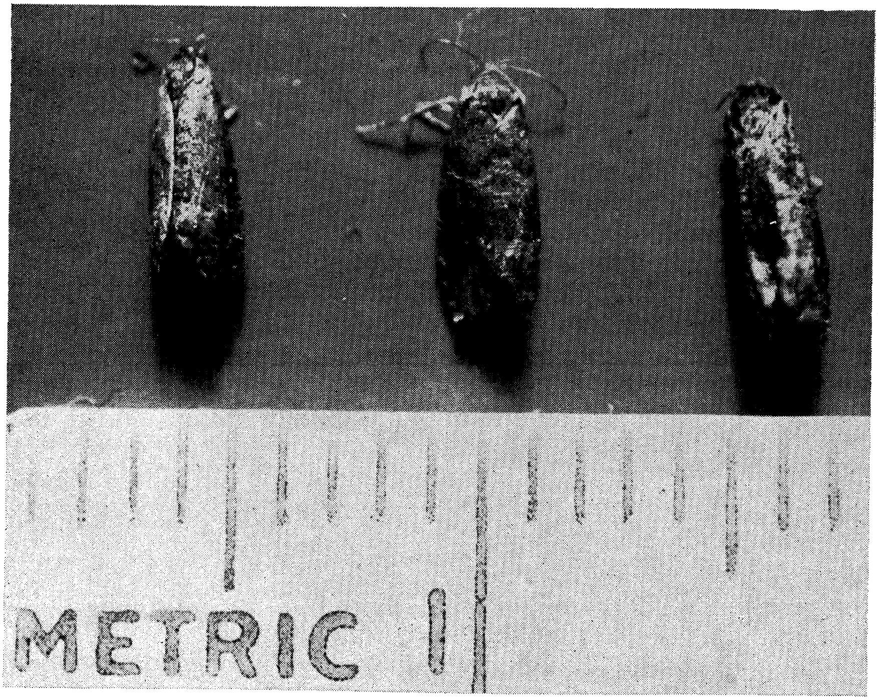

FIGURE 3. Adults of the cherry fruit worm.

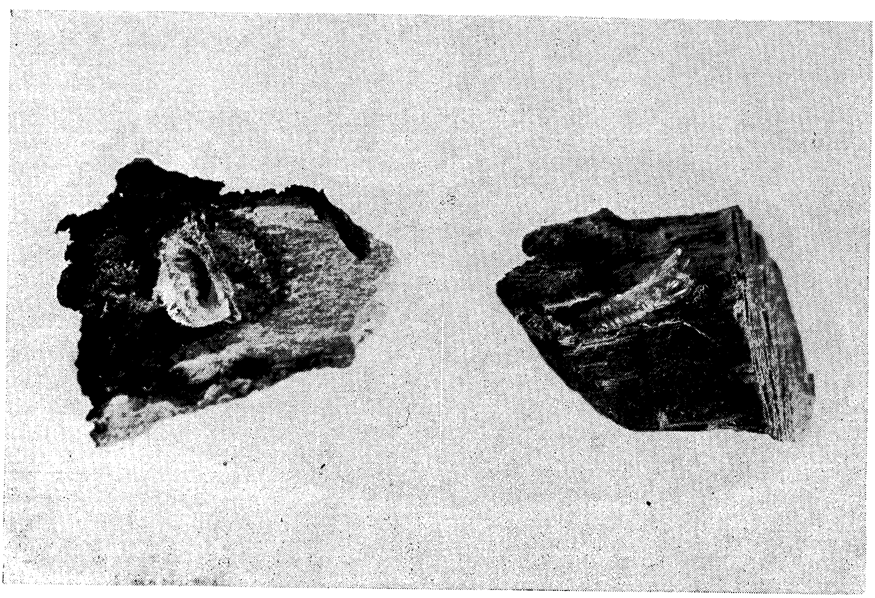

FIGURE 4. Overwintering nests of cherry fruit worm showing nest and empty pupal case.

the stubs of pruned branches. The winter is spent in these quarters as mature larvae.

Hibernation. The hibernacula have a light gray silken cover. The cover is easily removed to reveal two additional layers which are very black and quite tough and brittle. The hibernacula are extremely well concealed and are found in crevices, ends of twigs, bark curls, or similar depressions.

Although the places selected by the larvae may not be well protected it was thought that the well constructed hibernaculae would afford protection from severe cold. However, many of the larvae collected in the spring were dead. A white fungus growth was found on the larval bodies within the hibernacula. The fungus was identified as a non-pathogenic organism which lived as a saprophyte on dead and decaying organic matter. It appeared that some of the larvae may have been killed by severe winter temperatures.

The effect of temperatures on the larvae was investigated by simulating conditions of exposed and protected larvae. A collection of fruit infested with mature larvae was made in the fall of 1950. The infested fruits were divided into two lots of 25 infested fruits per lot.

One lot was placed in a glass battery jar in an outdoor insectary. Several strips of corrugated cardboard and several pruned cherry twigs were also placed in the jar to provide a place for the larvae to construct their hibernacula. Later in the season, it was found that some of the larvae had constructed winter quarters in the crevices of the corrugated cardboard; others, by boring into the cherry twigs.

The other infested fruits were scattered about the base of a five year old cherry tree of the Montmorency variety. The tree was completely enclosed by a screen wire cage. Hibernation sites were provided in the form of pruned cherry twigs scattered around the base of the tree. The larvae constructed hibernacula by boring into the ends of the twigs.

In the battery jar, those larvae which had bored into the pruned twigs survived the winter; those which had utilized the corrugated cardboard as overwinter sites, died. In the screen wire cage, all the larvae overwintering in the twigs survived and the adult moths infested the fruit on the tree. It was concluded that the larvae which hibernate under loose pieces of bark, etc., may not survive the severe winters encountered in the Door County area.

Pupation. The larvae pupate in their hibernacula in the spring (Figure 4). The pupae are slender, yellowish-brown, and measure approximately one-fifth of an inch in length. According to Hoerner and List (1952) the average length of the pupal stage is 29 days.

It is not uncommon to observe pupae projecting from the hibernacula just prior to and after adult emergence.

Adult activity. In Door County the appearance of the first adult moths will vary with seasonal conditions. On cool, humid, and somewhat cloudy days they commence flying about four o'clock in the afternoon. On warm sunny days they will not fly unless disturbed. They are strong fliers and exhibit a very erratic flight pattern. The records obtained for the three year period indicate that the moth flight commences two to four weeks after petal fall and lasts for a period of 14 to 21 days.

The seasonal moth flights for the three years were obtained by trapping the adults with fermented bait and light traps. The bait was the standard codling moth attractant of molasses, honey, and yeast in water. The light traps were superior to the bait traps but neither of the trapping methods was considered very efficient. The total number of moths trapped was exceedingly small and did not represent a true picture of the distribution of the adult population. An experiment was set up in 1951 to test the relative merits of several baits.

The basic bait of molasses and honey was retained but the yeast was not used. Instead of yeast one c.c. of various attractants was added. They were oleic acid, sorbitol borate, tartaric acid, eugenol, and acetic acid. Six baits were set out in an orchard which had previously been infested with cherry fruit worm. Five of the baits had the attractants added. The sixth bait or check was the ordinary fermented bait. These were replicated twice making a total of 12 bait pails. The baits were set out during the height of moth activity and records taken for one week. In all cases only one or two moths were trapped during the experiment. None of the chemicals tested was any better than the standard bait of honey, molasses, and yeast.

In 1952 another attempt was made to find a lure for the adult moths. In this experiment the standard oriental fruit moth attractant was tested. It consisted of 7.3 pounds of liquid dimalt and one and one-half ounces of sodium benzoate in 15 gallons of water. There were no moths trapped by this bait during the two week period of adult emergence. This was surprising since Tomlinson (1951) and Hoerner and List (1952) have both reported that the oriental fruit moth bait is effective in trapping fruit worm adults. If the evidence presented earlier in this paper concerning the apparent winter killing of the overwintering larvae is considered, it may be argued that the moth population was low. On the other hand, it is probable that the night temperatures during the period of moth activity were also a factor in limiting the adult flight. Few cherry fruit worm moths were trapped in an orchard located on the cooler, lake side of the Door peninsula (Palmer orchard). In this same orchard, the number of adults trapped of the bud moth, *Spilonota ocellana* D. & S., and the fruit tree leaf roller, *Archips argyrospila* Walk., were equally low. There was considerable incidence, however, of fruit damage by these three insects in this orchard. In orchards where cherry fruit worm adults were trapped the minimum and maximum temperatures were slightly higher than the temperature recorded in orchards located in the vicinity of the Palmer orchard. In view of this and the injury caused by the cherry fruit worm, it is concluded that the moth population is moderate but that the moth activity may be limited by low evening temperatures.

During the cool, wet growing season of 1950, the moth flight started during the first week of July and lasted for three weeks. In 1951 and 1952, however, the growing season was more temperate. This resulted in an earlier appearance of the first moths. In 1951 the moth flight lasted nearly three weeks, from June 12 to July 1. In 1952 the flight period was much shorter from June 9 to June 18. The prevailing temperatures during the period of moth activity were higher in 1952 than those which prevailed for the same period in 1951. Apparently seasonal temperatures have a pronounced effect on the initiation and duration of the adult flight of the cherry fruit worm.

As pointed out above, climatic differences in the growing periods for 1950, 1951 and 1952 caused a three week variance in the initiation of moth activity for the respective years. These differences also caused a variance in the blossoming period. In 1950 the blossoms started to open May 26 and were fully open by June 3. Petal fall was June 6. In 1951 blossoming was ten days earlier. It started May 16 and ended May 28, with full bloom May 24. In 1952 the blossom period occurred earlier, May 5, but was prolonged and ended May 22. Full blossom occurred from May 11 to 17. The period which elapsed between the appearance of the first adult moths and petal fall varied from 19 to 33 days over the three year period, 33 days in 1950, 19 days in 1951 and 22–29 days in 1952. Since these differences exist, the timing of spray recommendations for cherry fruit worm control should be based on annual records of adult activity.

Oviposition. The adult moths lay their eggs on the unripe fruit. According to Hoerner & List (1952) they may lay them anywhere on the fruit but a slight preference is shown for roughened areas. The author has usually found them next to the suture at the base of the petiole or at the calyx end next to the pistil scar. The eggs are whitish-yellow in color and circular to elleptical in shape. They are difficult to detect as their color corresponds to that of the fruit at the time they are laid. As they develop, the contents of the egg gradually turn grayish-white. Shortly before they hatch, the larval head capsule is readily visible.

Numerous attempts were made to obtain eggs from moths in the laboratory. The moths were obtained from reared collections, bait traps and mechanical traps. They were placed in oviposition cages and supplied daily with branches bearing several cherries. Only one egg was obtained and it hatched in four days. Hoerner and List (1952) observed an incubation period of seven days in the laboratory. They and Downes (1929) both report an incubation period of 10 days under field conditions.

Larval Development. The newly hatched larvae are whitish-gray with a black head and measure from an eighth to one-quarter of an inch in length. They bore through the epidermis of the cherry shortly after they hatch. The entrance holes may be near the petiole, on the side, or at the pistil scar. At first they tunnel just underneath the epidermis but gradually they work in toward the pit. Some of the larvae may attack several fruits before their development and leave the fruit.

The seasonal larval development is presented in Figure 5. The relatively light infestation which occurred in 1950 and 1952 made it difficult to follow larval development. In 1951, however, the infestation was adequate and fairly complete records were obtained. In 1950 the last instar was present in the fruit up to and during harvest (latest date August 8). On the other hand, in 1951 the larvae had matured and deserted the fruit as early as July 27 in the bay shore area and as late as August 3 in the lake shore area. In 1952 the majority of the larvae had left the fruit by July 20, although a few were still present as late as July 28. In 1951 and 1952 the larvae had left the fruit before harvest. Although the completion of the larval development before harvest does not lessen the damage caused by the fruit worm, it does remove a mortality factor. It is apparent that the over-wintering population of the cherry fruit worm will be reduced if larval development is not complete before the fruit is harvested.

An experiment was made to determine how the mature larvae migrated to their hibernation quarters after they deserted the fruit. On July 20, 1951, 68 mature cherry trees were banded with corrugated cardboard. The bands were four inches wide and were fastened to the tree with cellulose tape. Two bands were placed on the trunk, one above and one below a ring of sticky paste. Other bands were fastened to the main branches. These bands were examined every four days for mature larvae. Larvae were present in the bands above and below the ring of sticky paste. This indicated that the larvae either crawl down the branches of the tree or drop to the ground and crawl to the tree. Since they were also found in the bands on the main branches, it is concluded that they hibernate in any suitable place encountered during their migration. Whether

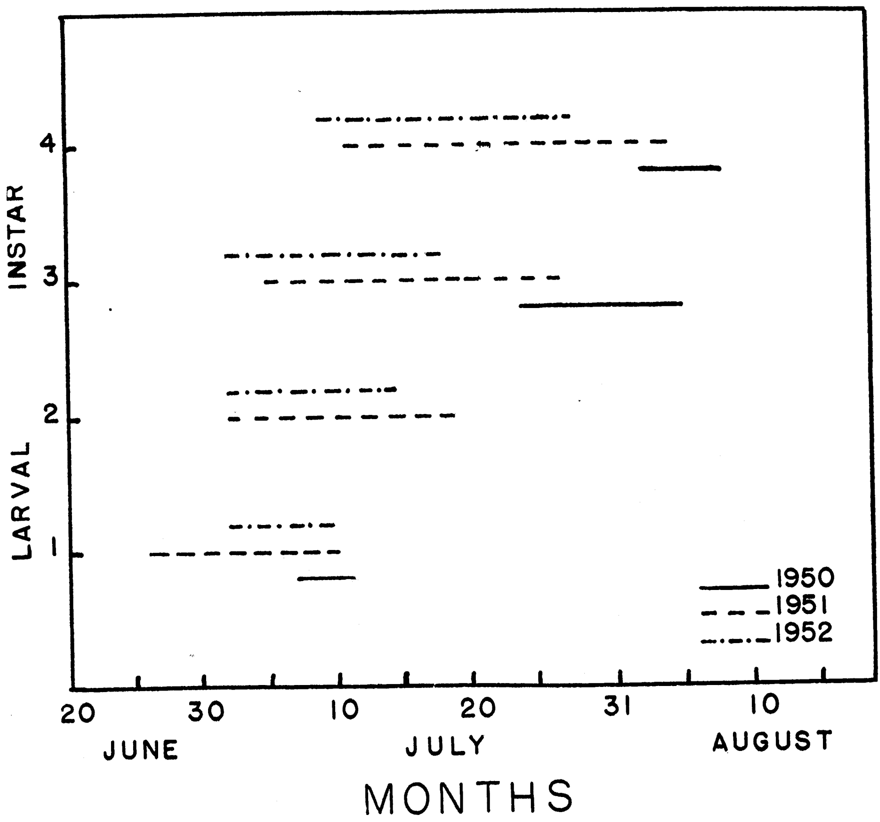

FIGURE 5. Seasonal development of cherry fruit worm larvae as determined by larval collections. Door County. 1950, 1951 and 1952.

they will hibernate in the soil or cover of the orchard floor in Wisconsin is not clear. According to Hoerner and List (1952) they do but the author has not found them in such locations in Wisconsin, despite repeated examinations of soil samples and grass stems.

Larval instars. Larval development consists of a series of molts or ecdyses. There are two methods which can be employed to aid in determining the number of molts for a given species (Wigglesworth, 1950). It has been shown by Dyar that the head capsule of caterpillars grow in geometrical progression, increasing in width at each molt by a ratio which is constant for a given species. Another empirical law is known as Przibram's rule. According to this rule the weight is doubled during each instar. Both the head capsule and weight measurements should be obtained in controlled experiments so that correct values can be assigned to the respective stages. In some cases, however, these measurement data do not

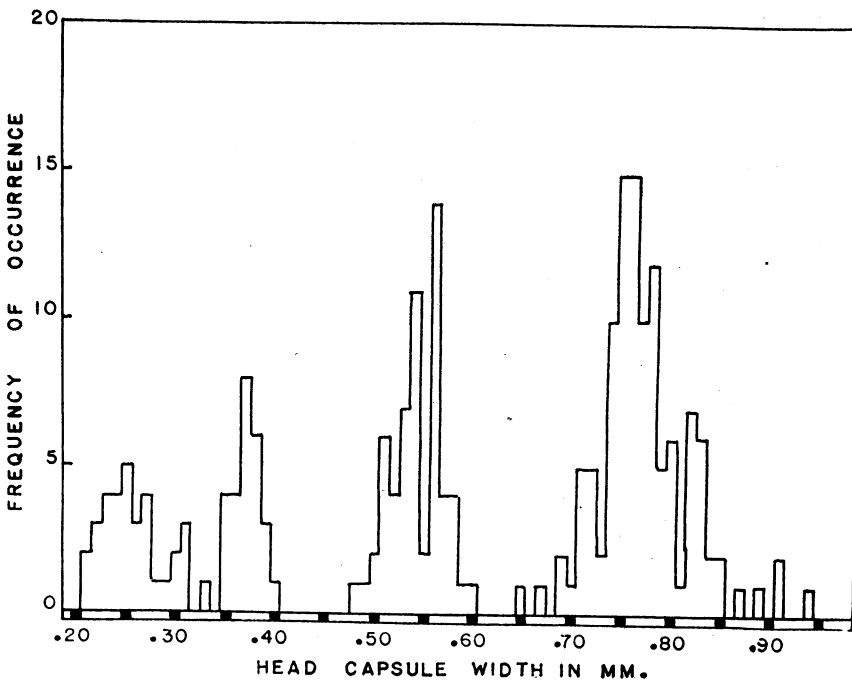

FIGURE 6. Frequency distribution of head capsule widths of cherry fruit worm larvae collected at regular intervals throughout the seasons of 1950, 1951, and 1952. Door County.

overlap and the larval instars are sharply differentiated. With this in mind, collections of the immature stages of the cherry fruit worm were made at periodic intervals and at various localities in Door County. The weight and head capsule size of these specimens were recorded to determine the number of instars of the cherry fruit worm. Initially the larvae were weighed on a Roller-Smith torsion balance before preservation in alcohol. This procedure was continued for one season and the data obtained evaluated. It was apparent that the weight ratio between instars of the field collected larvae was not in accordance with Przibram's rule, and would not add support to instar differentiation using head capsule measurements. Therefore, the recording of larval weight was discontinued and the collected larvae were preserved in 95 per cent ethyl alcohol.

The head capsules of the larvae were measured at the widest point of the vertex using a binocular microscope. These measurements provided sufficient data to determine the number of larval molts of the cherry fruit worm. The head capsule widths fell into four distinct groups when plotted graphically (Fig. 6). The minimum, maximum, and average widths of the head capsules in millimeters for the four groups were as follows: Group I—.210; .310; .255: Group II—.330; .400; .367: Group III—.480; .600; .543: Group IV—.650; .940; .772. The average width of .772 mm. is definitely that of the last instar as many of the larvae measured in this group were hibernating, and a cast head capsule was not found in numerous examinations of hibernacula in which the larvae had pupated. The calculated ratio according to Dyar's rule is relatively constant: .694 between Groups I and II; .675 between Groups II and III; and .703 between groups III and IV. This is supporting evidence that a distinct group does not exist between the four groups. This establishes four instars with the final instar having an average width of .772 mm. It cannot be stated conclusively that the first group with an average width of .255 is the first instar. If the average ratio of .69 observed between the other groups is considered there could be a distinct group having the average head capsule size of .175 mm. This could be the first instar. However, many larvae were collected that had just gained entrance to the fruit. There was no cast head capsule in the burrow. Therefore, if another instar exists the moult must occur before the larva enters the fruit. It was concluded that the measurements presented here are valid and indicate at least three larval moults in the development of the cherry fruit worm. It is possible that a fifth instar occurs, and if so, it is undoubtedly the first.

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NORTH PART OF THE OLD RIVER CHANNEL AT WISCONSIN DELLS

H. F. WILLIAMS
Wisconsin Department of Agriculture, Madison, Wisconsin

INTRODUCTION

The topographic features depicted on the accompanying map of the north part of the Old River Channel at Wisconsin Dells appear to have been almost entirely neglected by Wisconsin map-makers. No map was found showing significant topographic detail, other than rather steep smooth slopes on each side of the channel, in this small area of about one-quarter by one-half mile.

Yet, to anyone descending the approximately 100 feet from the comparatively level land on either side of the channel to the water surface, the topographic detail becomes very apparent since in many places it is impossible to negotiate the sandstone cliffs and ledges without long offsets to one side or the other. These offsets are more likely than not to necessitate other offsets through the dense vegetative cover with the result that once the channel level is reached one has only an obscure notion of his location. This was the experience of the writer when attempting to make a reconnaissance map in limited time during white pine blister rust control work in the summers of 1946 and 1955.

Except for the description of H. H. Bennett (1895), the several authors who have written about the Old Channel, inadequately characterize it as a wide expanse of sand, a vale of considerable extent, a gorge, a series of swamps and lakes, a depression, a clearly visible channel or simply as a channel.

I am indebted to the Upham Woods Project of the University of Wisconsin, the present owners, for permission to attempt a map of the area during the winter of 1955–1956 and to publish it with a description and a review of the literature.

Method of Survey: A Brunton magnetic compass was used for direction, distance was obtained by pacing, and the compass clinometer was used for elevations. Traverses were plotted on a base from an 8 inch to the mile Adams County aerial photograph No. BHT–7G–157 taken September 2, 1950 twice enlarged by pantograph. Stereoscopic examination of aerial photographs taken in 1938, 1941, 1950 and 1955, because of heavy shadows, failed to reveal clear-cut topographic features with differences in elevation of up to 80 feet that the writer knew were in the area.

Symbols and Names: Topography is shown on the map by hachure lines along the direction of slope mapped in connection with closed magnetic traverses; heavier hachure lines for nearly vertical sandstone cliffs; crossed hachures for interrupted or broken cliffs; isolated connected hachures for areas of ledges; light, widely spaced hachures for gradual slopes, closer together and shorter for steeper slopes, banks and low cliffs. Contours were precluded by the time available.

A similar treatment of topography was attempted by the writer for the Bad River country in Copper Falls State Park and vicinity, Ashland County, Wisconsin in 1949. A precise, short-interval, contour map would pose many interesting problems for the cartographer in this area and answer many interesting geological and physiographic questions.

Slope lines added under the stereoscope to aerial photographs during intensification of planimetric features can greatly aid the cartographer in locating himself on the ground in many areas. Maps of much of the state show no topography. By this simple technique the vertical beginning and ending and the curves and angles of many steep slopes can be located with precision if the vegetative cover is not too heavy. Many short steep slopes are lost between contours even on the best contour maps.

A location map is of practical importance in this area from the wildfire control standpoint. The principal readily identifiable features on the ground here are topographic. Conventional symbols are used for sand, streams, trails and water.

Names are applied to distinct topographic entities. The only name previously applied to a feature in the area is Allen's Creek. It is not strictly identifiable with any present ground feature though it bears a relation to the west side of the channel, Rockfall Creek and the G. L. O. Valley of the present map. The creek to which it was applied is gone, drowned, as it were, by the back waters from the dam at Wisconsin Dells. R. V. Allen was the builder and owner of the Old Dell House which stood on the east side of the Old Channel at its south end. Many other features—cliffs, valleys, caves and elevations—in the area are well worth naming.

GENERAL DESCRIPTION

The area is heavily wooded with a mixture of pines, hardwoods and hemlock, the latter mostly on the channel slopes on the south side. There is a level cultivated field adjoining on the north. The rock ledges and cliffs are of Cambrian, a very ancient, sandstone.

The pattern of valleys and cliffs appears to be governed by a system of rock joints at approximate right angles to each other as described by Van Hise (1895).

Hand-level lines were run from the channel ice to the tops of most of the higher elevations. They were all on the order of 70 (60–80) feet. Coldwater Island was the lowest, about 60 feet; Hanging, Lost and Pine Islands about 70 feet; Shipside Cliff and the tops of the elevations across the channel to the north about 80 feet. The level land back from the dissected area is some 20 to 30 feet higher, or about 100 feet above the water in the channel. Descents of 70 feet in as many horizontal feet are common, often interrupted by nearly vertical descents of 10 to 50 feet.

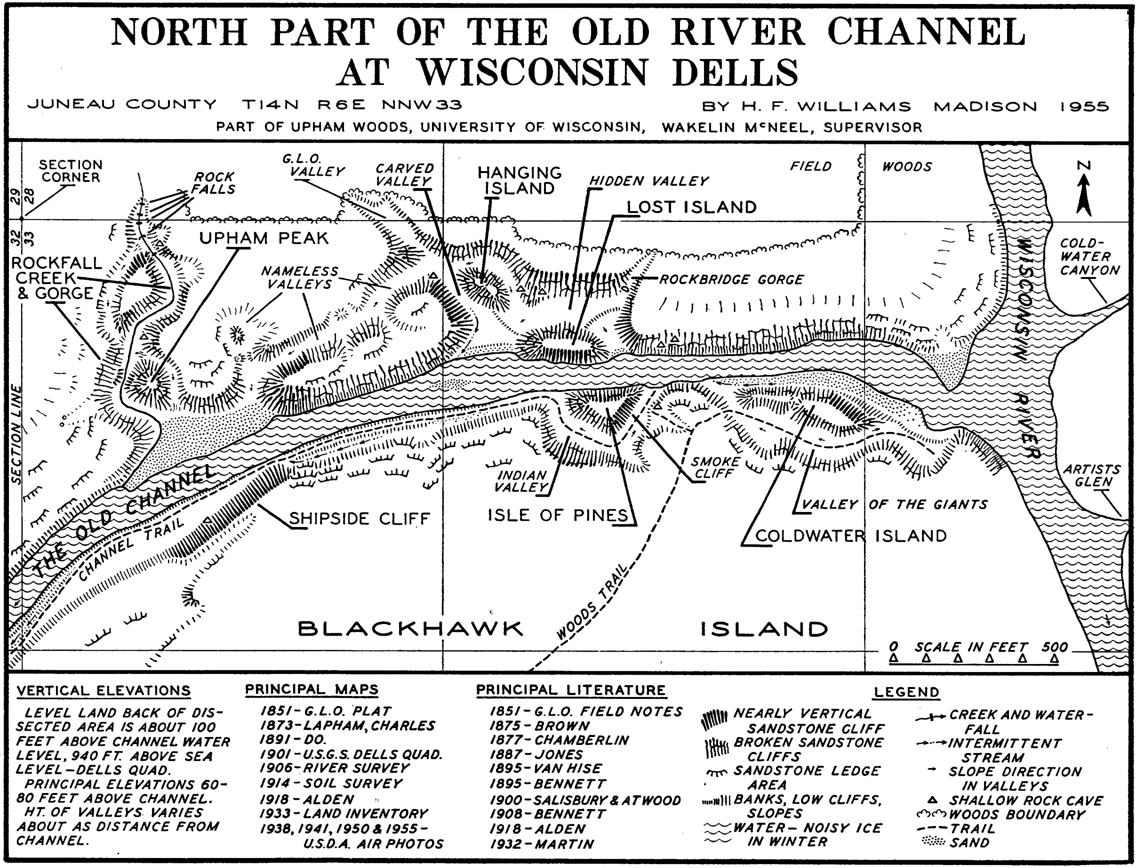
In general, the elevation of the valley floors above the channel is progressively higher the further they are from the channel towards the upland. This is indicated to some extent by the length of the hachures along the sides. Direction of drainage or slope in the valleys is indicated by small arrows where otherwise not clear.

In all the valleys having two mouths, drainage or slope is in both directions. Some half dozen examples are shown with the slope direction marked. Are these peculiar valleys the meanders of former streams, as seems probable, or did they originate by decomposition of the rock in situ? Excavation would determine the nature of their floors. Water worn cliffs recede into the valley detritus in several places.

The channel before the dam was built at Kilbourn (City of Wisconsin Dells) is described as choked with sand. Now it is filled with water the year round and averages throughout its length of a mile and a half about 100 feet in width.

The level of the tops of the sand banks, sand ridges and sand flats on both sides of the channel is several feet, as much as 15 or so in places, above the present water surface. A study of the nature and origin of this sand deposit, which is more extensive further down the channel, would be most interesting. The writer could not help but compare it with river terraces in glaciated areas or with valley trains, although it is designated by Alden (1918, Plate III) as of recent origin. On the landward side of the sand in three locations on the south bank intermittent streams formed by run-off from the land have eroded valleys in the sand. Run-off depressions similar to these form specialized habitats for plant life along many of the creeks and rivers in and adjacent to the glaciated area of Wisconsin.

In an area cut up so thoroughly topographically as this one, it is thought probable that very interesting studies could be made also as to the comparative age of the erosion at different elevations. It


NORTH PART OF THE OLD RIVER CHANNEL
AT WISCONSIN DELLS
JUNEAU COUNTY T14N R6E NNW33
BY H. F. WILLIAMS MADISON 1955
PART OF UPHAM WOODS, UNIVERSITY OF WISCONSIN, WAKELIN McNEEL, SUPERVISOR
SECTION CORNER
29
28
32
33
ROCK FALLS
G.L.O. VALLEY
CARVED VALLEY
HANGING ISLAND
HIDDEN VALLEY
LOST ISLAND
FIELD
WOODS
N
UPHAM PEAK
ROCKFALL CREEK & GORGE
NAMELESS VALLEYS
ROCKBRIDGE GORGE
WISCONSIN RIVER
COLD-WATER CANYON
SECTION LINE
SMOKE CLIFF
INDIAN VALLEY
ARTISTS GLEN
THE OLD CHANNEL
CHANNEL TRAIL
SHIPSIDE CLIFF
ISLE OF PINES
VALLEY OF THE GIANTS
COLDWATER ISLAND
WOODS TRAIL
BLACKHAWK ISLAND
0 SCALE IN FEET 500
VERTICAL ELEVATIONS
LEVEL LAND BACK OF DISSECTED AREA IS ABOUT 100 FEET ABOVE CHANNEL WATER LEVEL, 940 FT. ABOVE SEA LEVEL—DELLS QUAD.
PRINCIPAL ELEVATIONS 60-80 FEET ABOVE CHANNEL.
HT. OF VALLEYS VARIES ABOUT AS DISTANCE FROM CHANNEL.
PRINCIPAL MAPS
1851-G.L.O. PLAT
1873-LAPHAM, CHARLES
1891-DO.
1901-U.S.G.S. DELLS QUAD.
1906-RIVER SURVEY
1914-SOIL SURVEY
1918-ALDEN
1933-LAND INVENTORY
1938, 1941, 1950 & 1955-U.S.D.A. AIR PHOTOS
PRINCIPAL LITERATURE
1851-G.L.O. FIELD NOTES
1875-BROWN
1877-CHAMBERLIN
1887-JONES
1895-VAN HISE
1895-BENNETT
1900-SALISBURY & ATWOOD
1908-BENNETT
1918-ALDEN
1932-MARTIN
LEGEND
NEARLY VERTICAL SANDSTONE CLIFF
BROKEN SANDSTONE CLIFFS
SANDSTONE LEDGE AREA
BANKS, LOW CLIFFS, SLOPES
WATER—NOISY ICE IN WINTER
CREEK AND WATER-FALL
INTERMITTENT STREAM
SLOPE DIRECTION IN VALLEYS
SHALLOW ROCK CAVE
WOODS BOUNDARY
TRAIL
SAND

would seem likely that the more gentle rounded slopes back of the abrupt descents must be far older than the latter.

Numerous shallow caves in the sandstone testify to the friable character of the rock. About 10 such are shown on the map. Their depth seldom exceeds 10 feet. They have been a feature of exploratory activity by several generations of local youngsters. Archeologically, a few may be of interest.

The only stream having some water in it most of the year enters the area from the north over a series of rock falls, the highest being about eight feet. It has a gorge similar to others in the Dells area with broken sandstone cliffs rising as high as 70 feet or so and with rock walls only a few feet apart in two places. Two other valleys or gorges extend back to the cultivated field on the north. There is some indication, marked by sharp descents of a few feet, that one or both may be hanging valleys of sorts. The only hanging valley recognized at present in the Dells area is that of Artists' Glen across the river to the east.

REVIEW OF CARTOGRAPHY

Map makers missed the Dells area for many years as it lay north of the portage route between Green Bay and the Mississippi River. According to Kellogg (1921) the first map to indicate the Dells area was that of Featherstonhaugh (1835). Reference thereon was by caption and hachures from hearsay. Prior to the General Land Office Survey, I. A. Lapham and David H. Burr also indicated the Dells area by hachures and captions. None of these three, listed first below, showed any indication of the Old Channel. All of the maps listed are of small scale, none over two inches to the mile. The present map was drawn at 16 inches to the mile and a still larger scale might well have been used.

1835—Featherstonhaugh. On his "Map of a Portion of the Indian Country. . . . Made in the Autumn of 1835 . . ." the Dells passage of the Wisconsin River is shown by hachures and the caption, "A narrow passage with lofty mural Sandstone banks."

1836—Burr. The Dells passage is shown by hachures with the caption, "High Rocky Banks 3 miles in length overhanging the River so that one may jump across."

1846—Lapham. The Dells passage is shown by hachures with the caption, "The Dells. Perpendicular Rock Bluffs 300 f. high. River 40 f. wide."

1851—General Land Office (G.L.O.) Map. G.L.O. Valley of the present map is connected with the east end of the channel. Rockfall Creek is connected with the south end of the channel and there is no valley indicated between the two.

1873—Lapham, Charles. Rockfall Creek or G.L.O. Valley is connected to the south end of the channel and called Allens Creek. The Old Channel, separate from the creek, is shown by hachures cutting in a northeasterly direction directly across Blackhawk Island to a little north of the mouth of Coldwater Canyon. First map of the Old Channel.

1876—Nash and Morgan. Map shows a creek from Dell House (south end of the channel) to between Rockfall Creek and G.L.O. Valley, thence northeast for a quarter mile. No indication of rest of channel. NWNW Section 33 marked "Unknown Land." Remainder of NNW owned by R. V. Allen.

1877—Chamberlin and Others, Atlas Plate IV. The Old Channel is shown by hachures running nearly due north and south, somewhat similar to the 1873 map preceding. There is almost no "north part" of it. Allen's Creek is not shown.

1891—Lapham, Charles. Hachures are used to show the Old Channel which now is of approximate correct general shape. Allen's Creek now occupies the channel itself. The creek ends about 10 chains before reaching the east entrance to the channel. The channel is shown much too wide. There is no detail in the north part of the channel besides the regularly hachured valley, the terminus of the creek and two small ponds. The east entrance of the channel is now about correct with reference to the mouth of Coldwater Canyon. Forty years after the General Land Office Survey.

1900—Salisbury and Atwood. A copy of Lapham's 1891 map, page 141.

1901—U. S. Geological Survey, The Dells Quadrangle (Surveyed 1899). This map is still being reprinted without revision.* Contour interval 20 feet. A continuous single line stream is shown in the Old Channel. Contours are smooth on both sides of the north part of the Old Channel and from 840 to 940 feet above sea level. No topographic irregularities, branch streams or valleys are shown there.

1906—U. S. Geological Survey, River Surveys. 10-foot contour interval on land. In the north part of the Old Channel contours are from 820 to 910 on the island and 820 to 890 on the mainland. The latter is too low as it does not check with

* The U.S.G.S. has advised the writer that advance prints of a completely remapped The Dells quadrangle are scheduled to be available by May 1, 1958.

hand-level elevations nor with The Dells Quadrangle. One small closed 10-foot contour is shown at about the mouth of Rockfall Creek. It is not identifiable with any ground feature. A 20-foot closure of the east entrance to the channel is indicated. No water is shown in the north part. No other topographic irregularities or branch streams or valleys are shown although the contours, bending southward near the center of the NWNW of Section 33, gives a vague indication of the high land between the two main tributary valleys.

1907—Case. Map from Salisbury and Atwood (1900) which was from Lapham (1891).

1914—Webb Publishing Co. Atlas. The Uphams, from whom the University acquired the land, now own the area. No topographic detail.

1914—Whitson and Others, Soil Map. A continuous single-line water connection is shown around Blackhawk Island. No contours, topographic detail or tributary streams or valleys are shown. Area along both sides of the north part of the Old Channel is designated "Rough, Stony Land."

1918—Alden, Plate III. The north part of the Old River Channel is shown as a single-line stream bordered by a post-Wisconsin stage of glaciation, or Recent, alluvial deposit of flood-plain sand. The width of the deposit is shown about five times its actual width. The area is indicated as having been submerged by Glacial Lake Wisconsin.

1932—Martin. Map on page 346 shows a double-line north part of the Old Channel not connected to the river. No other detail there. Map on page 349 shows the old river channels based on The Dells Quadrangle (1901). No other detail in the north part of the channel.

1933—Land Economic Inventory Map of the Wis. State Dept. of Agriculture and Markets. Shows vegetation types. Channel a continuous double-line stream. No topographic detail.

1937—Holmes. Map on page 218 shows double-line Old Channel not connected to the main river similar to Martin's map on page 346.

1938—U.S.D.A. Aerial Photograph BHT–1–2, 3 and 4. Because of the heavy vegetative cover at all vertical elevations within the area and the black shadows cast by this cover combined with shadows of the elevations themselves, details of topography are indictinct or totally unrecognizable under stereoscopic examination. Photographs, however, provide the base for ground mapping here.

1941—U.S.D.A. Aerial Photographs AJA–2B–46 and 47; AJA–3B–35 and 36. See preceding.

1946—Cole. Pages 4 and 5 have a perspective map of the Dells area by A. G. Campbell. No authentic detail in the north part of the Old Channel but cliffs are rather well represented though exaggerated. Map on page 28 is a similar perspective somewhat better as to the shape of Blackhawk Island. On page 14 is a copy of Martin's map of the old channels. Map on page 16 shows the Old Channel as a single line without other detail.

1950—U.S.D.A. Aerial Photographs 7G–156 and 157, Juneau County. See under U.S.D.A. 1938.

1955—U.S.D.A. Aerial Photographs WR–5P–197 and 198, Sauk County. See under U.S.D.A. 1938.

Summary of Cartography. Nineteen maps are cited between 1851 and 1946 which bear indications of the north part of the Old Channel. Only two of these are contour maps. The rest omitted topographic indication or used generalized hachure or perspective representations. The many clear-cut topographic features in the area are largely or completely absent from all maps.

REVIEW OF LITERATURE

No specific mention could be found of any of the prominent individual topographic features along the north part of the Old Channel in the literature examined. Many of the references are obviously based on hearsay or copied with or without variations from others.

Prior to the construction of the present power dam at Kilbourn (City of Wisconsin Dells) in 1908, the east entrance to the Old Channel was closed during most of the year by a high sand bank. This, plus the difficulty of navigating the river here by canoe and lumber raft in the early days, insured a nearly complete indifference to the north part of the Old Channel for a long time.

A pamphlet published by the H. H. Bennett Studio of Kilbourn entitled "Old Days in the Dells" adds light on why the Dells area, including the north part of the Old River Channel failed to attract much attention in the early years. "In those days [prior to about 1875] few people traveled for pleasure in the wilds of Wisconsin, and little or no interest was excited by the few accounts of the scenery of the Wisconsin river. Most of the inhabitants of Kilbourn found the exploration of their river too difficult and paid little attention to their strange rock neighbors. . . ." (Page 6)

Even today much of the Dells area may fairly be described as virtually unknown in the sense that adequate maps and descriptions are non-existent.

The first three references following have to do with the Dells area itself while the remainder pertain to the north part of the Old River Channel.

1832—First mention of the Dells area in literature in connection with the capture of Black Hawk. (Kellogg, 1921)

1844—Lapham. "At the 'Dells,' the river runs for three miles, between perpendicular cliffs of rock about three hundred feet high, and only forty across." (Page 216)

1846—Lapham. The same statement but the distance was increased to eight miles. (Page 171)

1851—General Land Office Field Notes. The subdivider of Township 14 North of the Wisconsin Base Line, Range 6 East of the Fourth Principal Meridian was Henry S. Howell. In June of 1851 he ran a line north between Sections 32 and 33 to establish the north section corner common to these two Sections. At 58.0 chains he records a slough 70 links wide bearing southwest. This is the Old Channel on the west side of the present map. He noted that the land surface was "uneven" and "broken."

Running west from the northeast corner of Section 33, across both the gorges of Coldwater Canyon and the Wisconsin River, at 60 chains he crossed a ravine bearing southeast and south, 30 links wide and with rocky banks. This apparently was the G.L.O. Valley of the present map.

Neither the 58 nor the 60 chain measurements check closely with this map. Further, the measurement between the north line of Section 33 and the Old Channel as given for the river meander does not check closely. The section corner is marked on the ground by an iron pipe at a fence corner and the juncture of the north line of Section 33 and the river is similarly marked. Just how the corners and lines in this area were established as they are understood by the property owners in the area today is unknown to the writer. It may be noted parenthetically, that clearly marked subdivision corners are not common in the Dells area. Cadastral surveys are complicated by the topography which, away from the river, and along with the sandy soil, is not highly regarded.

Subdivision of land on air photographs according to the system of rectangular surveys, is similar to that of subdivision on the ground; both following the rules of proportional measurement of the U. S. Bureau of Land Management (formerly the General Land Office) as set forth in its several publications (e.g. 1947, 1952).

In relatively flat areas where the original survey was quite regular and where identifiable control points are not too far apart on the photos, unknown subdivision lines and corners can be plotted with a high degree of confidence. Even where control is only fair, as it is for the area under consideration, for many purposes this system is superior to that of pacing distances and determining direction by magnetic compass, where, of course, stadia or taped distances and transit azimuths would be prohibitively costly.

1875—Brown. The first guide-book to the Dells describes the Old River Channel: "Ancient River Bed. A high sand-bar faces this opening [opposite Coldwater Canyon], but the visitor will perceive a vale of considerable extent, and rocky bluffs beyond, where the river evidently once flowed, centuries and centuries ago; until it forced its way through its present narrow gorge." (Page 12)

This is the first specific reference found to the north part of the Old River Channel—81 years ago, 43 years after the first known reference to the Dells area. The references cited here are those found in the State Historical Society and University Libraries in Madison and the Public Library at Wisconsin Dells. Bennett, 1895; Bennett, 1908; Brown, 1875; and Wisner, 1875 were examined at the Bennett Studio in the City of Wisconsin Dells through the kindness of Miss Miriam Bennett.

1875—Wisner. Believed to be the second guide-book to the Dells. "The Ancient River Bed, or sand bank on the left [opposite Coldwater Canyon]. In an early day the river divided here and a part ran around, coming out and uniting with the main river at or below the Dell House, forming a large island." (Page 30)

1877—Chamberlin and Others. "The perpendicular sandstone walls are from 15 to 80 feet in height, the country immediately on top of them being about 100 feet above the river." (Page 418) This description, applied to the main river, fairly describes the vertical elevations in the north part of the Old Channel also.

Following is the first mention found in technical literature of the old river channels, "In several places branch gorges deviate from the main gorge, returning again to it; these are evidently old river channels and are now closed by sand." (Page 418) The side gorges: "The streams entering the river in this portion of its course make similar cañons on a smaller scale." (Page 418)

1879—Donan. "The Old River Bed, through which part of the river, if not all of it, once poured its waters, but now a wide channel of yellowish white sand, lies on the left [nearly opposite Coldwater Canyon]. (Page 18)

1880—Western Historical Company. "The Ancient River-Bed is seen [when ascending the river] as a sand bank on the left. In an early day, the river divided here, and a part ran around, coming out and uniting with the main river at or below the Dell House, forming a large island." (Page 473) Same description as Wisner, 1875.

1887—Jones. "Old River Bed. Here, in other days, the river used to run, the entrance being now closed by an immense sand heap. Very many interesting studies will be found by geologists in following this old channel to its outlet, about 3 miles." (Page 18) The distance is actually about half this; the prediction is still good. This is believed to be the third guide-book to the Dells area.

1895—Bennett. The "Old Channel of the River, now choked by a high sand bank, which is on the left in going up the river; but, high as it is in low water, some seasons the spring floods raise the river high enough so that a part of the stream runs over it and around a large tract of land, coming out and uniting again with the main river, near the old Dell House, forming an island. . . . Much of the way this old Channel is as well defined as the present river, and as interesting, several isolated rocks of strange shapes, that were islands, many caves and grottoes in the high cliffs, along either side, much of the distance.

"If you are strong take a tramp through the old channel some time in the autumn, when the day is not too warm, and you will enjoy it; but if you are feeble or indolent don't try it. . . ." (Page 9)

The famous H. H. Bennett, "The man with a camera," could also make pictures with words! Here described for the first time, though lacking specific reference, are the abandoned islands, the caves, the strikingly picturesque similarity of the Old Channel with the New, and not least, perhaps, the main reason why the area is even yet little known—it is not easy of examination.

1895—Van Hise. "Above the Narrows the old course of the stream may be seen to leave its present channel, and below the Narrows to again join the present course. While this old channel has not been followed personally it is said to be about 1½ miles in length. Because of the peculiar conditions which result in almost immediate base levelling of the side dells, and the rectangular system of joints, it is thought probable that side dells at the beginning and end of the Narrows [south of the Old Channel] began to develop; that because of the system of joints in two directions their heads intersected, and thus made the beginning of the new channel. . . . In this shorter course the erosion would go on more and more rapidly, and finally the old longer course would be abandoned for the shorter one. Thus . . . we have the unusual phenomenon of [a] strong river in a gorge abandoning its course to follow another gorge made by two small weak tributary streams which had no advantage in slope." (Page 558) As in the case of the Old Channel valley previously mentioned, careful studies of the age of the New Channel valley at its different vertical elevations might throw additional light on the drainage here in ages past.

1900—Salisbury and Atwood. "Not all the present route of the river through the dalles has been followed throughout the entire post-glacial history of the stream. . . . During high water in the spring, the river still sends part of its waters southward by the older and longer route." (Page 140) The old valley is described as a "depression."

1907—Case. "To one side of the Narrows can still be traced the abandoned portion of the channel in a series of swamps and lakes through which water still flows in time of high flood. . . . The river for some cause was deflected for a short distance and then returned to the old channel. . . ." (Page 143)

1908—Smith. No reference to the Old Channel. Refers to dams at Kilbourn. Present dam, then under construction, provided for a 17 foot maximum head of water. (Page 135) Van Dyke (1916) states that the present dam was begun in 1907 and the entire plant was completed and set in operation in August of 1909. (Page 78) According to the River Survey of 1906 there was but a slight drop in the water surface between the site of the dam and the east entrance to the Old Channel. The direct distance is only about two miles and the drop on the order of two or three feet in this distance. Hence, the water in the ponds and creeks in the Old Channel might have been raised as much as 15 feet. Records at the Wisconsin Public Service Commission Office in Madison indicate that the maximum head of water at this dam may today be somewhat higher than stated above. The height of this "artificial" water bears a direct relation, of course, to the problem of the sand deposit in the Old Channel.

Today Blackhawk Island is surrounded by water throughout the year. Due to variation in water level above the dam, as well as changes in temperature, the ice in the Old and New Channels cracks and groans throughout the winter, adding to the wild isolation of the place.

It is readily apparent that the sand deposit, especially along the south shore of the Old Channel, is being eaten into in many places. This process probably began as early as 1856 when a dam with a fall of eight feet was constructed at Kilbourn. This would have been sufficient to raise the water in at least part of the Old Channel by several feet. This dam was destroyed by irate lumbermen in 1859. Subsequent dams built in 1866 and 1871 probably were not high enough to greatly affect the Old Channel deposits. (Western Historical Co. Pages 809, 814, 817)

1908—Bennett. The following was written after completion of the dam started in 1907. The "Old River Bed, marked at the entrance by a sand bar [opposite Coldwater Canyon]. Formerly this bar choked the entire entrance, but since the raising of the river by the dam at Kilbourn the waters go through this old channel, and some of the time it is possible to make the trip through it by launch or rowboat, regaining the main river near the Old Dell House site." (Page 11)

1918—Alden. Several important references to the geologic history of the Dells area.

1932—Martin. "It is clear that the Wisconsin used to turn westward just below the mouth of Coldwater Canyon, looping back to the present channel about three-quarters of a mile down stream. . . . The stream in Artists Glen is then supposed to have flowed southward. . . . Subsequently the Artists Glen stream cut into its north bank and the Wisconsin cut into its own south bank so that the narrow strip of rock between the two streams was eventually cut through, presumably in a period of high water in the spring. As soon as the main Wisconsin River was diverted into the narrow channel of Artists Glen it quickly cut down, for it gained velocity because of the constriction and steeper grade. . . . From this it is clear that the old channel west of Coldwater Canyon is not the incised meander of a river in old age, as is sometimes suggested, but an exceedingly youthful form due to stream capture." (Pages 349–350)

1942—Derleth. ". . . The Wisconsin changed its channel three times; the two abandoned channels are clearly visible today." (Page 254) Lost, Coldwater and Isle of Pines are three unique "Islands" of the "River of a Thousand Isles." True, they each have only one foot in the water today.

1946—Cole. "Two abandoned channels can be found, one of them a short loop southwest [?] of the Old Dell House, the other from there south of the railroad to below the dam." (Page 13) "Before the stream was diverted by cutting through the sandstone the river flowed through the now deserted channel, entering the main stream near the Dell House site. Water flows through the old channel during high water, thus forming an island." (Pages 18, 19)

1946—Powers. "During its turbulent descent through the Dells, the Wisconsin River altered its course several times. Its latest abandoned channel runs from the mouth of Coldwater Canyon to the site of historic Dells House, and is pointed out by boat men on the river." (Page 84)

Summary of Literature. For the most part, descriptions of the Old Channel and its valley are incomplete. The valley of the north part of the channel is not a simple gorge or canyon; the land surface is more than broken or uneven; the expanse of sand that filled the bottom of the valley is not its most pronounced characteristic; it is least of all a simple depression.

DISCUSSION

The north part of the Old Channel and its valley is actually a complex system of rock prominences, cliffs, rock ledges and slopes associated with ten or more distinct drainage features or valleys besides the old river course itself. The differences in vertical elevation between these features are on the order of 60–80 feet in as many horizontal feet with more gentle slopes continuing upward for another 20–40 feet. The width of the valley varies, lacks sharp upper limits, perhaps averages a quarter mile. The bottom of the valley was filled at one time with a deep deposit of sand. A more exact topographic and geological correlation of all these features than is here attempted would be of great interest in understanding the formation of this valley itself and the others in the Dells area.

The writer believes he lacks sufficient data on this and the many other nearby valleys to speculate at any length on the origin of this complicated Old Channel valley. He is satisfied to point out and to map in some detail its complex topography. "The regimen of a stream is the result of the complex interaction of many variable factors. . . ." (Flint, 1947, page 483.)

The presently accepted theory as to the origin of the Dells area, including the north part of the Old River Channel, elucidated by

Van Hise (1895), Alden (1918) and Martin (1932) is that it is entirely postglacial and the result of the continental glacier pushing the Wisconsin River westward out of its preglacial course onto a broad, low, comparatively level ridge of friable, jointed sandstone. To the writer, this theory appears to lack studied detail to somewhat the extent that the maps of the north part of the Old River Channel lacked detail. He has been over much of the Dells area on foot and finds feature after feature, scarcely less pronounced than those of the north part of the Old Channel, unmapped, undescribed and unexplained.

The forces that carved the side dells were both glacial and non-glacial with respect to the position of the glacier, the latter but scarcely less effective than the former in carving dells and canyons. Presumably non-glacial erosive forces would have acted in the area long before the onset of glaciation, or if not, what was the cause of the earth movement that produced rock fractures in this area such that at about the end of the last glacial advance "almost immediate base levelling of the side dells" (Van Hise, 1899, page 558) occurred?

The possibility that the water in the Old Channel at one time flowed in the opposite direction, ultimately joining the Wisconsin to the north before the latter stream was pushed westward to its present course by the glacier, ought not to be overlooked. Such a possibility is not entirely speculative: The upland on the west side of the present map is considerably higher than that on the east; the height of the abandoned islands diminishes eastward; the stream in the Rocky Arbor part of the Old Channel flows eastward. If this could be proved, much interest, and indeed, dignity, would be added to the north part of the Old Channel as a river in its own right rather than primarily as an abandoned course of the Wisconsin. Correspondingly, the initiation of many of the tributary side dells might then have preceded the melting of the last continental glacier when its terminus stood a few miles to the east of the Dells area.

A network of precise vertical and horizontal control points established in this Old River Channel area would be a preliminary to its detailed mapping. Tied to the plane coordinate reference system, this network and the map based upon it would be susceptible of very exact identification in all its parts and exactly relatable to any other place in the system as described in the several publications of the U. S. Coast and Geodetic Survey (e.g., 1940, 1952).

In any more detailed analysis of the origin of the old channels, the possibility of finding organic material susceptible of radiocarbon dating in the channel deposits might be borne in mind. A reexamination of the rate of Dells area Cambrian sandstone erosion in the period since the last glacial epoch, a period according to carbon-dating data now believed to be only about half as long as formerly thought (about 12,000 as against 25,000 years), would also be in order. (Libby, 1956, page 108; Flint, 1947, pages 379–406; Thwaites, 1948, pages 104–106.)

CONCLUSIONS

1. Details of this small area of Wisconsin topography have remained unmapped and largely undescribed.
2. Published contour maps of this area give an erroneous impression of regular relief. The hachuring here attempted, while wanting in precise vertical elevations, provides a means of approximate point location on the ground, a feature of value, for example, in wildfire control.
3. Some fifteen distinct topographic entities with differences in vertical elevation averaging perhaps 70 feet are mapped and named and the location of others indicated.
4. Conventional air photographs do not satisfactorily reveal the topography of this area.
5. A precise topographic and geological study of this area should prove extremely interesting either as it would strengthen or modify the presently accepted theories as to the origin of the Wisconsin Dells area.

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ELLERY CHANNING IN ILLINOIS

KATHRYN WHITFORD and PHILIP WHITFORD

Departments of English and Botany, University of Wisconsin—Milwaukee

Nothing we know of William Ellery Channing would recommend him for a position as a frontier farmer. Thoreau's *Journal* reveals him as a man who did not relish being rained upon, who was likely to tire upon a long trip, and who failed to discipline himself to careful note taking—much less plowing. Sanborn paints a brilliant conversationalist and something of a snob—a man who liked to recall that in the houses where he called in his youth all the gentlemen wore silk stockings.[1] Surely if the record of Channing's life is a record of failures, one would be justified in expecting his year in a log house on the Illinois prairie to be a debacle.

Actually Channing seems to have conducted himself rather creditably, and the failure of the Illinois enterprise may be laid at least as much to the fact that the land failed Channing, as that Channing failed the land.

In 1839 when Channing went West, he was already a dedicated poet;[2] and, in consequence, he necessarily expected both economic support and poetic inspiration of the land to which he went. But in 1839 northern Illinois was not able to offer either, despite the glowing reports with which land speculators in Illinois flooded the Eastern cities and which bore about the same relation to reality that John Smith's *True Relation* bore to an earlier frontier. Illinois, in 1839, was still in the depths of the panic of 1837, which was felt more keenly in Illinois than in almost any other part of the country. Thousands of acres had been recently sold and, by the terms of the Specie Circular, land payments were required in gold or silver. In consequence, the West was drained of hard money. In addition, the state of Illinois was deeply in debt for an abortive system of land improvements, mostly canals, which it had begun shortly before 1837; the situation became so desperate that after July, 1841

> no attempt was made to pay even the interest on the public debt; taxation was high and the people were unable to pay even moderate rates. Illinois was in ill repute. There was no

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[1] Sanborn, F. B. "Ellery Channing and his Table Talk" *Critic* Vol. 47, p. 126.

[2] Channing, William Ellery, *Poems of Sixty-five Years*, ed. and with biographical introduction by F. B. Sanborn, Concord and Philadelphia, 1902, p. xix.

> trade; real estate was almost unsalable; business was stagnated; everybody wanted to sell his property and move away but there were only a few . . . who cared to buy.[3]

Conditions in Illinois did not improve until 1842–43, when it became clear that there would be no repudiation of the public debt and no increase in taxation.

Channing remained there despite the general depression, and if he demonstrated a lack of financial acumen by so doing he more than compensated for it by the shrewdness with which he selected and bought his land.

The 160 acres which he bought from Franklin Griffing for the sum of $500 was not a quarter section, but three separate parcels of land chosen to include the combination of prairie, marsh and timber which all settlers coveted.[4] Thus he provided himself with well-drained upland for crops, a bit of marsh for pasture, and trees for buildings, fences and fuel.

The largest tract of the three contained 80 acres of which 25 were probably open oak grove and the rest well-drained prairie. This tract was the one closest to Woodstock, and it seems reasonable to suppose that he built his log house[5] here, where there was timber to be cleared from good agricultural land, and where he was close to his 25 acres of prairie which lay half a mile to the north and included a small marsh which has since been drained. The third tract, containing 55 acres, lay five miles to the west on a gravelly moraine ridge which even now is used chiefly for pasture and timber and which still contains a few 200 year old oaks to testify to its character at the time of settlement.

A year later, despite the continuing depression, Channing was able to sell his land for $60 more than he had paid for it; but the question remains, why, after such an auspicious beginning, Channing was willing to sell his holdings to Pliny Hayward and return East. The answer appears to lie in the fact that McHenry County offered scant food for Channing's poetic imagination.

It must be borne in mind that Channing's natural inclinations as a poet led him to seek "the wild and lonely aspects of nature and the abodes of unconventional men."[6] But Northern Illinois had absolutely nothing in common with the frontiers which Cooper was even then describing. The land had never been notably wild, but

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[3] Pooley, W. V. *The Settlement of Illinois from 1830 to 1850,* Bull. of the Univ. of Wis. no. 220, History series vol. 1, no. 4, Madison, 1908, pp. 569–570.

[4] Schafer, Joseph, *Four Wisconsin Counties, Prairie and Forest,* Wisconsin Domesday Book, General Studies vol. 11, State Historical Society of Wis. 1927, p. 121.

[5] Channing, Op. cit. introduction by F. B. Sanborn, p. xx.

[6] Cooke, George Willis, *An Historical and Biographical Introduction to accompany the Dial,* Cleveland, 1902, p. 77.

was famous rather for its orderly and park-like beauty.[7] By 1839 it was no longer lonely, what ever it may have been only 10 years earlier—it was thronging with people much more conventional than Channing himself, and of types entirely familiar to him, since most of them had come across the route through the Great Lakes from New York and New England. The substantial character of this frontier can be demonstrated by a quotation from *The Settlement of Illinois from 1830 to 1850:*

> The settlers were of a class superior to the early pioneers of the southern counties. In many places "neat white houses, tasteful piazzas, neat enclosures and newly planted shrubberies" gave evidence of New Englanders or people from the Middle Atlantic States. The people, as a rule were contented with their homes and evinced no desire to emigrate except for a few who desired to go to the Oregon territory. Occasionally suprise is manifested at the character and intelligence of the settlers.[8]

The fact remains that Channing's imagination was not to be fired by the sight of solid New Englanders hewing solid and prosaic homes from a land which often had a cultivated aspect before it had ever been touched by an axe or a plow. In consequence, a scant handful of Channing's poems are all that appear to reflect his experiences during a year on the Illinois frontier.

None of these poems uses the word "prairie" or specifies in any way the background of their origin; but emphasis in some of Channing's early poetry is given to such prairie phenomena as winds and particularly wind-blown grasses, new or strange land, trees holding their leaves into the fall or winter, the spaciousness of the sky and the brilliance of the stars. When these elements appear in conjunction with each other, and are not accompanied by mentions of pine trees, hemlocks, or other characteristics of the Eastern landscape, they may be taken to indicate possible Illinois influence. Three of the poems which show such a conjunction of prairie images occur in the volume of 1843; one poem appears in the volume of 1847, and the last is a fragment from the long poem "John Brown"[9] which, though it was written many years after Channing's return from the West, might easily have evoked memories of Illinois as Channing attempted to describe the prairies of Kansas.

F. B. Sanborn wrote of the lines from "John Brown" beginning "Ah the old Kansas life ran in our veins. . . ." "Verse like this is

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[7] Vestal, A. G., Preliminary Vegetation Map of Illinois, n.p. 1930.
[8] Pooley, op. cit., pp. 552–553.
[9] Channing, *John Brown and the Heroes of Harpers Ferry,* Boston, 1886.

the reminiscence, half a century after the experience, of the prairie life of young Channing in Northern Illinois".[10]

If, on the authority of Sanborn (who by 1886 probably was as intimate with Channing as anyone was ever to be), one accepts the lines from "John Brown" as demonstrating prairie influence, then "The Stars"[11] which is demonstrably similar in content and feeling, and much closer in time to Channing's prairie year, must be accepted as having its origin also in prairie influences.

"October"[12] is the most philosophical of the five poems which seem to show prairie influence and, therefore, contains the fewest consecutive descriptive lines. Grass, wind, stars and dry leaves, combined as they are here are suggestive, but certainly not proof, of prairie influence. The reference to "wandering men" would appear to strengthen the claim of this poem to be included among the prairie poems. Of equal importance is the fact that this poem was published by Emerson in the *Dial* in 1840, which establishes this poem closer than any of the others to the year Channing spent in Illinois.

The case for considering "The Benighted Traveller"[13] one of the prairie poems is very strong despite the fact that Channing uses the term "moor" rather than prairie in the opening line. Channing consistently clothed his verses in the conventional vocabulary of English poetry, in which the word "prairie" had no place, even at the expense of strict accuracy. In similar fashion he used the term "red deer" in the poem "Woodland Thought"[14] although the red deer is European and not an American species. Putting aside the term "moor," Channing's mention of marshes, mist, the "herb that withered long ago, untouched before," and the traveller lost at night, are all significant in terms of Channing's Illinois experience. Roads in northern Illinois were poorly marked and since there were almost no fences a traveller went cross-country much of the time. In some seasons the prairie flies were so vicious that travellers deliberately chose to hazard becoming lost after dark rather than to attempt to travel by day.[15] The "withered herb, untouched before" implies not only an unpopulated area but also an ungrazed area; the marshes and mists which rose from them, while not peculiar to Illinois, were at least among Channing's most familiar memories of Illinois; for both his pieces of work-land overlooked the spreading marshes at the headwaters of Nippersink Creek. "A Woodland

[10] Sanborn, F. B. "Maintenance of a Poet," *Atlantic Monthly* Vol. 86, p. 821.
[11] Channing, *Poems*, Boston, 1843.
[12] *Ibid.*
[13] *Ibid.*
[14] Channing, *Poems*, Boston, 1847.
[15] Vestal, A. F. "Why the Illinois Settlers Chose Forest Lands", *Transactions of Ill. State Academy of Science*, Vol. 32, No. 2, p. 87.

Thought", published seven years after Channing's return from Illinois, appears in its first stanzas to contain memories of land-clearing in Illinois. These stanzas imply that the cutting is being done for purposes of settlement, and the reference to "church like wood" is more appropriately applied to the virgin forests of Illinois than to the largely second-growth forests of Massachusetts. But here all connection with Illinois ceases. The sea-going destiny of the planks is typical of New England and not Illinois; although it is true that Illinois logs were being rafted down the Mississippi to New Orleans, and there was a minor ship-building boom along the great lakes during the years just after the opening of the Erie Canal. The use of the term "spires" may be merely an extension of the image begun with "church-like", but it may also indicate that Channing was thinking in terms of conifers which do not occur in McHenry County.

Channing did not fulfill Emerson's hope that "This voice of love and harmony" might "teach its songs to the too long silent echoes of the Western forest";[16] but it must be assumed that he himself did not regard his year in Illinois as an entire failure, for by his words written to Thoreau,

> I see nothing for you in this earth but that field which I once christened "briars"; go out upon that, build yourself a hut, and there begin the grand process of devouring yourself alive.[17]

he implies approval for his friend of a path which he already had travelled.

In summary then, examination of the year which Ellery Channing spent in McHenry County, Illinois, reveals that young Channing exercised commendable judgment in his choice of land, that he was disappointed in the nature of frontier life as he encountered it in Illinois, and therefore sold his property and returned East; but also that he made tangible improvements during his year of ownership and was able to sell the land at a time when selling Illinois land was a difficult accomplishment. A group of at least five poems appear to reflect Channing's western experience, a number which is about proportionate to the duration of the experience, and if the poems which derive from the western year contain no immortal lines, at least their quality is consistently high by comparison with Channing's work as a whole.

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16 Emerson, R. W. "New Poetry", *Dial*, Vol. I, p. 232.
17 Thoreau, H. D. *Familiar Letters*, Boston and New York, 1906, p. 121.

HENRY KING: A POET OF HIS AGE

ROBERT F. GLECKNER
Department of English, University of Wisconsin

According to John Sparrow, who has edited the definitive edition of Henry King's poetry, King's best work is a thing not merely of interest, but of beauty.[1] Yet King has received little critical attention. To trace the development of his poetic powers, however, is an impossible task because of the lack of verifiable data concerning his methods or the dates of composition of his poems. Although some of the occasional pieces can be dated with reasonable certainty, all of his lighter lyrics, many of his imitations of Donne, and his religious poetry can be placed only conjecturally. The standard assumption is that most of King's secular poetry, including the so-called "slavish" imitations of Donne, belong to a period early in his life, and that his religious poems and many of his elegies are representative of his more sober maturity. This may or may not be true. What is more important is that King was born 20 years after Donne and Jonson and lived for nine years after the Restoration. One cannot assume from this, of course, that he wrote poetry all through his long life and is therefore representative of the late 16th century, early 17th century, and Restoration poetic modes; but it is valid to examine the effects of the multiform cross-currents of literature as they are revealed in the poetry he did write. In this way a progression or development is discernible—one which shows traces of all but a few of the literary genres, techniques, attitudes, tones, and ideas which made the first half of the 17th century such a storehouse of admirable works, and one which looks forward, at least, to the Restoration and the 18th century.

In order to explore to the fullest in a short essay this wide range of material, I have adopted an arbitrary system of "development" in King's poetry. This system is employed not to establish any chronology, nor to prove a growth of poetic power, nor to categorically pigeonhole King's poetry, but rather to show most effectively (1) that King consciously imitated Donne in several poems; (2) that he learned also from Jonson, and, after assimilating the lessons of both men, he produced what might be called his own individual style; and (3) that, especially in the later occasional

[1] John Sparrow, ed., *The Poems of Bishop Henry King* (London, 1925), pp. xiii. All page references to King's poetry will be from this edition.

pieces, he made use of the feeling, rhythm, vocabulary, felicity of phrase, and pointed diction of the succeeding century. To this end I have chosen not always the best poems, but those which best illustrate each of these three phases.

Though considerably younger than John Donne, King came to know him well, and it was natural that he try his poetical wings first with the aid of the master's support. Sir Herbert Grierson has suggested that Donne may even have criticised the poetry which King undoubtedly showed to him. This is an attractive possibility, of course, but even without it, a casual reading of the poems themselves will reveal that many are merely literary exercises in the manner of Donne, conscious attempts at a style and method which no doubt appealed greatly to King as to the other younger "metaphysicals." These poems comprise the first step in King's development as I have outlined it above.

The first poem in the canon, "Sonnet. The Double Rock," Saintsbury has called "very typical metaphysicality of a good *second* water."[2] In general my judgment would be more severe, but the poem is a good example of Donne-imitation—and, incidentally, of King's usual failure to erect a monument of any consequence to Donne's genius. There is a visible straining here for the paradoxical quality of Donne's verse with little of its depth of emotion or intensity of expression. The movement of the lines suggests something of Donne, especially the contrasting decasyllabic and tetrasyllabic couplets in which King cleverly uses the shorter line for a variety of effects. Despite its general lack of value as poetry, "The Double Rock" is of interest because the stanza form, along with that of "The Complaint," is the most radical King ever used: the dimeter lines never reappear in his work although they are probably the best lines in this poem. This is indicative of the direction in which King was eventually to go—toward greater, many times monotonous regularity in both stanza form and meter. He tried to accept the intricacies of Donne's method but revolted from the "licentiousness" of form which that method seemed to demand. "The Double Rock" is King's one experiment in that kind of form. That he was an experimenter (if that term may be used in a slightly less than literal sense) is important to an understanding of the enormous difference in the quality of King's poetry; his experimentation was not in new forms or new genres, but rather in the traditional poetry which the prolific writers of the era were turning out like pulp fiction today.

The two paradoxes, for example, though very ordinary indeed, perhaps deserve mention here for their apparent close connection

[2] George Saintsbury, ed., *Minor Poets of the Caroline Period* (Oxford, 1921), III, 169.

with Donne's prose paradoxes. King's are little more than prose pieces poured into pentameter couplet form, with corresponding wrenching of syntax and word order, interlarding, and generally poor poetic performance. One couplet will suffice to demonstrate not only the bad poetry but also the general lack of good taste:

> Dripping Catarrhs and Fontinells are things
> Will make You think You grew betwixt two Springs. (52)

"Madame Gabrina, Or the Ill-favourd Choice" is another of the stock-in-trade of the poets of the day, the ode to any ugly mistress, and King, I suppose, should not be censured for trying his hand at a standard-operating-procedure. But the poem is scarcely original. King merely softens the ugliness of poems like Donne's "The Anagram," "The Comparison," and "Julia" (Elegies II, VIII, and XIII respectively).

In view of these disappointing performances, it is likely that King's search for a congenial form was quickly over. "The Double Rock," the paradoxes, and "Madam Gabrina" were never duplicated in form or content, and he settled upon occasional verse, elegies, epitaphs, and the loose conception of the sonnet peculiar to the Caroline lyricists, as vehicles suitable to his talents. In general we must agree with his choice.

The earliest of these occasional poems to which a certain date can be assigned is "An Elegy Upon Prince Henry's death," written in 1612. Among the deluge of laments poured upon Henry's coffin was, of course, John Donne's "Elegie on the Untimely Death of the Incomparable Prince Henry." Although similar techniques are employed in both poems, the tone and total effect of Donne's differ radically from King's. Both poems begin with an imperative, Donne's addressed to Faith and God, King's to Nature, but immediately thereafter their divergence is marked. Donne suggests that the loss of Henry will cause the "chains" of Faith and Reason to break, while King's emphasis is on the total collapse of all Nature. Just so when Milton's Eve plucked the apple and ate,

> Earth felt the wound, and Nature from her seat
> Sighing through all her works gave signs of woe,

and when Adam followed suit,

> Earth trembled from her entrails, as again
> In pangs, and Nature gave a second groan.

King's version is as follows:

> Keep station Nature, and rest Heaven sure
> On thy supporters shoulders, lest past cure
> Thou dasht in ruin fall, by a griefs weight
> Will make thy basis shrink, and lay out thy height
> Low as the Center. . . . (66)

Though these lines are only vaguely Miltonic, King's skillful use of the enjambed couplet lends a certain majesty and "drive" to the sense of falling and collapse. Donne's elegy, on the other hand, begins with short, clipped sentences and phrases, the impact of which is oddly diffuse instead of solidly emphatic; what Donne takes three pages in explaining—the imagined collapse of reason and faith and hence of all life—King cautions against in a few lines. Donne's poem is a much more sustained performance, however, packed with syllogism, paradox, verbal and syntactical intricacy, but perhaps because of these very qualities it remains somewhat cold in comparison with the frequent warm sincerity of King's lines. For example:

> Heark! and feel it read
> Through the astonisht Kingdom, Henry's dead.
> It is enough; who seeks to aggravate
> One strain beyond this, prove more sharp his fate
> Then sad our doom. The world dares not survive
> To parallel this woe superlative.
> O killing Rhetorick of Death! two words
> Breathe stronger terrours then Plague, Fire, or Swords
> Ere conquer'd. This were Epitaph and Verse
> Worthy to be prefixt in Natures herse,
> At Earths last dissolution; whose fall
> Will be less grievous though more generall:
> For all the woe ruine ere buried,
> Throngs in this narrow compasse, Henry's dead. (66)

Still both poets seem to have used the occasion more as a starting point for an abstract essay (Donne's on Death, King's on Grief) than as a time for obsequies. Both avoid mention of the mere facts of Henry's life, both use a rough form of the couplet with extended enjambement, but whereas Donne sustains his effort to the end, King falls off badly and retrieves his earlier strong sincerity only in the smooth couplet close:

> Who, like the dying Sun, tells us the light
> And glory of our Day set in his Night. (67)

In such a couplet we can see that even in an early poem King did not subordinate his individuality to a complete acceptance of Donne's poetical precepts. As Robert Sharp has said *(From Donne to Dryden),* Donne seldom, if ever, subordinated his mind to an external form, and his phrases remain knotty and unsubmerged in couplets as well as in other forms (30); King could mold his thought to the couplet when the occasion demanded it.

Another "experiment" by King, this time in what Saintsbury calls "playing the dog," is the poem "To his unconstant Friend." It is a veritable goldmine of Donnean cliches, which fall slightly flat without the master's "awful fire" to carry them along. The tone of insolent sarcasm with which King opens the poem,

> But say, thou very woman, why to me
> This fit of weakness and inconstancie? (23)

is his approximation of the Donne who wrote in "The Expostulation":

> To make the doubt cleare, that no woman's true,
> Was it my fate to prove it strong in you?

These introductory questions are followed in both poems by a series of further questions of increasing bitterness, some of which in King's poem attain an acidlike tone not unworthy of Donne:

> I see friends are like clothes, lay'd up whil'st new,
> But after wearing cast, though nere so true.
> Or did thy fierce ambition long to make
> Some Lover turn a martyr for thy sake?
> Thinking thy beauty had deserv'd no name
> Unless some one do perish in that flame:
> Upon whose loving dust this sentence lies,
> Here's one was murther'd by his Mistriss eyes. (23)

A parallel passage in Donne's poem is as follows:

> And must she needs be false because she's faire?
> Is it your beauties marke, or of youth,
> Or your perfection, not to study truth?
> Or think you heaven is deafe, or hath no eyes?
> Or those it hath, smile at your perjuries?
> Are vowes so cheape with women, or the matter
> Whereof they are made, that they are writ in water; . . .

Despite their resemblance the two passages obviously were not written by the same poet: the cumulative effect of Donne's biting paradoxes King's muse was simply unable to achieve. Donne's poem is again sustained to the end, culminating in a final bitterness:

> Did you draw bonds to forfet? signe to break?
> Or must we read you quite from what you speake,
> And finde the truth out the wrong way? or must
> Hee first desire you false, would wish you just?

Unable to maintain a consistent tone or to build a climax, King is forced to settle for simple declarative sentences. What power and surge he has generated collapses in the flatness of a statement that Donne would have transformed into a bristling interrogative jibe. In the concluding section of his poem King does redeem his earlier weakness somewhat with a refreshing burst of wit that is rare in his poetry:

> I will not fall upon my pointed quill,
> Bleed ink and Poems, or invention spill
> To contrive Ballads, or weave Elegies.
> . . . .

> Nor like th'enamour'd Tristrams of the time
> Despair in prose, and hang my self in rhime
> Nor thither run upon my verses feet,
> Where I shall none but fools or mad-men meet,
> Who mid'st the silent shades, and Myrtle walks,
> Pule and do penance for their Mistress faults (24)

To this point I have been concerned with what I have called the first "step" in King's poetic development, a period probably early in his career when, perhaps under the tutelage of Donne, he was obviously dabbling in various types of poetry. The product of this dabbling is some of King's worst poetry (not all by any means), and it is bad because he tried to adhere too strictly to a style and manner for which he was not fully equipped. Apparently King himself realized this for there are relatively few "slavish" imitations, and he began to attune his lesser powers to a variation of Donne's example. Such a variation is symptomatic of the gradual watering-down process which the metaphysical school experienced because of the general incapacity of the minor poets to attain the heights that Donne and a few others so nimble scaled. As Robert Sharp has said, "The metaphysicals . . . were not nearly so much concerned with feeling. Wit as an intellectual faculty became of more importance to them, and poetry less a matter of experience than a 'knack of dexterity.' Their esthetic allowed this substitution. Superficial virtuosity replaced real feeling and served to conceal the lack of genuine inventive power. Consequently, wit assumed the importance of an end rather than a means; it became the whole poetic process" (*From Donne to Dryden,* p. 38). King, however, was not entirely one of these, for he developed, perhaps as an inheritance from Donne, a concern for genuine emotion. Rather than apply Sharp's criticism to him, then, let it be said that he was becoming a kind of quietist after the early excesses described above.

"The Surrender" is a good example of King's movement away from conscious imitation of Donne toward the quiet urbanity and wit of King's finest poetry. The bankruptcy metaphor of the first stanza is most effective and may recall Donne's use of usury in "Loves Usury" or of business in "Lovers Infiniteness." The tender reminiscence of the second stanza—

> We that did nothing study but the way
> To love each other, with which thoughts the day
> Rose with delight to us, and with them set, (17)

is similar to Donne's more famous lines in "The Exstasy":

> Wee like sepulchrall statues lay;
> All day, the same postures were,
> And wee said nothing, all the day.

In the third stanza King skillfully echoes the opening phrase of stanza two, reinvoking the reminiscent mood, and then goes on to describe the contented, mutually-exclusive privacy of the love affair with an increased awareness of its present loss—much as Donne described the same kind of relationship in "The Anniversarie." And, in the last section of the poem there is complete resignation to the lovers' fate and a depth of feeling beautifully subordinated to the abject quality of the verse movement:

> Fold back our arms, take home our fruitless loves,
> That must new fortunes trie, like Turtle Doves
> Dislodged from their haunts. We must in tears
> Unwind a love knit up in many years.
> In this last kiss I here surrender thee
> Back to thy self, so thou again art free.
> Thou in another, sad as that, resend
> The truest heart that Lover ere did lend.
> Now turn from each. So fare our sever'd hearts
> As the divorc't soul from her body parts. (18)

Although the versification is uneven, there can be no doubt as to the beauty and the *unconsciously* Donne-like quality of such lines. The metaphor of unwinding the love "knit up in many years" not only echoes two earlier lines ("and Heaven did untie / Faster than vowes could binde") but also lends support to the underlying framework of the whole poem, the structural theme of surrender, parting, releasing, separating. The closing couplet with its brief, almost terse, four-word sentence suggests complete resignation, a certain courage in accepting Fate's decision, and the lover's anxiety to quit the scene, to put it behind him. Other Donne-like qualities of the poem are its homely images and logical structure, the building to a climax, and the added force of a new analogy even in the closing couplet. The emotion is as close to genuine as King can get in an imagined experience.

Certain conclusions can now be drawn about the literary relationship between King and Donne. Not possessed with either the intellectual subtlety or the "awful fire" of Donne's brain, King nevertheless sought to imitate the impassioned dialectic of his friend. The desire is understandable. It is a tribute to King's good sense, then, that he realized such poetry could be written only by one whose personality and artistic ability were as singular as Donne's. King's poetry showed instead a tendency toward simplicity, greater straight-forwardness of statement, an almost "humbleness" of phrase, a preference and a facility for calm emotion. He recognized but did not adopt Donne's basic scepticism, bound up as it was with the "new philosophy" and the introduction of the Copernican system, and Donne's religious fervor, his sense of the transcendence of the spiritual, is all but absent from King's works. To compare King's few examples of purely religious poetry, "The Labyrinth" and "A Penitential Hymn," with Donne's is to realize that there can be no real comparison.[3] There is little descriptive poetry in either poet just as the imagery of each is less picturesque than scientific and philosophic, less "poetic" than realistic and homely. Perhaps, indeed, this was Donne's greatest legacy to his follower, for King used such imagery with extraordinary effect in his masterpiece, "The Exequy." The vein of sheer ugliness that runs through Donne's work, the recurring presentiment for details which are merely and almost wantonly repulsive, King happily ignores for the most part. Thus, though we cannot say of King, as Grierson says of Donne, that he is "at once passionate and ingenious," the existence of a debt must be acknowledged. The "Donne tradition" was accepted in part by King just as he relied on "Saint Ben" for another ingredient of his poetic style.

The debt King owed to Jonson is not less obvious than that owed to Donne, but it is less easily demonstrable. Douglas Bush has described the major difficulty: "The impossibility of a clear-cut grouping [of schools of poetry] is epitomized at the start in the much discussed question whether certain poems were written by Jonson or by Donne; and their contemporaries and successors, indifferent to posterity's need of distinct labels, drew in varying proportions from both masters" (*English Literature in the Earlier Seventeenth Century,* p. 104). In the following poems, then, it is safest to say that King relied on both men, or as Bush says, on "the whole set of traditions and conditions" for which the names of Jonson and Donne stand *(ibid.)*. The order in which the poems are discussed is designed to show King's gradual assimilation of these traditions and conditions until in his best poems he produced something uniquely characteristic of the King manner. I hasten to add that my contention is not that this Jonsonian influence operated after that of Donne. The poems mentioned thus far are only those in

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[3] It is a curious fact, this relative lack of religious poetry in the canon of King. It may be explained, perhaps, by certain apparently unrelated facts: (1) King was not an impassioned orator in the pulpit in the sense that Donne was. "There is an account of a sermon preached by him at Paul's Cross in 1617 in which 'he did'—as he usually did—'reasonably well, but nothing extraordinary'" (Sparrow, p. xi). Much of Donne's religious verse gains great power through the use of rhetorical elements. The two poems of King's cited are flat, shallow, and lacklustre in comparison. On the other hand, his sermons in general have been commended for their literary value. Perhaps sensing this inequality in his religious writings King was content to restrict his more pious thoughts to the sermons. (2) King, as far as we know, had no such inner conflict that provoked the intensive self-torture of the Dean of St. Paul's in his brilliantly wrought "Holy Sonnets." (3) It was not unusual for churchmen at the time to write more and better secular poetry than devotional. Others, for example, are Herrick, Strode, Corbet, and Cartwright. (4) This may be a further piece of evidence in associating King with the "sons of Ben," or, at least, in pointing out a definite Jonsonian influence.

which the "metaphysical" has all but submerged the "cavalier" manner. The poems to follow are not devoid of the realistic blend of emotion and wit so characteristic of Donne, but they do possess these qualities to a lesser extent as the Jonsonian spirit becomes more eloquent.

"The Defence" may be taken as an example of King's joining both traditions together in the same poem, though with a minimum of fire or spirit. The opening couplet is somewhat reminiscent of Donne while the handling of the octosyllabic couplet form throughout suggests the more famous "Master Johnson's Answer to Master Wither." King's poem begins:

> Say she were foul, and blacker than
> The Night, or Sun-burnt African,
> If lik't by me, tis I alone
> Can make a beauty where was none;
> For rated in my fancie, she
> Is so as she appears to me. (27)

Jonson's poem begins as follows:

> Shall I mine affections slacke,
> Cause I see a womans blacke,
> Or my selfe with care cast downe,
> Cause I see a woman browne?
> Be she blacker than the night,
> Or the blackest Jet in sight,
> *If she bee not so to mee,*
> *What care I how blacke shee bee?*[4]

Although the sentiment here is not peculiarly Jonsonian, is indeed more Donnean, the movement of the verse, its regularity and tendency toward a polished "finishedness," and the superficial, courtly tone are characteristic of Jonson's neo-classic bent. Most of his finest lyrics were cast in simple and unobtrusive metrical structures, such as the octosyllabic couplet and quatrain, and King eagerly accepted these structures as better adapted to his own talent than more complicated and subtle relationships of rhyme and meter. With this legacy came also Jonson's sense of design, his selectiveness, and a feeling for brevity and condensity.

King's two songs, "I prethee turn that face away" and "Dry those fair, those chrystal eyes," are respectable examples of his work in this mode; indeed they could have been written by almost any son of Ben. By far the best of King's Caroline lyrics, however, is the gem-like "Tell me no more how fair she is." Of all of his

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[4] On the disputed authorship of the Jonsonian poem see C. H. Herford and P. Simpson, eds., *Ben Jonson* (Oxford, 1925), I, 442n.

poems this possesses the unique perfection, the "urbane elegance,"[5] of a Jonsonian song:

Tell me no more how fair she is,
    I have no minde to hear
The story of that distant bliss
    I never shall come near:
By sad experience I have found
That her perfection is my wound.

And tell me not how fond I am
    To tempt a daring Fate,
From whence no triumph ever came,
    But to repent too late:
There is some hope ere long I may
In silence dote my self away.

I ask no pity (Love) from thee,
    Nor will they [sic] justice blame,
So that thou wilt not envy mee
    The glory of my flame:
Which crowns my heart when ere it dyes,
In that it falls her sacrifice. (7)

The inevitable comparison is with Jonson's "Song. To Celia." Just as in that poem the single trochee at the beginning is never repeated, although echoes of it occur in the trochaic words, so in King's poem. The trochee of his first line is doubly effective then—prosodically in setting up a unique foot to be repeated only within the lines in separate words, and in adding vigor and strength to the initial statement. The central paradox of the poem, stated in the final couplet of the first stanza, is accentuated by King in two ways: (1) by contrasting the affirmative of that couplet with the stout negatives of lines one, two, and four; and (2) by reversing in the last line of the stanza the antithetical "me" and "she" used in the opening line. The second stanza is noticeably toned down—mostly through the use of an initial iamb instead of the trochee of the preceding stanza: the lover is now less angry than irritated—and persistent in his hope. Again the negatives of the quatrain stand out in pronounced contrast to the assertive couplet. Here the affirmative note becomes more powerful in its suggestion of a possible hope which the lover still clings to. The imperative rhetoric of these two stanzas becomes in the third a plaintive request, an humble acceptance of fate, and the ironic "triumph" of the lover in sacrificing his heart. This "triumph" is prepared for and made more powerful by the second stanza where the possibility of any victory over Fate is denied. The irony of repenting too late, con-

[5] See F. R. Leavis, "English Poetry in the Seventeenth Century," *Scrutiny,* IV (1935), 236–256, for a survey of what he calls the tradition of "urbane elegance."

sidered as the only possible "triumph" in the second stanza, makes the concluding irony of the lover's actual victory more effective by virtue of the deliberate self-contradiction. The downward tonal spiral from indignant anger through a growing solemnity in resignation, to the almost-chanted religiousness of the final couplet is paralleled by the increased use of words with rich religious connotation. In the first stanza, as is to be expected, there are few—in fact only one—and that one, "bliss," serves properly to characterize the unattainable on earth. The second stanza subtly introduces the temptation and its inevitable consequence, repentence, until in the third we have the judgment, without mercy, passed upon the lover by the god of Love. The "glory," "crowns," and "sacrifice" of the final three lines add an unexpected power to the rather simple statement of the lover's ironic triumph.

To judge this poem upon the basis of degrees of exquisiteness, as Saintsbury does in the *Cambridge History of English Literature,* seems to me pointless. Still one can agree with Saintsbury that "There are few pieces which unite a sufficient dose of . . . exquisiteness with so complete an absence of all faultier characteristics—obscurity, preciousness, conceit, excessive sensuousness, 'metaphysical' diction, metrical inequality" (*CHEL,* 1932 ed., VII, 82). King's "Tell me no more," then, exemplifies a great change in 17th century poetry. The dicta of Horace's *Ars Poetica,* which Jonson translated and largely subscribed to, differ greatly from Donne's practise. For example, Horace states that "The force and charm of arrangement will be found in this: to say at once what ought at once to be said, deferring many points, and waiving them for the moment"; he will "aim at a poem so deftly fashioned out of familiar matter that anybody might hope to emulate the feat, yet for all his efforts sweat and labour in vain"; and he will "censure the poem that has not been pruned by time and many a cancellation—corrected ten times over and finished to the finger-nail."[6] King himself in one of his sermons echoes such views of decorum, brevity, and simplicity without pedestrianism: "I never liked him who served up more sauce than meat, more words than matter, or wit than religion—but yet I have ever thought choice matter ill dressed like good meat ill cooked, which is neither a credit to the bidder nor a pleasure to the guest."[7] Such a change in poetic modes was, of course, not abrupt but gradual, and in King's finest poem, "The Exequy," he created in the midst of these conflicting poetic

[6] Allan H. Gilbert, ed., *Literary Criticism: Plato to Dryden* (New York, 1940), pp. 129, 132, 137.

[7] Quoted by Rosemond Tuve, *Elizabethan and Metaphysical Imagery* (Chicago, 1947), p. 366.

forces a work of art which bears the unmistakable stamp of his own individual talent.

Apparently written between 1624 and 1630 when King was 32 to 38 years old, "The Exequy" is cast in octosyllabic couplets, the same meter as two other famous poems of powerful feeling, Marvell's "To His Coy Mistress" and Crashaw's "St. Theresa." Apart from subject matter there is also a great kinship between "The Exequy" and Donne's "The Exstasy," especially in the use of the conceit (though King is less fantastic) and in the portrayal of an ideal love. But the simple grace, the profound sincerity of emotion, and the precise handling of the couplet seem to me to be inspired by Jonsonian example, as in his epitaphs "On My First Daughter," "On Margaret Ratcliffe," "On My First Sonne," "On S. P. a Child of Q. El. Chappel," and "On Elizabeth, L. H." Donne and Jonson together have few poems of grief or sense of loss which are comparable in emotional power to this one.

Though the scope of this paper will not permit a full analysis of the poem (or even its full quotation), a few comments are necessary to point out the skillful synthesis King has effected of the arts of poetry as practised by Donne and Jonson. The poem falls rather neatly into two main parts, each having its own development and climax independent of the other and yet remaining an integral component of the whole. A final group of six lines draws both these sections together by a resolution of the poet's grief over his wife's death into a sort of "hope and comfort." Much of the first part of the poem is inspired by Donne, and yet the charge of conscious imitation would be unjustifiable and not a little imperceptive. The section on benighting the day and the eclipse sounds like Donne, but the peculiar aptness of the figures in the logical structure of the poem is vindication enough of King's own poetic ability. Furthermore, the basic contrast of black and white, night and day, the sun and an eclipse, is not only functional to thought and emotion but also a central concept which serves as an ironic climax to the first part of the poem—the climax being the permanence of the eclipse as long as the lover lives, the irony in that the eclipse took place in the "Noon-tide" of his wife's life, when the "Sun" normally is in its zenith. The short passage on the calcining of the body seems to me to come as close as any portion of the poem to conscious imitation of Donne, and significantly it is the least congruous and effective section of the first part.

The second part of the poem is a kind of symphonic rearrangement, or better, absorption of the theme and movement of the first; structurally, it echoes the first. King opens it with an almost prosaic statement of the fact that the earth now possesses his love; it proceeds by a gradual transition to observations about the time that separates him from his dead wife; and it concludes with an ecstatic vision of a heavenly reunion. If the first part of the poem could not have been written had Donne never lived, the second owes much of its tone and sentiment, its "tough reasonableness beneath the lyric grace," to Ben Jonson. This is perhaps best exemplified in brief by the justly famous climax of the poem. The thought of the poet's future reunion with his wife in death is triumphing over his earlier grief and despair:

> But heark! My pulse like a soft Drum
> Beats my approch, tells *Thee* I come;
> And slow howere my marches be,
> I shall at last sit down by *Thee*. (41)

The basic theme-metaphor of the first part of the poem (time) and that of the second (the journey) are here fused in the martial terminology of a march and a drum-beat. In addition, the quatrain climaxes the emotional progression from grief and despair, to a contemplation of hope, to the actual triumphal carrying out of that hope. The drum-beat itself is functional in three different ways which bring together all of the main elements of the preceding sections: (1) it is the clock which measures "How lazily time creeps about," the minutes and short degrees and hours, each of which for the poet is "a step toward thee"; (2) it provides the metrical pattern for the marching image with the spondee, "soft Drum," at the end of the line, immediately followed by the trochees in the first and third feet of the next line; (3) it emphasizes the quiet triumph of the poet over his grief, in that the sound of the drum echoing across the abyss between life and death, becomes the first link between the two lovers. The drum beats his approach, *tells* her he's coming, implying that he is so near now that she actually can hear this drum, his pulse, his heart. There is no terror in these lines, as I have pointed out elsewhere;[8] rather there is subdued, controlled elation (perhaps with a consequent quickening of the pulse) in the expectancy of reunion, coupled with a comfort and contentment which become explicit in the closing lines:

> I am content to live
> Divided, with but half a heart,
> Till we shall meet and never part. (41)

King's major achievement, then, was in the elegy (used in its loosest sense to include other poems like "The Anniverse" and "The Departure") and the classical-Caroline lyric. In these forms King emerged out of the streams of Donne's and Jonson's influence to become a poet in his own right. Indeed, in his later poetry, even in

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[8] *Explicator*, XII (1954), 46.

these very genres though most often in his longer occasional poems, he went beyond Jonson to anticipate the classical precision of Dryden and even Pope. Symptomatic of this was his increasing use of the heroic couplet. In Donne's couplets "his frequent avoidance of parallelism is secured by runover lines, by rhythms widely unequal in their duration, by riming masculine endings with feminine. . . . Stress-shifts, particularly when they make a line runover, are used to break up normal smoothness in favor of abrupt rhythms and thoughts. . . . Transitions are often brusque, and meant to clash with the smooth progress of an extended period. . . . And Donne does not usually avail himself of the epigrammatic potentialities—through parallelism—of the couplet unit."[9] As the century progressed the couplet gradually became prescriptively associated with the verse of definition and with occasional verse, and began to assume the precise proportions of the distinctive Augustan form, having taken its shape in the hands of Grimald and Marlowe, Drayton and Fairfax, Jonson and Waller. Though it is not my intention here to outline the development of the couplet form, it is important to note King's increasingly skillful use of that form.

In one sense King's so-called metaphysicality is anomalous to his conception of the physical form of poetry. If a variation of verse form is an integral part of metaphysical poetry, if a conscious interruption of smooth metrical flow is coincident with the expression of complex thought and feeling, then King is hardly metaphysical at all. Almost never did he employ anything but basically regular iambic pentameter or tetrameter lines; of the comparatively small number of irregular feet in his works, the majority stand first in the line; and almost all of his poems are cast in the couplet form, with an increasing restriction of the thought to that unit instead of the paragraphic form of most of his contemporaries. Indeed this sense of regularity and conformity is even more evident in his sermons, which seldom attain the impassioned eloquence of Donne's, for example. Noting this quality in the sermons, one of King's editors has remarked that "His instinct was all for system, establishment, orthodoxy. He was a sound adherent of organization—exalting the Letter above the Spirit, assent above conviction—one whose religion was ecclesiasticism: the Church *qua* Institution, the Bible *qua* Clerical Code of Law. In short, so far was he from any taint of non-conformity that it is almost just to say of him that he was more a Churchman than a Christian."[10]

Even King's youthful poetry displays such "orthodoxy" in its couplets. The following, for example, are from Donne imitations:

[9] Arnold Stein, "Donne and the Couplet," *PMLA*, LVII (1942), 696.
[10] Lawrence Mason, "The Life and Works of Henry King, D.D.," *Transactions of the Connecticut Academy*, XVIII (1913), 259.

Forth of my thoughts for ever, Thing of Air,
Begun in errour, finish't in despair. (3)

Lust is a Snake, and Guilt the Gorgons head,
Which Conscience turns to Stone, & Joyes to Lead. (54)

The following, also from early poems, show King's appreciation of the couplet's epigrammatic quality:

Who for this interest too early call,
By that exaction lose the Principall. (10)

Who thus repeats what he bequeath'd before,
Proclaims his bounty richer then his store. (19)

Beginning with the birth of Charles II in 1630 King devoted his talents almost exclusively to eulogy of royalty, "salutations," epitaphs, and funeral elegies, and it is in these poems that he appears most clearly as a forerunner of the Restoration and Augustan poets. In "Upon the Kings happy return from Scotland," for example, the verse has a definite affinity to Waller's. Here is King:

So breaks the day when the returning Sun
Hath newly through his Winter Tropick run,
As you (Great Sir!) in this regress come forth
From the remoter Climate of the North. (32)

Here is Waller, some 27 years later, in "To the King, upon His Majesty's Happy Return, in the Year 1660":

The rising Sun complies with our weak Sight,
First gilds the Clouds, then shews his Globe of Light
As [sic] such a Distance from our Eyes, as though
He knew what Harm his hasty Beams wou'd do.

And, later in the same poem:

That, if Your Grace incline that we shou'd Live,
You must not, SIR, too hastily forgive.

But King could be a kind of Dryden as well. In "An Epitaph on the Earl of Essex" (about 1646), "An Elegy on Sir Charls Lucas, and Sir George Lisle" (1648), and the two elegies on the death of Charles I (about 1649), King demonstrates that he is worthy to be considered among the number of ante-Drydenian poets who look forward to the elegies and satires of that celebrant, that signalizer *par excellance,* as Van Doren calls him. The opening lines of "An Elegy upon the most Incomparable King Charls the First" are an admirable introduction to the kind of verse that follows:

Call for amazed thoughts, a wounded sense
And bleeding Hearts at our Intelligence.
Call for that Trump of Death, the Mandrakes Groan,
Which kills the Hearers: This befits alone. (117)

King seldom if ever rose so to the heights of eloquent passion as the murder of King Charles caused him to do. Only the Lucas-Lisle elegy and "A Deep Groan" can approach it for sheer power of expression, whether or not it is good poetry. After eulogizing Charles in a series of comparisons with the "best of *Judah's* Kings," King curses the "Mountebanks of State" in terms that suffer little by comparison with Dryden's invective. Note particularly the swift and regular motion of the verse, the pronounced medial pause (even without punctuation), the alliteration that gives emphasis to the antithesis and balance:

> See now ye cursed Mountebanks of State,
> Who have *Eight years* for Reformation sate;
> You who dire *Alva's* Counsels did transfer,
> To Act his Scenes on *England's* Theater;
> You who did pawn your Selves in *Publick Faith*
> To slave the Kingdome by your Pride and Wrath;
> Call the whole World to witnesse now, how just,
> How well you are responsive to your trust,
> How to your King the promise you perform,
> With Fasts, and Sermons, and long Prayers sworn,
> That you intended *Peace* and *Truth* to bring
> To make your *Charls Europes most Glorious King.*
> Did you for this *Lift up your Hands on high,*
> To Kill the King, and pluck down Monarchy? (119)

The subtle irony and sarcasm underlying such comparatively quiet lines as 7–12 above is characteristic of Dryden, and gains more force here by being juxtaposed to the greater directness of the other lines. The ironic pattern of this passage culminates in the fine last couplet above, where the paradox becomes explicit. "Lift up your Hands," King reminds us in the gloss, is "the form of taking the Covenant," but here the lifted hands are also to be used for murder, and symbolically for breaking the covenant. The satire grows in fury and intensity as King describes the Remonstrance of the State of the Kingdom and the consequent flight of Charles, the pursuit of whom is likened to the hunt. Thus "debasing" the king to the lowly position of a hunted fox produces paradoxically a shrinking of the pursuers' characters (and shows, incidentally, that King was familiar with the rhetoric of satire). Then after comparing the destruction of the churches and tombs by the Puritans to other famous crimes of pillage, King goes on to recount the "murder" of King Charles in a passage which looks forward to Dryden especially in its structural use of the pronoun "you" and the emphatic heavy rimes:

> Though Pilate Bradshaw with his pack of Jews,
> God's High Vice-regent at the Bar accuse,
> They but reviv'd the Evidence and Charge,
> Your poys'nous Declarations laid at large;

Though they Condemn'd or made his Life their Spoil,
You were the Setters forc'd him to the Toil:
For you whose fatal hand the Warrant writ,
The Prisoner did for Execution fit;
And if their Ax invade the Regal Throat,
Remember you first murther'd Him by Vote. (130)

In this poetry of the "third step" King reveals the earlier hints of the separation of wit from judgment, of imagination from reason, which characterized the Restoration period. A greater emphasis on generalization, and a correspondent dulling of keen details, is beginning to push through the tradition of Donne, to require a broader brush and greater swiftness of strokes. King began to feel more at home, just as Dryden often was, when he was making statements. It has been said that the conventions were becoming easier to follow each year, and it is obvious that King was attaching himself actively to those new conventions. The poetry he produced in this manner is clearly not of the sublime, but as a contemporary of King's wrote, "The temper of the century had swiftly become suited to a sort of expression aiming 'rather at aptitude than altitude.' "[11] Thus, though Dryden may be said to have followed and developed Donne in a direct line of succession, too often the Restoration poets renounced Donne completely, and propriety even to insipidity usurped the throne of imagination. Perhaps the closest King ever came to such artifice and practised elegance is in "The Labyrinth," curiously a religious poem:

Dull to advise, to act precipitate,
We scarce think what to do, but when too late.
Or if we think, that fluid thought, like seed
Rots there to propagate some fouler deed.
Still we repent and sin, sin and repent;
We thaw and freeze, we harden and relent:
. . . .
Repentence is thy bane, since thou by it
Onely reviv'st the fault thou didst commit.
Nor griev'st thou for the past, but art in pain
For fear thou mayst not act it o're again.
So that thy tears, like water spilt on lime,
Serve not to quench, but to advance the crime. (92)

In a sense, then, King exemplifies the fact that "Metaphysical poetry, if we ignore its rich results, may be said to have only held back for a time the wave of European neoclassicism that had reached its first crest in Jonson." Though that movement was far from being merely literary, one of its clearest literary manifestations was the "turning back from troubled explorations of the in-

[11] The sentence is Mark Van Doren's, quoting a remark by Thomas Jordan in 1664, in *The Poetry of John Dryden* (New York, 1920), p. 137.

dividual soul to the accepted sententiousness of public occasions and general experience."[12] In these terms, King seems to be representative of his age. But the terms "representative" and "a poet of his age" have been used so glibly and so often without definition that they have nearly lost significance. Representative in regard to what, we may ask—the philosophy, the aesthetics, the politics or economics? Must one be representative of all these to be truly representative? What does "a poet of his age" really mean? In a sense this paper has been an attempt at one answer to this question, as well as an essay in method, a method by which such critical terms as the above can be revitalized.

In extra-poetical activity King was what might best be called a "dabbler." Along with other educated men, he recognized the great change in the universe, and in man's relation to the universe, brought about by the Copernican system. There are even some traces of scepticism in his poetry; there is a concern with the meaning of death and an afterlife; there are treatments of the vanity, brevity, and uselessness of man's life; there is political feeling voiced against the Puritans and eulogy of monarchy; and there are pleas for divine guidance and succour. But from the extent and intensity of the treatments accorded these various aspects of 17th century life, it is difficult to label King as a sceptic, pessimist, stoic, or anything else. He was, rather, not unlike most of the churchmen of his time, an intelligent man aware of the complexity of modern life but with no particular ax to grind—unless it be, quite naturally for an Anglican bishop, against the Puritans. In this paper, therefore, I have concerned myself mainly with his poetry and have deliberately avoided discussion, which would be largely fruitless, of the conventionalities of an orthodox Anglican clergyman's life. In the poetry it was precisely these same conventionalities which had to be examined to find out where Henry King the poet "belonged."

To say that King is representative, then, to say that he is of his age, implies several fairly definite ideas. First, the terms are descriptive rather than critical in that the representative poet must have an acute awareness of the various kinds of poetry being written by his contemporaries, whether he subscribes to the philosophic and aesthetic bases for that poetry or not. This awareness naturally leads to emulation, imitation, and, somewhat curiously, anticipation. Without Donne, Jonson, and Dryden, King could not be representative; he would merely be, perhaps, "second-rate." The terms, then, do have certain critical overtones. King is a minor poet

[12] Douglas Bush, *English Literature in the Earlier Seventeenth Century* (Oxford, 1945), p. 169.

because the poetic age of which he is representative was established by others greater than he. They are the men who give the age its name, so to speak, who define its limits, who prescribe its patterns, and who stand as touchstones for its evaluation. That King wrote better poetry than some of the other representative poets does not make him more representative, but simply a better poet. But I have said that he is an anticipator as well as an imitator, which suggests that the term "of his age" more often than not refers to an age of transition in poetry. Were King merely a follower of Donne, say, we should call him a "lesser Donne," in somewhat the same way that we label Henryson and Dunbar Chaucerians. On the other hand, poets like Gray, Collins, and Cowper are representative of the transition between neoclassic poetry and romantic poetry; they are poets of their age. Finally the representative poet tries his hand at many forms of verse—under the tutelage of many masters—and somewhere along the line he strikes the poetry of his own nature and talent. It is here, and only here, that he may transcend his representative limits.

That King the poet dabbled, like the man, is unmistakable. That the dabbling produced some bad poetry is expected; that it gives us an insight into a many-faceted poetic age is helpful; that it gave us a few poems like "The Exequy," "Tell me no more," "The Anniverse," is remarkable. If this is being representative, Bishop Henry King was surely a "poet of his age."

PRE-SETTLEMENT VEGETATION OF RACINE COUNTY

HAROLD A. GODER
*Department of Botany, University of Wisconsin**

An ecological source of information concerning pre-settlement vegetation is found in early land survey records. The origin of the land survey dates from 1785 when a government cartographer submitted to Congress a general plan of survey for the Northwest Territory. The plan was adopted, and the survey was begun in accordance with its terms. The field books of the land survey of Wisconsin are available for evaluation in the Public Land Office, Wisconsin State Capitol Building, Madison, Wisconsin.

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INTRODUCTION TO SURVEYORS' METHODS

A north–south line was surveyed from the Ohio River to Lake Erie; then east–west lines, six miles apart were run at right angles to the east boundary of the Northwest Territory. North–south lines were surveyed parallel with the east boundary forming tracts six miles square, each constituting a government Township. To survey a Township, the crew would start in the lower right corner of the six mile square tract and measure an imaginary section line 80 chains* due north. If any trees occurred on the line between the starting point and the 80 chain end point, the species, the diameter, and the number of chains from the starting point were recorded in a field book. The surveyors established 40 and 80 chain points by blazing witness trees. The species, diameter, angle of direction, and the number of links from the 40 and 80 chain points to the witness trees were noted. Upon completing the north–south line, the men would survey an east–west line at right angles to the 80 chain section corner. They repeated the process until they had surveyed all interior section lines.

The paucity of witness trees on the prairie necessitated the establishment of section corners by earthen mounds.

Surveyors worked through the spring and summer of 1836 to complete the surveying of Racine County, which lies in the south-

* Now at Wisconsin State College, Platteville, Wisconsin.
* 80 chains, 66 feet; 100 links, 1 chain; 1 link, .6 foot.

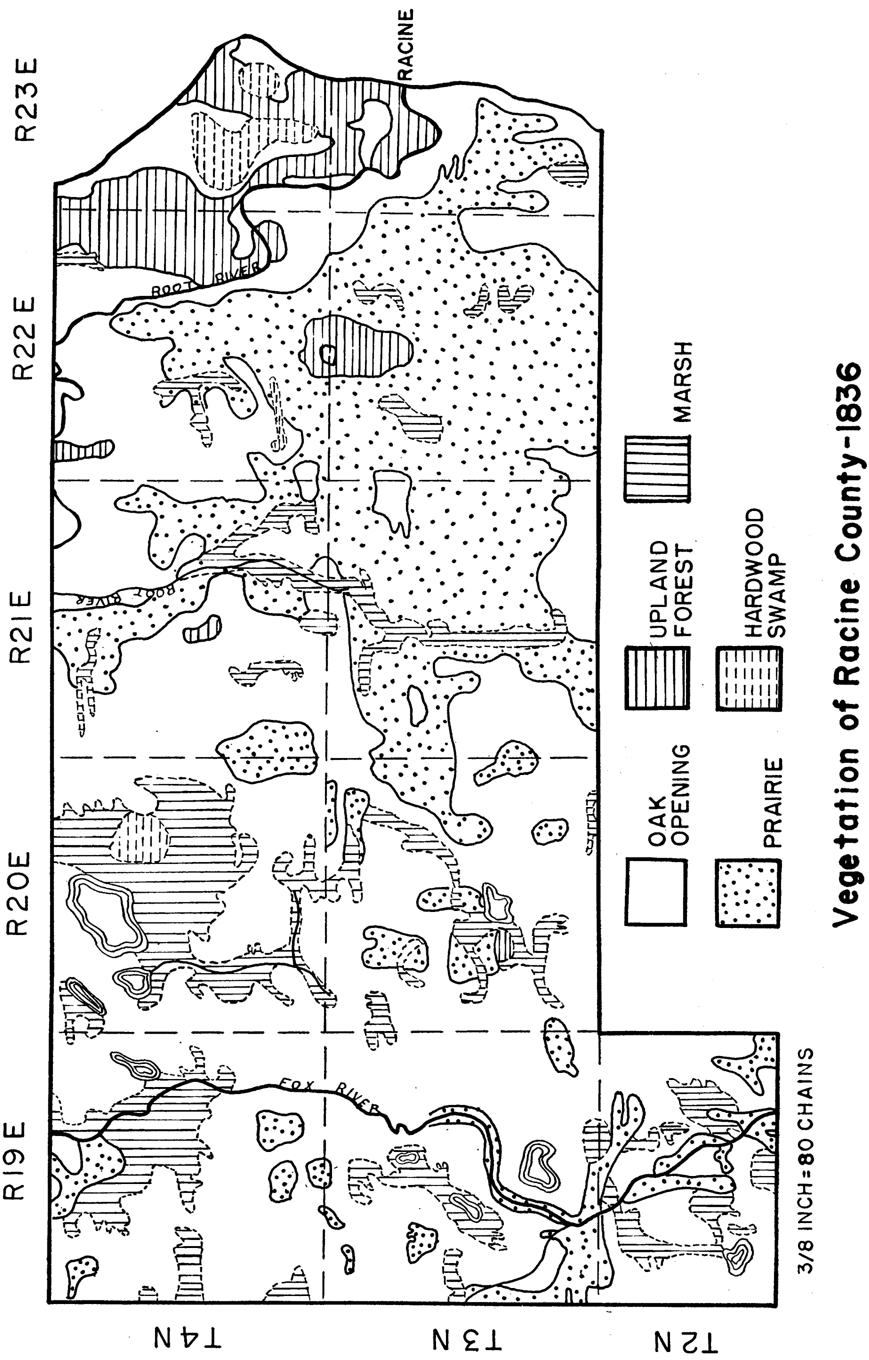
R19E
R20E
R21E
R22E
R23E
T4N
T3N
T2N
RACINE
ROOT RIVER
ROOT RIVER
FOX RIVER
OAK OPENING
UPLAND FOREST
MARSH
PRAIRIE
HARDWOOD SWAMP
Vegetation of Racine County-1836
3/8 INCH=80 CHAINS

FIGURE 1.

eastern part of Wisconsin. At the time of the survey the City of Racine had a white population of 600; the whole county, 1,400.

DESCRIPTION OF RACINE COUNTY

The surface features of the county fall into several divisions. Beginning at Lake Michigan is a terrace, which was noted by the surveyors as a bluff, extending west from the lake for a mile. From a line just east of the terrace limits to a line west of Wind Lake (T4N, R20E) is a belt of undulating morainic country. The topography of the western edge of the county varies from gently rolling to hilly and broken. In this area most of the lakes of the county are found.

The county is drained by two rivers. In the east, Root River emanates in Milwaukee County and flows southward into Racine County and then into Lake Michigan. The Fox River courses southward through the western part of the county.

At the present time the economy of Racine County is based upon industry and agriculture. The greatest change in vegetation has occurred through cropping of the prairie, drainage of marshes, and reduction of wooded areas.

METHODS

The data for this report were taken from surveyors' records. Data were transcribed from the original field books for each township. The recorded diameters, taken from the surveyors' records, were converted to dominance (basal area in square inches). The basal areas, number of individuals in each size class, and the number of points of occurrence for each species were transferred to data summary sheets. Each quarter and section corner counted as one point of occurrence.

The importance value (Curtis, 1951), a summation of relative per cent frequency, density, and dominance, was calculated for each species. Relative per cent frequency, density, and dominance are determined by dividing the total value of each into the species individual value.

To supplement the above values, the distance in links was converted to feet by using a two-arm protractor and a special rule (Cottam, 1949). The two revolving arms, each graduated in links, extend from the center of a disc on which the cardinal points of the compass are printed. The ruler converts the distance to feet. For example: two trees 11½ degrees west of south and 17 degrees east of north, 46 and 13 links from the 40 chain point were noted. The arms of the protractor are rotated to 11½ degrees west of south and 17 degrees east of north. The ruler is placed from link point 46

TABLE 1

TABULATION OF IMPORTANCE VALUE (IV) AND MEAN BASAL AREA (BA) OF TREES RECORDED BY THE SURVEYORS IN PLANT COMMUNITIES ANALYZED

Species	Plant Community							
	Oak Opening		Prairie		Upland Forest		Hardwood Swamps	
	IV	BA	IV	BA	IV	BA	IV	BA
Acer saccharum					60.7	135.5		
Betula papyrifera							59.5	26.5
Carya ovata	5.1	48.4			5.4	64.4		
Fraxinus americana	3.8	215.5			12.9	124.2		
Fraxinus nigra					24.5	225.7	147.5	88.7
Fagus grandifolia					123.7	103.8		
Juglans cinerea					3.9	153.7		
Ostrya virginiana					7.2	28.4		
Populus spp.					9.0	97.6		
Quercus alba	48.3	215.8	8.7	153.9	14.6	75.9	33.3	176.6
Quercus macrocarpa	199.7	150.5	206.8	183.9			31.4	153.9
Quercus rubra					6.4	119.7		
Quercus velutina	43.1	122.1	84.5	240.7	10.1	42.8		
Tilia americana					13.6	146.0		
Ulmus americana					8.0	40.3	27.9	113.0

to link point 13 across the arms of the protractor and the distance in feet is read from the ruler.

The map (Figure 1) is drawn to scale from a master copy which is kept in the Ecological Laboratory of the University of Wisconsin. The master copy includes the location and species of each witness tree utilized by the surveyors.

RESULTS AND DISCUSSIONS

The pre-settlement vegetation recorded by the surveyors separates into several plant communities. Approximately 80 per cent of the area was recorded as oak opening and prairie. The remaining 20 per cent was composed of forest, marsh, and swamp communities.

Oak Openings: The oak opening represents an ecotone between prairie and forest. The openings were most frequently noted in an area bordered by the Fox River in the west and by the Root River in the east. Early settlers described the openings as natural parks of oaks through which deer roamed. In the summer the grasses were overlaid with red, yellow, white, and purple flowers, forming a carpet throughout the openings (Leach, 1925).

The presence of bur oaks *(Quercus macrocarpa)* and the great distance between trees were used as indicators to delimit areas of oak openings for analysis (Table 1). The dominant tree was bur oak, accounting for 69 per cent of all the trees recorded in the oak opening area. The high per cent of bur oak can be correlated with its ability to resprout from grubs after the main trunk has been destroyed. White oak *(Quercus alba)* and black oak *(Quercus velutina)* were subdominant. Minor species included white ash *(Fraxinus americana)* and shagbark hickory *(Carya ovata)*.

The greatest per cent of all trees occurred in the 10 to 12-inch diameter size class. The largest trees noted, bur oaks, were in the 36-inch diameter size class. The mean distance between witness trees was 206.1 feet. The greatest distance recorded was 620 feet and the shortest distance, 11 feet.

Prairie: The greatest single expanse of prairie was recorded in T3N R21E, R22E, R23E and T4N R21E, R22E (Figure 1). West of this area the region described as prairie by the surveyors was dissected by streams and ridges into small areas of 10 to 60 acres. The prairie extended to the west bank of Root River but was not recorded east of this waterway; nor were arboreal species recorded west of the river in high numbers. Along the exterior lines of 29 sections picked at random the surveyors recorded only 40 trees, a fact that indicates the paucity of arboreal vegetation on the prairie.

The encroachment of the prairie by arboreal species was related to the presence of fires. Fires, sweeping from the southwest across the rolling prairie, were halted at the west bank of the Root River. Numerous accounts of early settlers state that at certain seasons of the year fires would sweep across the prairie and destroy all rank vegetation (Leach, 1925).

The gradation between oak openings and prairie is not a distinct boundary. Part of the region described as prairie by the surveyors was probably the ecotone between true prairie and oak opening. The trees most frequently recorded were those able to withstand fire (Table 1).

The mean distance between bur oaks utilized for witness trees was 329 feet; whereas, between black oak the distance was 1205 feet. The mean distance between all trees was 427.2 feet. The greatest per cent of trees occurring on the prairie was in the 24-inch diameter class.

An admixture of pioneer and climax forest species occurred in an area called Skunk Grove (T3N R22E Sec. 3, 4, 9, 10 and T4N R22E Sec. 33 and 34). Within this disruption of the fecund prairie, the surveyors recorded bur oak, white oak, and black oak from the periphery and ironwood *(Ostrya virginiana)* and sugar maple *(Acer saccharum)* from the interior.

Present day investigations reveal a topography of slightly higher elevation than surrounding areas and dissection by many small streams. If fires occurred on all sides of Skunk Grove, an inherent character of the area prevented the destruction of the arboreal species. The topography probably prevented fire, but other causes were also present.

Upland Forest: The largest area of upland species was east of Root River. In this region arboreal species were protected from the prairie fires. Here, sugar maple and beech *(Fagus grandifolia)* (Table 1) were dominant. Of these two species, beech was most frequently utilized as a witness tree. Beech and sugar maple were recorded in all size classes; this fact indicates that reproduction of these species had not been disturbed by fire. The greatest per cent of trees recorded occurred in the 8 to 12-inch diameter size class. The mean distance between all trees was 32.4 feet.

In summarizing the area, the surveyors noted that almost every variety of hard timber for sawing, hewing, and fencing was available. It was also recorded that the undergrowth included the same species as the upper stratum.

Hardwood Swamps: Hardwood swamps are designated by the absence of tamarack *(Larix laricina)*. The largest hardwood swamps were localized east of Root River in T4N R23E although smaller swamps were noted adjacent and east of the Fox River. Black Ash *(Fraxinus nigra)* was the dominant swamp species (Table 1). Most of the trees were in the 5-inch diameter size class. The mean distance between trees was 29 feet.

The largest tamarack swamp occurred east of Wind Lake in T4N R20E, covering approximately 500 acres at the time of the survey.

Small marsh areas were scattered throughout the county.

SUMMARY

The land survey of Racine County was completed in 1836. Utilizing the information recorded by the surveyors, the writer separated the pre-settlement vegetation into several plant communities. Oak opening and prairie communities predominated. Other types were upland forest, swamp, and marsh. Topography, drainage systems, and fire influenced the pattern of vegetation.

SUMMARY OF EXCERPTS TAKEN FROM FIELD NOTES AND PIONEER LETTERS

T2N R19E—thinly timbered with white, black, and bur oak; no undergrowth. Land level and poor to rolling, second rate. Wet prairies along Fox River, tamarck swamps and considerable marsh.

T3N R19E—prairie along Fox River wet; prairie west of river dry and rolling. Timber white, bur, and black oak; linden, and some aspen and hickory. Willow swamps, lakes, and river. Oak openings east of the river.

T4N R19E—small prairies lying west of river dry and rich. Land east of river wet, timbered with black ash and willows. Bur, white, and red oak; linden, elm, hickory, ash, ironwood, sugar, and some oak openings on upland. Prairie grasses Section 4. Thick undergrowth of rose, alders, vines, red root, and rosin in northern tier of sections. Considerable marsh.

T3N R21E—southeast part of prairie dry and rolling. Two-thirds of township dry prairie. Bur oak openings bordering prairie. Some marsh.

T4N R21E—marsh along south branch of Root River nesting place for wild geese, ducks, and pelicans. Prairie rolling and fairly dry. Timber white, black, red, and bur oak; ironwood, red ash, wild cherry, hickory, elm, aspen, and black walnut. Some oak openings. Northeast sections have understory of cherry, hazel, alders, prickly ash, red root, rosin weed, and rose.

T3N R22E—considerable ploughed land on prairie and border regions. Prairie rolling and rich. An area called Skunk Grove located in Sections 33–34. In grove sugar, linden, aspen, white thorn, plum, hazel, hickory, black walnut, white ash, elm, ironwood, beech, white, bur, black and red oak.

T3N R23E—Racine, Section 9. Reach first timbered areas here when traveling north from the south. "I remember just how everything appeared to me at that time; from the river bank east to the bluff of the lake, and north to what is now 7th street stood large scattering oaks. Down the bluff next to the river were red and white cedar. The flat across Root River in the vicinity of the present State Street there were sugar maples, black oak, basswood, elm, beech, hickory, and white and black ash with a few scattering butternut and black walnut"—a letter. Root River is a rapid, limebedded stream which falls into slack water just above the south boundary of Section 8 where depth is 3 feet but becomes much deeper a short distance below.

T4N R23E—considerable black ash and willow swamps. Linden, hickory, black ash, beech, basswood, red oak, and sugar maple. Beech and oak undergrowth.

T4N R22E—west of Root River prairie high and dry. Ploughed land within prairie. East of river trees sugar, beech, butternut, hickory, ash, elm, and basswood.

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NOTES ON WISCONSIN PARASITIC FUNGI. XXII

H. C. GREENE
Department of Botany, University of Wisconsin

The collections of fungi referred to in this series of notes were made, unless indicated otherwise, in the season of 1955.

SYNCHYTRIUM CELLULARE J. J. Davis was reported on *Pycnanthemum virginianum* in my Notes I (Trans. Wis. Acad. Sci. 32:79. 1940). J. S. Karling, in a recent article entitled "Prosori in *Synchytrium*" (Bull. Torr. Bot. Club 82:218–236. 1955), states, as a result of his examination of the Wisconsin material of *S. cellulare,* that "It is not certain that the parasite which Greene collected on *Pycnanthemum virginianum* is identical with *S. cellulare*", but he does not identify it further. The galls induced on *P. virginianum* differ from those on the other hosts according to Karling.

PHYSODERMA CLAYTONIANA Greene, described from Wisconsin material (Farlowia 1:569. 1944), was discussed by Sparrow (Amer. Jour. Bot. 34:325. 1947) who, on the basis of specimens collected in Michigan and Ontario, concluded that the type material was somewhat immature and produced an emended description adjusting the limits of spore size upward. D. B. O. Savile has recently compared the type with specimens on both *Claytonia virginica* and *C. caroliniana* from Quebec and finds them to match closely. Savile considers all this material to be mature and concludes that the Michigan and Ontario organism is at least varietally distinct.

PLASMOPARA HALSTEDII (Farl.) Berl. & DeToni often infects *Silphium terebinthinaceum* in Wisconsin, but has not so far been observed on *Silphium laciniatum* which is closely related to *S. terebinthinaceum* and indeed often hybridizes with it. Possibly pointing to a definite resistance in *S. laciniatum* is a situation observed in the University of Wisconsin Arboretum at Madison where, in an artificially seeded area, numerous plants of both species are growing intermingled and are so closely crowded that many of their leaves are in contact. Here, in June, there was heavy infection of nearly all the *S. terebinthinaceum* leaves, but none could be found on *S. laciniatum,* although in some cases the leaves were being dusted with spores from leaves of *S. terebinthinaceum* rubbing against them. Although other parasites have been found on *S. terebinthinaceum* X *laciniatum,* it may be significant that *Plasmopara* has not, perhaps indicating resistance imparted by *S. laciniatum.*

SPHAEROTHECA HUMULI (DC.) Burr. appears systemic as it occurs on *Physocarpus opulifolius* in Wisconsin, producing witches' brooms of the lateral twigs, which become stiffly elongate and upright and whose leaves tend to grow upright and parallel to the twig. In April, in a woods near Brodhead, Green Co., infected *Physocarpus* shrubs were found where the leaves and twigs were so heavily studded with perithecia as to appear coal black and were very noticeable from a considerable distance. The fungus seemed to have exerted a preservative effect on the leaves and all remained in place on the twigs despite the vicissitudes of a severe previous winter.

Undetermined powdery mildews have been collected on the following host species: *Liatris spicata.* Dane Co., Madison, June 27; *Solidago patula.* Sauk Co., Parfrey's Glen, August 23.

RHYTISMA ASTERIS Schw. and *Rhytisma solidaginis* Schw. are different names applied to what is probably the same fungus, depending on whether it occurs on *Aster* or *Solidago.* Specimens taken recently at Madison are on *Aster pilosus* and *Solidago nemoralis.* Most commonly encountered on *Solidago graminifolia,* but Wisconsin specimens on *Solidago patula,* on *Aster sagittifolius* and *A. linariifolius* are in our herbarium.

MYCOSPHAERELLA sp. occurs on *Bromus latiglumis* collected at Nelson Dewey Memorial Park near Cassville, Grant Co., August 3, 1954. This is on a leaf bearing lesions with *Colletotrichum graminicola* (Ces.) Wils. and the perithecia are adjacent to the *Colletotrichum* but not intermingled with it. The perithecia are gregarious on the dead distal portion of the leaf. They are black, subglobose, approx. 100–200μ diam., ostiolate, with asci narrowly clavate with a rather long pedicel, about 45 x 7μ overall. The hyaline ascospores are 15–17 x 3μ. Connected with the *Colletotrichum?*

MYCOSPHAERELLA which is believed to almost surely represent the perfect stage of *Didymaria didyma* (Ung.) Schroet. has been studied on an overwintered leaf of *Anemone canadensis.* On several occasions leaves of *A. canadensis* have been observed in late summer closely studied with black perithecium-like bodies which, at first sight, were suggestive of *Phleospora anemones* Ell. & Kell., but which proved to be immature. Material collected near Arena, Iowa Co., August 10, 1954, was kept out-of-doors over winter at Madison and brought in for examination following a period of heavy rains in late April 1955. At this time numbers of the black bodies had developed at their apex conidiophores and conidia identical with those of *Didymaria didyma,* commonly found on *A. canadensis* in Wisconsin. Others of the bodies proved to be mature perithecia of *Mycospharella.* These were globose, about 125–150μ diam., bearing short-clavate asci, 35–40 x 12–14μ. The uniseptate hyaline ascospores are slender-fusoid, 4–6 x 17–20μ. So far as examination of the rather meager specimen showed, imperfect and perfect stages were not produced on and in the same sclerotoid body, but there is no doubt in my mind that they are one and the same. Although it seems extremely probable, it is not proved that the imperfect manifestation is really *Didymaria didyma*. Various similar cases of overwintering of conidial stages have been reported by me where there was no question that the sclerotoid bodies had followed the primary infection.

PHYLLACHORA LESPEDEZAE (Schw.) Sacc. is the subject of a recent morphological-cytological investigation by J. H. Miller (Amer. Jour. Bot. 41:825–828. 1954). It is interesting to note that his findings in general confirm speculations made by me in my Notes III (Trans. Wis. Acad. Sci. 35:114. 1944) concerning this species as it appears in Wisconsin on *Lespedeza capitata*.

RAVENELIA EPIPHYLLA (Schw.) Diet. I on *Tephrosia virginiana* has been collected at Tower Hill State Park, Iowa Co., June 28. This is the first Wisconsin collection of the uredinoid aecia.

UROMYCES SPARGANII Clint. & Peck is now applied to include the former *U. pyriformis* Cooke, originally described as a distinct species confined to *Acorus calamus,* following studies of Parmelee and Savile (Mycologia 46:823–836. 1954) where they show *U. sparganii* and *U. pyriformis* to be morphologically identical and cross-inoculable. *Uromyces sparganii* is also shown to have a hitherto unrecognized aecial stage on *Hypericum virginicum.* The authors state, "There are presumably numbers of specimens of the aecial stage of *Uromyces sparganii* filed in herbaria under *U. hyperici.* Unfortunately *Hypericum virginicum* also takes the latter rust and the aecia do not seem to be safely distinguishable." It is of interest to me that in the summer of 1954, at Tower Hill State Park, Iowa Co., I collected heavily rusted *Acorus* immediately adjacent to plants of *Hypericum virginicum* bearing rather passé aecia. There are no uredia or telia present, as there so commonly are in the autoecius *U. hyperici,* so it seems highly probable that the aecia are those of *U. sparganii* as described by Parmelee and Savile.

PHYLLOSTICTA sp. has been found on aecia of *Aecidium avocensis* Cummins & Greene, collected near Avoca, Iowa Co., June 22, 1951. These were mistaken, under a hand lens, for *Darluca filum* (Biv.) Cast. The pycnidia are small, black, flask-shaped bodies about half again as high as wide, containing numerous, small, hyaline conidia, about 2–2.5μ x 3–4μ. Possibly parasitic.

PHYLLOSTICTA sp. on the nodal swellings of flowering stalks of *Festuca ovina* occurred at Madison, August 10. The affected areas are closely beset with small, 40–60μ diam., black, globose pycnidia which contain hyaline (yellowish in mass), narrow-cylindric conidia, approx. 5–8 x 1.5–2μ. Since this late in the season the flower stalks are dead it is not possible to say with certainty whether or not the fungus developed as a parasite, but it seems probable that it did.

PHYLLOSTICTA sp. on *Erythronium albidum* was found at two stations in Green Co., May 5. This appears to be a strong parasite, with large areas of the leaves closely beset with the numerous pycnidia. The body of the pycnidium is subglobose to rather markedly flattened, sooty, darker above, often with a well-defined short beak, ostiole present but not well marked, 50–115μ diam., with small, hyaline, rod-shaped microconidia, approx. 4–7 x 1.5μ. There is profuse production of tortuous, coarse mycelium throughout the affected host tissue. Stained prepared sections show evidence of intraepidermal origin of the pycnidia, and further show nothing to indicate the presence of any early ascomycetous stage.

PHYLLOSTICTA sp., of dubious status as to parasitism, is on leaves of *Ribes cynosbati* collected at Wyalusing State Park, Grant Co., August 17. The rounded to oval spots are sordid grayish-brown with narrow darker border, approx. 2–4 mm. diam.; pycnidia amphigenous, clustered, dark brown, widely ostiolate, globose, small, 30–40μ diam.; conidia hyaline, bacilliform, 3–4 x 1μ.

PHYLLOSTICTA sp., of somewhat doubtful parasitism, occurred on leaves of *Tephrosia virginiana,* collected in Tower Hill State Park, Iowa Co., June 28. The spots are small, irregular, somewhat sunken and pale brown. Pycnidia are strongly erumpent, appearing almost stalked in some cases, sooty, pseudo-parenchymatous, approx. 100–150μ diam.; conidia hyaline, broadly ellipsoid or short-cylindric, 2.5–3.5 x 5–7μ. Reminiscent of *Stagonospora tephrosiae* Greene in the spots and the disposition of the pycnidia on them, and mistaken for that species in the field.

PHYLLOSTICTA which it seems may possibly be only a poor development of *Ph. fraxinicola* Curr. occurred in sparse development on leaves of *Fraxinus pennsylvanica* var. *lanceolata* near Arena, Iowa Co., August 12. The pycnidia are decidedly more erumpent than those in other specimens seen and not more than two or three per spot, in contrast the many per spot in *Ph. fraxinicola.* The conidia are very similar, however, and neither fungus is far removed from *Coniothyrium,* as a matter of fact.

PHYLLOSTICTA sp. occurred on leaves of *Gentiana andrewsii* at Madison, June 26. The whitish to pale tan spots are rounded, thin, translucent, sunken, approx. 1.5–3 mm. diam., often confluent; pycnidia scattered to gregarious, pale brown, variable in size, approx. 75–150μ diam.; conidia hyaline, rod-shaped, short-cylindric or subfusoid, 3.5–6 x 2–3μ. Possibly secondary, but there is no positive indication that any other agent was involved.

PHLLOSTICTA sp. on current season's capsules of *Castilleja sessiliflora* was discussed as a possible parasite in my Notes XVIII (Trans. Wis. Acad. Sci. 42:70. 1953). In July 1955 what appears to be the same fungus was found on the 1954 capsules of the related *Aureolaria grandiflora* at Madison.

PHYLLOSTICTA sp. on *Solidago altissima,* collected at Madison, August 25, approaches *Ph. solidaginis* Bres., as it is represented by specimens on *Solidago gigantea* in the University of Wisconsin Cryptogamic Herbarium, but the conidia are somewhat shorter, and the rounded grayish spots smaller and not zonate.

PHOMOPSIS sp., which may be parasitic, occurs on the midrib of a leaf of *Wulfenia bullii* collected near Brodhead, Green Co., July 10. The pycnidia are black, slightly elongate, about 125μ diam. Most of the conidia seen were scolecospores, hyaline, continuous, mostly strongly curved, tapering to a point at one end, approx. 20–30 x 1–1.5μ. Reversing the usual situation in *Phomopsis,* only a few conidia of the other type were observed. These were hyaline, broadly fusoid, 7 x 3.5μ.

ASCOCHYTA LOPHANTHI J. J. Davis is another of those borderline species to which little violence would be done if it were placed under *Stagonospora,* as this writer has already formally done with *Ascochyta thaspii* Ell. & Ev. In a specimen of *A. lophanthi* on *Lycopus americanus,* collected at Madison, July 7, a sizeable minority of the large and well-developed conidia are 2-septate, and a very few have 3 septations.

ASCOCHYTA sp. occurs on leaves of *Monarda punctata* collected near Dekorra, Columbia Co., July 15. The spots are ashen, translucent, rounded, with a narrow purplish border, 1–1.5 mm. diam.; pycnidia one to two or three per spot, epiphyllous, subglobose, black, firm-walled, approx. 100–150μ diam.; conidia hyaline, cylindric, 9–13 x 3–4μ, showing a median septum very consistently. The spots are somewhat like those usually associated with *Phyllosticta decidua* Ell. & Kell., but the fungus is plainly different. I do not find any reports of *Ascochyta* on *Monarda.* Parasitism rather questionable.

STAGONOSPORA POLYTAENIAE Greene (Amer. Midl. Nat. 39:454. 1948), described before I recognized that *Ascochyta thaspii* Ell. & Ev. is a good *Stagonospora* and transferred it to that genus (Amer. Midl. Nat. 48:52. 1952), appears upon review and study of additional recent material to belong under *S. thaspii* (Ell. & Ev.) Greene. Specimens on *Polytaenia nuttallii* and on *Pastinaca sativa* (Amer. Midl. Nat. 44:636. 1950) must therefore be transferred.

SEPTORIA DIDYMA Fckl. has been reported on *Salix interior (longifolia)* in Wisconsin on the basis of several collections. Comparison of the Wisconsin specimens with Fungi rhenani No. 1677, issued as this species and stated on the label to have been collected by Fuckel, shows definitely wider and more robust spores in the latter, which is reminiscent of *Marssonina*. Otherwise the Wisconsin material is quite similar and is certainly not more than varietally different.

SEPTORIA DIDYMA Fckl. and *S. salicina* Peck represent, it would appear, the extremes of an intergrading series of parasites on *Salix* in Wisconsin. *Septoria didyma* var. *santonensis* Pass. was erected to receive forms which are intermediate and the late J. J. Davis assigned specimens on *Salix fragilis* to this variety, containing those forms with a spore length of approx. 22–38μ. The range for *Septoria didyma* is about 15–25μ and for *S. salicina* 40–60μ. In my Notes II (Trans. Wis. Acad. Sci. 34:93. 1942) I assigned long-spored specimens on *Salix fragilis* to *S. salicina*, with the statement that I was unable to see a satisfactory distinction between *S. salicina* and *S. didyma* var. *santonensis*. Recent collections on *S. fragilis*, however, are exactly intermediate and I am led to conclude that the varietal category is probably of value and should be recognized.

DILOPHOSPORA ALOPECURI Fr., as it occurs on *Calamagrostis canadensis*, was discussed in my Notes IV (Farlowia 1:577. 1944). As stated, this was described by E. A. Bessey on leaves which had been sent to him from Kenosha Co., Wis., for study of nematode infestation. Bessey mentions the occurrence of the fungus on the same leaves, but does not indicate any closer association with the nematode galls. In a recent collection made near Brodhead, Green Co., and to a much lesser extent in two earlier specimens on the same host from Madison, there is a striking association, and the elongate, golden-yellow galls, in which the nematodes are developed, are closely studied with *Dilophospora* pycnidia. The youngest and newest of the galls are free of the fungus, so that it seems that it becomes established on the galls following infestation. Lesions where the fungus occurs alone, and there are many such, are tissue-paper thin and there would be no subsequent opportunity for development of the thickened, hypertrophied galls.

LEPTOTHYRIUM sp. occurs on leaves of *Liatris aspera* var. *intermedia* (Lunell) Gaiser collected in the University of Wisconsin Arboretum at Madison, August 16. The spots are large, 1.5–3 cm. diam., orbicular, grayish-brown, subzonate. The fruiting bodies are amphigenous, scattered, shining black, rounded above, flattened and imperfect below, approx. 150–200μ diam., scattered to gregarious. The conidia are hyaline, cylindric or short-cylindric, 6–10 x

3–4.5μ. The status of the fungus seems questionable and it is perhaps secondary, although there is no clear-cut evidence that any other external agent has produced the spotting.

COLLETOTRICHUM sp. occurs on conspicuous spots on the leaves of *Geranium maculatum*, collected at Madison, August 7. Parasitism is somewhat uncertain and the possibility cannot be overlooked that the spots were primarily caused by *Cercospora*, as some *Cercospora* conidia were found in one of the half dozen mounts made, although no conidiophores could be found. The spots are orbicular to broadly ellipsoid, .3–1.5 cm. diam., with a wide, blackish-brown border and cinereous center; acervuli epiphyllous, loosely gregarious on the cinereous area, small, approx. 30–50μ diam.; setae uniform purplish-black, straight or moderately curved or tortuous, tapering gradually toward the subacute tip, continuous, in number from a half dozen to 20 or more in the acervulus, 20–45μ long, 2.5–3μ thick; conidiophores short, almost obsolete, closely packed; conidia hyaline, cylindric or subfusoid, 12–14 x 4–4.5μ.

VERMICULARIA COMPACTA C. & E. on petioles of *Parthenocissus vitacea* was reported in my Notes XX (Trans. Wis. Acad. Sci. 43: 179. 1954). A specimen collected in July 1954 near Wautoma, Waushara Co., occurs on leaf blades of this host. The large, 3–6 cm., rounded, dull bronze lesions are very conspicuous, and in general habit and spore characters the fungus corresponds well with the earlier specimen on petioles. Coll. S. D. Van Gundy.

BOTRYTIS sp., which appears parasitic, has been collected on blighted buds and leaves of *Paeonia officinalis* at Madison in the summer of 1955. On the leaves the spots are light brown, large, rounded and sharply delimited, with the fungus hypophyllous on them. According to Whetzel (Trans. Mass. Hort. Soc. 1915) (1): 108. 1915) *Botrytis* blight is by far the most common and destructive disease of the peony. In his opinion at least two distinct species of *Botrytis* are involved.

BOTRYTIS sp. occurs on large, pale brown, subzonate lesions on leaves of *Menispermum canadense* collected near Juda, Green Co., August 11. Over the years an impressive list of hosts bearing *Botrytis* as a putative parasite has been assembled, but determinations of the species of *Botrytis* concerned have presented equally impressive difficulties.

CLADOSPORIUM sp., which may be parasitic, occurs on leaves of *Desmodium nudiflorum*, collected in Tower Hill State Park, Iowa Co., June 28. The spots are orbicular, approx. 3–7 mm. diam., or sometimes confluent over larger areas, pale brown with very narrow red-brown borders. Fruiting amphigenous, grayish, localized in center of spots. Hyphae non-fasciculate, but tending to be closely ranked and in contact by their swollen bases, pale grayish brown, simple or subgeniculate, 15–70 x 3.5–5.5μ, 1–2-septate; conidia pale olivaceous, subfusoid or cylindric, smooth, 10–21 x 3.5–4μ, continuous or 1-septate.

CLADOSPORIUM HUMILE J. J. Davis, the conidial stage of *Venturia acerina* Plakidas, occurs in consistent and intimate association with *Rhytisma acerinum* on leaves of *Acer saccharinum,* collected at Madison, August 19. The *Cladosporium* has developed about the periphery of the tar spots, perhaps indicating only a rather weak degree of parasitism.

CERCOSPORELLA FILIFORMIS J. J. Davis (*Cercospora filiformis* (Davis) Chupp) on *Anemone patens* var. *wolfgangiana,* like *Cercosporella saxifragae* Rostr., overwinters in a sclerotoid condition on the dead host leaves and with the spring rains, produces a large number of fresh conidia on the sclerotoid bodies. These conidia presumably infect the developing current season's leaves, thus perpetuating the fungus without intervention of a perfect stage. This observation is based on leaves bearing the sclerotoid stage, collected near Cambria, Columbia Co., in September 1954, and held outdoors over winter in a cage at Madison.

CERCOSPORA on *Lathyrus latifolius* (cult.), Madison, September 1953, appears to best fit *C. lathyrina* Ell. & Ev., but might possibly also be assigned to *C. lathyri* Dearn. & House.

CERCOSPORA sp. on *Vitis riparia,* collected in small amount in the New Glarus Woods Roadside Park, Green Co., September 7, does not well match any of the species hitherto described on Vitaceae, as outlined in Chupp's monograph of Cercosporae. The fungus is hypophyllous, with effuse, largely superficial, pale olivaceous mycelium, from which the short conidiophores arise in non-fasciculate, seemingly more or less haphazard fashion. The conidia are faintly olivaceous, indistinctly multiseptate, very narrowly obclavate—almost acicular—with a conic base and prominent scar, approx. 3.5–4 x 55–90μ.

CERCOSPORA SII Ell. & Ev., which parasitizes *Sium suave* in Wisconsin, has an uncertain taxonomic status. The late J. J. Davis relegated it to *Fusicladium depressum* var. *sii* (E. & E.) Davis, while Chupp in his recent monograph states "Petrak . . . suggests that this is a synonym of *Fusicladium depressum.* It dose not seem related in any way to *Fusicladium,* but the spores being nearly all 1-septate, the stromata slight, and the conidiphores relatively long, the fungus is here classed under *Piricularia* rather than *Cercospora.*" A specimen recently collected at Madison has many 2-septate conidia, and an occasional one with 3 septa, so I prefer to retain this species under *Cercospora,* while recognizing its variability.

Spartina pectinata, collected at Madison, September 5, bears an interesting, but as yet undetermined loculate fungus which is apparently strongly parasitic. An elongate, narrow, dark stroma is produced between leaf ribs on the top surface, just below the cuticle and rupturing and upraising it. The stromata, while only about 150μ wide at the most, may be up to 1 cm. or more long. The locules are developed at varying levels and quite closely adjacent below the dark continuous common stroma and they are of variable diameter. Vast numbers of hyaline, rod-shaped microconidia, 3–4 x 1μ, are produced in some of the locules, while others show structures that are possibly the immature stages of an Ascomycete. It seems likely that the conidia are spermagonial in nature.

Salix discolor, collected in Columbia Co. near Pardeeville, Sept. 24, 1954, has conspicuous sclerotized areas on leaves, the major portions of which are still green and living. The fungus tends to permeate the tissue between the veins, so that the vein islets are black and the veins themselves are pale brown and the venation pattern is strikingly shown. The fungus is sterile, but sections through the infected area show profuse mycelium and the organism appears parasitic.

All scientific papers dealing with taxonomic and ecological studies of fungi which have been carried out on Wisconsin material through 1953—so far as known to the authors—are listed on pp. 37–42 of a paper entitled "A Bibliography of Wisconsin Vegetation" by H. C. Greene and J. T. Curtis. This is No. 1 of a new scientific series of the Milwaukee Public Museum called "Publications in Botany".

ADDITIONAL HOSTS

The following hosts have not been previously recorded as bearing the fungi mentioned in Wisconsin.

PERONOSPORA PARASITICA (Pers.) Fr. on *Hesperis matronalis.* Green Co., near Brodhead, June 3.

ERYSIPHE CICHORACEARUM DC. on *Polemonium reptans.* Dane Co., Madison, June 29. Only slight fruiting, as the fungus tended to kill back the leaves at an early stage in its development before perithecia could form.

HPOXYLON PRUINATUM (Kl.) Cke. has been reported on *Populus tremuloides* in Wisconsin in these lists. I am reliably informed that *Populus grandidentata* and *P. balsamifera* are additional hosts for this state.

RHYTISMA SALICINUM (Pers.) Fr. on *Salix petiolaris.* Dane Co., Madison, August 31.

COLEOSPORIUM CAMPANULAE (Pers.) Lev. II on *Campanula rotundifolia*. Marquette Co., Observatory Hill near Montello, July 20. Coll. H. H. Iltis. Not listed on this host in Arthur's Manual.

MELAMPSORA BIGELOWII Thum. II, III on *Salix bebbiana*. Dane Co., Madison, September 6.

MELAMPSORA ABIETI-CAPREARUM Tub. II on *Salix petiolaris*. Dane Co., Madison, September 3.

PUCCINIA GRAMINIS Pers. II, III on *Glyceria borealis*. Dane Co., Madison, July 30.

PUCCINIA CORONATA Cda. II, III on *Agropyron trachycaulum*. Dane Co., Madison, September 5, 1954. Apparently not hitherto reported on this host.

PUCCINIA ANGUSTATA Peck II on *Scirpus cyperinus*. Dane Co., Madison, August 15. Hitherto reported from Wisconsin only on the very distinct var. *pelius*.

PUCCINIA EXTENSICOLA Plowr. I on *Solidago missouriensis*. Green Co., near Brodhead, June 3. On *Solidago speciosa*. Lafayette Co., Red Rock, June 7.

PUCCINIA EXTENSICOLA Plowr. II, III on *Carex cephalophora*. Pierce Co., Hager City, July 24, 1952. Coll. J. R. Bray. Wisconsin is cited as a host locality in the North American Flora treatment of *P. extensicola*, but there is no mention of its occurrence in Davis' notes, nor do I find a specimen in the Wisconsin Cryptogamic Herbarium. Also on *Carex lanuginosa*. Dane Co., Madison, August 7, 1954. Host det. J. H. Zimmerman.

PUCCINIA CARICIS (Schum.) Schroet. II on *Carex lanuginosa*. Dane Co., Madison, July 23.

PUCCINIA ANDROPOGONIS Schw. I on *Pentstemon digitalis*. Dane Co., Madison, July 13. The affected plants were much stunted and deformed. Closely adjacent plants of *Andropogon scoparius* bore a very heavy uredial infection of *P. andropogonis*.

PUCCINIA ELEOCHARIDIS Arth. I on *Eupatorium altissimum*. Rock Co., near Tiffany, July 29. Although the specimen was small and old, it was readily identifiable. Seemingly the first report on this host.

PUCCINIA LIATRIDIS (Webber) Bethel I on *Liatris spicata*. Kenosha Co., 5 mi. S. of Kenosha, August 9. The specimen is old, but aecia with identifiable spores occur at the periphery of some of the lesions.

UROMYCES JUNCI (Desm.) Tul. I on *Helianthus rigidus*. Sauk Co., Spring Green, June 7. Referred here provisionally on the basis of spore size and host, as was done with a similar specimen on *Helianthus occidentalis* in my Notes XVI (Amer. Midl. Nat. 48:743.

1952). There seems to be no satisfactory morphological character other than spore size to differentiate the aecial stage of *U. junci* from *Puccinia helianthi,* and an even more dubious host character to differentiate it from *Uromyces silphii.*

CERATOBASIDIUM ANCEPS (Bres. & Syd.) Jacks. on *Steironema ciliatum.* Iowa Co., near Arena, June 28. On *Eupatorium maculatum, Solidago altissima.* Dane Co., near Cottage Grove, July 12.

XENOGLOEA ERIOPHORI (Bres.) Syd. on *Scirpus fluviatilis.* Dane Co., Madison, July 22.

PHYLLOSTICTA CHENOPODII-ALBI Siemaszko on *Chenopodium hydridum.* Green Co., Oakly, August 2.

PHYLLOSTICTA PUNCTATA Ell. & Dearn. on *Viburnum lentago.* Dane Co., Madison, September 12. The conidia are slightly smaller and the pycnidia somewhat larger than indicated in the description, but the lesions seem highly characteristic.

SELENOPHOMA EVERHARTII (Sacc. & Syd.) Spr. & Johns. on *Danthonia spicata.* Lafayette Co., Red Rock, June 7.

ASTEROMELLA ANDREWSII Petr. on the following cultivated gentians at Madison, August 1954. Coll. & det. J. T. Curtis: *Gentiana cruciata, G. newberryi, G. parryi,* and *G. flavida* X *andrewsii.* The latter is an authentic hybrid produced under controlled conditions.

ASCOCHYTA COMPOSITARUM J. J. Davis on *Eupatorium perfoliatum*. Dane Co., Madison, July 25. The pycnidia measured are rather small for this species, only about 100μ diam., but the conidia are large, well-formed and characteristic. Associated with the *Ascochyta* on the largely dead leaves is a somewhat immature *Mycosphaerella.* Also on *Eupatorium maculatum.* Dane Co., Madison, Sept. 8.

STAGONOSPORA THASPII (Ell. & Ev.) Greene on *Osmorhiza claytoni.* Dane Co., Stewart's Woods, S31, Town of Verona, July 1.

STAGONOSPORA CIRSII J. J. Davis on *Carduus acanthoides.* Iowa Co., Jonesdale, August 5.

SEPTORIA PASSERINII Sacc. Microspore stage on *Hystrix patula.* Green Co., near Monticello, September 1, 1954. Det. R. Sprague.

SEPTORIA DIDYMA Fckl. on *Salix nigra.* Dane Co., Madison, September 7.

SEPTORIA CAMPANULAE (Lev.) Sacc. on *Campanula rotundifolia.* Marquette Co., Observatory Hill near Montello, July 20. Coll. H. H. Iltis. Apparently the first report on this host.

SEPTORIA SOLIDAGINICOLA Peck on *Solidago canadensis.* Dane Co., Madison, August 22. The conidia are somewhat longer than in many of the collections of this species, but the lesions are highly characteristic.

SEPTORIA ATROPURPUREA Peck on *Solidago speciosa.* Lafayette Co., Red Rock, June 7. The pycnidia are somewhat more prominent and erumpent than is usual with this species, but the relatively long and thick spores are characteristic.

SEPTORIA ATROPURPUREA Peck on *Aster prenanthoides.* Sauk Co., Parfrey's Glen, August 23.

SEPTORIA CIRSII Niessl on *Carduus acanthoides.* Iowa Co., Jonesdale, June 18. There seem to be no earlier reports of parasitic fungi on this troublesome weed.

GLOEOSPORIUM RIBIS (Lib.) Mont. & Desm. on *Ribes cynosbati.* Grant Co., near Montfort, July 18.

GLOEOSOPORIUM CORNI H. C. Greene on *Cornus alternifolia.* Dane Co., Madison, September 6. Since the original collection on *C. femina* other specimens on that host and the current one suggest that this fungus may be associated with insect activity. However, whether or not it is a strong parasite, it is a highly characteristic fungus occurring on sharply delimited spots, usually one to a leaf, on leaves which are otherwise green and vigorous.

COLLETOTRICHUM MADISONENSIS H. C. Greene on *Carex trichocarpa.* Green Co., Oakly, August 2.

CYLINDROSPORIUM APOCYNI Ell. & Ev. on *Apocynum cannabinum.* Rock Co., near Tiffany, July 29.

OVULARIA SPHAEROIDES Sacc. on *Vicia cracca* var. *tenuifolia.* Dane Co., Madison, August 17, 1954. Coll. S. D. Van Gundy.

RAMULARIA STOLONIFERA Ell. & Ev. on *Cornus obliqua.* Grant Co., Blue River, August 5.

RAMULARIA DISPAR J. J. Davis on *Eupatorium maculatum.* Dane Co., Madison, September 8. An earlier specimen collected by J. J. Davis at Crivitz, Marinette Co., labeled as on *E. purpureum,* appears also to be on *E. maculatum.* There is no doubt in my mind that these species are distinct.

CERCOSPORA CARICIS Oud. (*C. caricina* Ell. & Dearn.) on *Carex stricta.* Dane Co., Madison, August 4. On *Carex rostrata.* Sauk Co., Parfrey's Glen, August 23. On *Carex sartwellii.* Dane Co., Madison, September 16.

CERCOSPORA SALICIS Chupp & Greene on *Salix interior (longifolia).* Iowa Co., Arena, August 12.

CERCOSPORA HELIANTHI Ell. & Ev. on *Helianthus rigidus.* Dane Co., Madison, September 2.

TUBERCULINA PERSICINA (Ditm.) Sacc. on *Puccinia bolleyana* Sacc. I on *Sambucus canadensis.* Dane Co., Madison, July 7.

ADDITIONAL SPECIES

The fungi mentioned have not been previously reported as occurring in Wisconsin.

MICROSPHAERA EUONYMI (DC.) Sacc. on *Evonymus europaeus* (cult.). Dane Co., Madison, September 21, 1954. Coll. C. G. Ehlers. This species is distinguished primarily by the fasciculate habit of the long appendages, the ultimate branchlets of which are not regularly and strongly recurved as is the case in *Microsphaera alni*. Salmon in his monograph of the Erysiphaceae states that "*M. euonymi* is confined to Europe; the record of its occurrence in California "on *Euonymus*" by Harkness and Moore is doubtless an error." Conceivably the fungus could have been imported along with the cultivated host to account for its presence at Madison, but in this connection it is of real interest that this same fungus has recently been collected, October 11, 1955, on the native *Evonymus atropurpureus* in an isolated maple woods near Oakly, Town of Spring Grove, Green Co. This would seem to demonstrate beyond any reasonable doubt that *M. euonymi* is endemic.

FABRAEA THUEMENII sp. nov. is the name proposed by E. A. Stowell in a 1955 University of Wisconsin doctoral dissertation on the fungus which causes leaf blight of English hawthorn, *Crataegus oxyacantha,* and which has as its conidial stage *Entomosporium thuemenii* (Cooke) Sacc. This was reported by me for Wisconsin material as *Fabraea maculata* (Lev.) Atk. (Trans. Wis. Acad. Sci. 34:94. 1942), but Stowell seems to have shown that *F. maculata* is correctly applied only to the fungus causing leaf blight of pear and quince.

RHIZOSPHAERA KALKHOFFI Bub. on *Picea glauca*. Dane Co., Madison, May 19. This caused a destructive needle cast of large specimen trees in the University of Wisconsin Arboretum, resulting in virtual defoliation. Waterman (Phytopath. 37:507. 1947) described this disease in some detail, as it affected cultivated *Picea pungens* in Connecticut.

USTILAGO ANOMALA Kze. on *Polygonum cilinode*. Marathon Co., Rib Mt. near Wausau, June 28, 1942. Coll. C. G. Shaw and L. H. Shinners. This specimen is in the mycological herbarium of the Department of Plant Pathology at the State College of Washington, but has been seen by me and a label placed in the University of Wisconsin herbarium.

PHYLLOSTICTA CONFERTISSIMA Ell. & Ev. on *Ulmus americana*. Dane Co., Madison, September 26. Although the conidia are of the micro-type there is nothing about the lesions or the fungus to suggest that this is the precursor of a perfect stage. Both lesions and fungus correspond very closely to the original description.

SEPTORIA OUDEMANSII Sacc. on *Hierochloe odorata.* Waukesha Co., near Eagle, May 24, 1941. Coll. C. G. Shaw. Det. R. Sprague.

Colletotrichum lucidae sp. nov.

Maculis fuscis, zonatis, conspicuis, amplis, orbicularibus vel irregularibus, 0.5–3 cm. diam. ca.; acervulis epiphyllis, sparsis, inconspicuis, subcuticularibus, 110–175μ diam.; setis, rectis, flexuosis, vel subgeniculatis raro, apicibus subobtusis, claro-brunneis, supra pallidioribus leviter, 50–65 x 4–5μ, 1–2-septatis; conidiophoris subcylindraceis, subhyalinis, confertis, 12–15 x 3–5μ; conidiis hyalinis, obtusis, cylindraceis, 13–19 x 4–6.5μ.

Spots dark brown, banded-zonate, conspicuous, large, orbicular or irregular, approx. 0.5–3 cm. diam.; acervuli epiphyllous, scattered, inconspicuous, subcuticular, 110–175μ diam.; setae straight, flexuous, or rarely subgeniculate, clear brown, becoming somewhat paler toward the subobtuse tips, 50–65 xx 4–5μ, 1–2 septate; conidiophores subhyaline, subcylindric, crowded, 12–15 x 3–5μ; conidia hyaline, obtuse, cylindric, 13–19 x 4–6.5μ.

On living leaves of *Salix lucida.* University of Wisconsin Arboretum, Madison, Dane County, Wisconsin, U.S.A., September 4, 1955.

The zonate banding of alternate dark and somewhat lighter brown is very pronounced and characteristic in the larger spots, some of which do not show any acervuli. In this connection it is interesting that the specimen in the Wisconsin Herbarium of Fungi Columbiani No. 3872, issued as *Septogloeum salicinum* (Peck) Sacc. appears to bear sterile *C. lucidae* lesions with *Septoria salicina* Peck included within the boundaries of the larger spots. Although subcuticular, the acervuli are very firmly seated on the epidermis and there is nothing of the superficial saprophytic *Colletotrichum* about *C. lucidae.* The straight, rigid, cylindric conidia are not of the type ordinarily encountered in *Colletotrichum,* but in other respects the fungus seems a characteristic representative of the genus.

SPHACELOMA MURRAYAE Jenkins & Grodsinsky on *Salix lucida.* Sauk Co., Parfrey's Glen, August 23. On *Salix nigra.* Dane Co., Madison, September 2. On *Salix discolor, S. interior.* Dane Co., Madison, September 8.

Cladosporium coreopsidis sp. nov.

Maculis nullis; conidiophoris amphigenis, non-fasciculatis, obscuro-brunneis, fere rectis vel subtortuosis, prope geniculatis supra, basibus non inflatis, 30–65 x 3.5–4.5μ, 2–3 septatis; conidiis catenulatis, fusoideis vel angusto-fusoideis, levibus, pallidis fumoso-brunneis, 13–20 x 3.5–4μ, 1-septatis vel continuis.

No distinct spots; conidiophores amphigenous, arising individually and not in fascicles, dark brown, almost straight to subflexuous, closely geniculate above, base not enlarged, 30–65 x 3.5–4.5μ, 2–3 septate; conidia catenulate, fusoid or narrow-fusoid, smooth, pale smoky brown, 13–20 x 3.5–4μ, 1-septate or continuous.

On living leaves of *Coreopsis palmata*. University of Wisconsin Arboretum, Madison, Dane County, Wisconsin, U.S.A., June 27, 1955.

A somewhat similar undetermined *Cladosporium* on *Coreopsis* which, however, differed in important characters, particularly in having much shorter spores, was mentioned in my Notes XX (Trans. Wis. Acad. Sci. 43:171. 1954). The present fungus is well-developed and many host plants were infected. The most noticeable effect on the host is a pronounced stunting with suppression of flowering on the infected stalks. Healthy *Coreopsis palmata* clumps are normally very floriferous, with a terminal flower on all or almost all the stems. The conidiophores bear many closely crowded spore scars near their tips and the geniculation often is not very pronounced. The origin of the phores is not obvious in free-hand sections, but they do not appear deep-seated.

CERCOSPORA ALNI Chupp & Greene was described as a new species on *Alnus crispa* (Farlowia 1:580. 1944). S. J. Hughes (Can. Jour. Bot. 31:571. 1953) points out that on the basis of the description this is unquestionably *Passalora bacilligera* Mont. & Fr. Comparison of the Wisconsin specimen with authentic European specimens shows that Hughes is correct and the name *Cercospora alni* is a synonym.

PASSALORA ROBINIAE (Shear) Hughes replaces *Fusicladium robiniae* Shear as the name for this fungus occurring in Wisconsin and elsewhere on *Robinia pseudo-acacia*. Hughes (Can. Jour. Bot. 31:572. 1953) regards an inflated basal cell of the conidium as the best criterion distinguishing *Passalora* from *Cladosporium*. Hughes also transfers *Fusicladium depressum*, occurring on various Umbelliferae, to *Passalora*, but to this writer, basing his opinion on a number of the many specimens in the Wisconsin Herbarium, the shift does not seem justified, in view of the extreme variability noted.

CERCOSPORA ITHACENSIS Chupp on *Geranium maculatum*. Wisconsin specimens on *G. maculatum*, hitherto regarded as being *C. geranii* Kell & Sw. are considered as distinct by Chupp and described as a new species in his "Monograph of Cercospora", p. 241.

CERCOSPORA PTELEAE Wint. on *Ptelea trifoliata*. Green Co., near Juda, August 2.

AN UNPUBLISHED MANUSCRIPT OF E. A. BIRGE ON THE TEMPERATURE OF LAKE MENDOTA; PART I

JOHN C. NEESS and WILLIAM W. BUNGE, JR.
Departments of Zoology and Geography, University of Wisconsin

INTRODUCTION

Edward A. Birge's career as a limnologist opened with some studies on the anatomy and taxonomy of the Cladocera which he began at Harvard while he was a graduate student and which he continued later, after he arrived at Madison and became installed as a member of the faculty of the University of Wisconsin. In the years before 1900 his interest moved rapidly from the structure and classification of these animals as mere crustaceans to their ecology as representatives of the zooplankton community in Lake Mendota, and thence to the more purely physical and chemical qualities of the whole environment of the zooplankton community. Before the close of that career he had contributed richly and widely to the study of lakes in its many various aspects; his affection remained, however, primarily attached to physical considerations, and the investigations in which he retained throughout his life the greatest personal interest were of heat and light and their interrelations.

While studying the behavior of the Cladocera in Lake Mendota Birge began assembling information for two great monographs on physical limnology. One of these was a study of the gases dissolved in lake water, and is familiar as the famous "Dissolved Gases" paper of Birge and Juday, published in 1911 in Bulletin Number 22 of the Wisconsin Geological and Natural History Survey. The other was a study of temperature and heat distribution in lakes that seems never to have been finished.

In 1894, along with his sampling of the zooplankton in Lake Mendota, Birge began taking water temperatures. The results must have interested him considerably, for he accelerated his collection of temperature data in each subsequent year, so that by 1899 he had assembled some 25,000 individual readings (according to his own estimate in an unpublished manuscript written in 1899; see below). He persisted in making regular and frequent observations of temperature until about 1916, then continued to make them, in smaller quantity, until about 1931, by which time his attention had been largely displaced to the lakes of northern Wisconsin.

Taken all together, these temperature records represent probably the most elaborate set in existence for a single lake. Particularly during the period 1895–1916, observations were made throughout the entire year, not just during the warmer months; they were made at several points on the lake's surface and at all depths. In some years, temperatures were taken twice daily at all stations on every day during the open season safe for a small boat. On occasion, the records included also temperatures taken at several depths in the mud, temperatures within the ice-layer, observations of ice-thickness and of other phenomena relating to water temperature. Birge was helped substantially in making these observations by many individuals, most of whose names now seem to be lost; he was helped also by the invention, in 1895, of the first electrical resistance thermometer that could be used practically in the field (the "thermophone" of Warren and Whipple, described by these authors in 1895).

Small parts of this vast collection of temperatures have been used from time to time in publications (see particularly Juday, 1940), but no complete study of the temperature régime in Lake Mendota has ever appeared in print. Most of the collection has remained in the original fieldbooks or in partly summarized form among the papers left by Birge in the Department of Zoology.

Birge himself had apparently very early decided that he would write an extended monograph describing all aspects of the thermics of Lake Mendota, including descriptions of the temperature cycles, the heat content, the annual and diurnal heat budgets, the mechanics of heat distribution, etc., and he had apparently planned also to make this part of a still larger comparative study of similar phenomena in a large group of lakes. In a short note published by *Science* in 1913 (describing very briefly the program in which he was engaged at that time of making determinations of the depth of penetration of solar energy into lake water: see below), he remarks in passing: "This work is still in progress and when completed will be incorporated in a general report on the temperatures of Wisconsin lakes." Although no such "general report" has been published, it was nevertheless at least partly written, and it is from several uncompleted manuscripts of it, left by Birge, that we have prepared the following paper.

The first manuscript of this sort was begun apparently in 1899, and took as its point of departure the body of temperature data gathered from Lake Mendota between 1894 and 1899. It contains a careful summary of temperature conditions in the lake, but nothing more than cursory mention of such topics as heat budget or heat distribution; it refers also to temperature measurements made in several other lakes, all in southeastern Wisconsin. The manuscript is roughly typed and heavily annotated by Birge in ink; data for years through 1905 have been added to some of the tables, and a number of means have been recalculated to take these corrections into consideration. Seemingly even by 1905 Birge was unsatisfied with this version; he used it however as the skeleton for a second.

The second manuscript, which is also the most recent we have been able to find, was prepared in 1916, or at least is based only upon data accumulated up to that time; it contains reference to all information available in 1916, including what had been used in the earlier manuscript, and was thus apparently meant to supersede it. It is much longer than the first, with not only a detailed résumé of general temperature conditions but also discussions *in extenso* of many other topics—the heat budgets, the distribution of heat by sun and wind, diurnal changes in heat-content, etc.—in which data from many other lakes, in Wisconsin and elsewhere, are used comparatively. This version had reached essentially finished form: there is a draft apparently prepared by a secretary, with very few amendations by hand, and an incomplete carbon-copy.

We have divided the more recent manuscript into two parts, one including only the temperature observations and a discussion based upon them, making up together a description of the temperature cycle alone. The other part is composed of several chapters of computation and discussion, all relative to the heat budgets or to the vertical distribution of heat, and contains much additional material, data and discussion, for other lakes. Of these two parts, the first is essentially finished, and provides a complete and cohesive dissertation that could scarcely be improved, even by the inclusion of more recent data.* The second is less well organized, and does not contain, furthermore, any data as such that are not in the first section, but simply computations based upon them.

The paper that follows is essentially the first part of the 1916 manuscript. The second section we have considered might remain unpublished. It contains no data of its own, and the significant generalizations and conclusions in it have all found their ways into the literature elsewhere (in Birge, 1904, 1910a, 1910b, 1915 and 1916). It has perhaps a stronger flavor than any of the published works, of Birge's intense preoccupation with the comparative study of heat-budgets that was eventually to prove to be so infertile (cf.

* If there have been systematic changes in the temperature régime of the lake since 1894 or 1916, which might invalidate some of Birge's description as far as conditions at the moment are concerned, his data would nevertheless be of considerable value for comparative purposes because of their completeness. He had studied enough years in detail so as to make it quite clear not only what conditions were in fact found in any one year, but also what kind of variation might be expected in the normal course of events from one year to the next and to what extent ordinary variations in external weather impress variations on the temperature régime of the lake.

Mortimer, 1956), but it does not enlarge in any important way upon the contents of these other papers. The data in the first section, on the other hand, are of considerable interest in themselves. In addition to the water temperatures, certain other data of a sort that was in Birge's time completely unique and that is at the present still relatively rare in limnological literature appear and are discussed in the first section, data, for example, on changes in the thickness of the ice-layer through the winter, on temperature distribution within the ice-layer and on temperature inversions beneath the ice in late winter. It should perhaps be credited to Birge that he became interested in some of these phenomena long before his colleagues.

In preparing this version of the manuscript, we have followed Birge's own wording wherever the draft he left was found to be complete. A few minor changes have been made: in some cases the meanings of sentences have been clarified, and numerical entries and the results of computations have been corrected where these were found to be in error; references to sections of the manuscript not included here have been omitted. All substantial corrections and editorial material have been given in numbered footnotes rather than as unidentified alterations of Birge's text. Many of the figures had already been drawn in final form, and we have simply used these as they were found, after verifying the numerical values; in other cases, we have redrawn figures or prepared missing ones from the original data.

In addition to the exclusion of the second part of the 1916 manuscript, we have made one other substantial change in what appears to have been Birge's plan. A few of the sections of the 1899 manuscript have no counterparts in the later one. These are sections including descriptions of the thermocline, its mode of formation, its changes in dimension and its vertical displacements under the influence of wind, and of the autumnal cooling period and the formation of ice. Apparently some sections containing discussion of the thermocline were written for the 1916 manuscript, but only fragments of them are now extant, and we have been unable to find descriptions of the autumn period or of ice-formation belonging to the later manuscript. It is not clear whether the later sections were never written, or whether parts of them have simply been lost. In order to keep the description of the annual temperature cycle complete, we have used several sections of the 1899 manuscript to fill obvious vacancies in the 1916 version.

The most important difference between any two corresponding sections from the two manuscripts lies in the different quantities of data available to support the generalizations stated in them, the later version having an advantage over the earlier in this respect.

In order to make it quite clear from which of the two manuscripts each section has been taken, we have placed a date, 1899 or 1916, opposite its title.

The original material from which this paper has been prepared, along with all other documents assembled at the same time from among the papers having to do with limnological work and left by Birge in the Department of Zoology, have been collected into the nucleus of a library of data referring chiefly to Lake Mendota. The collection is housed in the library of the Wisconsin State Historical Society at Madison, where it may be consulted. Material now in this collection includes all of the fieldbooks of Birge and his collaborators (containing the entire original assemblage of temperature readings), all drafts of the manuscripts mentioned above, a number of charts and figures belonging to these manuscripts, along with tabular summaries of data in the fieldbooks. There are also several, variously complete or incomplete, hand- or typewritten discussions of a number of topics related to temperature (the thermocline, the work of the wind in distributing heat, the penetration of solar energy into lake-water, etc.) which may have formed either the beginning drafts of later-published papers on these subjects, or were perhaps intended to be chapters in the larger work alluded to. It has been impossible, of course, to give in the following paper all of the original temperature data that might at some time prove of use to those who will continue to carry out investigations in Lake Mendota; they are, however, for the most part in good order and available for consultation, as noted above.

One other manuscript has been placed in the collection along with the material described above. This is entitled "Experiments on Diathermancy of Water" and ought to be mentioned here, if with nothing more than mere antiquarian interest as excuse. As Birge accumulated information on temperature he became almost at once preoccupied with the mechanisms of heat distribution. In 1899, the same year in which the first draft of this temperature paper was written, he requested of Professor B. Snow, of the Department of Physics, that a senior student be assigned the problem of investigating the absorption of solar energy by water. And so it came to pass that in that year the student, F. W. Axley, gathered the first experimental information for Birge on a subject that was to remain his greatest single interest and to occupy him almost literally to his dying day, the penetration of sunlight into lake water. Axley worked only with distilled water, using a thermopile. The matter was again taken up in 1904 when another student, A. G. Worthing, increased the collection of data, using the same instrument, more carefully distilled water and some unfiltered water from Lake Mendota. In 1899, meanwhile, Birge had himself begun studying light penetration in the lake with a vacuum-covered black-bulb thermometer (a technique he learned from Forel, 1895), and in 1900 Chancey Juday made determinations in several other lakes. The manuscript in question, which seems to have been prepared in 1904, summarizes the information collected by these four, a sort of prologue to the long series of papers that appeared later (Birge and Juday, 1929a, 1929b, 1930, 1931, 1932) and ended with one of the last published works of Birge's life (James and Birge, 1938).

But this version was not published, perhaps for the same reasons that caused Birge to withhold all of his papers on thermics. Seen from any vantage-point, the subject of temperature and energy-content in lakes is vast and complicated; Birge, to whom the accumulation of data was the most important of the several facets of scientific activity generally, probably felt that any report was incomplete so long as there was a visible means for improving the available collection of facts.

One is tempted to believe also that there was another reason, that he had in mind an even larger project than any that have been described above. It does not seem at all unlikely, in view of the vast amount of particular information collected from the lakes of northern Wisconsin during later years and never used, that he would at some time have liked to produce a great monograph in regional limnology, a comparative study undertaking to describe in detail all of the fresh waters of Wisconsin. During his last years, even up to within a few days of his death, he kept always before him on his desk in the Biology Building sheets of paper on which he had arranged alphabetically lists of all the lakes of the state, county by county, which he methodically checked and rearranged many times over. A catalog from which one then could strike out work accomplished and so see what remained to be done? But even two lives would not have been time enough.

I LAKE MENDOTA (1916)

The physiography and hydrography of Lake Mendota are fully described in other bulletins issued by this [Wisconsin Geological and Natural History] Survey and the descriptions will not be repeated here. (See Fenneman, 1910, pp. 37–59; Juday, 1914, pp. 11–19.)

The position of the Washburn Observatory, which lies near the shore of the lake, about 200 m. (600 ft.) south of its margin, has been exactly determined. It lies in lat. 43° 4′ 37″ N.; long. 89° 24′ 28″ W. In all general computations, such as those concerning the sun's radiation, the latitude of the lake has been taken as 43°. It is about 259 m. (849 ft.) above the sea.

TABLE I–1

HYDROGRAPHIC DATA FOR LAKE MENDOTA

LAKE MENDOTA

T. 7 and 8 N., R. IX E.

Length . . . . . 9.50 km.	Maximum depth . . . . . 25.6 m.	Shore development 1.47
Breadth . . . . . 7.40 km.	Mean depth . . . . . 12.1 m.	Mean slope of bottom . . . . . 0° 43′
Area . . . . . 39.40 sq. km.	Length of shoreline . . . . . 32.4 km.	Number of soundings 4,500

Depth	Area		Length of Contours	Stratum	Area Between Contours	Volume		Slope	
Meters	Sq. km.	Percent of total	Kilometers	Meters	Sq. km.	Cubic meters	Percent of total	Degrees	Percent
0	39.4	100.0	32.4	0– 3	7.4	106,922,000	22.4	0° 43′	1.2
3	32.0	81.2	28.9	3– 5	3.0	61,004,000	12.8	1° 3′	1.8
5	29.0	73.9	27.5	5–10	5.0	131,987,000	27.6	1° 3′	1.8
10	24.0	61.0	26.8	10–15	7.2	101,165,000	21.1	0° 38′	1.1
15	16.8	42.6	22.8	15–20	10.2	63,843,000	13.3	0° 20′	0.6
20	6.6	16.8	13.5	20–25.6	6.6	13,449,000	2.8	0° 12′	0.3
					Total	478,370,000			

The lake occupies a depression which is an old river valley enlarged and perhaps deepened by the ice of the latest glacial invasion. This depression has been filled in its deepest parts with fine blue clay and superjacent lake deposits to a depth of 30m.–40 m., above which lies the water whose maximum depth is 24 m.–25 m.

The more important hydrographic data are given in the accompanying table (Table I–1).

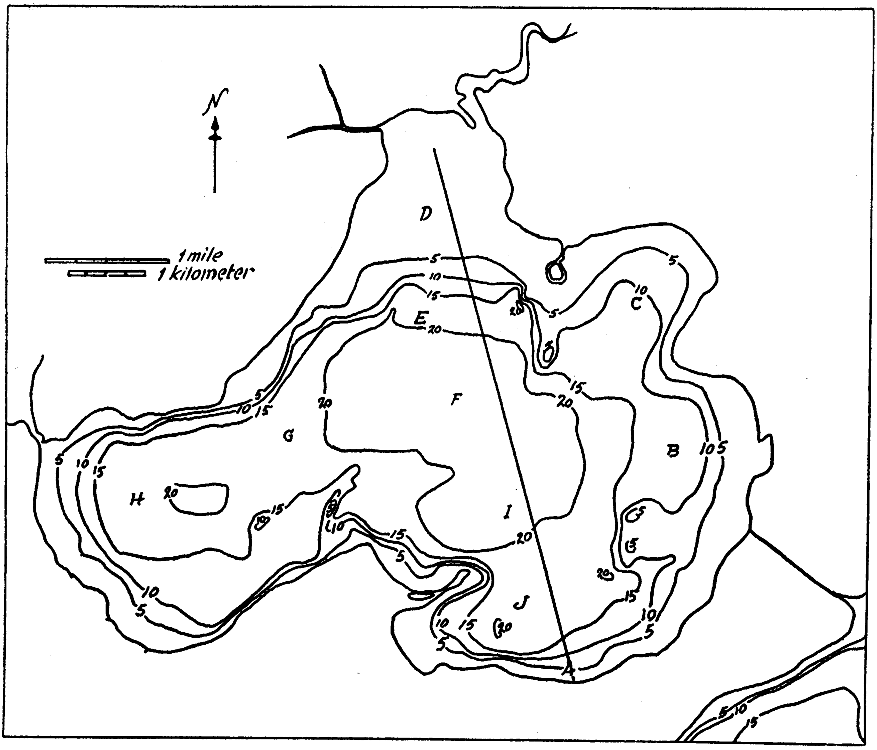

FIGURE 1. Map of Lake Mendota, showing stations and transect on which observations have been made (see text). Depths of contours are in meters.

The regular temperature observations have been taken at two different stations. Those previous to 1899 were in the south basin of the lake at the point marked *J* on the map (Fig. 1). The temperature of the water in the central basin was taken 1–3 times a week in order to keep track of the warming and cooling of the deeper strata. The regular observations of 1899 and later years were made in the central basin at the point marked *I* on the map. In all years when regular observations were made a buoy was anchored in the lake, to which the boat was attached during the observations. The readings of any season were, therefore, made at the same spot.

In all years series of observations were made at different points of the lake for purposes of comparison, and in 1911, 1912, 1913, and 1914 observations were regularly made at 10–12 stations in order to compare the results obtained at station *I* with the mean of those from more numerous stations. These are indicated by letters on the map. Starting with a reading near shore at the boathouse *(A)* the boat went to *B, C,* etc. From *E* it went to *H* and then came back to *G, F, I,* and *J* in order, and so returned to *A* again, when the final reading was made. The effect of this was to give six stations, spaced at about equal intervals, on the N–S axis of the lake, and four on the E–W axis. As the east end of this last line would have ended at Maple Bluff, readings were taken both to the north and to the south of this point near the outer limit of water deep enough to include most or all of the thermocline. In all series the temperature of the shoal water close to the shore was taken on the north and the south side of the lake and in the earlier series the same was done on the northeast bay, near *C* and in the west bay, near *H*. But it soon appeared that these last two readings added little knowledge and they were omitted in order to save the additional distance and time which they required. From four to five hours were usually needed to make the entire circuit.[1]

VARIATIONS IN THE LEVEL OF THE LAKE (1916)

The level of the lake is controlled by a dam which raises the water about 1.2 m. (4 ft.). It is, therefore, possible to lower the lake to that extent below its normal level. This is never done, however, and the level of the lake does not ordinarily vary during the open season more than one-fourth meter on each side of the mean. In computations for temperature no allowance has been made for this variation. The heat budget is stated in calories per sq. cm. of surface, and its amount depends on the computed mean depth of the lake and of its several strata. The mean depth, however, changes very little with ordinary changes of level, since the area increases or decreases in a ratio not dissimilar to that of the depth. For minutely exact results more exact computations would be needed, but the observations at hand do not call for more exact mathematical treatment than they have received.

TRANSPARENCY (1916)

Lake Mendota has in general a low transparency. The turbidity is mainly biological and is due to the amount of plankton suspended in the water. Sometimes, though rarely, violent rains in summer

[1] The "thermophone" was used to measure all temperatures from 1895 onwards. Ed.

cause mechanical turbidity of the water, and more often melted snow causes a similar turbidity in winter.

The transparency has not been regularly read during the ice-period. During all the years of temperature observation the transparency has been observed occasionally with Secchi's disc and during four years it was read at all temperature observations during the open season.

The disc used is of metal enameled in white. It is 10 cm. in diameter. Its readings have been carefully compared with larger discs of 20 cm., 50 cm., and 75 cm. diameter, and its determinations are regularly about 10% smaller than those of the larger discs. This correction has been made in stating the results.

TABLE I–2

TRANSPARENCY OF LAKE MENDOTA DURING THE OPEN SEASON, STATED IN TERMS OF STANDARD SECCHI'S DISC

Month	Transparency			
	Mean	Maximum	Minimum	No. of obs.
April*	2.1 m.	3.5 m.	1.0 m.	29
May	2.3	3.8	1.2	69
June	2.7	4.7	1.4	85
July	2.2	3.3	1.7	102
Aug.	3.1	4.7	1.7	101
Sept.	2.4	3.8	1.8	93
Oct.	2.6	3.9	1.7	81
Nov.	3.1	5.0	2.4	66
Dec.†	3.8	5.3	2.8	21

*April 15–30
†Chiefly in Dec. 1–15

Table I–2 shows the results from these observations. In general the transparency for the warmer season—April–October, inclusive—lies between two and three meters. The maximum observed is 4.7 m., the minimum 1.0 m. The minima come during periods of excessive development of plankton. The lowest reading—1.0 m.—was made on April 20, 1916, at a time when there was an enormous growth of a minute species of the diatom *Stephanodiscus*. In this year there was a period of about a week when the transparency hardly exceeded 1.0 m.

The maxima of transparency—during the warm season—come when large crops of algae, especially diatoms, are settling to the bottom and when, therefore, the surface water is sparsely populated until a new growth comes up. At such periods the transparency regularly exceeds 4 m. Two such periods have been noted in

May during five years, four in June (4 years), none in July (4 years), three in August (4 years), none in September (4 years). The absence of such periods in July is noteworthy, as also is their frequent occurrence in August and their long continuance then, raising the average transparency of that month to the highest of the seven months, April–October.

The rise of the fall growth of diatoms in September usually prevents the appearance of any exceptionally great transparency in that month, and the same may be said of October.

In November and December the algae usually decline in number and the transparency becomes greater. This condition is by no means uniform. In December, 1913, there was an enormous growth of *Anabaena* and similar growths have taken place in other years. In 1916 the average transparency in December was below that in November (3.1 m. and 3.3 m. respectively).

During the ice-period the water usually clears up. The highest transparency noted was 7.5 m. on February 17, 1914. A rapid thaw, however, which carries large quantities of snow water into the lake, may reduce the transparency below 1.0 m. Such water spreads out under the ice as a relatively thin layer of very turbid water and the suspended particles are very slow to settle.

Lakes Monona and Waubesa lie below Lake Mendota and in the same chain. The color of their water is substantially identical with that of Mendota. In both lakes the transparency is apt to be very low in summer, often below 1.0 m., due to enormous growths of blue-green algae. Both lakes, however, are frequently very transparent in the spring, as transparency goes in Wisconsin lakes. Lake Waubesa has shown in May a transparency of 8.8 m. and Lake Monona one of 9.5 in June. These are among the highest transparencies observed in Wisconsin. This condition was due in both cases to great swarms of *Daphnia pulex,* which ate up the plankton algae. Similar phenomena have never[2] been seen in Lake Mendota, in which *D. pulex* occurs, but never in great abundance. The maximum transparency observed in Monona in June is much greater than anything seen in Mendota, even in winter.

II THE CLIMATE OF MADISON (1916)

A fairly complete account of the climate of Madison has been given by Bartlett (1905). This account will not be repeated; only such facts will be noted as are of importance in the heat budget of the lake. All data come from the records of the station of the

[2] In more recent times this same phenomenon has occurred in Lake Mendota, a result of heavy populations of both *D. pulex* and *D. longispina,* particularly the latter. Ed.

TABLE II-1

CLIMATE DATA FOR MADISON, WISCONSIN

Month	Temperature of Air								
	Monthly					Daily			
	Mean	Max.	Year	Min.	Year	Max.	Year	Min.	Year
Jan.	— 8.6	+ 0.8	1880	—17.1	1912	+14.4	1880	—34.0	1887*
Feb.	— 6.4	+ 1.1	1882	—15.8	1875	+17.2	1882	—33.5	1899
Mar.	— 1.0	+ 6.6	1878	— 5.6	1888	30.0	1862	—25.0	1913
April	7.0	12.2	1915	+ 1.4	1857	30.0	1887	—13.5	1886
May	14.2	19.2	1881	9.4	1907	32.2	1874	— 4.5	1857
June	19.1	23.3	1856	16.6	1916	36.6	1870	+ 3.4	1897
July	22.4	26.5	1901	19.3	1891	40.0	1901	8.9	1891*
Aug.	20.9	24.0	1900	17.6	1915	36.6	1916	6.1	1915
Sept.	16.2	19.9	1897	13.0	1873	34.5	1913	— 1.6	1899
Oct.	9.4	15.1	1879	3.2	1869	28.9	1879*	—11.0	1887
Nov.	+ 1.2	6.0	1909	— 2.9	1880	24.5	1915	—25.5	1887
Dec.	— 5.2	+ 3.7	1877	—12.5	1872	16.6	1877	—33.5	1872

*This temperature reached more than once.

TABLE II–1

CLIMATE DATA FOR MADISON, WISCONSIN

Wind										
Mi. per hour	M. per sec.	Prevailing Direction	Percent of cloud 1905–1916	Percent of sun 1905–1915	Max.	Year	Min.	Year	Percent of sun 1911–1915	Transparency of air 1909–16
10.4	4.67	NW	65	42	70	1905	18	1914	38	84.4
11.0	4.95	NW	59	52	68	1905	27	1915	49	84.4
11.4	5.14	S	61	53	80	1910	38	1906	53	83.8
11.6	5.22	S	60	53	61	1913	36	1909	54	78.2
10.3	4.64	SW	60	54	68	1914	35	1915	53	74.4
8.5	3.80	S	52	64	76	1910	51	1915	62	75.9
8.1	3.64	S	55	66	74	1914	51	1915	64	72.1
8.0	3.61	S	49	61	72	1908	43	1913	56	74.2
9.4	4.23	S	51	58	75	1908	44	1915	55	75.8
10.5	4.73	NW	54	52	61	1915	37	1911	51	77.2
11.5	5.17	NW	62	44	64	1904	31	1910	40	82.7
10.9	4.90	NW	63	41	49	1911	31	1915	41	83.6

TABLE II–1

CLIMATE DATA FOR MADISON, WISCONSIN

Precipitation Mean		Monthly Extremes			
In.	Mm.	Max.	Year	Min.	Year
1.56	40	93	1874	2.5	1903
1.47	37	138	1881	6.6	1895
2.21	56	121	1882	1.0	1910
2.38	60	173	1909	T	1877
3.62	92	213	1858	13.0	1897
4.10	104	236	1880	15.0	1895
3.99	103	240	1881	7.4	1909
3.21	82	192	1906	14.0	1894
3.18	81	277	1915	9.7	1891
2.42	62	232	1881	T	1889
1.80	45	153	1879	0.8	1904
1.77	45	144	1884	5.3	1898

United States Weather Bureau at Madison. This is in one of the buildings of the University of Wisconsin, about 200 m. (600 ft.) from the lake, and the instruments are at an elevation of about 40 m. (130 ft.) above the lake.[1]

The data for temperature begin in 1853 but observations were not continuous until 1869. In earlier years they were irregularly gathered in the several months, July and August having the smallest number of years, 53 and 52 respectively; March and April have 60 years, and the rest 56 to 59. The record of precipitation is continuous since 1869, and irregular in earlier years back to 1855. About 55 years are included in the means. The records for wind cover 36–38 years, back from the present time. Those for cloud are based on eye observations every two hours beginning in 1905. The sunshine records begin in October, 1904.

Air Temperatures (1916)

The records are based on observations from 1853–1864 and 1869–1916.

The annual mean temperature of Madison is 7.4°; the maximum was 9.8° in 1878; the minimum, 5.6° in 1885. The mean annual precipitation in rain or melted snow is 789.2 mm. (31.71 in.); the maximum, 1343.9 mm. (52.91 in.) in 1881; the minimum, 342.6 mm. (13.49 in.) in 1895.

The preceding table (Table II–1) shows the data for the several months.

[1] The station of the Weather Bureau has, since this was written, been moved from the campus to Truax Field, the Madison municipal airport, immediately northeast of Lake Mendota. Ed.

Fig. 2 shows the curve of normal air temperature as compared with the temperature of the lake. In constructing this curve the monthly means are platted and connected by a smooth curve. From this curve the normal daily temperatures are taken and these are used as the standard for comparison below. In Fig. 3 the normal curve is compared with the mean temperatures of the years employed in the study of the lake (1895–1915), and also with the mean of the five years, 1911–15, used in the study of the supply of solar energy. The month is divided into four quartiles, as explained

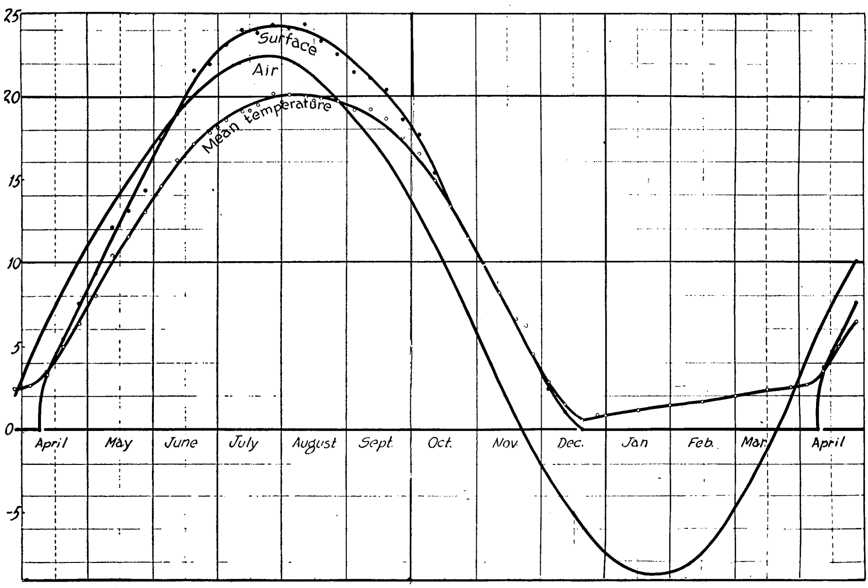

FIGURE 2. Mean and surface water temperatures in Lake Mendota compared with "normal" air temperature (see text).

for the observations on the temperature of the lake, and the mean of the 12–15 quartiles is platted in its proper place. The mean curves, especially that of the longer period, are in fair agreement with the normal, so close that in general the mean lake temperatures are probably substantially normal. At one point of the mean curves, however, there is a notable departure from the normal curve, which is registered in the temperature of the lake. This is in the three weeks beginning July 15, just at the maximum of the normal curve. Here the temperatures are much below normal. The difference comes almost wholly from the years 1911–15, as the diagram shows. This abnormality has had its effect on the temperature of the surface of the lake, as may be seen from Figs. 16, 17, 18, 19 and 20. At the most, the surface temperature of the lake was lowered 0.3°–0.4° and it is doubtful whether any appreciable effect was produced on the general temperature of the water.

The diurnal movement of air temperature is shown in Fig. 4. These curves are platted from the observations during the ten years 1906–1915, a period too short to yield perfectly smooth curves. In

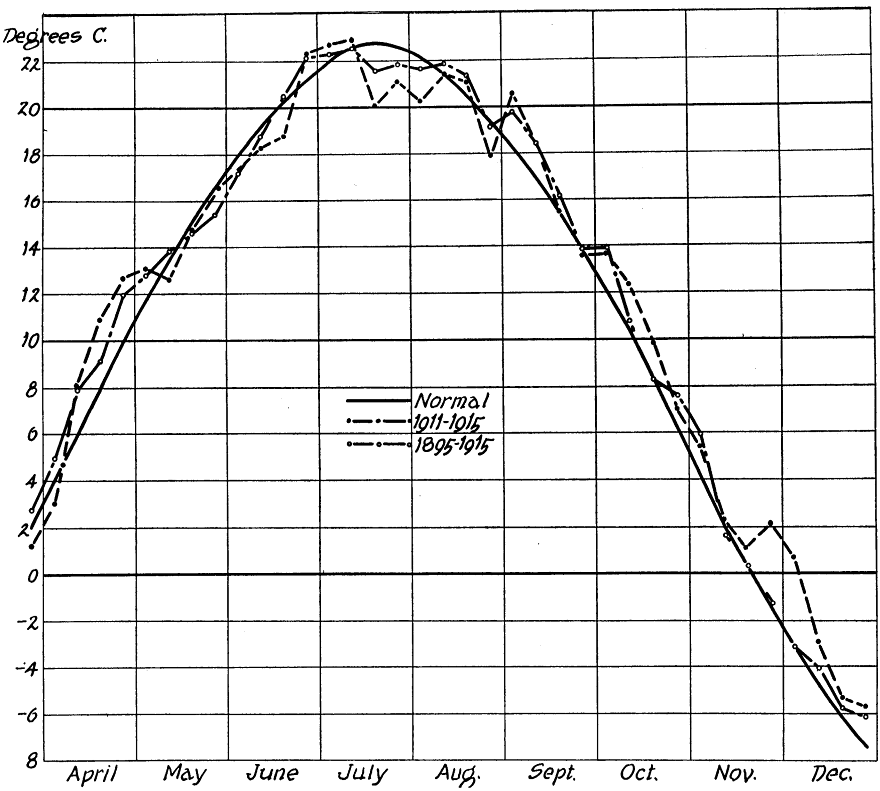

FIGURE 3. "Normal" air temperature at Madison, Wisconsin, compared with mean quarter-month air temperatures for particular periods during which observations or computations have been made.

the data of the curve for April the first seven days of the month are omitted, the record beginning at the mean date on which the lake is freed from ice. The diagrams show the range of daily temperature and the form of the diurnal curve, which is at its minimum about sunrise and reaches its maximum in the third hour after noon.

An interesting relation of water and air is shown by the line indicating the mean temperature of the surface of the lake for

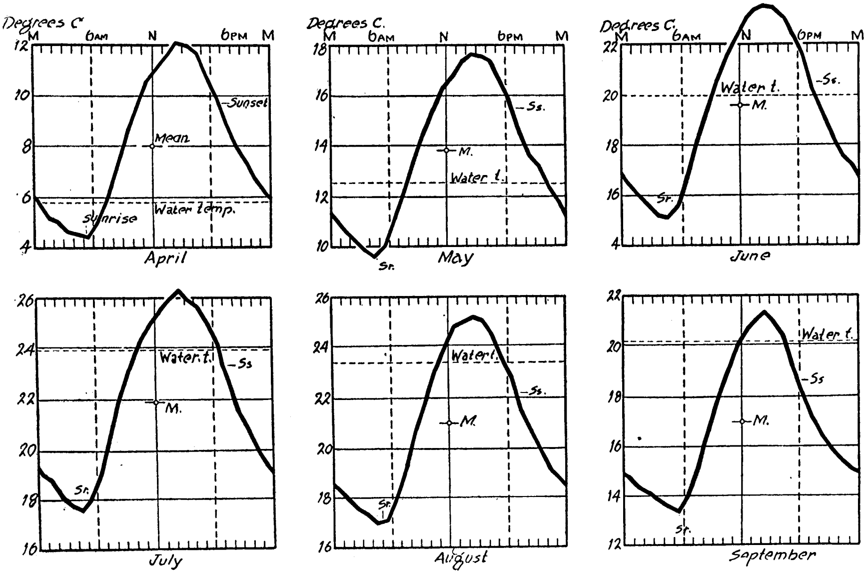

FIGURE 4. Diurnal variation in air temperature at Madison, Wisconsin, by month. Mean monthly air temperatures (-o-) are shown and also mean monthly temperatures of the surface water of the lake (dotted line).

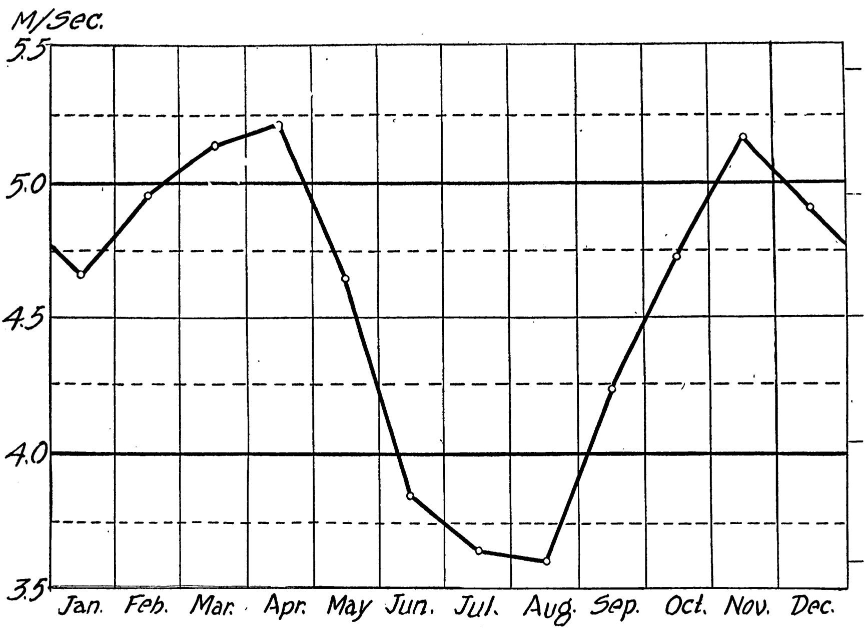

FIGURE 5. Mean wind velocity at Madison, Wisconsin, by month.

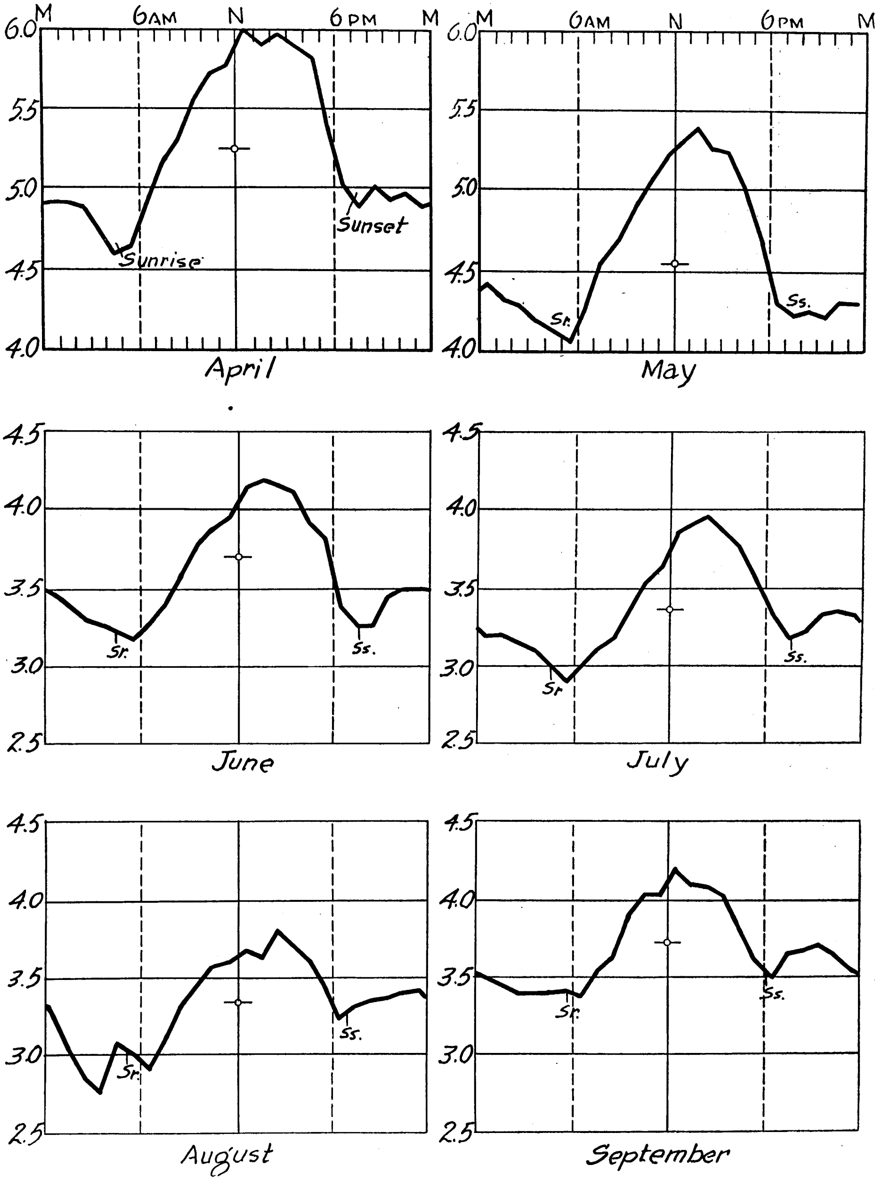

FIGURE 6. Diurnal variation in wind velocity (in meters per second) at Madison, Wisconsin, by month. Mean monthly wind velocity is inciated by the symbol -o-.

each month. In April the temperature of the air is below that of the lake from about 12:30 to 6:30 a.m. and the maximum difference is about 1.2°. The difference is 1.0°, or more, for about 2.5 hours. The mean temperature of the air is 2.2° above that of the lake. It is plain that the mean loss of heat from the lake to the air must be very small under such conditions. In May the air is below the lake from about 10 p.m. to 8 a.m., and the maximum difference is 3.2°. The mean temperature of the air is above that of the lake, though the difference is smaller than in April, being 1.6°. In the last diagram—that for September—the temperature of the air is above that of the water for only about 5 hours, beginning just before noon, and the mean air temperature is 3.2° below that of the water. In October and later the highest point of the daily curve is below the water temperature.

WIND (1916)

The mean velocity and direction of the wind are shown in Table II–1. The results are based on observations for 36–38 years, differing in the several months. The results are shown in Fig. 5. It appears that the warming period of the lake (April–August) is one of rapidly decreasing wind velocity. The wind is at a maximum in April (11.6 mi. per hour; 5.12 m. per sec.) during which time the lake gains heat most rapidly. The velocity falls rapidly through May and June, then declines a little to July, and almost imperceptibly to August (8 mi. per hour; 3.61 m. per sec.) when it is less than 70% as great as in April. During the period April 16–30 the mean velocity, as derived from a smooth curve drawn through the monthly means, is about 5.18 m. per sec., and in the second half of May about 4.45 m. per sec. The influence of such winds on the lake would be as 100:88:74 respectively. During this period, therefore, the influence of the wind in warming the lake is at a maximum, the thermal resistance to mixture of the water is low, and the gains of heat by the lake are correspondingly large, both absolutely and in relation to the heat supply and to gains later in the season.[2]

If the influence of the wind in mixing the water of the lake is proportional to the square of its velocity, the effect in April is more than twice as great in July and August. The relations would be as follows:

April	100	July	48	October	82
May	78	August	48	November	98
June	53	September	65	December	88

[2] Birge's marginal notation opposite this statement ("No") suggests that he was not certain about the quantitative relations given between wind-velocity and rate of mixing. According to unpublished information kindly supplied by Professor Reid A. Bryson of the Department of Meteorology, University of Wisconsin, wind-stress is approximately proportional to the square of velocity at velocities above about 10 mi. per hour. Ed.

The decreased viscosity of the water, as it warms, would partly compensate for this reduction in efficiency due to increased velocity.

The diurnal movement of the wind for the months April–September, as derived from a ten-year mean, is shown in Fig. 6. These diagrams show that the minimum velocity is near sunrise, that the maximum comes about 2 or 3 p.m. and that from this point there is a rapid decline to about sunset, followed by a small recovery and a further decline to sunrise. This relation of the wind is not without influence on the distribution of heat. The maximum velocity of the wind coincides, in general, with the maximum delivery of heat, and this relation tends to neutralize the mixing effect of the wind. At night when the surface of the lake is cooling and when, therefore, wind mixture of the water could most readily be effected, the velocity of the wind is least. In May, for example, the hourly influence of the wind at night would be only about 55% of its effect in the middle of the day.[2]

The diurnal movement of the air also affects the time of maximum temperature of the lake's surface. In a general way, the daily maximum of sun and wind come together, and, therefore, evaporation, cooling, and mixing are at a maximum and are tending to keep down the temperature of the surface when the sun is hottest. As the afternoon passes the wind falls rapidly and the declining heat of the sun is kept in the surface strata of the water. This undoubtedly brings the maximum surface temperature later in the day than that of the air. Continuous records extending over a considerable time would be needed to establish the relation quantitatively and such records have never been made.

It would be interesting to attempt to correlate the distribution of heat through the lake in any year with the wind. But such attempts do not lead to any definite results. The details of the distribution of heat depend not so much on the mean amount of wind as on the violence, duration, and direction of specific storms. Not only so, but the temperature condition of the lake at the time of high wind is an important factor in the result, as is also the temperature of the air. A violent, hot, south wind following a period of bright, calm weather may have very little effect on the general temperature of the water. A north wind, with cool, bright weather, may distribute a great amount of heat to deep water. If the curves of air and water are followed in Figs. 9 to 12, it will be seen that, in general, a fall of temperature of air in April or May does not cause a fall in the temperature of the water, although that of the surface declines. On the contrary, the curve of gain of temperature may rise, unchecked by the depression in the air. This is because the cool waves of spring are usually accompanied by fresh north wind and bright sun and the gains by the rapid distribution of heat by the wind often exceed the losses due to low temperature. Indeed, the total gains of heat by the water during such a period may easily exceed those of a warm calm period.

Sunshine and Clouds (1916)

The amount of sunshine and cloud have been determined in two ways: first, by eye observations of the percent of cloudiness of the sky, taken at two-hour intervals during the day; second, by the amount of sunshine as registered by the Marvin recorder.[3] These two methods do not agree. The mean percent of cloudiness is always greater than 100 minus the percent of sunshine, as is shown by Table II–1.

There are two chief reasons for this relation: first, in case of a sky partly covered by scattered clouds the area near the horizon appears more completely covered than is the fact, and thus the percent of cloud is rated too high. A sky of this sort with an average of 50% cloud would give much more than 50% of sunshine during the middle hours of the day. Second, the Marvin recorder registers sunshine not only when the sky is clear, but also when the haze or clouds are thin enough to allow the sun to cast a distinct shadow. Thus a day in which the eye reports that the sky is entirely overcast may record much sunshine by the Marvin instrument.

The mean annual cloudiness, as determined by the eye, is 57%; the mean sunshine by the recorder is 53%, indicating a mean cloudiness of 47% by this method. In this matter the Marvin recorder gives the more accurate information, so far as its bearing on receipts of solar radiation is concerned. It will not do at all to assume that clouds cut off 57% of the sunshine. Such results are quite too low. On the other hand there is a close correspondence between the results of the Marvin recorder and those of the Callendar[4] recorder. The Marvin instrument gives nearly 25% more sunshine than would be inferred from the eye estimates. The discrepancy is still greater if the middle hours of the day are considered, in which most of the sunshine is received. Bartlett (1905, p. 3) gives the cloudiness at 2 p.m. as 58% as the result of observations for 26 years. The 10-year mean for 2 p.m. by the Marvin instrument is 72% of sun or 28% of cloud, or less than one-half of the eye estimates. The years in the two means are not the same but each series is long enough to give a fair average result.

If the amount of cloud determined by eye is compared with the quantity of heat received from the sun on the same day, there will

[3] Formerly a standard instrument used by the United States Weather Bureau; it is essentially a double air-thermometer. For description, see Middleton, 1941. Ed.

[4] See: Kimball, H. H., Monthly Weather Review. 42(8):474–487. United States Department of Agriculture, Weather Bureau. U. S. Gov. Printing Office. August, 1914. Ed.

very frequently be found a marked absence of correlation. It is plain that no trustworthy estimate of quantity of heat received from the sun can be made by estimating the amount delivered by the sun from a clear sky, deducting the percentage corresponding to the cloudiness, and adding, for the diffuse energy of cloudy periods, say 40% of the direct energy for the same time.

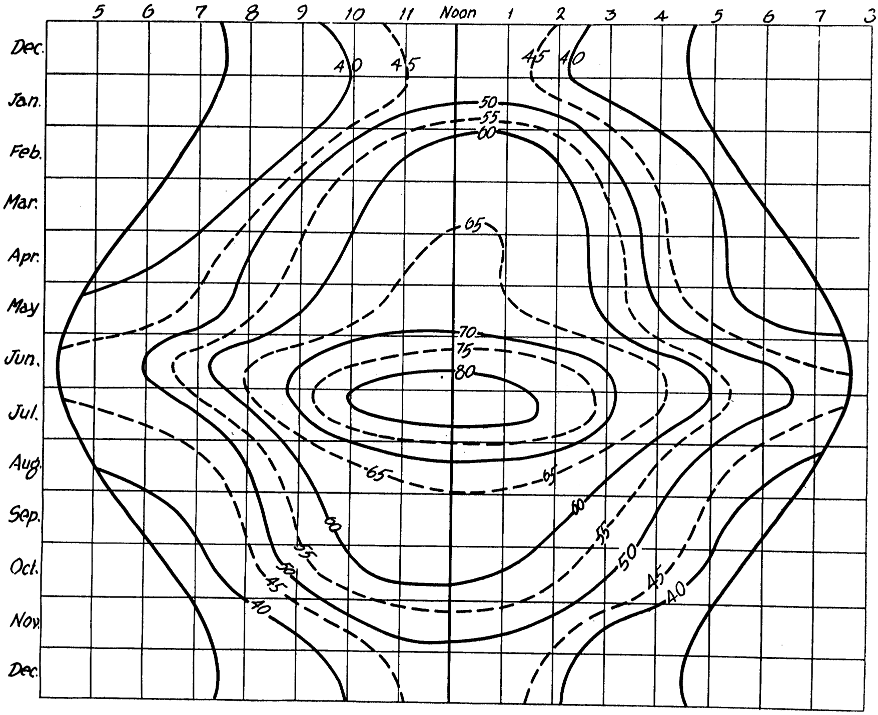

FIGURE 7. Percentage of potential sunshine at Madison, Wisconsin, by hour and month (see text).

The percentage of sunshine derived from a ten-year mean is shown in Fig. 7. The time is too short to permit very accurate curves. The mean sunshine for each hour of each month is platted at the center of the allotted space and the contours are drawn as well as possible. The curves for 35% might have been inserted in the corners of the diagram but the Marvin recorder is not reliable close to sunrise and sunset and it was not worth while to follow the matter so far.

One of the striking facts in the chart is the rapid rise of the percentage of sun at noon from about 48% in December to 60% shortly after February 1. Then follows a very slow rise, reaching

65% about April 25[5] and 70% just before June 1. Then follows a rapid rise to 80% about the solstice and this condition continues for a month. The central hours of the day, therefore, in April and May have about the same percentage of sun. This fact finds expression in the relatively small increase of the receipts of solar radiation in May as compared with April, and also in the renewed and rapid rise of solar radiation in June (see Table II–2). It is necessary here only to call attention to the fact that the percent of sunshine is greatest at those hours of the day when the quantity of radiation is greatest; also that the percent of sunshine is greatest in those months when the sun's altitude is highest. Both facts tend to accentuate the difference between the amount of solar radiation delivered in mid-summer and that received earlier or later. Taken in connection with the monthly and the diurnal variation in wind they help to account for the rapid decrease in the percent of the solar radiation absorbed by the lake as the season passes on from April to mid-summer.

TABLE II–2

SOLAR RADIATION RECEIVED AT THE LAKE SURFACE, IN CALORIES PER SQUARE CENTIMETER PER DAY

April	i	372	June	i	512
	ii	414		ii	537
	iii	442		iii	549
	iv	449		iv	551
May	i	446	July	i	551
	ii	460		ii	541
	iii	447		iii	510
	iv	472		iv	481

TRANSPARENCY OF THE AIR[6] (1916)

The numbers in this column (See Table II–1) give the transparency of the air or its coefficient of transmission. They show the mean percent of the radiation from the sun in the zenith which would reach the earth in the absence of cloud. The difference between the several numbers and 100 equals the percent of loss suffered by the sun's radiations in passing through the air under the same conditions. It is equal to the amount of radiation cut off by the air, by invisible water vapor and by dust or other similar suspended particles.

The months of the year fall into two sharply marked sets, those with high and those with low coefficient of transmission. The first

[5] Apparently March 25 is meant here. Ed.

[6] A handwritten addition to the manuscript, perhaps therefore in less finished form than other sections. Ed.

includes the period November–March, inclusive, in which the mean transmission is above .825 and below .850. These are the months when the ground is wet or covered with snow, so that dust is at a minimum and also months of low temperature, so that there is only a small quantity of water vapor in the air. The conditions in the period May–September, inclusive, are the reverse as to dust and water vapor and the transmission is much lower, above .720 and below .760. April and October are in some sense intermediate in this respect but much nearer to the months with low transmission.

This difference in transparency is reflected in the quantity of solar radiation delivered to the surface of the lake during these two periods. The mean elevation of the sun may be determined for each hour of the day in each month, and also the mean number of calories delivered during the same hour when the sun shines as indicated by the Marvin recorder. If the transparency of the air were equal throughout the year the number of calories received by the lake during each sunshine hour would be a function of the sun's altitude. In fact, however, if a diagram is constructed in which the mean number of calories received in each sunshine hour of each month is plotted against the mean altitude of the sun in the same hours, the results will arrange themselves into two curves. The amount of radiation received per hour from November 1 to April 1 is always higher than that received at an equal altitude of the sun during the summer months. The results for April and October fall in general between the two curves. The relation between the altitude of the sun and the number of calories delivered is surprisingly close, when one considers the rather crude principle on which the Marvin recorder operates in recording sunshine.

III THE ANNUAL TEMPERATURE CYCLE

"Average" Temperature of the Lake (1899)

Two meanings may be given to the expression "average temperature". The phrase may mean, first, the average temperature of a column of water in the deepest part of the lake; or, second, it may mean the temperature which the water of the lake would assume if it were thoroughly mingled. Where the lake is nearly or quite homothermous, there is little or no difference between the averages obtained in these two ways, and during late fall, winter and early spring they may be considered as practically identical. When, however, the surface layers become warm so that they have a temperature decidedly higher than that of the subjacent water, the difference between the two expressions increases and may become very considerable. If the sides of the lake were vertical the two averages would still remain the same, but since the upper strata of water are much greater in volume as well as higher in temperature than those below, the two expressions may become quite different. For example, in the second week of July, 1897, the average temperature of the column of water was 17.43°, while the average temperature obtained by mingling the water of the lake, taking the average temperature by five-meter layers, was 19.97°, a difference of 2.54°. In the second week of August, the results were 17.88° and 20.30°, a difference of 2.42°. In 1898, the temperature for the fourth week in July was 17.63° and 20.09° and for the first week in September, 17.82° and 20.35° respectively. These were the maximum differences for the two years.

In general, by "average temperature" in what follows is meant the average temperature of a column of water at the deepest part of the lake. This is a much more significant figure for general use than the other, since the average temperature reached by mingling the water will vary greatly in different lakes with the amount of shoal water surrounding the deeper portions of the lake. Still further, this result can be obtained only in lakes of which a careful hydrographic survey has been made, so that the cubic contents of the different strata can be determined with reasonable accuracy, while the temperature of the column of water can be readily determined without such survey.

SPRING (1916)

With the departure of the ice the water is exposed directly to the full influence of the sun's rays. The temperature is below that of maximum density and the incident heat is easily and rapidly distributed through the whole depth of the lake, and since distribution of heat is rapid, little is used in evaporation. The same may be said of losses to the air, since the mean temperature of the air is above that of the water. The lake, therefore, warms rapidly up to the temperature of 4.0°. This requires an average gain of about 1.4°, or more than 1700 cal. per sq. cm. of surface. The records of 15 seasons (See Table III–1) show that 10.7 days after the opening are needed to secure this amount of heat. In these 15 years the mean date of opening was April 5, so that the lake reached the temperature of 4.0° on April 15. In the computations of gains of heat, etc., it has been assumed that the average date for the temperature of 4.0° is the middle of April and that the gains of heat which constitute the summer heat-income begin at that time.

In 1899 the water on April 19, one day after the departure of the ice, was at 4.1°, so that it must practically have reached 4.0° on the preceding day. In that year, however, the bays and much of the shallow water were free from ice for some 5 days before the opening and doubtless absorbed much heat. In 1911 the lake opened

TABLE III–1

LAKE MENDOTA: SPRING TEMPERATURES, ETC.

Year	Date of Opening of Lake	Date When 4° was Reached	Number of Days	Temp. of Water at Opening	Rise Needed to Reach 4°	Calories per Sq. Cm. of Surface	Daily Gain in Calories
1897	Apr. 10	Apr. 21	11	2.4	1.6	1936	176
1898	Mar. 27	Apr. 8	12	2.8	1.2	1450	121
1899	Apr. 18	Apr. 18	...	4.0	...	...	...
1901	Apr. 11	Apr. 18	7	2.3	1.7	2060	294
1906	Apr. 8	Apr. 20	12	2.3	1.7	2060	171
1907	Mar. 24	Apr. 10	17	2.9	1.1	1330	78
1909	Apr. 7	Apr. 18	11	2.4	1.6	1940	176
1910	Mar. 26	Mar. 31	5	2.4	1.6	1940	387
1911	Mar. 20	Apr. 13	24	2.8	1.2	1450	61
1912	Apr. 13	Apr. 21	8	2.0	2.0	2420	302
1913	Apr. 2	Apr. 16	14	2.5	1.5	1820	130
1914	Apr. 10	Apr. 18	8	2.4	1.6	1940	242
1915	Apr. 9	Apr. 16	7	2.7	1.3	1570	225
1916	Apr. 8	Apr. 15	7	2.7	1.3	1570	225
1917	Apr. 10	Apr. 20	10	2.3	1.7	2060	206
Mean	Apr. 5	Apr. 15	10.2	2.59	1.41	1700	

March 20 and the water reached 4.0° on April 13, or after 24 days. The temperature of the water rose from 2.8° at opening to 3.4° on March 25; remained about stationary for a week of cloudy, fairly warm weather, then fell to 2.8° on April 7, under the influence of cold and stormy weather, and then rose again. This is the only year in which such marked alternations occurred, but in 1907 there were 17 days (March 24–April 10) between opening and reaching 4.0°. In 1910 the lake opened March 26 and reached 4.0° on March 31, a gain of 1.4° in 5 days, or at the rate of 387 cal. per day, the most rapid gain on record.

The slowest average gain was 61 cal. per day for 24 days, omitting 1899 when the lake had reached 4.0° before opening. The mean gain was about 170 cal. per day, if each day's gain is given equal weight. If equal weight is given to each year, the mean daily gain is 186 cal. It will be seen later that these gains are smaller than those of the lake in the second half of April. There is one obvious reason for this. The ice of the lake is apt to break up during a warm period and some of the days following the opening are, therefore, pretty sure to lie in colder and stormy weather, such as is likely to follow a warm period in March or early April.

The Open Season (1916)

The mean length of the open season of Lake Mendota is 255 days, from April 7 to December 18. The story of the temperature changes during this period is found in the various tables and diagrams. The central facts are shown in the diagram Fig. 2. In this diagram the mean temperature of the water at the freezing and the opening of the lake is platted at the mean dates on which the ice forms and disappears. For the open season the mean temperature of each quarter month is platted in its proper place and a smooth curve is drawn through the points thus determined. The curve, representing the mean temperature of the water, starts at about 0.6° at the time of freezing, rises slowly and regularly, reaching 2.0° about March 15. During the rest of the ice period it rises more rapidly, reaching 2.6° at the date of opening. The curve crosses the line of 4.0° about April 16, and returns to the same temperature about December 1. It reaches a maximum of 19.77° about August 8, and the rise and fall are almost exactly symmetrical curves about an axis drawn through this date. At no point does the curve in rising or falling depart more than a day or two from the corresponding date on the other side. The exactness of this correspondence is due no doubt in part to the relations of area and depth of the lake to its temperature. In a smaller lake the maximum would come earlier in the season, and in a larger and deeper one the maximum might

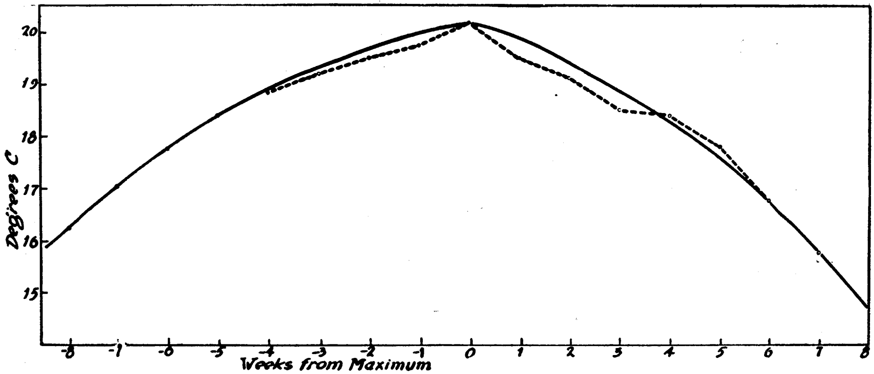

FIGURE 8. Comparison of the approach to the maximum mean lake temperature by curves of a) quarter-month mean temperatures (solid line) and b) mean temperatures at uniform intervals from the day of maximum mean temperature regardless of the date on which this is reached (dotted line).

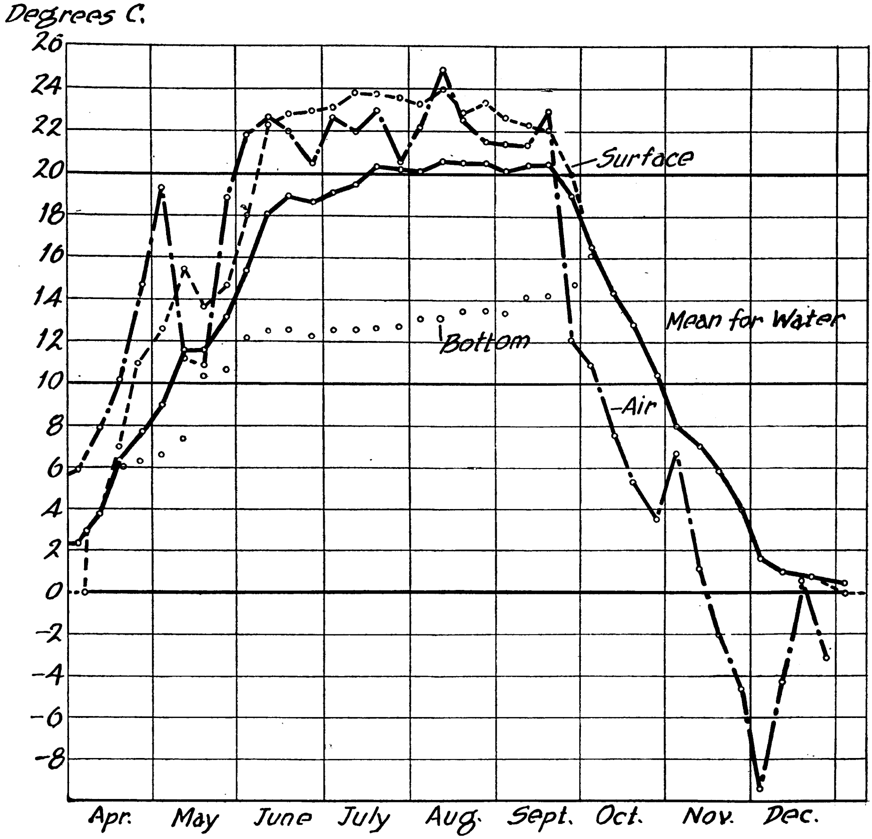

FIGURE 9. Temperatures in Lake Mendota during the open season of 1895 (April 8 to January 5, 1896).

come a month later. In either case the symmetry of the curve would not be so marked.

The mean maximum temperature of the water is 19.77° as derived from the averages of the quarter months. This, however, is not the mean of the annual maxima, since these come at various dates, ranging from July 3 to September 1. The mean of these maxima is 20.15° and the mean date for this maximum is about August 16, say, the middle of August. A curve may be platted, starting from this maximum and showing on one side the average approach to the maximum by weekly intervals and on the other the decline. Fig. 8 shows the resulting curve. It is by no means so symmetrical as the mean curve, since the rise of temperature is slower than the decline. During the two months preceding the maximum the total rise is 3.90°, and two months after the maximum the temperature has fallen 5.35°. This result would be expected, since the date of the maximum is nearly two months after the solstice.

A smooth curve may be drawn through the points thus established, but although such a curve fits fairly well at the ends of the series it lies above all the points near the maximum, if it passes through the latter point. This indicates that, in general, the maximum is reached by a short, rapid gain of heat—a spurt following a period of slow gain and itself followed by a period of even more rapid loss of heat. In other words, the annual maximum ordinarily comes at a time when a warm wave allows the temperature of the epilimnion to come to its highest point.

It is to be noted that the curve as thus platted does not show the relatively flat top which the mean temperature curve displays. The latter curve is above the temperature of 19° and below 20° for nearly two months; the former curve crosses the line of 19° 3.5 weeks before the maximum, and recrosses it a little more than two weeks after the maximum.

Examination of Figs. 9 to 22 will show the great difference displayed by the different years in the rise and fall of temperature. The most noteworthy of the individual peculiarities are indicated in the appearance of the figures themselves and need not be repeated here. Fig. 23 shows the departure of each quarter month period from the mean of that period. Each year has its own symbol but in certain cases the departure was identical and space for all symbols could not be found in the diagram. Yet it will be possible for any one who is curious in such matters to follow the course of the several years through the diagram. This is not the purpose of the figure, whose lesson comes from its general aspect and not from its details. In the last week of March the average departure of temperature is less than 1.0° on each side of the mean and the total range of variation hardly exceeds 2.5°. The departures rapidly increase during April and May, covering in May a maximum range of over 6.5°. This fact is due to the great variations in the rate of warming of the lake in the several seasons, caused by difference in occurrence, length, and vigor of the several warm and cold periods of the weather. The departures decrease and during the month of

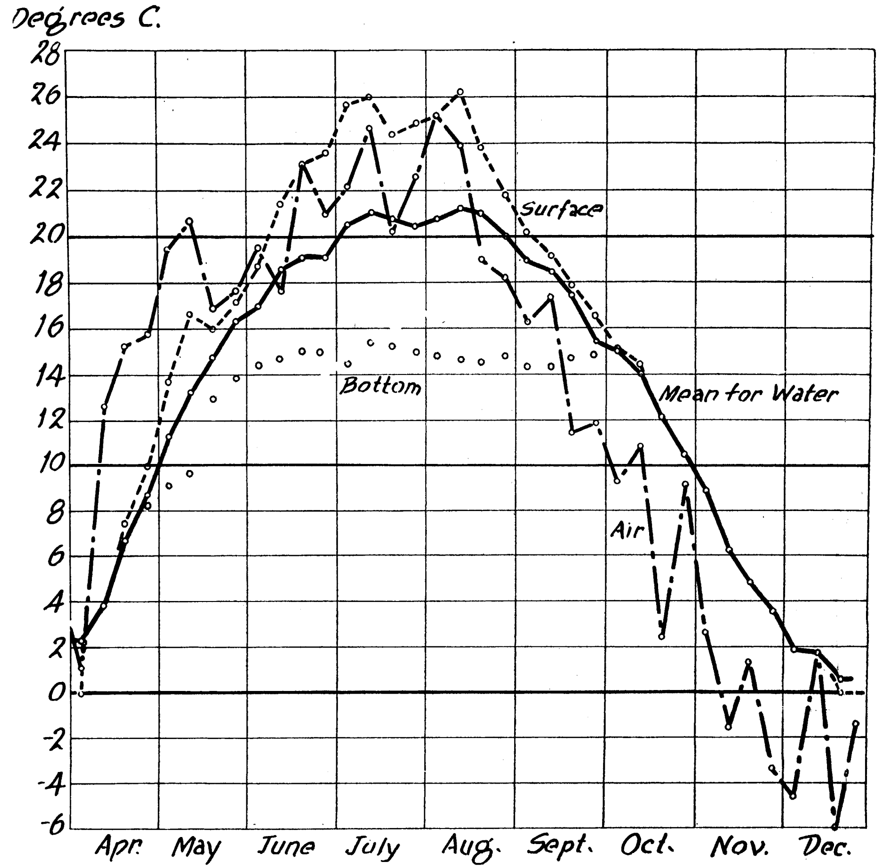

FIGURE 10. Temperatures in Lake Mendota during the open season of 1896 (April 5 to December 24).

August they lie mostly within the distance of 1.0° on each side of the mean. It is this fact which makes it possible to determine the approximate heat budget of a lake from temperatures taken in August. This uniformity depends, on the one hand, on the great supply of solar heat during July, as compared with the amount absorbed by the lake. On the other hand, it depends on the balance between daily receipts and losses of heat during August. Either or

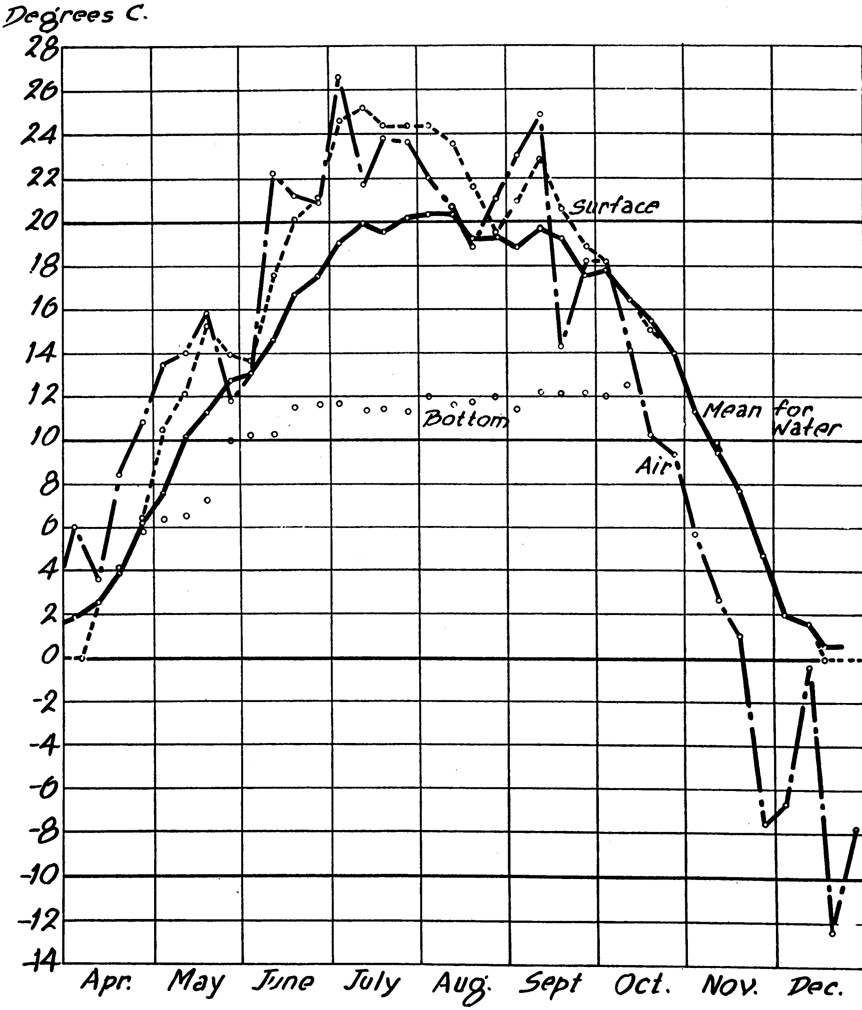

FIGURE 11. Temperatures in Lake Mendota during the open season of 1897 (April 10 to December 17).

both of these fundamental conditions may be seriously affected by exceptional weather, but the average condition recurs with surprising regularity, as the diagram shows.

After the decline of temperature has fairly set in during September the rate of decline varies in different years, and with this

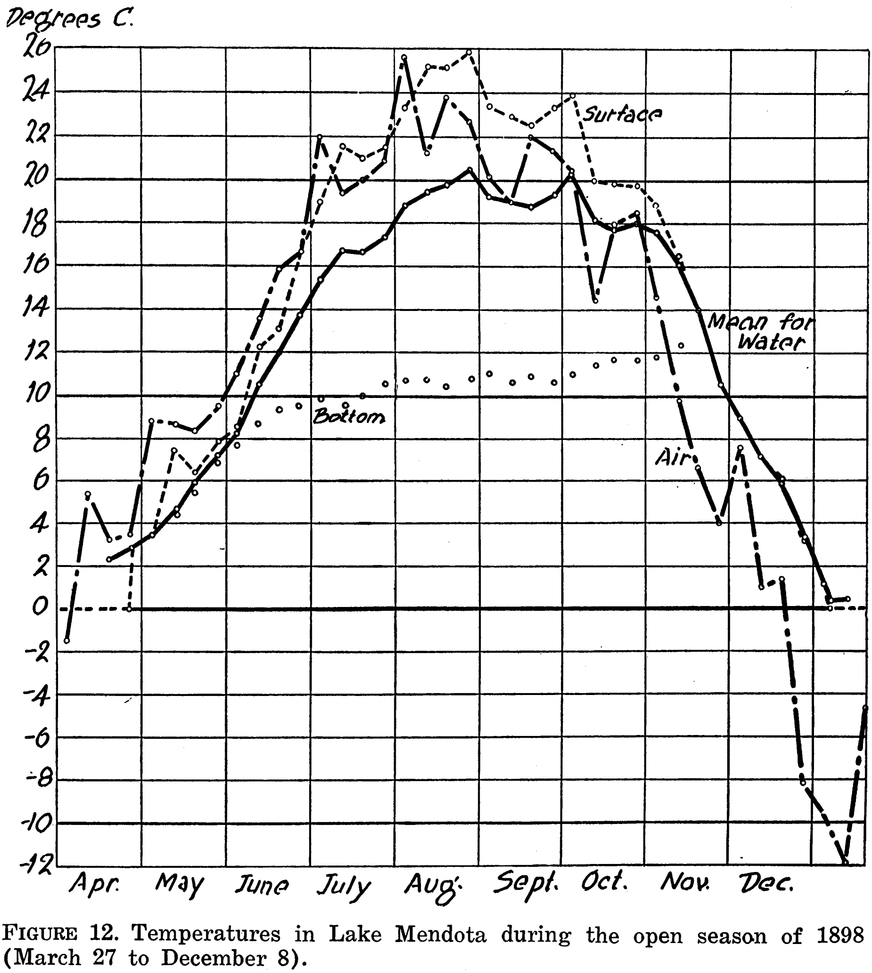

FIGURE 12. Temperatures in Lake Mendota during the open season of 1898 (March 27 to December 8).

variation the departures from the mean increase, reaching a maximum in late October or early November. The range in autumn is not so great as in spring, the range of variation being below 6.0°. As the late fall comes on and the lake approaches winter conditions, the departures from the mean become smaller until in December they hardly exceed those of March or August.

Thus the water of the lake starts in the spring with temperatures closely similar in different years; it warms irregularly and at very different rates; but has reached in August of all years temperatures which are very much alike. From this uniformity the temperature falls irregularly during autumn but in December of all years has come back to very similar heat conditions.

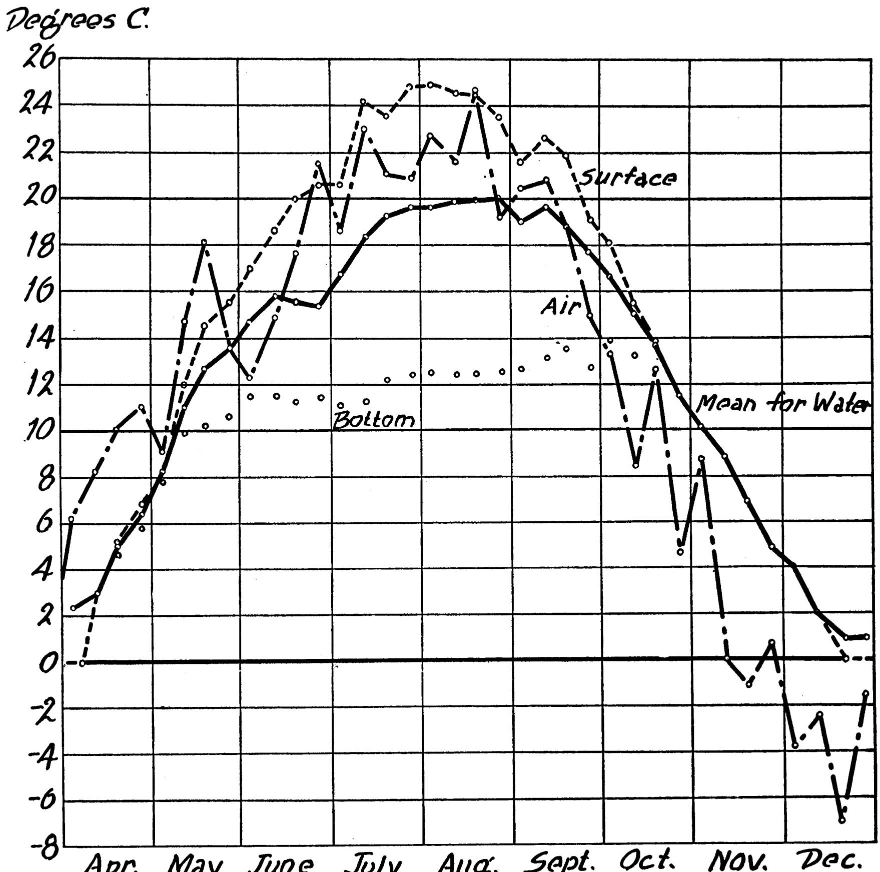

FIGURE 13. Temperatures in Lake Mendota during the open season of 1906 (April 8 to December 20).

SURFACE TEMPERATURES (1916)

The general course of surface temperature is shown in Fig. 2. This is, of course, zero during the ice period of 110 days. It rises practically instantly to that of the mean temperature of the water as the wind blows the ice away and the waves crumble it into loose crystals. Then follows a rapid and almost uniform rise during April, May, and the first half of June, until the temperature of 20.0° has been reached. During this time the mean temperature of the air is above that of the surface. The difference between air and surface is constantly becoming smaller and consequently the

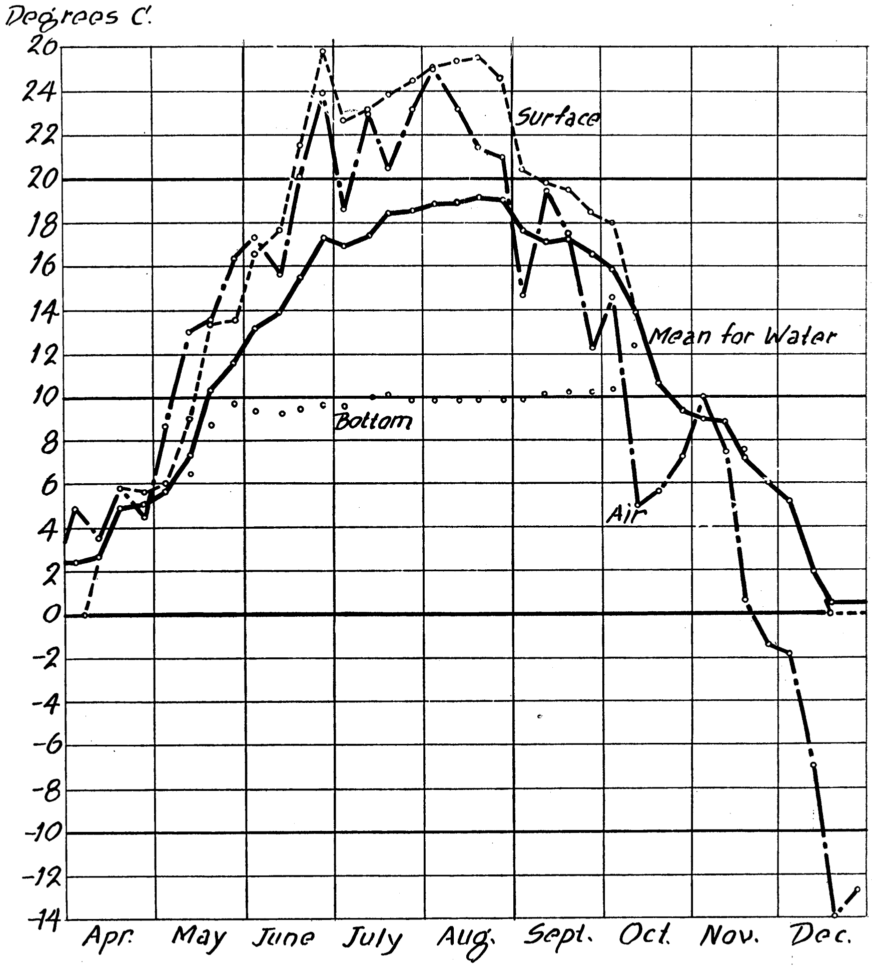

FIGURE 14. Temperatures in Lake Mendota during the open season of 1909 (April 7 to December 18).

nocturnal losses to the air are growing; but the supply of heat from the sun is also increasing and no noteworthy slowing of gains is found until the mean temperature of the surface rises above that of the air. This crossing of the temperature curves for air and surface comes just before the middle of June and almost immediately thereafter the rate of increase of temperature slows down. The mean weekly maximum of 24.3° is reached not far from July 23, about a week after the air maximum. This is, at least, the indication of the curves. The actual means of the surface at this place show irregularities, due to the exceptional weather conditions of the years during which the lake was studied (see Part I).

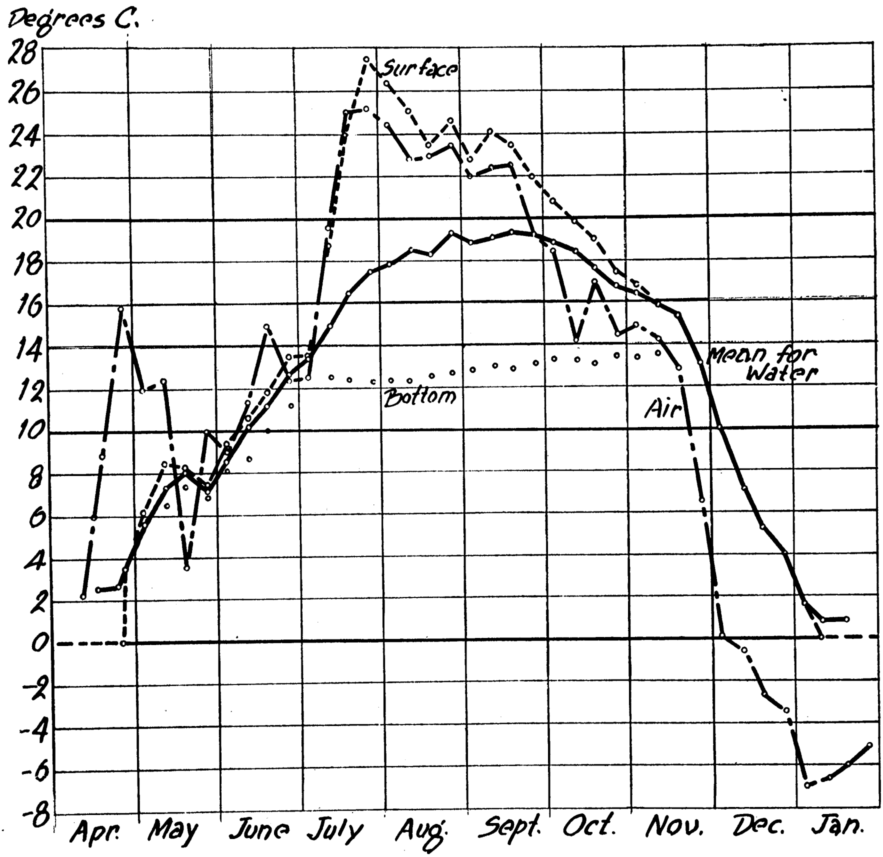

FIGURE 15. Temperatures in Lake Mendota during the open season of 1910 (March 26 to December 9).

The temperature then falls, at first slowly, declining about 2.0° during August; then more rapidly, losing some 4.0° during September. About 3.0° are lost in the next two weeks, and about the middle of October the water becomes homothermous throughout its depth. In periods of cooling during autumn the surface must be colder than the subjacent water; on calm, bright days it is warmer. But the differences are very small in general and they tend to neutralize each other in the mean. Resulting differences are quite too small to show on the diagram.

In general, therefore, Lake Mendota has an autumnal period of full circulation of the water, extending from Oct. 15 to Dec. 1, when the temperature passes 4.0° and the period of inverse stratification begins. The inverse stratification, however, is little more

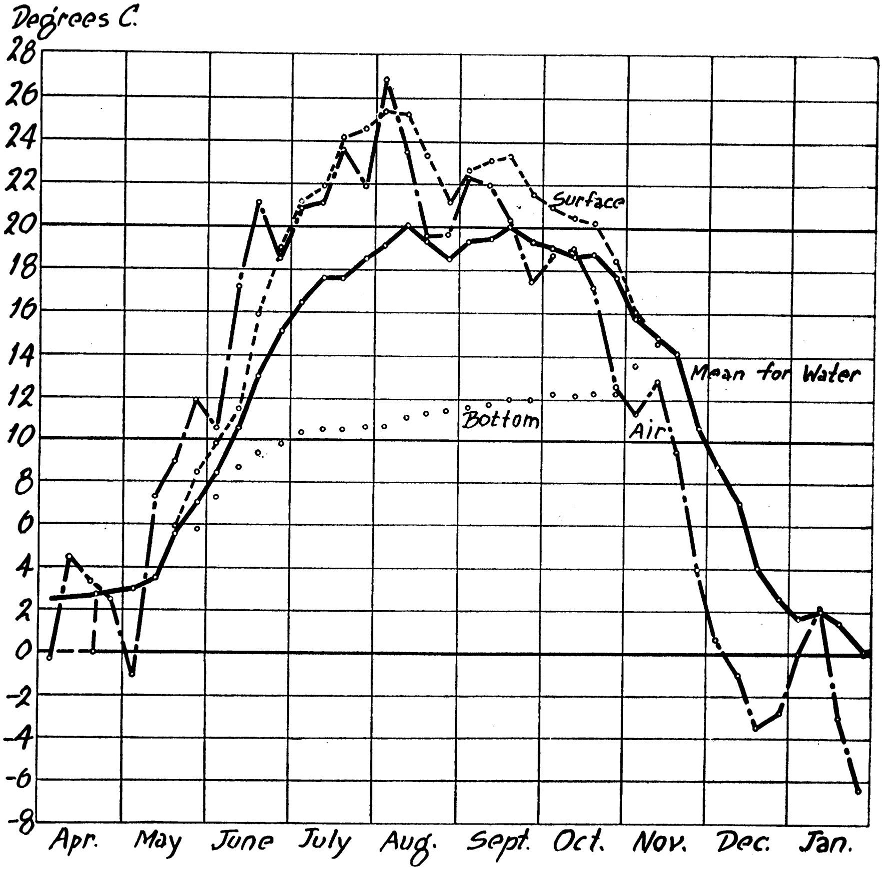

FIGURE 16. Temperatures in Lake Mendota during the open season of 1911 (March 20 to December 28).

than nominal in Lake Mendota until the lake is frozen. The depth of the water is not great, the difference in density of the cooling water is small, and the winds are high. There is consequently little evidence of inverse stratification until the mean temperature of the water declines to nearly 1.0°. The lake cools irregularly and inverse stratification may appear during a warm period but the next cold day with high wind obliterates it.

It is worthwhile to note the relation of the mean temperature of the air to that of the surface, as shown in Fig. 2. Air and surface mount together during April and May, gradually approaching each other and finally crossing near the middle of June. Both continue to rise, the air more slowly, so that at the maximum it is about 1.5° below the surface. This difference increases to 2.0° early

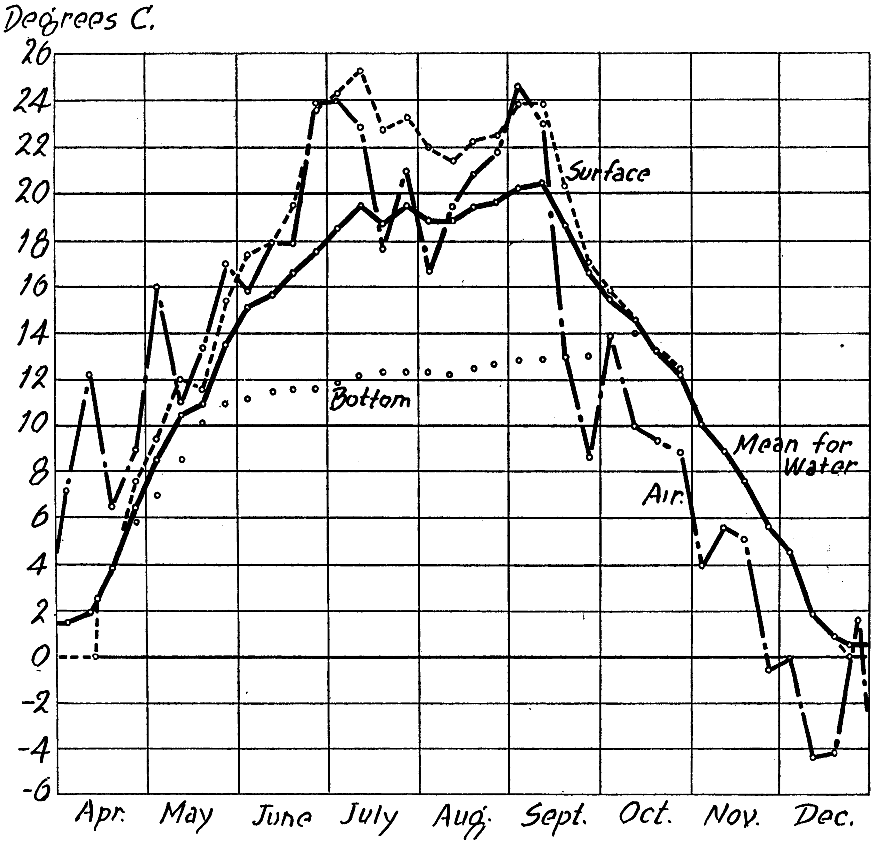

FIGURE 17. Temperatures in Lake Mendota during the open season of 1912 (April 13 to December 24).

in August; to 3.5° by the first of September; it is about 5.0° the first of October, nearly 6.0° the first of November, and about 6.25° by December 1. Thus there is a progressive widening of the difference between lake and air, growing rapidly at first, then more slowly, and remaining nearly stationary after the difference has risen to 6.0°.

Thus, in spite of the declining amount of solar radiation which the lake receives as the autumn advances, the temperature of the lake does not fall so rapidly as that of the air, and the losses of the lake in heat do not increase as the difference between air and surface widens. The chief cause for this fact doubtless lies in the decreasing use of heat in evaporating water as the temperature of lake and air fall. The losses of the lake to the air must rise as the difference in temperature increases, but the total losses of the lake do not increase proportionally.

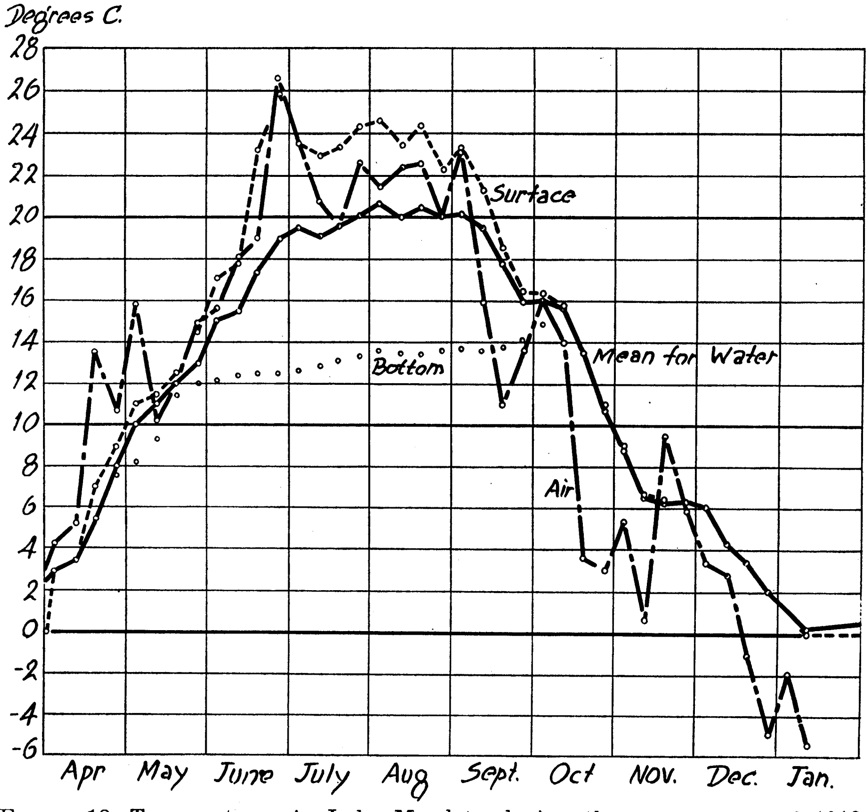

FIGURE 18. Temperatures in Lake Mendota during the open season of 1913 (March 27 to January 12, 1914).

The relations between temperatures of air and surface are shown in detail in Figs. 9 to 22 and the appearances of these diagrams call attention to the more striking phenomena. Two things may be mentioned here. The numerous warm periods of autumn seem often to have very little effect in checking the decline of the temperature of the water, so that the curve of the water is far more regular than that of the air. There is far less correlation between the air and surface during autumn than during spring and

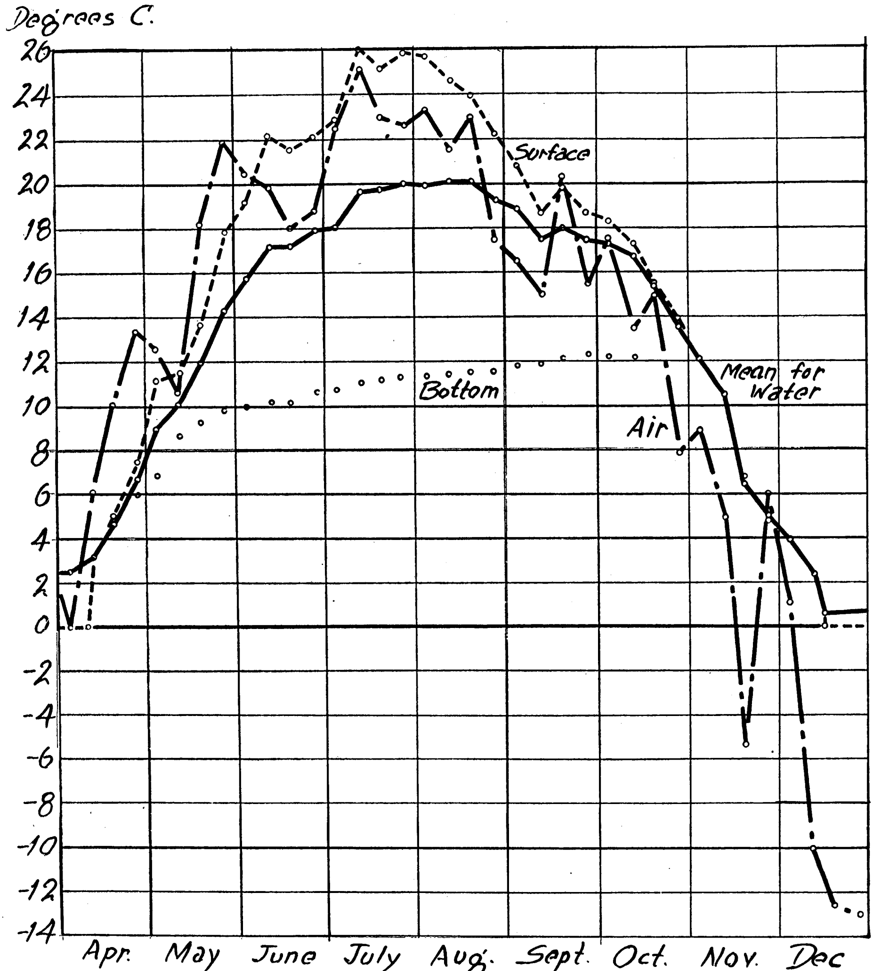

FIGURE 19. Temperatures in Lake Mendota during the open season of 1914 (April 1 to December 15).

summer. In spring, and especially in summer, the surface follows the air pretty regularly, though always with smaller range and with a decided lag which sometimes obscures the relation. But in autumn no such close relation is seen. This is partly due to the greater mass of water to be affected after the lake has become homothermous, partly also to the increased evaporation of warm

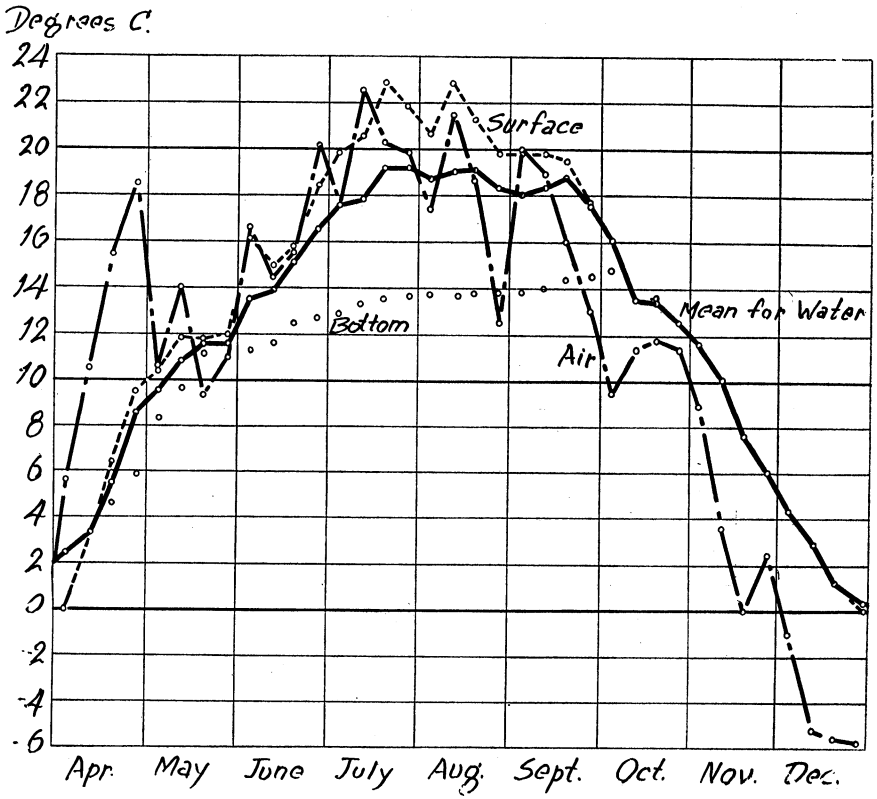

FIGURE 20. Temperatures in Lake Mendota during the open season of 1915 (April 9 to December 15).

periods which uses up more heat, and thus prevents a corresponding rise of surface temperature.

A second fact to be noted is the unfavorable effect of a very high surface temperature on the heat budget of the lake. This was especially noteworthy in 1910, when the surface rose above 27.0° in June and remained above 24.0° until the middle of August. Meanwhile the mean temperature of the water rose very slowly and remained low in spite of the extremely hot surface strata. This condition persisted until the declining sun and warmth of late

August ushered in the autumnal losses of heat. This is the best illustration of the difficulty with which a lake recovers from a heat-debauch. The similar conditions of July in 1916 came on later and although the effects were similar, they were not so plainly registered in the mean temperature of the water.

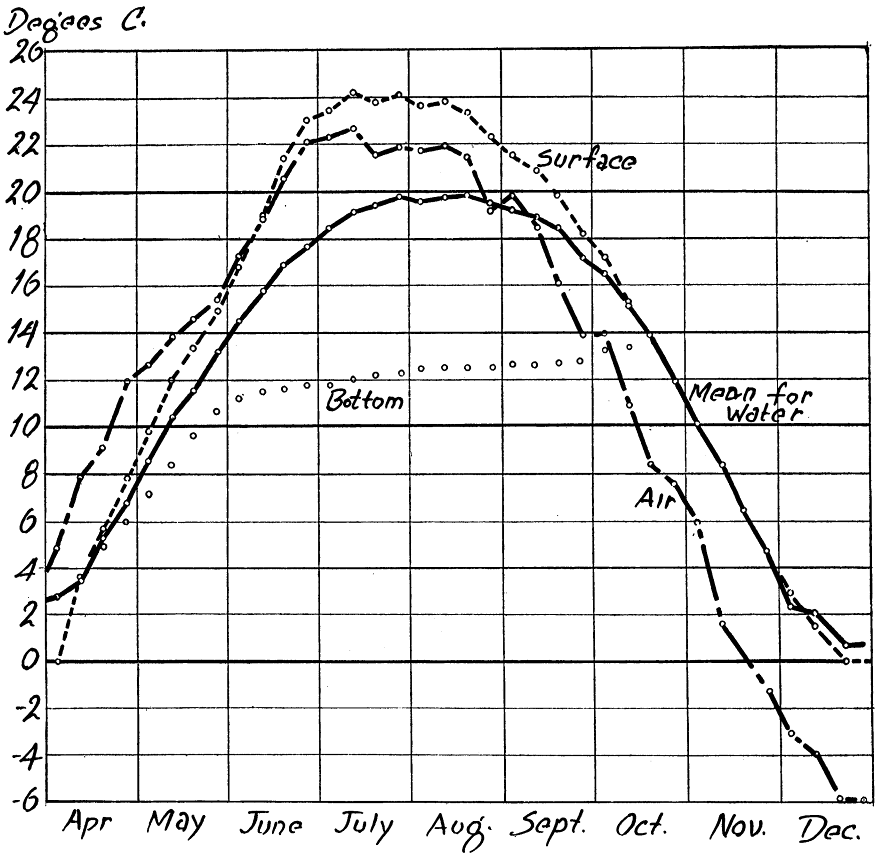

FIGURE 21. Mean temperatures in Lake Mendota for the period 1895 to 1915 inclusive, computed at quarter-month intervals.

The summer heat-increase is due to a great wave of heat which, starting at the surface of the lake, is propagated to the deeper water. The wave passes down very rapidly at first and its effects quickly reach the bottom at the depth of 23 m.–24 m. during April and early May. But soon the progress of the wave is slowed; the rate of penetration of the water is lessened; the successive isolines reach the bottom after long delay, or not at all. The successive stages of the heat wave appear at the surface during late May and

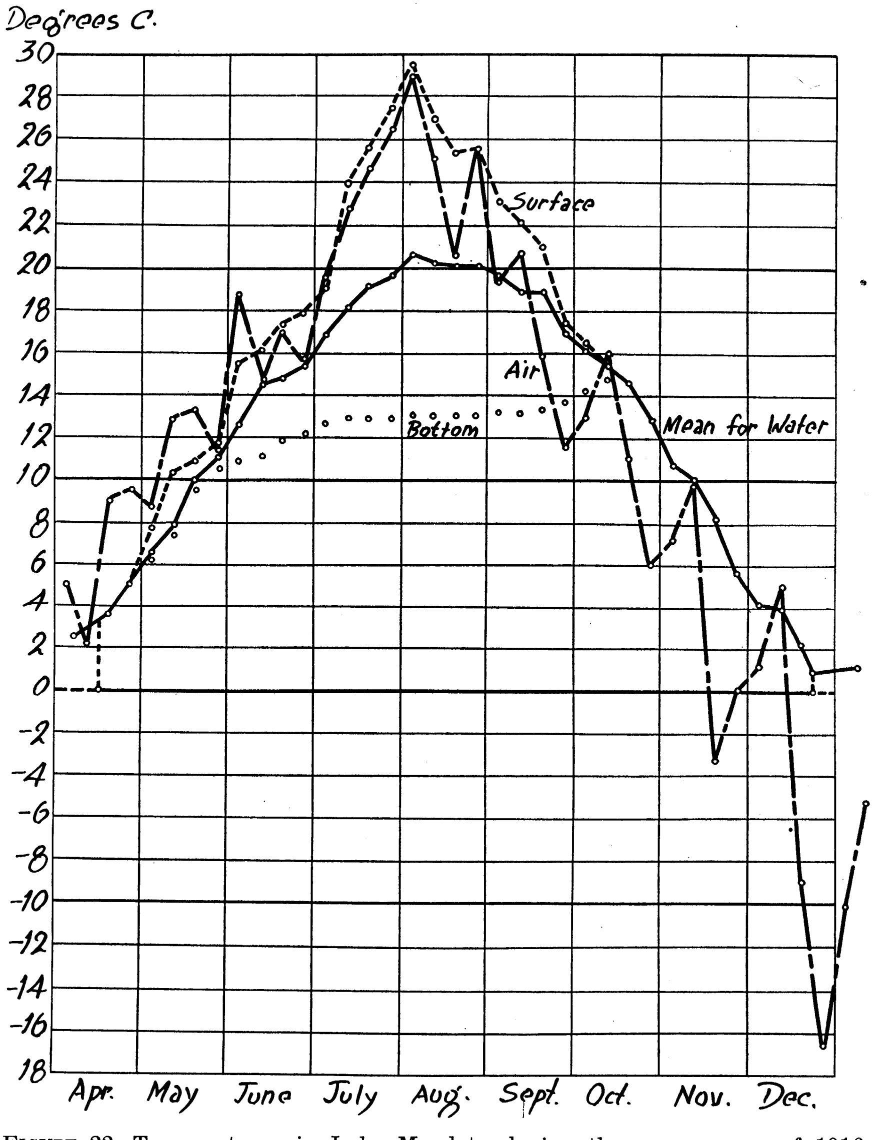

FIGURE 22. Temperatures in Lake Mendota during the open season of 1916 (April 8 to December 15).

June nearly as rapidly as at earlier dates. They penetrate the upper meters of the water almost as rapidly, but their progress is soon checked, and at depths increasingly smaller as the temperature rises. The upper isolines, therefore, run for a time nearly parallel to each other and more nearly horizontally than vertically. The upper region of the lake, the zone of permanent rapid penetration of heat, constitutes the epilimnion; the underlying zone where the isolines run almost horizontally is the thermocline (or mesolimnion) which grades off below into the hypolimnion.

As the temperature of the surface falls, the epilimnion cools and becomes thicker; the successive isolines disappear from the thermocline and it slowly sinks in the lake. By late September the epilim-

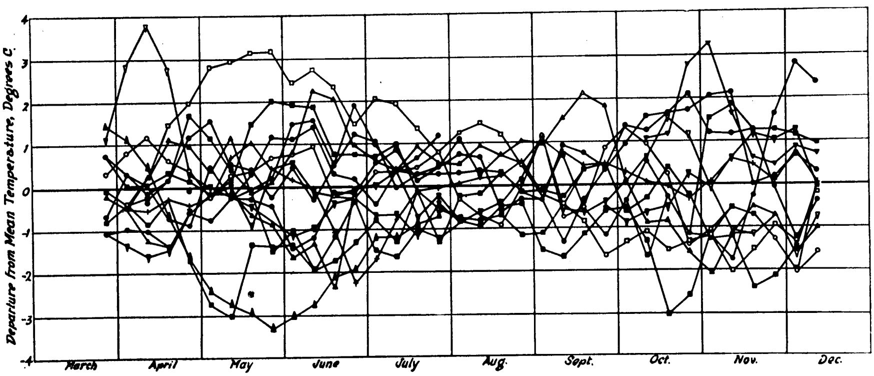

FIGURE 23. Departures of quarter-month mean temperatures in the various years studied from the general mean for the same period. Individual years are not identified (see text).

nion is over 15 m. thick and the thermocline, which earlier contained 5°–8°, is reduced to 1°–2°. Its final disappearance and the restoration of the homothermous condition comes with some storm or high wind of early or middle October.

If the isolines of Fig. 24 are examined in detail, increasing lag of their penetration of the water will become apparent. The temperature of 4.0° appears at the bottom about three days after it appears at the surface, that of 8.0° requires nearly 12 days to reach the bottom, that of 11.0° needs nearly three weeks, while 12.0°, after passing down as rapidly as 11.0° for the first 14 m., is checked there and requires six weeks for the remaining 9 m. The reason for this delay obviously lies in the increasing energy of the sun, in the increasing temperature of the surface, and the increasing thermal resistance of the water to mixture by the wind, coupled with the decreasing energy of the wind as the season advances.

The isoline of 13.0° reaches the depth of 9 m. about a week after appearing at the surface; in the following month it sinks about 6.5 m.; it requires 2.5 months more to descent to 20 m. The remainder of the descent is more rapid, under the influence of the winds of late September and early October. The other isolines do not reach the bottom, but are removed from the thermocline as the epilimnion cools. The rounded curve in which the slowly sinking isoline meets the nearly vertical line with which it goes out to the

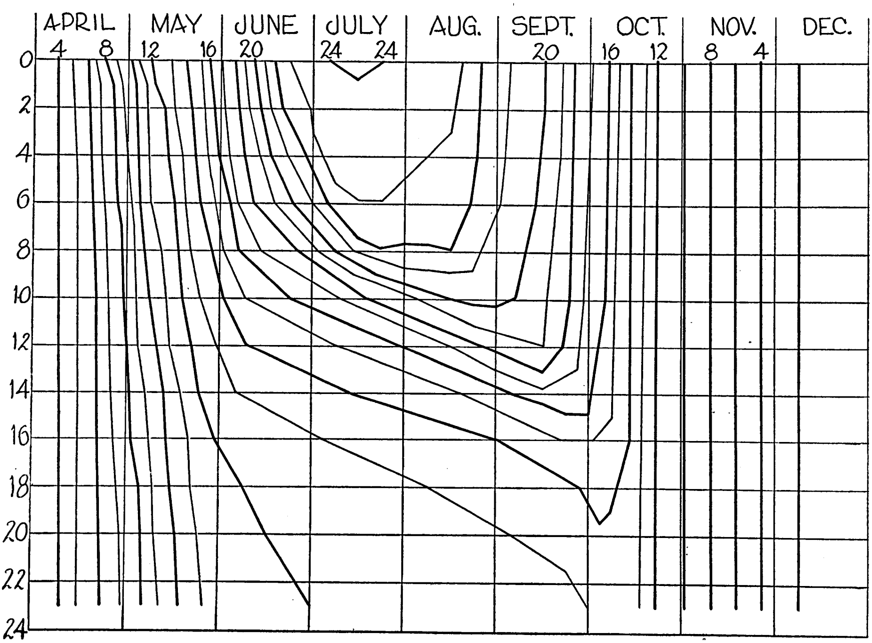

FIGURE 24. Mean distribution of temperature in Lake Mendota during the open season, based upon data from 1895 to 1916 inclusive.

surface is due to averaging the positions of the degree in question for a series of years. In a diagram representing any one year the isoline would go on sinking until the whole mass of water above it had fallen to its temperature and would show at the close a nearly vertical line sharply intersecting it.

The temperature of the lake falls from about 13.0° at the middle of October to 2.0° about Dec. 10. All of the isolines are nearly vertical, but not quite so. The fall of temperature of the surface as indicated by weekly means regularly lags a day or two behind that of the bottom. The surface is frequently found one or two tenths of a degree above the bottom and rarely below it. This is due to the fact that, during the cooling period the chilled water does not ordinarily sink *in situ* but is transported by the wind to one side of the lake, cooling as it goes and returning along the bottom. It is also due to the process by which water chilled at night in the shallows below the temperature of the lake water may sink and flow down to the bottom of the basin without any definite aid of the wind.

It will be noticed that there is no evidence of marked inverse stratification during the period shown on the diagram. Its absence is due to the small depth of the lake. Water 150 m.–200 m. in depth would keep a considerable stratum at the bottom which fell but little below 4.0°. No Wisconsin lake belongs to this class, though no doubt Green Lake and Lake Geneva show more indication of inverse stratification in early winter.

(To be continued in Volume 46)

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