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## TABLE OF CONTENTS

# THE ELK IN EARLY WISCONSIN

A. W. SCHORGER

The elk *(Cervus canadensis canadensis)* was once a common animal in Wisconsin and there is reason to believe that it occurred throughout the state. At present there are records of its presence in 50 of the 71 counties. Remains are still being found so that there is a strong probability that many of the gaps in the range will be filled. The elk ate grasses and sedges to a greater extent than the other members of the deer family. On the Great Plains it was formerly found intermingled with buffalo. In Wisconsin the elk was most numerous in the open woodlands, oak openings, and at the border of grassland and forest. There habitats prevailed in the southern and western parts of the state.

Radisson[1] was in northwestern Wisconsin in 1661–62 and mentions "staggs" among the animals killed. A few years later Allouez[2] found "large and small stags [deer]" abundant at the mouth of the Wolf River, Winnebago County. During Le Seur's voyage up the Mississippi in 1700, an elk was killed on the Black River, La Crosse County. The account reads: "On the 10th, [September] at daybreak, they heard a stag whistle on the other side of the river; a Canadian crossed in a little Sciou (Sioux) canoe that he had found. He soon after returned with the body of the animal, which is easy to kill in the rutting season, that is from the beginning of September to the end of August [October]. During that season the hunters make a little whistle of the first bit of wood or cane, and when they hear a stag whistle, they answer; the animal supposing it to be another stag that whistles comes to them, and they kill it without any difficulty."[3] Subsequently Le Seur passed the mouth of a river so abounding in elk and other large game that it was called Bon Secours, this being the present day Chippewa River.

Jonathan Carver[4] arrived at Lake Pepin on November 1, 1766. The land on the Wisconsin side was described as covered with grass and a few groves of trees near which large droves of elk and deer were frequently seen feeding. The following year he ascended the Chippewa River and mentions that for a distance of sixty miles the banks contained fine meadows on which were seen larger droves of elk and buffalo than he had found elsewhere. Capt. Goddard, who accompanied Carver, wrote on May 29, 1767: "This is a fine river . . .; there is plenty of animals, such as stag, deer, bear and buffalos, of which we killed every day one sort or other."[5]

Information on the early status of the elk in southeastern Wisconsin is scanty. Fonda carried the mail from Green Bay to Chicago the winter of 1827–28. The third day out of Milwaukee he came to a prairie where some resident Indians were starving even though the country teemed with elk and other game. There is no subsequent mention of a live elk. Lapham (1846) wrote that "horns of the elk are still occasionally found scattered over the prairies."[7]

Elk appear to have disappeared from southwestern Wisconsin prior to 1840. Hoffman[8] was at Prairie du Chien in February, 1834. The army officers at the fort maintained dogs especially to run elk which abounded at a distance "over the river." The latter could have been either the Wisconsin or the Mississippi. Smith[9] was in the lead region in 1837 and was informed that elk were still to be found along the shores of the Wisconsin. A decade later this animal was stated by McLeod[10] to be extinct.

Schoolcraft[11] was at Rice Lake, Barron County, in August, 1831. In this area, described as prairie, elk and deer were common. The tracks of these animals were also abundant on the sand bars at the mouth of the Chippewa. Brunson, in 1843, traveled by team from Prairie du Chien to La Pointe, a good indication of the openness of the country. In describing the route from Black River Falls to Chippewa Falls, he stated that it was largely through prairie where, "The elk and deer tracks were very numerous. Some of the company saw elk but we killed none."[12]

In 1857, Davis[13] assisted in the survey for a railroad to run from Portage to Chippewa Falls. Numerous shed elk antlers were noted along the line. No elk were seen and he suggests that there may have been none at that time.

The most extensive account of the elk in Wisconsin is contained in the following paragraph from Copley: "The elk is to be found in the west, on the neutral ground lying between the Sioux and Ojibway nations; at the head waters of the Wisconsin; in the northern parts of Michigan, and near the Chippeway, St. Croix, Rum and Red rivers. This is one of the noblest looking animals in our country. When on the run, its head is held high, its back curved, on which its horns appear to rest. At one time, in 1837, I saw a drove of five hundred; and a more animating sight I never beheld. I shot one, and being at that time a prisoner at the foot of Lake Pepin, and wishing to be generous to my enemies, I took it to the chief of the tribe that held me. Soon after I was liberated, and with my cousin Johnson permitted to depart."[14]

Bunnell came to La Crosse in 1842 and mentions frequently the hunting of elk, especially along the Trempealeau River. Regarding distribution he wrote: "Elk were also abundant there [mouth of the Chippewa River] in the Mississippi bottoms, on the prairie, and in the oak thickets below and east of Eau Claire, extending their range over the headwaters of all the streams south of the pine-belt as far as Black river. The writer saw a band of sixty elk, in 1845, on a prairie about eight miles below Eau Clair, two of which were killed by William Richmond and myself."[15]

EXTINCTION. The elk, being a large, unwary animal, was extirpated quite early on the prairies. It persisted longest in the western part of the state where it had learned to adapt itself to woodlands. Small droves were pursued with persistence by hunters with the knowledge that the majority of the elk could be killed.

In November, 1866, a band of twelve old and young elk crossed a road in which two hunters were standing, about fifteen miles west of Menomonie, Dunn County.[16] When a dog seized one of the young, the adult elk came to the rescue giving the hunters an opportunity to shoot nine of them. Three elk escaped.

The elk may not have become until 1868. Early in January of this year two hunters from Stevens Point hunted west of town, across the Wisconsin River, and returned with a "buck" that weighed 573 pounds and had antlers with a spread of six feet.[17] Only an elk would fit these data.

Strong[18] reported in 1883 that elk were to be found very rarely in northern and central Wisconsin. It is very doubtful if they persisted to this date. In the spring of 1886, six elk killed in the "Lake Superior regions" were shipped through Chetek.[19] It is highly probable that they were killed in Minnesota.

PLEISTOCENE ELK. An extinct species of elk, *Cervus whitneyi*, found in a crevice while mining for lead at Blue Mounds, Wisconsin, was described by Allen[20] in 1876.

The University collection contains the radius of an elk, UMZ 12,707, found at Boyd in 1937, and donated by George B. Lane of Bloomer. This specimen, identified by U.S. National Museum, was overlain by five to six feet of peat and six feet of marl, and may be Pleistocene.

On November 13, 1953, through the courtesy of Professor W. F. Read, Lawrence College, I received the fossilized basal portion of an elk antler. It was found in the bed of a creek in northeastern Columbia County by Luzern Livingstone, of Madison, at an unknown date. This is a massive antler and measures nine inches in circumference between the bez and trez tines.

Since it was not found in a specific geological formation, its age is not determinable.

INTRODUCTIONS. An illustrated article by Reese[21] describes the attempts to restore the elk to the Wisconsin fauna. In 1913 a carload of elk from Yellowstone Park was shipped to Trout Lake. The sole survivors were two females. Later a bull elk was obtained and the herd increased slowly in the enclosure provided for it. A second carload of elk, all young, consisting of 32 cows and eight bulls, was obtained from Jackson Hole, Wyoming, in February, 1917. Although the animals arrived in good condition, 14 died during the winter. In August, 1932, the 15 elk remaining were released from the enclosure. They were not known to have ranged out of Vilas and Oneida Counties. At the present time not over two elk survive due to shooting by hunters and other causes.

RECENT ELK REMAINS. Bones of elk are seldom found, but the antlers have been discovered in considerable numbers. Due to their porosity, antlers on the uplands soon disintegrate. The process is hastened by gnawing by rodents. At the present time antlers are found only in stream beds, lake bottoms, and marshes, in or around boggy springs, and in Indian burials. Where waters have a high alkalinity, due to "lime," destruction of the bones and antlers by decay is much slower than in acid waters. Elk were drowned frequently by breaking through the thin ice. Miring, either accidental or from stampeding by wolves and Indians, appears to have been a more frequent cause of death.

The Indians sometimes threw antlers into sacred springs and hung the heads or antlers in the crotch of a small tree as propitiatory offerings. In 1859 the Wisconsin Historical Society received two specimens of elk antlers embedded in oaks, one from a white oak cut in Sauk County, and the other from a bur oak from Walworth County. About 40 years ago the Society gave the Forest Products Laboratory at Madison a specimen embedded in a white oak and this is still in their possession. The section of this tree shows approximately 95 annual rings and is 14.5 inches in diameter. If it is the specimen found in Sauk County in 1857, the tree began life about 1760, and it is probable that the antler was hung in it 10 to 15 years later.

RECORDS. The distribution of elk as shown by the literature and the discovery of antlers is shown on the accompanying map. The range of the elk in the state was strikingly like that of the buffalo,[22] showing that the elk was also predominantly a prairie animal. The records by counties are given below.

*Adams.* Two hunters, L. S. Crain and J. Haggerty, killed an elk on the Roche-a-cri River in November, 1855.[1] Being too large to transport, it was sold for $10.00. An elk horn four feet in length was found in the county under a windfall in 1890.[2]

[1] Milwaukee *Daily Wisconsin,* Dec. 11, 1855. [2] Grand (Wisconsin) Rapids *Reporter,* April 24, 1890.

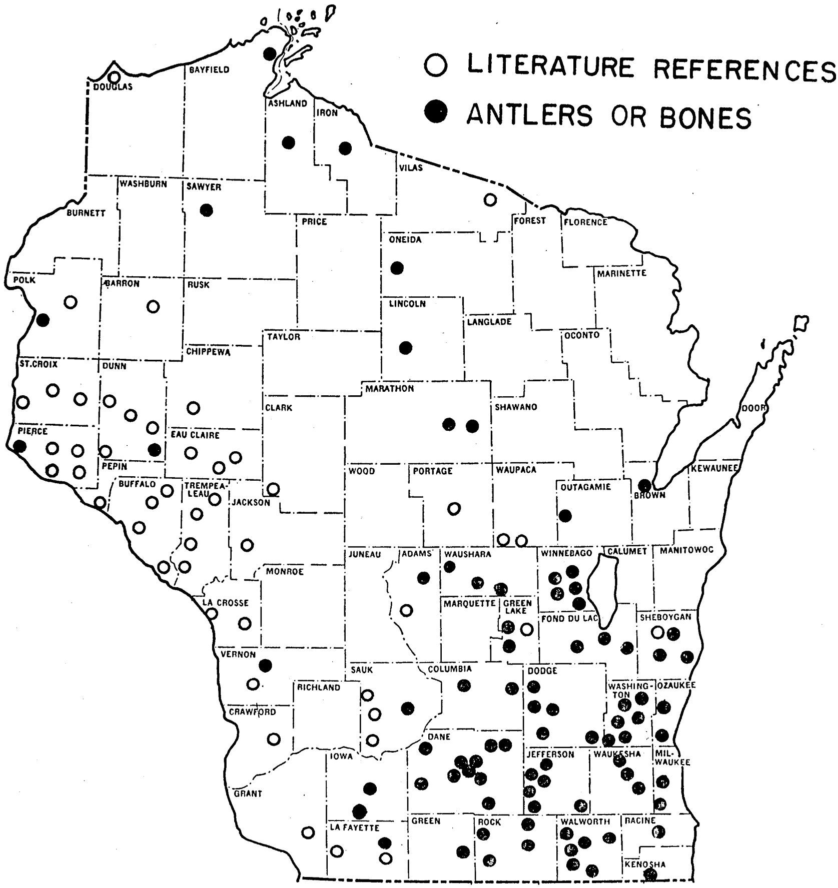


FIGURE 1. Records of Elk in Wisconsin.

*Ashland.* Jackson states that he has examined antlers from the county.[1]

[1] Jackson, H. H. T. *A preliminary list of Wisconsin mammals. Bull. Wis. Nat. Hist. Soc.,* 6 (1908) 15.

*Barron.* Schoolcraft, as previously mentioned, found elk tracks numerous at Rice Lake in 1831. Government surveyors in 1852–53 found a herd of five elk near the present site of Prairie Farm,[1] Hoy[2] reported elk on Hay River in 1863. This stream flows through Barron and Dunn Counties.

[1] Eau Claire *Telegram,* Sept. 20, 1922. [2] P. R. Hoy, *Trans. Wis. Acad. Sci.,* 5 (1882) 256.

*Bayfield.* An antler was found near Bayfield by William Cadotte.[1]

[1] *Wis. Cons. Bull.,* 2 (6), (June, 1937) 38.

*Brown.* Brayton,[1] writing in 1882, stated on the authority of B. H. Van Vleck that elk were still to be found in the vicinity of Green Bay. The accuracy of this statement is doubtful, especially from the following: "An elk horn was found in digging the water-works trench on Webster Avenue. . . . It was in the old swamp . . . and embedded about six feet in the ground. . . . The memory of the oldest inhabitant (and there are some who have lived here 70 years or more) does not go back to the time when elk roamed in these forests."[2] Only one antler and no bones were found.

Under date of July 23, 1953, H. V. Bloemen, Conservation Department Warden, wrote that about 1900 his father while seining at the mouth of Ashwaubanon Creek, which enters the Fox River about a mile below DePere, brought up a part of an elk antler with a large piece of the skull attached. About 1930, while a student at Lawrence College, he gave the antler to Dr. Rufus Bagg. The specimen cannot now be located.

[1] Brayton, A. W. *Report on the geological survey of Ohio.* Vol. 4, Part 1 (1882) p. 80. [2] Green Bay *Advocate,* Nov. 18, 1886.

*Buffalo.* Cooke gives a good account of the abundance of elk in 1856. The Sioux crossed the Mississippi to hunt in the county on account of the abundance of game. Regarding the winter of 1856–57 with its deep snow, he wrote: "During the winter we often saw elk cross the valley, always led by a bull elk. . . . He would take a few jumps and stop, the cows would follow, jumping into the bull's tracks. Then he would move on a little ways and again stop, then the cows would follow as before."[1] Harvey Brown killed a few elk during this winter.[2]

The Indians in the fall of 1857 killed three or four elk in the vicinity of Elk Creek.[3] This stream flows into the Buffalo River in the northeastern corner of the county. In 1858 a party of hunters from Lancaster killed an elk on Beef (Buffalo) River.[4] Kessinger,[5] writing in 1888, stated that elk were once common but were now extinct. Mr. Jacob Bream, of Cream, informed Cory[6] that in 1870 he found a pair of antlers attached to the skull in Township 22, Range 11, West.

[1] Cooke, W. W. *Wis. Mag. Hist.,* 23 (1940) 288, 291, and 297; *cf.* F. Curtiss-Wedge, *History of Buffalo and Pepin Counties, Wisconsin.* Winona (1919) p. 953.

[2] Brown, H. *Wis. Cons. Bull.*, 8 (5), (May, 1943) 19. [3] Milwaukee (d) *Sentinel*, Oct. 3, 1857. [4] Madison *State Journal*, Oct. 4, 1858. [5] Kessinger, L. *History of Buffalo County*. Alma (1888) p. 42. [6] Cory, C. B. *The mammals of Illinois and Wisconsin*. (1912) p. 71.

*Burnett*. There is no definite record. Curot[1] had a trading post on the Yellow River the winter of 1803–04. In the translation of his journal elk are mentioned several times. This is incorrect for the MS reads *orignal*, the French for moose. His haunches of *Manichinsse* may mean elk, but I have been unable to find an Indian or French–Canadian word to support this suggestion.

In October, 1877, a party of hunters camped in the Town of Waubeek, Pepin County, en route to the Yellow River where they expected to get elk.[2]

[1] Curot, Michel. *Journal*, 1803–04. *Wis. Hist. Colls.*, 20 (1911) 396. [2] Durand *Times* Oct. 11, 1877.

*Chippewa*. Elk Creek rises in the Town of Howard. Joseph Roberts came to Chippewa Falls in the spring of 1840 when deer and elk were plentiful.[1] H. A. Town settled in the Town of Wheaton in 1857.[2] In March, 1862, a drove of about a dozen elk appeared for the first time in years. Neighbors, mounted on horses, wantonly slaughtered them.

A writer mentions that elk were extinct in 1874, but that eight years previously he found their tracks numerous in the northern parts of Chippewa and Dunn Counties.[3] Two hunters are stated to have found two large elk, and wounded one of them, in the Town of Arthur in November, 1888.[4] It is doubtful if elk persisted to this date.

[1] Chippewa Falls *Herald*, Nov. 26, 1880. [2] Eau Claire *Leader*, Jan. 6, 1923. [3] Chippewa Falls *Herald*, July 3, 1874. [4] Chippewa Falls *Herald*, Nov. 16, 1888.

*Clark*. An elk weighing 450 pounds dressed was killed on Halls River, 20 miles above Black River Falls, by Isaac S. Mason on August 9, 1854.[1] This would place the locality in southwestern Clark County. The antlers were stated to weigh 43.5 pounds.

[1] La Crosse *Republican*, Aug. 23; Milwaukee (d) *Sentinel*, Sept. 1, 1854.

*Columbia*. Numerous remains of elk were found in Swan Lake about 25 years ago while dredging for marl. About five years ago some boys brought to Elmer A. Werner, Pardeeville, the antlers of an elk, part of the skull containing a few teeth, and some of the other bones. Only the antlers were preserved and these I have seen. The outside measurement of one antler was 44.75 inches.

J. W. Jamieson, Pardeeville, has fragments of two antlers found in Swan Lake about 15 years ago. These measure 31 and 37 inches, respectively. M. G. Cornford, Randolph, has the basal fragments of two antlers, found in a tamarack swamp, Town of

Courtland, which I have seen. They measure 24.5 and 17.5 inches.

*Crawford.* There are several references to the abundance of elk along the Kickapoo River in the 1850's.[1]

[1] Lancaster *Herald,* Sept. 25, 1849; Milwaukee *Wisconsin,* June 20, 1850; Milwaukee *Advertiser,* Jan. 14, 1852; Prairie du Chien *Courier;* Milwaukee (w) *Wisconsin* Nov. 26, 1856.

*Dane.* There is no reliable record of a live elk having been seen in the county. H. A. Tenney, who came to Madison in 1846, merely states that the elk found a home here.[1] Nathan Crampton, who settled in Madison in 1847, informed Willis E. Barber[2] that he had stood for hours watching herds of elk and deer gather in the evening on the present site of the University campus. On April 26, 1942, I consulted Dr. Samuel Chase on this statement. He said that Crampton was fundamentally honest but confused in his knowledge. He doubted the statement and gave as evidence that his grandfather, Jonathan Larkin, settled at Lake Wingra in 1842, and that no elk were present at that time.

In 1891, A. Waterman, while cleaning out a spring on his farm in the Town of Rutland, near Stoughton, found a pair of antlers attached to the skull.[3] An antler four feet in length was recovered from a spring on the Ephraim Baker farm, Town of Bristol, in 1894.[4] On May 14, 1939, I examined part of an antler that was found in the small bay at the southwestern corner of Fish Lake, Town of Roxbury. There is a part of an antler 21 inches in length at the Nevin Fish Hatchery and presented by Otis Bersing. The latter informed me that it was found by a local resident in 1917 in the Town of Rutland while excavations were being made on Badfish Creek, near County Trunk A, about three miles southeast of Oregon. While digging a trench in the Town of Vermont in 1886, an antler weighing 14 pounds was found.[5]

Numerous remains of elk were found at Lake Wingra in excavating the lagoons at Wingra Park, and in dredging for the Lake Forest real estate development.[6] One antler, UMZ 4324, was found in 1906 or 1907. On July 16, 1953, through the generosity of Mrs. John Russell, a fine pair of elk antlers attached to the skull was obtained for the University. This find was made in Lake Wingra by her brother William Priebe. Subsequent search of the local papers revealed that the discovery was made in July, 1918.[7] The entire skeleton was present. Mrs. Russell informed me that subsequent to removal of the antlers, Priebe returned to secure some of the bones but could not locate the place. Length of antlers, 51 inches; spread 47.5 inches; weight with skull, 34.5 pounds.

Harold Longua has informed me that in 1928, while seining for carp in the "widespread" of the Cherokee Marsh (Yahara River) he brought up a large elk antler. I have a section of an antler, 19 inches in length, donated by Art Amundsen, Nevin Fish Hatchery. It was found about 40 years ago by William Anderson on Straavoldson's Marsh, Section 16, Town of Dunkirk.

[1] Tenney, H. A. In W. J. Park, *Madison, Dane County and surrounding towns.* Madison (1887), p. 541. [2] Barber, W. E. In M. M. Quaife, *Wisconsin: its history and its people.* Chicago, Vol. 2 (1924) 386. [3] Portage *Register,* Oct. 3, 1891. [4] Portage *Register,* Sept. 29, 1894. [5] Milwaukee *Journal,* Sept. 29, 1886. [6] Brown, C. E. *Lake Wingra. Wis. Archeol.,* 14 (3), (Sept. 1915) 79. [7] Madison *State Journal,* July 7, 1918, p. 7.

*Dodge.* It is stated by Charles Mortimer that a fine elk was seen in the Town of Ashippun in the spring of 1846; also a pair of antlers was unearthed in plowing a piece of marshy ground in the fall of 1897.[1]

The University Museum has a pair of antlers, UMZ 4325, originally donated to the Wisconsin Historical Society by Mrs. Emma House, Reeseville. There are no further data.

In cleaning the Vita, or Ackerman, Spring at Beaver Dam many elk and deer antlers were found.[2]

On October 6, 1953, the University received from V. G. Hamilton, Fox Lake, two elk antlers found in Fox Lake by C. M. Sager about 50 years ago. The antlers represent two elk as they differ considerably. A. Amundsen has informed me that two antlers were found in Fox Lake in 1935 while seining for rough fish.

[1] Oconomowoc *Free Press,* Jan. 22, 1898. [2] Juneau *Telephone,* March 19, 1880; Anon. *The history of Dodge County, Wisconsin.* Chicago (1880), p. 453.

*Douglas.* Elk, deer, and moose were mentioned in 1855 as attractions for tourists.[1] Sergeant William Glader stated that in this year there was little to eat at Superior except elk and fish.[2]

[1] Superior *Chronicle,* Sept. 4, 1855. [2] Superior *Telegram,* Sept. 12, 1916.

*Dunn.* A pioneer wrote in 1884 that herds of elk formerly roamed the "Big Woods" that covered the western part of the county; that the elk made its best speed while trotting and was ungainly when forced into a gallop.[1] Gilbert[2] had a mill on the Menomonie River in 1843 and obtained elk meat from the Indians. In August, 1855, Harvey Lesure saw a herd of twelve elk near the present site of Colfax.[3]

Elk, by 1855, had become uncommon. Albert Quilling came to the Iron Creek District in June, 1855.[4] There were only a few elk, but shed antlers could be found in the groves and prairies. He states that in the vicinity of Elk Mound a Mr. Ramsey found two bull elk with locked horns and he killed the one that remained alive. Eugene Wiggins came to the county in May, 1855, and never saw more than one drove of elk. In the fall of 1857, Cartwright[6] came upon the tracks of twelve to fifteen elk and pursued them all day without success. Near the Eau Galle River, in December, 1858, he pursued seven elk. One was wounded and found dead the next day.

An elk killed in the Menomonie woods in February, 1860, by K. Freeman, was brought to Sparta and shipped to Fond du Lac.[7] John Bailey, who came to Knapp in 1862, spent much of his time hunting deer and elk.[8] Two elk were killed by a Menomonie hunter in November, 1864.[9] The last elk were killed in 1866.[10]

Bartlett mentions seeing several good specimens of elk antlers found in Elk Creek in the southeastern part of the county.[11] An antler measuring four feet and five inches was found in the creek in 1879.[12]

[1] "Pioneer." *Recollections of early days in the 'Big Woods' of Dunn County.* Menomonie *News,* Feb. 2, 1884. [2] Gilbert, O. *Pioneer reminiscences. Wis. Mag. Hist.,* 14 (1930) 190. [3] Eau Claire *Telegram,* Sept. 20, 1922. [4] Menomonie *News,* Oct. 23. 1919, 7. [5] Menomonie *News,* June 14, 1923. [6] Cartwright, David W. *Natural history of western wild animals.* (1875) pp. 238, 242, and 244. [7] Fond du Lac *Commonwealth,* Feb. 22; Madison *Patriot,* Feb. 18, 1860. [8] Menomonie *News,* Feb. 15, 1879. [9] Menomonie *Lumberman:* Milwaukee *Sentinel,* Nov. 23, 1864. [10] Menomonie *News,* Dec. 1, 1866. [11] Eau Claire *Telegram,* April 28, 1926, 3. [12] Eau Claire (w) *Free Press,* Oct. 9, 1879.

*Eau Claire.* Ivory Livermore came to the Town of Otter Creek in 1856 and he saw many elk.[1] His father killed two or three from a herd of sixteen. An elk was killed in 1857 a few miles west of Eau Claire.[2] On January 1, 1858, a herd of 60 elk was seen in the Town of Bridge Creek.[3] This herd was pursued on the 2nd by three men, among them the noted hunters J. F. Stone and Charles Buckman. Late in the afternoon, they caught up with the elk on the Buffalo River, about three miles below Osseo, Trempealeau County, and killed four of them. The pursuit was continued the following day and four additional animals killed.

Nine elk were killed from a drove in the Town of Bridge Creek in January, 1860.[4] The four elk subsequently exposed for sale in the Milwaukee market and stated to have been killed in Eau Claire County, were probably from this lot.[5]

[1] Bartlett, W. W. *History . . . Chippewa Valley.* [1929], p. 214. [2] Madison *State Journal,* Aug. 17, 1857. [3] Eau Claire *Free Press,* Dec. 2, 1858. [4] *Ibid.,* Jan. 12, 1860. [5] Milwaukee *Wisconsin,* Jan. 21, and *Sentinel,* Jan. 23, 1860.

*Fond du Lac.* It was stated in 1860 that elk were common a "few years ago".[1] While excavating at Lake de Neveu, Town of Empire, in 1867, the antlers and skeleton of an elk were found. Among the bones was a flint arrowhead.[2] In 1875 a pair of antlers was found in a spring in the Town of Oakfield.[3]

On July 17, 1953, the boys at the Boy Scout Camp on Long Lake, Town of Osceola, while swimming, found an antler and several bones of an elk. Prof. R. A. McCabe and I went to Long Lake on July 30 to investigate the site. The remains were found close to the pier in 5 feet of water and about 100 feet from the shore which is a high bank. The antler measured 47.5 inches. Subsequently the other antler and most of the bones were recovered. These are now in the University collection. Clyde T. Smith, Acting Area Coordinator, Kettle Moraine State Forest, informed me that Long Lake was originally largely marsh, and was converted to a lake by a dam constructed about 70 years ago.

[1] Fond du Lac *Commonwealth,* Feb. 22, 1860. [2] Fond du Lac (w) *Reporter,* Sept. 7, 1867. [3] Watertown *Democrat,* Dec. 23, 1875.

*Grant.* Hollman[1] settled at Platteville in 1828 and at that time elk and other game were to be found in "astonishing quantities". The MS of his autobiography was written in 1870.

[1] Hollman, F. G. *Auto-biography of Frederick G. Hollman.* Platteville. n.d., p. 3.

*Green.* An elk antler was found in 1877 on an uncultivated piece of ground near Brodhead.[1] Old settlers stated that it was about 40 years since elk occurred in the neighborhood.

[1] Brodhead *Independent:* Madison *State Journal,* May 1, 1877, 1.

*Green Lake.* Dart[1] came to the county in 1840 when elk were still to be found on Willow River, and at times around Green Lake. Shed antlers were found often. Bones of elk were found in a "sacred" spring near the Fox River.[2] Leroy C. Hansen, of the Wisconsin Conservation Department, has informed that some years ago, while seining for rough fish, he found a pair of elk antlers in the Fox River at Princeton.

[1] Dart, Richard. *Settlement of Green Lake County. Proc. Wis. Hist. Soc. for 1909.* (1910) p. 260. [2] Brown, C. E. *Wis. Archeol.,* 5 (1), (Oct., 1905) 214.

*Iowa.* In 1861, while prospecting near Dodgeville, J. A. Hamilton sunk a shaft eight feet deep.[1] On removing some rock he found a complete elk antler that became crumbly on exposure. I have the basal part of an antler donated by Henry Wagner, Mineral Point. It was found by him on August 2, 1953, in the Rock Branch of the Pecatonica River, Town of Mineral Point. The antler with the above data was brought to me by Cleveland P. Grant.

[1] Dodgeville *Advocate:* Madison *Argus & Democrat,* Aug. 6, 1861, 1.

*Iron.* Jackson[1] states that he has examined antlers of elk found in this county.

[1] Jackson, H. H. T. *A preliminary list of Wisconsin mammals. Bull. Wis. Nat. Hist. Soc.,* 6 (1908) 15.

*Jackson.* On January 31, 1857, fifteen elk were killed out of a drove of thirty.[1] The locality is not stated.

[1] Black River Falls *Banner:* Janesville *Democratic Standard,* March 2, 1857.

*Jefferson.* Excavations at ancient Aztalan yielded fragments of antlers and several scapulae of elk.[1] The latter, perforated with a square hole, were used to remove the "bark" in the preparation of fibers.

A pair of "gigantic elk horns" was brought up from the bottom of Rock Lake by a fisherman in 1875.[2] Hough[3] mentions a perfect pair of antlers found near Palmyra in 1895. According to Hawkins[4] the elk had disappeared from Faville Grove Prairie prior to settlement. He saw two antlers that had been plowed up and had heard of others being found.

Mr. Omar Huebner has written me that in plowing a piece of low ground, about 1918, he uncovered a single elk antler about four feet in length. He has about 15 inches of the basal portion of the beam, the remainder being too decomposed for preservation. It was found 100 yards south of U. S. Highway 16, Section 17, Town of Ixonia.

In 1932 a pair of elk antlers was found deeply buried at Lake Ripley by workmen constructing a bathing beach.[5] They came into possession of Mrs. Ernie Wrolstad, Amherst Junction, Wisconsin. Elmer Herman, Fisheries Supervisor, has informed me that on April 8, 1954, an elk antler was found in this lake in seven feet of water.

Chester J. Skelly, Milton, has informed me that an elk antler found by carp seiners in Lake Koshkonong about ten years ago is now in the possession of Carl Schmeling, Maple Beach, Lake Koshkonong. The brow tine of a small antler, found in July, 1953, on the Faville Grove Prairie, Town of Milford, has been donated by James Zupke, Lake Mills.

[1] Barrett, S. A. *Ancient Aztalan.* Milwaukee, (1933), pp. 170, 183, 289, and 290. [2] Watertown *Democrat,* Oct. 7, 1875. [3] Hough, E. *Elk horns in Wisconsin. Forest and Stream,* 45 (1895) 271. [4] Hawkins, A. S. *A wildlife history of Faville Grove, Wisconsin. Trans. Wis. Acad. Sci.,* 32 (1940) 57. [5] Cambridge *News,* Sept. 30, 1932.

*Kenosha.* In 1896 Otis Baker, Bristol, presented to the Historical Society of Wisconsin an elk antler found at Bristol in 1851.[1] It weighed 22 pounds. This specimen cannot be located.

[1] *Proc. Hist. Soc. Wis. for 1896,* (1897) p. 49.

*La Crosse.* Bunnell has been previously cited on the abundance of elk when he arrived in 1842. A party of La Crosse hunters under Major Brandenburg killed seven elk on a hunt made in December, 1858.[1]

In a cave in the Town of Barre, there were found in 1878 drawings of an elk and a bodkin seven inches in length, made presumably from the leg bone of this animal.[2]

[1] La Crosse *Independent Republican,* Dec. 22, 1858. [2] Brown, E. *Wis. Hist. Colls.,* 8 (1879) 176–79.

*Lafayette.* Elk Grove, Town of Elk Grove, is reputed to have been so named from the former occurrence of elk.[1] Charles Rodolph settled at Fort Hamilton, now Wiota, Town of Wiota, in 1834, at which time there were some elk.[2] On January 16, 1954 Fred Wagner showed me the basal portion of an elk antler, 22 inches in length, loaned by Edward Saalsaa, South Wayne. It was found by him about seven years previously at the junction of Applebranch Creek and Whiteside Creek, Town of Wiota.

[1] Conley, P. H. *The early history of Lafayette Co. Wis. Mag. Hist.,* 2 (1919) 329.
[2] Rodolf, C. *In History of Grant County, Wisconsin.* Chicago (1881), p. 800.

*Lincoln.* On October 19, 1874, Joseph Gordon, wrote from Grandfather Falls, Town of Rock Falls, that he had found an elk antler a mile to the eastward. The antler was received by the editor of the Wausau *Wisconsin.*[1]

[1] Wausau *Wisconsin,* Nov. 4, 1874.

*Marathon.* Cory[1] was informed by Paul Hohnheiser, Wausau, that he had a large pair of antlers, measuring 45 inches in length, found in a lake in that vicinity. An antler was found by N. C. Ewing, Wausau, at the bottom of Lake Go-to-it, Town of Norrie.[2]

[1] Cory, C. B. *The mammals of Illinois and Wisconsin* (1912) p. 71. [2] Quaife, M. M. *Wisconsin: its history and its people.* Chicago, Vol. 2 (1924) 386.

*Milwaukee.* There were no elk at Milwaukee in 1800, according to Le Claire.[1] A pair of elk antlers, said to be the largest ever taken in Wisconsin, was on exhibit in Milwaukee in April, 1857.[2] Their provenance is not stated.

Hough[3] mentions seeing a skull and antlers in the taxidermy shop of Carl E. Akeley in Milwaukee. They were found at Hales Corners, about 18 miles from the city. About 1889 the Public Museum received from F. Miller part of an antler found four feet below the surface at Miller's Brewery in Wauwatosa.[4]

[1] Le Claire, A. *Wis. Hist. Soc. Colls.,* 11 (1888) 240. [2] Milwaukee *Sentinel,* April 18, 1857. [3] Hough, E. *Elk in Wisconsin. Forest and Stream,* 44 (1895) 369. [4] Ward, H. L. *The American elk in southern Wisconsin. Bull. Wis. Nat. Hist. Soc.,* 6 (1908) 146.

*Oneida.* Arthur A. Oehmcke, Wisconsin Conservation Department, has informed me of the discovery of elk antlers at the edge of a cedar swamp, Sec. 32, T38N, R4E, northwest of Willow Lake. In 1914 or 1915, Ed Wilson, a trapper, found an elk antler that is now in the possession of Charles Talbot who has a resort south of Willow Lake. Mr. Talbot, in 1921 or 1922, in the same swamp found "parts of three or four antler sets" that were so weathered as to crumble on handling.

*Outagamie.* On September 6, 1898, Charles Millard found part of an elk antler in the bank of the Embarrass River 3.5 feet below the surface of the ground.[1]

[1] New London *Press,* Sept. 8, 1898.

*Ozaukee.* Philip Schlegel, West Bend, has in his collection the basal half of an antler found in a swamp in Section 20, Town of Mequon. He stated that about 50 years ago some boys, while skating on the clear ice of one of the small lakes in the central part of the county, discovered a pair of antlers. The latter were taken to a saloon in Newburg.

*Pepin.* Statements on the abundance of elk along the Chippewa River by the early writers have been cited previously. A drove of elk in 1844 nearly capsized the canoe of Bunnell[1] in Buffalo Channel (Beef Slough). Later he killed one elk out of a drove of sixty.

[1] Bunnell, L. H. *Winona and its environs.* (1897) p. 54.

*Pierce.* Elk were quite common in the 1850's. In the winter of 1855–56, John McLaughlin, Town of Trimbelle, killed five elk that were sold for 7 to 10 cents per pound.[1] He is stated to have killed several elk the winter of 1856–57 while camped in the Rush River Valley, Town of El Paso.[2] In February, 1857, elk were stated to be "comparatively plenty" and that several were killed along the Trimbelle and Rush Rivers.[3] Wise saw many deer and elk tracks along the Rush River.[4]

A white oak was cut in 1866 four miles below Prescott that contained imbedded in it, eight feet from the ground, a pair of elk antlers.[5] The latter had a "spread of four feet from tip to tip."

[1] Prescott *Transcript,* Jan. 25, Feb. 8, 1856; Milwaukee *Sentinel,* Feb. 4, 1856. [2] Ellsworth *Herald,* April 5, 1882. [3] Prescott *Transcript,* Feb. 14, 1857. [4] Wise P. V. *A winter Excursion.* Madison *Patriot,* Jan. 8, 1857. [5] Prescott *Journal,* Feb. 3, 1866.

*Polk.* Elk were stated to be plentiful at Balsam Lake in 1855.[1] Excavation in a bed of marl near Osceola, yielded a few bones of elk and caribou.[2] It is not known if these were Recent.

[1] Hudson *Star,* July 11, 1855, 3. [2] Eddy, S. and Jenks, A. E. *Science,* 81 (1935) 535.

*Portage.* It is highly probable that the 'buck" weighing 573 pounds, shot in 1868, was an elk.[1]

[1] Stevens Point *Lumberman,* Jan. 10 1868.

*Price.* No definite record. There is an Elk Lake at Phillips draining through Elk River into the South Fork of the Flambeau. The origin of the name is unknown. It is stated on the editorial page of the Prairie du Chien *Courier* of June 11, 1878, that some "large elk" and bears were being killed on the Flambeau River near Butternut Lake. The editor had an article describing the Butternut area in the May 21 issue of this paper and did not mention elk among the game animals.

*Racine.* West[1] wrote in 1903 that elk antlers were found frequently in spring holes and marshes.

[1] West, G. A. *Wis. Archeol.,* 3 (1), (Oct., 1903) 7.

*Rock.* The winter of 1858–59, Jeremiah Dame, Town of Harmony, cut down a white oak 20 inches in diameter that contained an elk antler imbedded in it four to five feet from the ground.[1] A crew seining rough fish at the southern end of Lake Koshkonong in 1937 brought up a large pair of antlers between Thiebeau and Bingham Points.[2] A part of an elk antler found in a marsh on the Knutson farm near Orfordville in 1951 was identified by Prof. W. H. Burt, University of Michigan, as that of an elk.[3] I have been informed by Ray Roberts, Brooklyn, that about 1949 he found an antler in a marsh on his farm 1.5 miles east of Union, Town of Union.

[1] Janesville (d) *Gazette,* April 14, 1859. [2] *Wis. Cons. Bull.,* 2–3 (Dec.–Jan., 1937–38) 68. [3] Milwaukee *Journal,* Sept. 16, 1951.

*Saint Croix.* Elk were stated to be plentiful on the St. Croix River in 1850[1] and in the environs of Hudson in 1855.[2] In the late fall of 1866, J. Hurd and Elias Grimes, Town of Richmond, came upon a drove of 12 elk in the "Big Woods" in the eastern part of the county. Of this drove nine were killed and two were wounded.[3] The hunters remarked on the ease with which the elk were killed. Hallock[4] listed elk among the game of the county in 1877. This was probably incorrect.

[1] Milwaukee (d) *Wisconsin,* April 15, 1850. [2] Hudson *Star,* Aug. 8, 1855, 3. [3] Hudson *Star and Times,* Dec. 5, 1866. [4] Hallock, C. *The sportsman's gazetteer.* (1877) p. 177.

*Sauk.* The elk antler embedded in a white oak has been previously described.[1] Canfield[2] came to the county in 1842 and followed its natural history closely. He states that only one or two elk were killed by white men. T. J. Morgans[3] settled in the Town of Franklin in 1848, Section 32, where he saw an elk killed. Dr. F. D. Hulburt, Reedsburg, has stated that the Indians killed a bull elk in the Town of Washington in 1850, at which time elk were scarce in Wisconsin.[4] According to Cole,[5] the last elk was killed by John Cooper in the Town of Franklin in 1854. Elk antlers were found quite frequently by the early settlers.[6] The so-called deer effigy in the Town of Troy, with its backward sweep of the antlers, is far more suggestive of an elk.[7]

[1] Baraboo *Republic,* Jan. 31, 1857, 2. [2] Canfield, W. H. *A catalogue of the indigenous animals of Sauk County.* (1870) p. 39. [3] T. J. Morgans. *Seventh annual meet-*

*ing of the Sauk County old settlers' association.* Aug. 22, 1878, p. 7. [4] Baraboo *News,* Oct. 29, 1921. [5] Cole, H. E. *A standard history of Sauk County, Wisconsin.* Chicago, Vol. 1 (1918) p. 104. [6] Cole, H. E. *Wis. Archeol.* n.s. 1 (3), (Aug., 1922) 84. [7] Stout, A. B. *Wis. Archeol.,* 5 (2), (Jan.–April, 1906) 253.

*Sawyer.* On July 28, 1953, Ernest Swift, Director of the Wisconsin Conservation Department, wrote to me that about 1905 Peter Larson found an elk antler in Mosquito Brook, about three miles northeast of Hayward.

*Sheboygan.* In 1901 William Schwartz sent to the Milwaukee Public Museum a large pair of antlers found in Elkhart Lake about 32 years previously.[1] William Kuhlmey an old resident of the Town of Plymouth, had elk antlers in his collections.[2] The bones of "bear, elk and deer" have been found at the Indian village sites on the shore of Lake Michigan south of the mouth of the Black River, Town of Wilson.[3] The Potawatomi, Simon Kaquados, stated that formerly there were many elk at Elkhart Lake.[4]

[1] Plymouth *Review,* Nov. 13, 1901. [2] *Ibid.,* Dec. 4, 1901. [3] Gerend, A. *Wis. Archeol.,* 1 (3), (April, 1902) 15. [4] Lawson, P. V. *Ibid.,* 19 (2), (April, 1920) 69.

*Trempealeau.* "Elk were found in great abundance along the whole length of the Trempealeau River."[1] Eight elk were killed January 2 and 3, 1858, along the Buffalo River in the northern part of the county.[2] In 1862 one elk was killed out of a drove of ten in the northern part of the county.[3] Pursuit of the others was abandoned on account of a severe storm.

[1] Randall, T. E. *Early history.* Black River Falls *Banner,* Feb. 10, 1869; *cf.* L. H. Bunnell, *l. c.* [2] Eau Claire *Free Press,* Dec. 2, 1858. [3] Galesville *Transcript,* Jan. 31, 1862.

*Vernon.* A hunting party in the spring of 1850 killed an elk at the head of the Bad Axe River.[1] Ole Espe, Viroqua, has written to me that about 1920 he found an elk antler in a stream near Viroqua, Town of Jefferson.

[1] *North-western Wisconsin.* Madison *Argus,* June 18, 1850.

*Walworth.* Elkhorn is stated to have derived its name from the finding of a pair of elk antlers in a tree in 1836 by Col. Samuel Phoenix of Delavan.[1] A pair embedded in a bur oak in the Town of Spring Prairie was also found in 1857.[2] E. B. Warner found a pair of antlers in 1876 in a spring on his place about five miles south of Whitewater.[3] A pair of antlers found in an Indian burial at Fontana was contributed to the Geneva Lake Historical Society.[4] The elk teeth found in a similar grave at Lake Geneva were evidently part of a necklace.[5]

Hollister wrote in 1908 that sections of antlers were still found occasionally in the county, frequently in marshy ground, and that a fine pair was recovered from Delavan Lake a few years previously.[6] A pair was also found in this lake in 1939 by a state crew in removing rough fish.

[1] Elkhorn *Independent*, June 23, 1932. [2] Madison *Patriot*, Oct. 10, 1857. [3] Delavan *Republican*, Aug. 11, 1876. [4] Walworth *Times*, Oct. 3, 1929, 1. [5] Brown, C. E. and Brown, T. T. *Wis. Archeol.* n.s. 7 (3), (April, 1928) 148. [6] Hollister, N. *Notes on Wisconsin mammals. Bull. Wis. Nat. Hist. Soc.*, 6 (1908) 137.

*Washington.* An antler was found near Hartford in 1855.[1] T. Baldwin made an unpublished archeological report (Hist. Soc. of Wis.) in which he stated that an elk antler was removed in 1936 from Green Lake, Town of Farmington. Philip Schlegel, West Bend, has a large collection of horns and antlers. He has the basal end, 13 inches in length, of an antler found on the surface of a swamp, Section 19, Town of Trenton; also a fragment 10.5 inches in length, with skull containing teeth attached, found in a spring hole on Gov. Phillips Farm, Town of Hartford. Other finds to his knowledge are: a set of antlers from Silver Lake, Town of West Bend; a set from Big Cedar Lake, Town of West Bend; and two sets from the Town of Hartford, one being found in Pike Lake, and the other in a swamp on the edge of Pike Lake.

[1] Milwaukee *Democrat,* May 1, 1855, 3.

*Waukesha.* The Milwaukee Public Museum has a set of antlers plowed up on the farm of Frank Clark in the Town of Pewaukee.[1] Walter C. Pelzer has sent me a photograph of a splendid set of antlers, attached to the skull, found in a spring hole on the Ryan Farms, Route 1, Pewaukee, the summer of 1953. Some bones were found also. Dr. Frank W. Lehmann has written to me that about fifty years ago William Marquandt found the entire skeleton of an elk in Lake Keesus, Town of Merton.

[1] Ward, H. L. *The American elk in southern Wisconsin. Bull. Wis. Nat. Hist. Soc.*, 6 (1908) 145–46.

*Waupaca.* On January 12, 1941, Guy Mumbrue, Waupaca, wrote to me that his father was a persistent hunter. About 1870 his dog routed an elk with a "big spread of horns" from a swamp five miles northeast of Pine River, Town of Dayton. The animal may have been in Waushara County. He failed to get a shot. He also stated that in the 1850's, N. W. Nourse, an old hunter saw a large bull elk on a large, nearly bald hill, about eight miles south of Waupaca.

*Waushara.* Mrs. F. N. Hamerstrom has informed me that Frank Ingalls, who lives on the Roche-a-cri River, southwest of Plainfield, has a pair of elk antlers that he found in this stream.

H. J. Kent has described two fragments of antlers found in a marl deposit at Spring Lake, Town of Marion, that he considered "fossilized".[1] The University has from this deposit a cervical vertebra, UMZ 14,435, identified by Dr. D. Dwight Davis, Chicago Natural History Museum, as from a *Cervus,* probably *canadensis.* According to Kent, "other large fossils" found by Dana Spees in a marl pit west of Wautoma crumbled soon after exposure.

[1] Kent, H. J. *Fossilized antlers on display at Argus.* Wautoma *Argus,* April 29, 1943.

*Winnebago.* In 1887, George Cross, a farmer living on Ball Prairie, presented Mayor Dale of Oshkosh, a pair of elk antlers found about thirty years previously and about twelve miles from the city.[1]

The Oshkosh Museum has several whole antlers and fragments which I inspected in 1942. At that time A. P. Kannenberg of the Museum, and George Overton, Lake Butte des Morts, considered remains of elk common, particularly at Indian camp sites.

Part of an antler was found at Lasley Point on the eastern shore of Lake Winneconne, Town of Winneconne, during archeological excavations.[2] Other finds have been recorded.[3] During excavation of the burials at the Reigh site on Lake Butte des Morts, T18N, R16E, Section 7, a project of the Archeological Survey, two axes made of elk antlers were found July 15 and 19, 1953. The site has been identified as Glacial Kame culture, about 1000 A.D. This type of artifact was previously unknown for Wisconsin. Mary Jane Overton, Route 4, Oshkosh, has fragments of two elk antlers found by her father, George Overton, in a refuse pit, 30 inches deep, in a gravel pit, T19N, R15E, NW¼ Section 3, in 1925. There were ashes and charcoal at the bottom of the pit.

[1] Oshkosh (w) *Northwestern,* Sept. 15, 1887. [2] Bullock, H. R. *Wis. Archeol.,* 23 (2), (June, 1942) 40. [3] Kannenberg, A. P. *Wis. Archeol.,* 18 (2), (Jan., 1938) 49; Overton, G. *Ibid.,* n.s. 11 (3), (April, 1932), 115 and 11 (4), (July, 1932) 158.

*Wood.* The statement made in 1875 that elk had been discovered in the county is probably an error.[1]

[1] Milwaukee *Commercial Times,* Sept. 28, 1875, 2.

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# THE EFFECTS OF GAPEWORM DISEASE IN PHEASANTS[1,2]

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## INTRODUCTION

The gapeworm, *Syngamus trachea* (Montague, 1811) V. Siebold, 1836, has been studied in chickens, turkeys, and pheasants, as well as many other species of birds. Megnin (1881) and Ortlepp (1923) described the development of the gapeworm eggs, early larval stages, and adults in pheasants and chickens, respectively. Wehr (1937a) redescribed the early stages and found that the larva moulted twice, making the infective stage a third-stage larva· Olivier (1943) reported on the resistance of chickens, turkeys, and ring-necked pheasants to the gapeworm. Nodules produced as a host reaction to gapeworms in the trachea of pheasants and in turkeys have been described grossly and histopathologically by Clapham (1935) and by Wehr (1937b) respectively. Gross abnormal changes in the lung were noticed by Morgan and Clapham (1934) in one chick five days after infection in their work on gapeworms. Other researches on the gapeworm of poultry have been concerned mainly with its transmission from one species of bird to another, and its relationship to the earthworm which can serve as an intermediate host. Few papers have dealt with the effects of the parasite on the host itself. In order to fill some of the gaps in our knowledge on this latter phase of the problem, the following researches were undertaken.

## MATERIALS AND METHODS

All experimental birds were ring-necked pheasants raised on the Wisconsin State Game and Fur Farm, according to the procedure described in the Wisconsin Conservation Department

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[3] Now at University of Wisconsin Extension Center, Green Bay, Wisconsin.

[4] The authors wish to acknowledge the cooperation and assistance of the supervisor, game managers, biological aids: Dr. Wm. Ozburn, Messrs. Barger and Rinzel, Messrs. Fuller and Grunkie and the many workmen at the Poynette Game Farm.

Bulletin, "Pheasant Propagation." The procedure involved taking one-day old pheasants and placing them in brooder houses which held approximately 75 pheasants. They were kept in brooder houses and adjacent raised wire porches for periods of several days to one week. Pheasants to be used for controlled experiments were transferred when one week old to wire mesh pens that were one foot off the ground. They had no contact with the ground, nor any means of coming in contact with gapeworm eggs, larvae, or the intermediate hosts in the ground.

Gapeworm eggs which were to be used to infect pheasants were teased from the uteri of female gapeworms and placed in uncovered Petri dishes with 10 cc. of water; the cultures were kept in a relative humidity of 100% at room temperature. The cultures eventually contained infective larvae as well as embryonated eggs. When needed the eggs and larvae were mixed with a known amount of water, shaken, and measured amounts were administered directly into the crops of experimental pheasants with a pipette.

Pheasants were killed by a blow on the head in the occipital region. This method kept the lungs and trachea intact and there was no hemorrhaging in the region of the lungs. The pheasants were opened carefully and the sternum, the heart, the liver, and the esophagus were removed, leaving the lungs and trachea exposed. These then were removed intact for observation. Pieces of lung and trachea for histological studies were fixed in buffered calcium formal solution and a vacuum was applied briefly to replace air in the lungs with the fixative. Sections were cut from 6 to 10 $\mu$ and were stained in Harris' haematoxylin and eosin.

Measurements of female gapeworms were made by placing them on the scale of a flat millimeter ruler.

## Experimental Data

*Experiment 1.* The first experiment was performed to establish the number of days after an initial infection before gapeworms migrated into the trachea and before egg production began. Each of nine parasite-free pheasants, eight weeks old, was fed an equal but undetermined number of gapeworm eggs and larvae. These pheasants were sacrificed and examined at various intervals after exposure. Data concerning the times the pheasants were examined, the numbers of paired worms, the sizes of the female worms, the presence of a verminous pneumonia, and the presence of inflammatory nodules in the trachea are given in Table 1.

## TABLE 1

DATA ON THE LIFE CYCLE OF GAPEWORMS IN PHEASANTS (EXPERIMENT 1)

| Number of Pheasant | Duration of Infection in Days | Location of Gapeworms | Numbers of Paired Gapeworms | Sizes of Female Gapeworms | Presence of Gapeworm Eggs | Presence of Verminous Pneumonia | Presence of Nodules in Trachea |
|---|---|---|---|---|---|---|---|
| 1 | 6 | Lungs | ... | ... | ... | Present | ... |
| 2 | 8 | Lungs | ... | ... | ... | Present | ... |
| 3 | 9 | Trachea | 1 | 6 mm | None | Present | None |
| 4 | 13 | Trachea | 3 | 10 mm | None | Present | None |
| 5 | 15 | Trachea | 9 | 10–12 mm | Present (1) | Present | Present (2) |
| 6 | 16 | Trachea | 9 | 12–15 mm | Present | Present | Present (2) |
| 7 | 21 | Trachea | (3) | ... | Present | Absent | Present |
| 8 | 21 | Trachea | (3) | ... | Present | Absent | Present |
| 9 | 21 | Trachea | (3) | ... | Present | Absent | Present |

(1) Eggs beginning to form, 3 in 8-cell stage.
(2) Nodules small but grossly visible.
(3) Present but numbers and sizes unrecorded.

The results in Table 1 show that the first pheasant to have gapeworms in the trachea was one autopsied nine days after exposure, and that every pheasant autopsied after the ninth day had paired gapeworms in the trachea. Eggs in the eight-cell stage were present in all female worms 16 days after infection, whereas only one worm of the nine found in the pheasant examined 15 days after infection had eggs in the eight-cell stage. A verminous pneumonia was visible grossly in infections six to 16 days old, and nodules were found in the tracheae of those pheasants examined 15, 16, and 21 days after exposure. The small nodules found in pheasants examined 15 and 16 days after infection were visible only on the inside of the tracheae. Those present in pheasants examined 21 days after infection were large and could be seen on the outside as well as on the inside of the tracheae. Histological sections of these nodules showed that the male gapeworms had penetrated through the cartilage, and that there was considerable areolar connective tissue with an infiltration of lymphocytes in the nodular area on the outside of the trachea (Figure 7). In some sections the cartilage around the opening through which the male passed had proliferated forming a ridge around the worm.

*Experiment 2.* This experiment was performed to collect additional data on the migration of gapeworms and the time egg production began after exposure. In addition it was performed to determine the duration of the infection, the times at which a verminous pneumonia could be observed, and to observe the formation of nodules around the heads of the male worms in the tracheae of infected pheasants. Each of 26 parasite-free pheasants 22 days old, was fed a mixture of approximately 200 gapeworm eggs and larvae. The pheasants were sacrificed and examined at intervals ranging from six hours to 47 days after exposure. Data concerning the age of the infection at the time that the pheasant was autopsied, the number of pairs of worms found in the trachea, the sizes of the female worms, the presence of a verminous pneumonia, and the presence of inflammatory nodules in the trachea of each pheasant are shown in Table 2.

The results presented in Table 2 shows that the first worms were found in the trachea nine days after exposure, and that all of the pheasants examined thereafter either had worms in the trachea or inflammatory nodules indicating that the worms had been in the trachea. Third-stage larvae were found in the lungs of pheasants examined 36 hours and four days after exposure. Paired gapeworms were found in the lungs six, seven, and eight days after exposure. The pheasant examined 27 days after exposure and those examined on or after the thirty-sixth day of infec-

TABLE 2

DATA ON THE LIFE CYCLE OF GAPEWORMS IN PHEASANTS (EXPERIMENT 2)

| Number of Pheasant | Duration of Infection | Location of Gapeworms | Numbers of Paired Gapeworms | Sizes of Female Gapeworm | Presence of Gapeworm Eggs | Presence of Verminous Pneumonia | Presence of Nodules in Trachea |
|---|---|---|---|---|---|---|---|
| 1 | 6 hrs. | ... | ... | ... | ... | None | ... |
| 2 | 12 hrs. | ... | ... | ... | ... | None | ... |
| 3 | 22 hrs. | ... | ... | ... | ... | None | ... |
| 4 | 36 hrs. | Lungs | ... | ... | ... | None | ... |
| 5 | 48 hrs. | Lungs | ... | ... | ... | Present | ... |
| 6 | 3 days | ... | ... | ... | ... | None | ... |
| 7 | 4 days | Lungs | ... | ... | ... | None | ... |
| 8 | 5 days | ... | ... | ... | ... | Present | ... |
| 9 | 6 days | Lungs | ... | ... | ... | Present | ... |
| 10 | 7 days | Lungs | ... | ... | ... | Present | ... |
| 11 | 8 days | Lung | ... | ... | ... | Present | ... |
| 12 | 9 days | Trachea | 28 | 6 mm | None | Present | None |
| 13 | 10 days | Trachea | 4 | 7–8 mm | None | Present | None |
| 14 | 13 days | Trachea | 10 | 8–10 mm | None | Present | None |
| 15 | 15 days | Trachea | 8 | 10 mm | None (1) | Present | None |
| 16 | 17 days | Trachea | 5 | 10–15 mm | Present | Present | Present |
| 17 | 21 days | Trachea | 20 | 9–15 mm | Present | Present | Present |
| 18 | 24 days | Trachea | 8 | 17–20 mm | Present | None | None |
| 19 | 27 days | Trachea | 8 | 13–17 mm | Present | None | 11 present |
| 20 | 31 days | Trachea | 5 | 19–22 mm | Present | None (2) | 9 present |
| 21 | 36 days | Trachea | ... | ... | Present | None | 5 present (3) |
| 22 | 41 days | Trachea | 3 | 20 mm | Present | None | 6 present |
| 23 | 44 days | Trachea | 2 | ... | Present | None | 5 present (4) |
| 24 | 47 days | ... | ... | ... | ... | None | 6 present (5) |
| 25 | 47 days | ... | ... | ... | ... | None | 11 present (6) |
| 26 | 47 days | Trachea | 1 | 32 mm | Present | None | 7 present |

(1) Eggs in four-cell stage in uterus.
(2) Portion of lung necrotic.
(3) 3 nodules without worms, 1 with living male, 1 with living male and dead female attached.
(4) 3 nodules without worms, 2 with dead male worms.
(5) 2 well developed nodules, 4 cartilage rings.
(6) 2 nodules without worms, 1 nodule with living male, 8 cartilage rings.

tion had more nodules than worms in the tracheae, indicating a loss of worms in these older infections.

Eggs in the eight-cell stage were present in all worms examined 17 days after exposure. Some eggs in the four-cell stage were found in the uteri of the female gapeworms from the pheasant examined 15 days after exposure.

Coughing became evident in almost every experimental pheasant seven days after exposure to gapeworm eggs and larvae. Rales could be heard with a stethescope as early as six days after infection.

A verminous pneumonia was observed grossly in all pheasants autopsied five to 21 days after exposure, but pheasant 5 had hemorrhagic areas of a dark brown color which varied in diameter from 2 to 5 mm. and extended a few millimeters into the lung tissue two days after exposure. Histopathological changes were evident as early as two days and as late as 36 days after exposure. Sections from pheasants examined 48 and 96 hours after exposure showed a marked hyperemia with slight lymphocyte infiltration and a general edema. An exudate was found in several of the parabronchi. Six days after infection there was a very noticeable increase in exudate in both major and minor air passages. In some areas of lung, the air capillaries were completely filled with exudate containing lymphocytes, and where this occurred there was a hyaline change in the walls of the small blood vessels. The first eosinophilic granulocytes were found in lesions at this time. The greatest changes were found in sections obtained seven and eight days after exposure at which time small paired gapeworms were apparently moving towards the bronchi. Sections from both seven- and eight-day infections showed a high degree of inflammation with eosinophilic granulocytes in and around the edges of compact masses of lymphocytes. Multinucleate giant cells were found with the lymphocytes. There was a general edema, increase in mononuclear phagocytes, a change in the walls of small blood vessels, and air capillaries were filled almost completely with exudate leaving very little respiratory surface. Figure 1 shows these conditions. Old hemorrhages in which red blood cells were hemolysed and had pyknotic nuclei and were surrounded by a connective tissue wall were found in the parabronchi. Paired gapeworms were found in the parabronchi near the edges of highly inflamed areas in the lungs. Figure 2 shows an immature gapeworm in the lungs eight days after exposure.

Sections of lung taken from pheasants after the worms had migrated from the lung to the trachea showed a gradual healing. On the thirteenth day after exposure sections showed many eosinophilic granulocytes in areas where the exudate was breaking up. The lymphocytes were less numerous than before, but the areas of lymphoid tissues in the lungs were much larger than normal. On the fifteenth day after exposure there were still large numbers of eosinophilic granulocytes within the exudate, and the larger air capillaries were partially open. On the twenty-first, twenty-seventh, and thirty-first day following single exposure, the lungs became progressively more nearly normal. Some areas containing exudate including eosinophilic granulocytes still existed, however, and although many of the smaller air spaces were open some large areas of lymphoid tissue remained as shown in Figure 3. By the thirty-sixth day after exposure the lungs were normal with the exception of a few places containing exudate.

Nodules were present in all but pheasant 18, after the infections were 17 days or older. Those nodules in pheasants examined 17 days after exposure were small but visible on the mucosa of the trachea. In pheasants examined after that time the nodules were visible on the mucosal and serosal surfaces of the tracheae but the predominate part of the nodule was on the serosa. The heads of the male worms were found to project several millimeters into them. Histological sections of tracheae showed that on the thirteenth day after infection the head of the male worm pressed against the inside of the tracheal cartilage and was embedded in lymphocytes. At this time the perichondrium in the region of the buccal capsule had disintegrated, and the cartilage had an indented ring on it (Figure 6). The tracheal epithelium had undergone metaplasia from its normal pseudostratified glandular type to a stratified squamous type of epithelium in the region of the nodule. Not only was the area around the head of the male infiltrated with lymphocytes, but the whole trachea had lymphocytes in the mucosa. As yet there was no areolar connective tissue, no eosinophilic granulocytes, nor any inflammation on the outside of the trachea. Characteristics observed in sections of a nodule with the head of a male gapeworm from a 44-day old infection showed characteristics similar to those described in Experiment 1, 21 days after exposure, but this nodule was filled with eosinophilic granulocytes and was purulant. Proliferation of cartilage was evident around the openings through the tracheal cartilage made by the male worms. Zones of necrotic acidophilic tissue surrounded the heads of the male gapeworms and also was found in the buccal capsules of the males. Sections showed that though the head of the female worm was never embedded in the trachea, the mucosa of the trachea was found extending into the buccal capsule and the epithelial lining of the trachea in that area was absent.

PLATE I

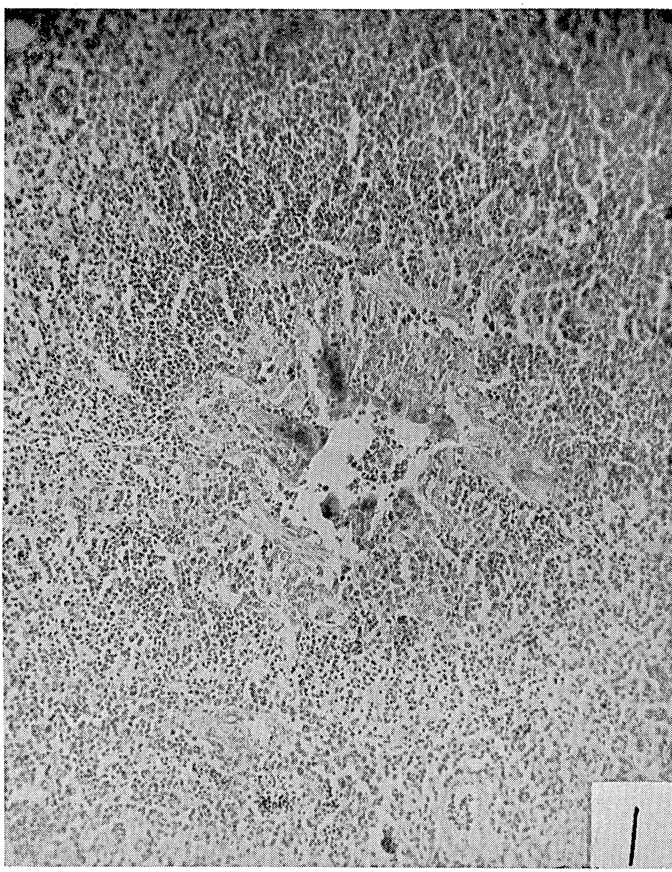


FIGURE 1. A portion of pheasant lung showing exudate and inflammatory products eight days after infection with gapeworms.

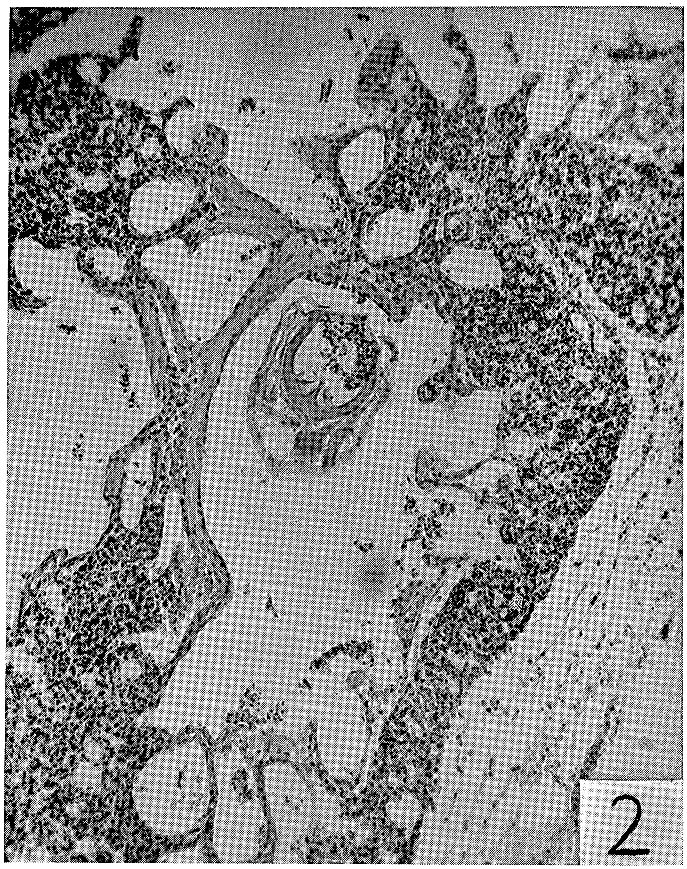


FIGURE 2. A portion of pheasant lung showing the head of a gapeworm in a parabronchus eight days after infection.

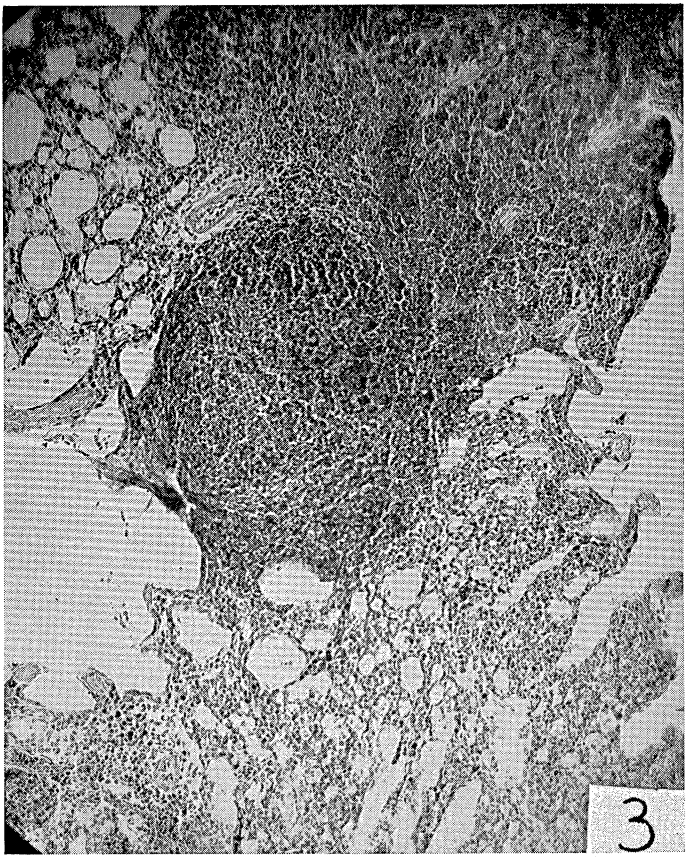



FIGURE 3. A portion of pheasant lung with an enlarged area of lymphoid tissue 27 days after infection with gapeworms.


FIGURE 4. A portion of lung showing a caseous cyst with an entrapped larva from a pheasant with three infections five, 14, and 23 days old.

PLATE II


FIGURE 5. A portion of lung showing an old hemorrhage in a parabronchus from a pheasant with two infections 11 and 48 days old.

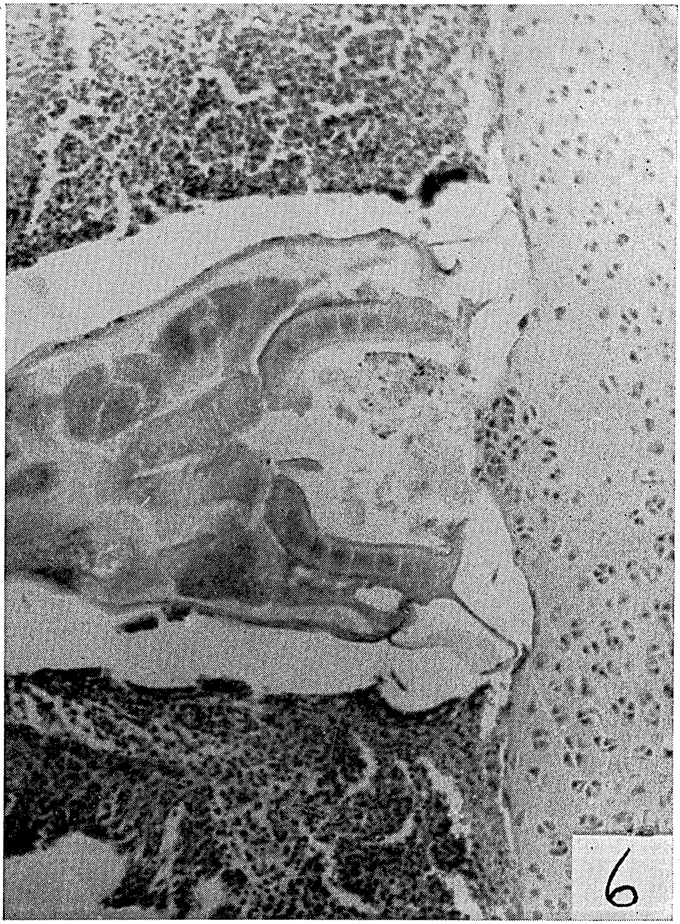



FIGURE 6. A portion of trachea showing the head of a male gapeworm penetrating a tracheal cartilage 13 days after infection.


FIGURE 7. A section of trachea showing part of a male gapeworm 22 days after infection. Note that the male has penetrated through to the outside of the trachea.

*Experiment 3.* This experiment was performed to get data on the migration of the third-stage larvae from the time of exposure until they entered the lung. Two parasite-free pheasants, 45 days old, were used. Pheasant 1 was exposed to two inoculations each of 750 gapeworm eggs and larvae, the exposures being given three hours apart. This pheasant was autopsied when the infections were two and five hours old respectively. No larvae were found in portions of heart, liver, and lung of this pheasant. Pheasant 2 was given three exposures each with 750 gapeworm eggs and larvae at six-hour intervals. This pheasant was autopsied when infections were 12, 18, and 24 hours old, respectively. Motile third-stage larvae were found in teased liver, heart, and lungs from this bird.

*Experiment 4.* The fact that two distinct sizes of gapeworms were found in the trachea of many naturally infected pheasants taken from rearing pens, indicated that these pheasants had been infected more than once. The males of the larger pairs of worms were embedded in well-developed nodules and the females were producing eggs while the males of the smaller pairs were not embedded and the females were not producing eggs. It seems evident therefore that the smaller worms were younger and that pheasants may harbor gapeworms from two separate infections. This experiment was performed to obtain data on double and triple infections. It was divided into three parts. In the first part each of five parasite-free pheasants, numbers 1 to 5, 35 days of age, was exposed to a mixture of approximately 200 gapeworm eggs and larvae. On the ninth day after the first exposure they were re-exposed to a second mixture of approximately 200 gapeworm eggs and larvae. They were sacrificed and examined at various intervals after the second exposure as indicated in Table 3. From the sizes of the worms present at autopsy it was concluded that in all cases gapeworms developed as a result of the second exposure. In no case were the lesions resulting from the two infections more serious than those produced by an equal number of worms resulting from a single infection. In the second part of this experiment, each of five parasite-free pheasants, numbers 6 to 10, 35 days old, was exposed to a mixture of approximately 200 gapeworm eggs and larvae; then, nine days later they were exposed to approximately 200 gapeworm eggs and larvae. Nine days after this second exposure each was again given approximately 200 gapeworm eggs and larvae as a third exposure. The results on Table 3 show that the pheasants with three exposures all appeared to have worms from the second exposure. The third exposure manifested itself only as fourth-stage larvae in the lung of pheasant 7 and as a small pair of

TABLE 3

DATA ON THE REINFECTION OF PHEASANTS WITH GAPEWORMS (EXPERIMENT 4)

| Number of Pheasant | Durations of Infection in Days | Location of Gapeworms | Numbers of Paired Gapeworms in Trachea | Sizes of Female Gapeworms in mm. | Presence of Gapeworm Eggs | Presence of Verminous Pneumonia | Presence of Nodules in Trachea |
|---|---|---|---|---|---|---|---|
| Pheasants with double infections nine days apart | | | | | | | |
| 1 | 2 | Lung | ........ | ........ | ........ | ........ | ........ |
| | 11 | Trachea | 1 | 11 | Absent | Present | None |
| 2* | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 3 | 6 | Lung | ........ | ........ | ........ | Present | ........ |
| | 15 | ........ | ........ | ........ | ........ | | ........ |
| 4 | 10 | Trachea | 2 | 6–8 | Absent | Present | Absent |
| | 19 | Trachea | 5 | 12–13 | Present | | 2 present |
| 5 | 15 | Trachea | 21 | 9–12 | Absent | Present | Absent |
| | 24 | Trachea | 7 | 13–15 | Present | | 5 present |
| Pheasants with three infections nine days apart | | | | | | | |
| 6 | 3 | ........ | ........ | ........ | ........ | Present | ........ |
| | 12 | Trachea | 3 | 10–12 | Absent | | Absent |
| | 21 | Trachea | 2 | 15–17 | Present | | 5 present |
| 7 | 5 | Lung | ........ | ........ | ........ | Present | ........ |
| | 14 | Trachea | 3 | 12–13 | Absent | | Absent |
| | 23 | Trachea | 6 | 15–17 | Present | | 7 present |
| 8 | 10 | ........ | ........ | ........ | ........ | Present | ........ |
| | 19 | Trachea | 10 | 15–17 | Present | | ........ |
| | 28 | Trachea | 7 | 21–23 | Present | | 7 present |
| 9 | 14 | ........ | ........ | ........ | ........ | Present | ........ |
| | 23 | Trachea | 2 | 17 | Present | | 4 present |
| | 32 | ........ | ........ | ........ | ........ | | ........ |

TABLE 3—*(Continued)*

DATA ON THE REINFECTION OF PHEASANTS WITH GAPEWORMS (EXPERIMENT 4)

| Number of Pheasant | Durations of Infection in Days | Location of Gapeworms | Numbers of Paired Gapeworms in Trachea | Sizes of Female Gapeworms in mm. | Presence of Gapeworm Eggs | Presence of Verminous Pneumonia | Presence of Nodules in Trachea |
|---|---|---|---|---|---|---|---|
| 10 | 14 | Trachea | 1 | 15 | Absent | Absent | ... |
| | 23 | Trachea | 2 | 20 | Present | | 6 present |
| | 32 | ... | ... | ... | ... | | |
| Pheasants with two infections eighteen days apart | | | | | | | |
| 11 | 3 | ... | ... | ... | ... | Present | ... |
| | 21 | Trachea | 3 | 13–18 | Present | | 3 present |
| 12 | 5 | ... | ... | ... | ... | Present | ... |
| | 23 | Trachea | 1 | 20 | Present | | ... |
| 13 | 10 | Trachea | 25 | 7–8 | Absent | Present | Absent |
| | 28 | Trachea | 3 | 20 | Present | | 3 present |
| 14 | 14 | Trachea | 3 | 13–15 | Absent | Absent | 2 present |
| | 32 | Trachea | 2 | 20–23 | Present | | 4 present |
| 15 | 20 | ... | ... | ... | ... | Absent | 2 present |
| | 38 | ... | ... | ... | ... | | |
| 16 | 20 | ... | ... | ... | ... | Absent | 2 present |
| | 38 | ... | ... | ... | ... | | |
| 17 | 20 | ... | ... | ... | ... | Absent | 1 present |
| | 38 | ... | ... | ... | ... | | |
| 18 | 20 | Trachea | 13 | 12 | Present | ... | ... |

gapeworms in the trachea of pheasant 10. The initial infection was present in pheasants 6, 7, and 8, examined 21, 23, and 28 days after exposure respectively, but it was apparently expelled before the thirty-second day, since it was not present in pheasants 9 and 10 which were examined when the initial infection was 32 days old. Sections of lung from pheasant 7 with infections five, 14, and 23 days old showed exudative areas with large numbers of eosinophilic granulocytes and lymphocytes in the air capillaries. In an area of inflammatory products and in the cavity of a parabronchus, there was a caseous cyst containing a degenerated larva from the first or second exposure (Figure 4).

In the third part of Experiment 4, each of 7-parasite-free pheasants, numbers 11 to 17, 35 days old, was exposed to a mixture of approximately 200 gapeworm eggs and larvae. Eighteen days later they were re-exposed to a second mixture of approximately 200 gapeworm eggs and larvae. These pheasants were autopsied at the intervals shown on Table 3. The results show that a second infection developed as in pheasants 13 and 14. Pheasant 14 examined when the first infection was 32 days old, had four nodules in the trachea but only one pair of worms from this exposure, indicating that the greater proportion of worms was lost before this time. The second infection which was 14 days old at this time, was represented by three worms with two large nodules associated with them. These large nodules were thought to be indicative of an increased response by the host because of a previous infection for in single infections nodules did not become visible until the fifteenth to eighteenth day after exposure. No worms were found in pheasants 15, 16, or 17, which were examined 38 days after the first exposure and 20 days after the second. However, each of these birds had nodules in the trachea indicating that worms from at least one if not both exposures had established themselves, and that the worms had been expelled from the trachea earlier than they would have been if the pheasants had had only single exposure. The lung of pheasant 11 was sectioned and showed exudative changes with large numbers of eosinophilic granulocytes in the smaller air spaces and enlarged collections of lymphoid tissue. The appearance of this lung was similar to the appearance of those in repair previously described in Experiment 2. These changes were presumably from first exposure since the second exposure was only three days old at the time of autopsy. The 48-day old pheasant (No. 18 Table 3) which was given 200 eggs and larvae from the same culture and at the same time as pheasants 6–17 to test the viability of the eggs, harbored 13 pairs of gapeworms 20 days after exposure.

*Experiment 5.* The preceding experiment in which the second exposure was given nine or 18 days after the initial exposure showed that double infections occurred in pheasants. This experiment was performed to see if a second infection derived from a moderate number of eggs and larvae in a second exposure would develop in pheasants that already had comparatively old infections. Two of four parasite-free pheasants, (1 and 2) three weeks old, were exposed to a mixture of approximately 200 gapeworm eggs and larvae. Thirty-seven days later each was given a second exposure to 200 gapeworm eggs and larvae. At this time one large female gapeworm could be seen near the glottis in one of the pheasants but the other appeared to have lost its infection. The two previously uninfected pheasants, 3 and 4, 57 days old, were exposed to a mixture of approximately 200 gapeworm eggs and larvae from the same culture and at the same time the second exposures were given to pheasants 1 and 2. All pheasants were examined 11 days after the last exposure.

When pheasant 1 was examined 48 days after the first and 11 days after the second exposure, no gapeworms were present in the trachea, but six nodules from the first infection were present; the lungs showed a severe verminous pneumonia. Sections of this lung showed encapsulated hemorrhages with necrotic centers, and an extreme inflammation evidenced by exudative areas with large numbers of lymphocytes and eosinophilic granulocytes (Figure 5). Almost every atrium and its subdivisions in the midregion of the lungs were filled with inflammatory products. These conditions were evidently caused by an infection from the second exposure since the changes in the lung brought about by the first exposure should have been repaired by this time. There were no small gapeworms in the trachea, thus it was concluded that gapeworms from the second exposure apparently had reached the lung but had failed to establish themselves in the trachea. Pheasant 2 was examined also when the first exposure was 48 days old and the second exposure was 11 days old. Five pairs of gapeworms were present in the bronchi; the female worms measured 7 to 8 mm. in length. This was the only case in all of the naturally or experimentally infected pheasants that were examined where paired gapeworms had established themselves in the bronchi. Six nodules were present in the trachea, presumably from the first infection. One dead pair of gapeworms was associated with one of these nodules and one dead male was associated with another. Four nodules were vacant. A severe verminous pneumonia was present and small white nodules were found throughout the lung. Pheasants 3 and 4 were examined when their infections were 11 days old. They had 35 and 46 pairs of gapeworms, respectively; the females in the trachea measured 8 to 9 mm. in length. These data indicated that pheasants were difficult to infect 37 days after a small preceding infection.

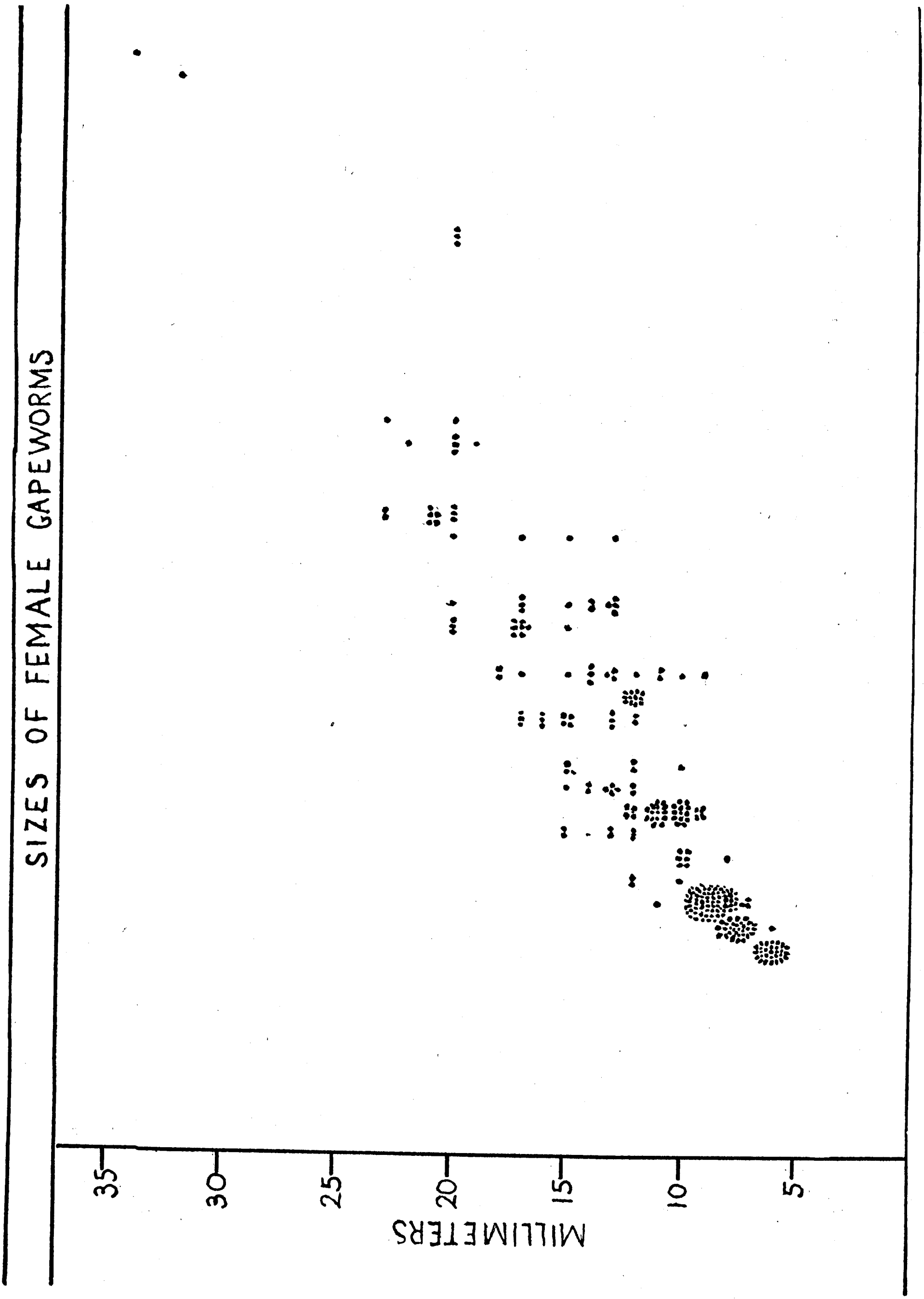
## Discussion

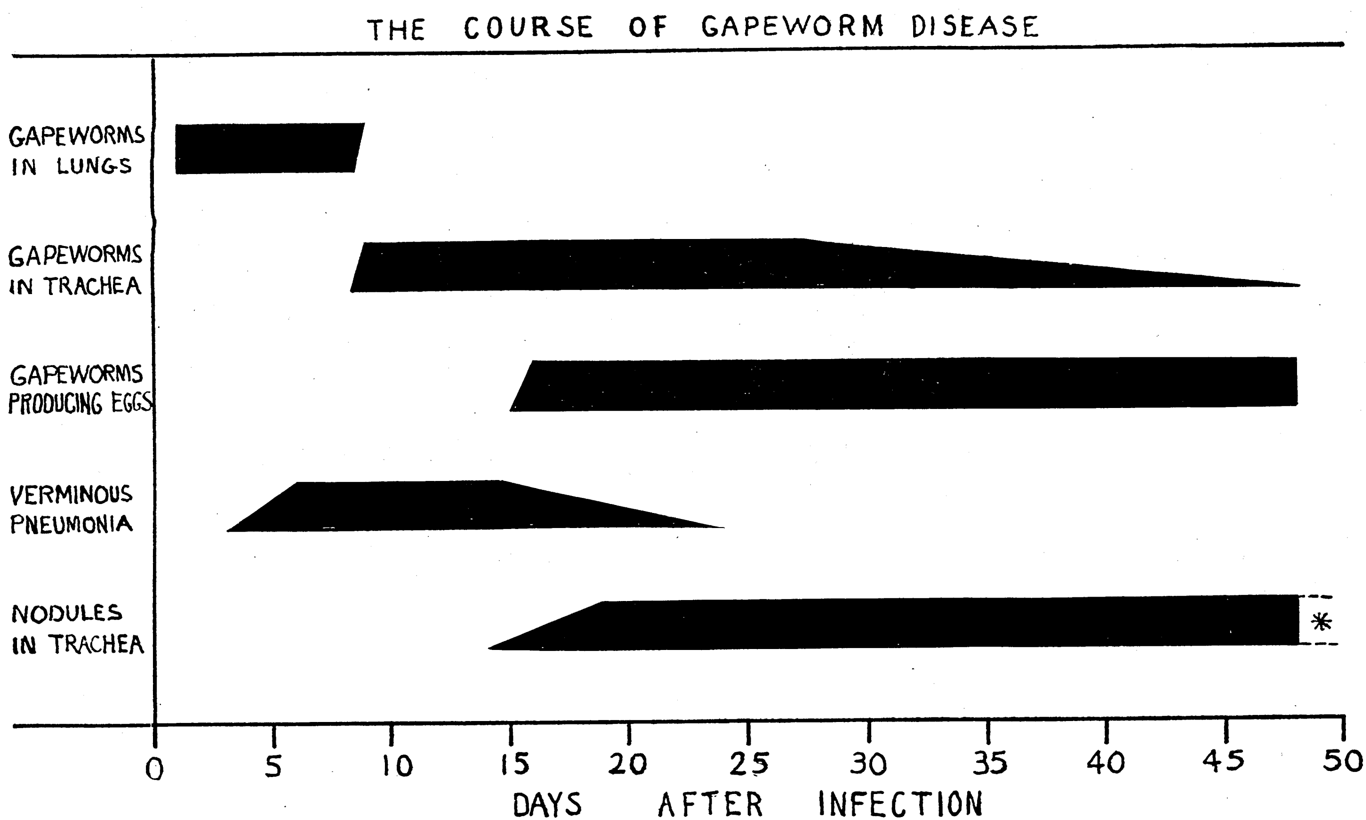
The times required for early stages of gapeworms to appear in the lungs of pheasants were similar to those found by other authors for them to appear in chickens. Ortlepp (1923) found infective larvae in chickens in the air sacs near the duodenum, under the mucosa of the esophagus, and in the alveolae of the lungs 24 hours after exposure to gapeworms. Third-stage larvae were found in the lungs and liver of a chick having 18-, 21-, and 24-hour infections by Wehr (1937a). Experiment 3 of the present investigation was similar to Wehr's experiment and showed similar results in pheasants. Wehr's experiment indicated that the third-stage larvae migrated from the digestive tract through the blood stream, and Experiment 3 of this work substantiates his conclusion but as Wehr has pointed out however, the early migration of gapeworm larvae has not been completely determined. In this investigation third-stage larvae were found in the lungs of pheasants 24 hours to four days after exposure. Fourth-stage larvae were found in the lung five days after exposure while small paired gapeworms were found six, seven, and eight days after exposure. Nine days after exposure gapeworms were found in the trachea. Wehr found fourth-stage larvae in chicks three and seven days after the initial exposure and believed the final stage gapeworms paired between the third and seventh days after exposure. Ortlepp found copulating worms in the lung on the fifth day after infection. Such pairs were found at this time in pheasants.

Apparently chickens suffer little if any, from the migration of gapeworm larvae through the lung. Morgan and Clapham (1934) noted hemorrhagic spots with larvae in the lung of one chicken which died from gapeworm disease on the fifth day after exposure. Ortlepp (1923) found no abnormal changes in the lungs of chickens even in sections in which the larval stages were found. Other writers do not mention changes. Autopsies and sections of lung from naturally and experimentally infected pheasants in this work showed that there was a verminous pneumonia present in most infected pheasants. Pheasants with experimental infections from six to 14 days old showed a pneumonia that was evident by gross examination. Some pheasants with two- to five-day old infections and some with 14- to 21-day old infections also showed a pneumonia grossly. For the most part pneumonic lesions were evident on the dorsal side of the lung. Some pheasants had hemorrhagic areas of a dark brown color. The lungs of many pheasants of these experiments and of naturally infected pheasants had a hyperemia which gave the whole dorsal surface of the lung a uniform cloudy purple color, but had no hemorrhagic spots such as those mentioned above. White, cloudy areas appeared on the dorsal portions of the lungs in many pheasants as the infection aged. The dorsal surfaces of the lungs of still other pheasants were of a uniform, dark, brownish-purple color. Pheasants with older infections commonly had white areas in association with small dark petechiae on the dorsal surface of the lungs, and some infected pheasants had dark colored lungs with small white areas 1 to 2 mm. in size scattered over the dorsal side. These are more or less typical appearances of verminous pneumonias in early and late stages caused by other parasitic worms and as is found in Ascaris infections. The caseous cyst described in Experiment 4 was similar in all respects except in size to the cysts described by Schwartz and Alicata (1932) in which *Ascaris lumbricoides* larvae were trapped in their migration through the lung.

Every pheasant of Experiments 1, 2, and 4 examined nine or more days after exposure had gapeworms in the trachea or evidence in the form of nodules, that gapeworms had been in the trachea. Nine days after exposure active pairs of gapeworms were dispersed from the bronchi to the glottis. None of these were attached to the trachea and the majority were near the glottis in pheasant 12 of Experiment 2. Similar conditions were observed in naturally infected pheasants when the worms were small and active. It was assumed from the activity and numbers of worms of this size and age in these pheasants, that many worms were lost before they could establish themselves in the trachea. On the ninth day after exposure the female worms were immature and measured 6 mm. in length; they became progressively larger as the infection aged and their rate of growth appeared to be relatively constant. The largest female gapeworm observed, 34 mm. in length, was found in a 48-day infection. Graph 1 shows the relationship of size to age of female gapeworms collected from Experiments 1, 2, 4, and 5.

Morgan and Clapham (1934) found small paired gapeworms in the trachea nine days after infection, and Wehr (1937a) found paired gapeworms in one chicken seven days after infection and in another chicken nine days after infection. Ortlepp (1923) also found worms in the trachea of chickens seven days after infection, while Megnin (1881) assumed that seven days after infection there were worms in the trachea of pheasants.


SIZES OF FEMALE GAPEWORMS
35
30
25
20
15
10
5
MILLIMETERS




GRAPH 1. The relationship of the size of female gapeworms in relation to age and a summary of the course of gapeworm disease in pheasants compiled from information in Experiments 1, 2, 3, 4, and 5.

It would appear from experiments conducted on the game farm that gapeworms appeared in the trachea of pheasants on the ninth day after infection but not before.

Egg production in the worms apparently began between the fifteenth and sixteenth days after infection. All female worms taken from the tracheae of pheasants with 16-day or older infections had eggs in the eight-cell stage in the uteri. Ortlepp (1923) believed that gapeworms attained sexual maturity 10 to 14 days after infection, but believed the first eggs that the worm passed were abnormal and that in chickens the worms produced normal eggs 17 to 20 days after infection. In this work it would appear that gapeworms in pheasants were more consistent in the time that they produced eggs for no normal or abnormal eggs were found prior to 15 days after exposure. The female worms apparently remained gravid until they were expelled from the trachea.

The oldest living pair of gapeworms found in an experimental pheasant was in a bird that retained its infection for 48 days. Either dead gapeworms were found in the trachea from the twenty-seventh to forty-seventh day after exposure or after 27 days there were more nodules than there were pairs of worms, indicating that the pheasants lost worms as the infection progressed beyond 27 days. The older the infection the more nodules there were in proportion to the worms in the trachea. Morgan and Clapham (1935) found no gapeworm eggs in pheasants after nine weeks of infection. Although Clapham (1935) reported a pheasant retaining gapeworms for over a year, she did not present evidence to show that the pheasant had not acquired a later infection. Olivier (1944) found that pheasants lost most of their gapeworms by 41 days after infection. Although different species of birds retain gapeworms for varying lengths of time, from our observations on experimental pheasants, on pheasants raised under normal conditions, and from the works of Olivier and of Morgan and Clapham, it would be safe to conclude that by far the greatest proportion of gapeworms are gone from the trachea by the forty-eighth day after exposure. Since the female gapeworms produced eggs from the sixteenth day after exposure until the time they were expelled from the trachea 27 to 48 days after exposure, the infected pheasant was potentially dangerous as a contaminator.

The trachea of experimentally and naturally infected pheasants revealed that when the gapeworms were of large size nodules were present around the heads of the male worms. These nodules were grossly similar to those described by Clapham (1935) except that they were white instead of red, and the greater proportion of each nodule was on the serosa of the trachea instead of on the inside. There was little blockage of the trachea from nodules. Microscopic examination of nodules showed them to be of a lymphoid character and revealed definite dissolution of cartilage mentioned by Wehr and by Clapham. However, our sections did not show the giant cells, caseation necrosis, nor areolar connective tissue cutting off the nodule as described by Clapham. A cartilage proliferation in rings was evident around the openings through the tracheal cartilage made by the male worms. These rings remained after both the inflammation and the nodules disappeared and thus could be used as evidence of former infections in pheasants long after the worms had been expelled from the trachea. Many naturally infected pheasants which were autopsied in the winter had these rings as evidence of former infections.

Olivier (1943) showed that an acquired immunity developed in pheasants following their infection with large numbers of gapeworm eggs. Olivier fed 3,000 gapeworm eggs and larvae to each of 50 pheasants 38 days old. Seventeen of these survived the infection and each was fed 5,300 eggs and larvae 41 days after the first infection, when the latter was presumably gone. After 13 days his control birds averaged 94 pairs of worms while the reinfected pheasants averaged 0.7 worms per bird from the second infection. An acquired immunity appeared to be present in the two pheasants that were infected with 200 gapeworm eggs and larvae in Experiment 5 of this work. Though only two pheasants were used in our experiment it seemed to indicate that such extreme numbers of eggs and larvae used by Olivier were unnecessary in order to produce an immunity in pheasants, since even moderate numbers apparently gave some immunity in a period of 37 days. Even though double infections were acquired by pheasants which had been given exposures nine and 18 days apart, there is evidence in Experiment 4 that an 18 day period was sufficient for enough immunity to develop that the first infection was lost before the thirty-eighth day and the second infection was lost before the twentieth day after exposure. Pheasants with three exposures to approximately 200 gapeworm eggs and larvae, given nine days apart demonstrated that the third infection had difficulty in establishing itself since it manifested itself as only a fourth-stage larva in the lung of one pheasant and as one small pair of gapeworms in the trachea of another.

Graph 1 indicates the location of the gapeworms at different periods of time after exposure, the times at which eggs were found in the eight-cell stage, when the pheasant had a verminous pneumonia and when nodules were present in the trachea.

## SUMMARY

1. The periods of time that the early stages of the gapeworms appeared in pheasants were similar to those in chickens.

2. The gapeworms matured and produced eggs in the eight-cell stage between the fifteenth and sixteenth day after exposure.

3. From the twenty-seventh to the forty-eighth day after infection there was a gradual decrease in the number of worms in the trachea.

4. A verminous pneumonia developed soon after gapeworm larvae were found in the lung and was still in evidence four to five weeks after exposure.

5. The male gapeworms penetrated the tracheal cartilage and were found partially embedded in a nodule on the outside of the tracheae as early as two or three weeks after exposure.

6. Pheasants acquired more than one infection.

7. A resistance developed to a second infection 37 days after an initial exposure, and worms were lost prematurely in double infections given 18 days apart.

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# GEORGE BANCROFT ON MAN AND HISTORY

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George Bancroft did more than span the nineteenth century. He was the champion of its ideas and ideals, crowned with its smile of fortune. Born in 1800, he was reared in a theological atmosphere seeking to retain the best of the Enlightenment while ridding itself of the supposed excesses. He participated in, may in fact have helped to form, the liberal movement of the mid-century. Then by the simple process of standing still, he became a conservative amidst the increasing complexities of life near the century's close. Being what he preached, he provides an admirable "case history" of how a man may both think as he lives and live as he thinks.

In determining the constituent parts of Bancroft's thought I have divided the study into three major divisions: there is first of all his concept of human nature, pre-formed in the Bancroft household and his Harvard years but made structurally sound by experience and the attrition of new ideas;[1] secondly, there is his religious belief, moulded by a New England background and given extension by German theology, particularly that of Schleiermacher; and finally, there is his philosophy of history, logical only in terms of the two divisions preceding. From out of these three major divisions emerges Bancroft the philosopher, the theologian, the interpreter of history to a sympathetic nineteenth-century audience.[2]

## I. HUMAN NATURE

In his conception of human nature, Bancroft believed that character was relative to circumstances. The Enlightenment had emphasized the idea that man is the product of his environment. The early nineteenth century, influenced probably by the idealist schools of philosophy which Descartes had engendered and by the work of such men as Jacob Fries, admitted the efficacy of environment but emphasized heredity also. Heredity seemed to explain the philosophical belief in innate ideas. Bancroft was undoubtedly introduced to such ideas through his reading of

[1] For the development of Bancroft's mind and art see Russel Nye's excellent biography *George Bancroft, Brahmin Rebel* (New York, 1944).

[2] Within Bancroft's lifetime his early volumes went through over twenty-five editions—some of which were merely reprintings.

Mme de Stael's *De l'Allemagne* while at Harvard.[3] But the real influence came with his years at Göttingen, when he plunged into Biblical Criticism.[4] In his first year he studied Ethnography under Heeren and Old and New Testament exegesis under Eichhorn,[5] besides enrolling in the usual language courses. Within the bounds of New England conservatism, Bancroft was enthusiastic with his biblical studies. German theological works, he wrote Andrews Norton, were "far, very far before all the rest of Christiandom in learning, but not in piety nor in talent."[6] Bancroft soon recognized that no great rewards were to be expected from teaching such a rarified discipline in America, but he felt that the establishing of "a thorough school of Theological Critics" would carry its own reward, not measurable in terms of fame or money.

Rumors that German biblical criticism lost in spirituality what it gained in historicism filtered back to New England.[7] But to the on-the-scene Bancroft, it was an exciting pastime. Later, when he returned to America and began popularizing German study, it is significant that he chose Herder as the subject for one of his earliest articles. "The influence of Herder on his age," Bancroft wrote, "was wide, and entirely beneficial to the best interests of our race; he has been extensively read and admired, and always with results beneficial to morals and sentiments of philanthropy."[8] Herder's view that Scripture was not written by

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[3] See Bancroft's later review of Henry Dwight's *Travels in the North of Germany, American Quarterly Review,* VI (1829), 189–216, for a laudatory description of Mme de Stael. By this time he was confirmed in his belief in the uniqueness of cultural and individual life caused by environmental and hereditary factors. He describes *De l'Allemagne* as "elaborate" and "excellent" and says that "Everything which she heard, received a livelier character, as it passed through her mind; the trials which she had herself encountered, but never fully sustained, fitted her to understand the deep character of the German nations . . ." (p. 191).

[4] Bancroft was expected to study Divinity at Göttingen. President Kirkland wrote Professor Eichhorn that Bancroft should especially study philology, ancient languages and oriental literature in order to become "an accomplished philologian and biblical critic." Mark Antony De Wolfe Howe, *The Life and Letters of George Bancroft* (New York, 1908), I, p. 33.

[5] *Ibid.,* I, p. 58. Through Eichhorn, Bancroft would have been introduced to the whole of German biblical study. He specifically mentions Schleusner. Since Johann Gottfried Herder was commonly acknowledged to be one of the great founders of the new discipline, his name was probably prominent in course discussion. This is later borne out by Bancroft's essay on Herder, in which he reveals a more than adequate knowledge of the German's philosophy.

[6] *Ibid.,* I, p. 64.

[7] Bancroft soon found it necessary to allay the fears of his New England patrons. In January, 1819, he wrote President Kirkland: "I add one word about German Theology. I have nothing to do with it, except so far as it is merely critical . . . . I trust I have been too long under your eye, and too long a member of the Theological Institution under your inspection to be in danger of being led away from the religion of my Fathers." *Ibid.,* I, p. 55. Bancroft was later more liberal and ventured to suggest "That Christianity has nothing to fear from investigation; . . . Germany is the centre and main support of protestantism on the continent." "Men of Science and Learning," *Literary and Historical Miscellanies* (New York, 1857), p. 166. Referred to hereinafter as *Miscellanies.*

[8] "Herder's *Works,*" *North American Review,* XX (1825), 144. On Herder, see J. Mace Andress, *Johann Gottfried Herder as an Educator* (New York, 1916);

"inspired oracles" was perhaps in bad taste, but, Bancroft hastened to add, "religion does not suffer from freedom of inquiry."[9] It was more important to note that Herder had been among the first to recognize the great truth that "the elevating feelings and faith," which link men with God, "appear under the most various forms, and are modified by the different circumstances of times and countries, by national character, and the diversity in the intellectual habits of all reasoning men."[10]

To turn the pages of Herder's work was like "walking in a botanical garden" where one could find faithfully and truthfully rendered the spirit and substance of other cultures and other days.[11] Herder, among others, had taught Bancroft that "A great poet is the mirror of his time, just as a great philosopher is the exponent of its general culture."[12] Far from man making his culture, it was culture that made the man. And thus it was, said Bancroft, that "National literature varies with national character. It represents the aspect under which the world is contemplated, and shows the coloring imparted by climate, government, and society."[13]

The idea obtained is reflected throughout Bancroft's writings. Ideas, institutions, laws: all are "appropriate" to the "condition of the people."[14] "Neither philosophy, nor government, nor politi-

F. McEachran, *The Life and Philosophy of Johann Gottfried Herder* (Oxford, 1939); Henry Nevinson, *A Sketch of Herder and His Times* (London, 1884); and Arthur Lovejoy, "Herder and the Enlightenment Philosophy of History," *Essays in the History of Ideas* (Baltimore, 1948). Andress calls Herder the "founder of the genetic method of study." "He established the principles of the genetic method of study long before Charles Darwin appeared on the scene. Not only were these principles advanced but they were put into practice by Herder himself and others who came under his influence. Such a method, coupled with a wonderful breadth of human knowledge and an unusual capacity for work make Herder a pioneer in modern scholarship, and even a founder of many studies. There was scarcely a subject in the vast field of culture from theology, literature, history, anthropology, art, philosophy, to education that he did not anticipate or stimulate. He was one of the world's greatest pathfinders." (p. 9).

9 *Ibid.*, p. 143.

10 *Ibid.* Herder had many accomplishments and failings with which Bancroft could sympathize. Bancroft's celebration of "variety of attainments," industry, and pure morality found confirmation in Herder, and Bancroft, just then suffering from the failure of his *Poems*, could sympathize with a man of poetic nature who yet lacked "the highest qualifications of the poet." Too, Herder had been the first to vindicate "for the songs of the people their place in the annals of human culture" and had sympathized with the American revolutionaries.

11 *Ibid.*, p. 139. Bancroft's dislike for Goethe, an outgrowth of his moral outlook, was rationalized by saying that Goethe failed to reflect the people truthfully. ". . . Goethe, is the poet, who represents the morals, the politics, the imagination, the character, of a broken-down aristocracy, that hovered on the skirts of defeated dynasties, and gathered as a body-guard round the bier of legitimacy." *Miscellanies*, p. 200.

12 *Miscellanies*, p. 198.

13 *Ibid.*, p. 102.

14 *History of the United States . . .* (Boston, 1864), II, p. 145. The passage is repeated in the Author's Last Revision (New York, 1883), I, 416. In the body of the paper, quotations from the *History of the United States . . .* are compared with similar passages in the Author's Last Revision, and will be referred to respectively as *History* and ALR. Citations from the *History* will give the edition and date as well as the volume and page number.

cal institutions, nor religious knowledge, can remain much behind, or go much in advance, of the totality of contemporary intelligence."[15] History is a long continuity of cause and effect, each "spirit of the age" unique in itself and yet growing out of preceding ages.[16] A people cannot rise above its acquisitions; each state in which man finds himself is his "natural state at this moment," but change brings added acquisitions and these in turn mark off a new "natural state."[17] Time cannot be compartmentalized, for time is a vast flowing and flowering out of the past and into the future. Present opinion is the product of past opinion and both together make the opinion of the future. The resulting diversity "gives relief to the production of each nation" and extends to the world a rich heritage which would be lacking in pale uniformity.

Bancroft's mind was always alive to the intellectual world about him. Herder had been one of the first to conceive of culture as a totality of organic relationships. This undoubtedly influenced Bancroft. But when Bancroft was in Germany the concept of organicism literally permeated the intellectual atmosphere, receiving its most extreme form in Hegel's thought.[18] In point of time, Bancroft was among the first Americans to receive the new doctrine. After stating that the "present is always the lineal descendant of the past," it was no metaphorical accident that he should continue: "A new form of political life never appears but as a growth out of its antecedents, just as in nature there is no animal life without a seed or a spore. In civil affairs, as much as in husbandry, seed-time goes before the harvest, and the harvest may be seen in the seed, the seed in the harvest."[19]

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[15] *Miscellanies,* p. 485. Thus it was that Bancroft believed that a nation's literature "commends itself to the attention of enlightened curiosity, even independently of its intrinsic merits, from the knowledge it sheds on the nature of man." *Miscellanies,* p. 104. In a letter to Jared Sparks, proposing an essay on Italy, Bancroft says he would show how the "physical characteristics" of the sections "influence" division and decide "the character of each part" and how "the spirit of Catholicism" influences manners and "religious sentiments and public display." J. S. Bassett, "The Correspondence of George Bancroft and Jared Sparks 1831–1832," *Smith College Studies in History,* II (Jan. 1917), 101. And he once wrote his wife (1842) apropos another volume of the *History:* "I have made some collections of considerable value, but have gained more by striking the veins of tradition, and hearing anecdotes revived, that lets me get glimpses into the parties and malignant spirit of old times." Howe, I, 240.

[16] Consequently Bancroft believed that nations should change "their institutions but slowly." ". . . a man can as little move without the weight of the superincumbent atmosphere as escape altogether the opinions of the age in which he sees the light." *History,* IX (1st ed., 1866), 501; ALR, V, 257.

[17] *Miscellanies,* p. 485.

[18] Bancroft studied for a time under Hegel but was completely incapable of making sense of the lectures. In a very general sense some of Bancroft's comments seem Hegelian. It is probably true that Bancroft utilized some of the popularly known Hegelian doctrines, such as the triadic scheme, but there was no conscious adherence to Hegel's philosophy.

[19] *History,* IX (1st ed., 1866), 436; ALR, V, 199. Bancroft's ideas of continuity and organicism were almost surely supplemented by Charles Lyell's *Principles of*

Organicism was actually the basis for Bancroft's idea of cultural relativism. All things in a culture made for "reciprocal action, advancing, receding, crossing, struggling against each other and with each other."[20] States and nations "resembled living plants,"suffused with "inward energies" realizing themselves through growth.[21] An "indwelling necessity," formed by the ramifications of culture, determined new phases of living;[22] "organic laws" introduced to reality greater ideals.[23] In this light the American Revolution became explicable, for the "vigorous vitality" of the American people had "refused conformity to foreign laws and external rule. They could take no other way to perfection than by the unconstrained development of that which was within them."[24] Not the wisdom of individuals but the "growth of necessity" made for the slow and gradual development of the American institutions.[25] Within society lay all the seeds for growth. "Society," said Bancroft, "is many and is one; and the organic unity of the state is to be reconciled with the separate existence of each of its members."[26] Following Kant, he held that there was both the drive to despotism and the drive to anarchy in society, mediated by a third power which strove to conciliate the two. All were necessary to the essential well-being

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*Geology* (first published 1830–33). In his essay on the progress of man (1854) Bancroft says that the geologist "has perused the rocky tablets on which time-honored nature has set her inscriptions. He has opened the massive sepulchres of departed forms of being, and pored over the copious records preserved there in stone, till they have revealed the majestic march of creative power, from the organism of the zoophyte entombed in the lowest depths of Siluria, through all the rising gradations of animal life . . ." *Miscellanies,* p. 498. But while admitting organic evolution, Bancroft was with Agassiz and Cuvier that man was specially created and a distinct species.

[20] *History,* ALR, VI, 443.

[21] *History,* IV (18th ed., 1864), 55; ALR, II, 351. In a footnote to the 18th edition Bancroft cites "Bacon de Augmentis Scientiarum. Lib. vii, cap. ii . . ." Cf. also Bancroft's statement that "Human nature is forever identical with itself; and the state ever contains in its own composition all the opposite tendencies which constitute parties . . . and it will be found, that as every class of vertebrate animals has the forms of the same organs, so an exact generalization establishes the existence of every element of civil polity, and of the rudiments of all its possible varieties and divisions in every stage of human being." *History,* VIII (3rd ed., 1864), 118; not in ALR.

[22] *History,* ALR, VI, 90.

[23] *History,* IX (1st ed., 1866), 502–503; ALR, V, 258.

[24] *History,* VII (7th ed., 1864), 23; ALR, IV, 4. *Cf.* Bancroft's statement that the Declaration of Independence was a development out of the people and the time, and his statement that the greatest jurists "have perceived that law itself is necessarily moulded and developed from its inward nature." *History,* VIII (3rd ed., 1864), 248; not in ALR.

[25] *History,* VII (7th ed., 1864), 354; ALR, IV, 191. Bancroft continued: "The American constitution came from the whole people, and expresses a community of its thought and will. The nation proceeded not after the manner of inventors of mechanisms, but like the divine architect; its work is self-made; and is neither a copy of any thing past, nor a product of external force, but an unfolding of its own internal nature."

[26] *History,* VIII (3rd ed., 1864), 118–119; not in ALR.

of society, but any one out of alignment contributed to destruction.[27]

In his "Doctrine of Temperament"[28] Bancroft first developed the place of heredity in the human scheme. Between environment and heredity, human nature at any one time was fairly well fixed. Bancroft rests his case on the findings of contemporary physiologists. At birth the infant is already possessed of various traits which will set it off from others and also identify it with groups. "It has its passions, its desires, its propensities; and not only its physical organization is decided, but also the complexion of its character."[29] There are of course the conditioning roles of education and environment but in the main the limits are set: "The features of the mind, as of the face, are fixed beyond the possibility of change."[30] The infant has certain advantages, certain deficiencies, certain faults, which will continue with him throughout life.

After passing over the "universal division" of sex which "renders a diversity of moral character inevitable,"[31] Bancroft lists five sources of physiological differences: racial, national, family, individual, and differences of the age. Temperaments themselves, which he claims hold "a conspicuous place in physiological science,"[32] are somewhat analagous to the old idea of humours. In all there are seven temperaments,[33] each one of which can be utilized to characterize a particular individual. An individual's temperament is indelibly stamped on him; it cannot be changed. But with a certain degree of skepticism, Bancroft admits that, just as the breeds of dogs have been improved over generations, the physiologists in time may succeed in adjusting the temperaments into a harmonious working relationship so that "the most brilliant prospects [may be] opened for the amelioration of the human race, and the happiness, health, and virtue of future generations."[34] Still, however, there would remain "an infinite variety of character" induced by the influences of "climate, age, regimen, and pursuits."[35]

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[27] *Ibid.,* pp. 119–120. Thus "every party has an honest origin in human nature and the necessities of life in a community." Kant's ideas are expressed in his *Idea of a Universal History.*

[28] The essay is in the nature of a popular article, and he spends little time on any one point. He cites no physiologist and adduces few results from scientific findings. Blumenbach, physiologist at Göttingen while Bancroft was there, is the most logical source for Bancroft's ideas here.

[29] *Miscellanies,* p. 2.

[30] *Ibid.*

[31] *Ibid.*

[32] *Ibid.,* p. 7.

[33] Sanguine, athletic, bilious, phlegmatic, melancholic, nervous, and the tempered temperament (which Bancroft despairs of ever seeing).

[34] *Miscellanies,* p. 42.

[35] *Ibid.,* p. 43.

While one must admit that the differences of the age "are the result of the state of society in its influence on the individuals who compose it," Bancroft insists that such differences are "in some measure hereditary" and that their genetic characteristics may be adduced by "analogies drawn from the whole animal creation."[36] Individuals are diversified from one another by the totality of traits which they receive as members of the age, race, nation, family, and local conditioning factors. Certain elements of "mind and tastes" can be related to the individual's family; for example, the "lineaments and constitution" may be inherited from the father and the "temper" from the mother.[37] On the matter of race and nationality, Bancroft is ambiguous. He seems to mark a division between the two, but it is no hard and fast one and very often he tends to equate them. He assumes national traits to be much more prevalent than one would think, predisposing individuals to "certain habits and particular sentiments" that may lead to rapacity or goodness. "It gives an aptitude for acquiescing in certain forms of society and government, and a facility for the acquisition and use of a particular language."[38] Thus the French are naturally cheerful, "having ideals, character, courage, waywardness and inventions" of their own.[39] Similarly, the Arabs, Tartars, Germans, Siamese,—all the nations—have traits on a national scale which are uniquely their own and serve to distinguish them from other nationalities.

On the grand plateau of race Bancroft was most at home.[40] The race was "immortal," whereas individuals were but "shadows" incapable of extended reasoning and of shallow experience. It was the race that had "a life and progress of its own," in its totality overruling the waywardness of the individual and by a sort of collective understanding pursuing almost without error the standard of truth.[41] The Anglo-Saxons, of

[36] *Ibid.*, p. 3.

[37] *Ibid.*, p. 5.

[38] *Ibid.*, p. 4. Bancroft continues: "the infant in the valley of the Euphrates inherits, it may not be doubted, an aptness to learn the diffuse forms of its Oriental language; and on the borders of the Seine to prefer the dialect of Paris to the deeper accents of the Germans. Though a man may have acquired a foreign language in his infancy, his thoughts were not destined by nature to flow in it; and perfect success in the use of words is obtained only in the mother tongue." (p. 5) This concept was later abandoned when Bancroft wrote his third volume of *History* (1842) where he held that language was a product of the particular environment of the individual.

[39] Howe, *op. cit.*, II, 86. Bancroft propounds a peculiarly Lamarckian doctrine when he states that traits first adopted by the parent may be passed on to the children. Animals, he says, "often show peculiar skill in matters, to which not they but their parents, have been trained. The books of the naturalists furnish well-attested examples of qualities thus inherited." *Miscellanies*, p. 4. Such a concept of rapid evolution was soon abandoned when his vision became more panoramic.

[40] While he admits that the races have a common origin, he says that pragmatically considered there are differences in both "physical and moral characteristics."

[41] *History*, VI (13th ed., 1864), 168; ALR, III, 294.

course, above all others had benefited the world,[42] for their collective mind, endowed by a temperament that never went to extremes, cherished an "active instinct for personal freedom" which expressed itself in a love for possession and legislative power.[43] And in America, where Bancroft seemed to think there lay an incipient racism, the people, prompted by environmental conditions, were becoming distinguished by a spirit of versatility, enterprise and invention which was becoming inherent.[44]

In addition to instinct peculiar to the individual, family, nationality and race, there were instincts common to all man.[45] Some were bad and some good. The bad could be transcended by the "innate loves" which fostered themselves by seeking a knowledge of the spirit of God. In spite of the fact that Bancroft held that the "instincts of humanity are the same in every age" and are fostered by environmental and hereditary factors, he felt that the manifestation of these instincts could be controlled. Instincts simply had to be "disciplined," and this was done by acknowledging the inward voice of God. In essence, all men were equal. The Indian and the Negro had the same number of inherent faculties as did the white. "The constitution of the human mind varies only in details," he wrote,[46] echoing what he had said earlier—that every man "in substance" was equal to every other.[47] This was the reason why Bancroft was so skeptical of the hopes of the physiologists that they could so change man that all his temperaments could be channeled in the direction of goodness. No amount of breeding or changing of environment could alter what made him man. Man was necessarily imperfect.

Bancroft did not entertain so low an opinion of man as did Alexander Hamilton.[48] But he was completely in sympathy with John Adams in holding that the vagrant instincts must be con-

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[42] Howe, *op. cit.,* II, 18. It should be recalled that Bancroft had studied ethnography under Heeren. Bancroft took great pride in his knowledge of races, and on one occasion ridiculed Thiers as knowing so little "of the ethnology of his own continent" that he thought the German Lancers from Prussia were of Uhlan blood. Howe, II, 249.

[43] *History,* II (20th ed., 1864), 452; ALR, I, 609.

[44] *History,* ALR, VI, 442–443.

[45] A complete list would be formidable. Among others, Bancroft cites selfishness, vanity, love of power, cupidity, ambition, avarice, egoism, covetousness, self-preservation, love of liberty, a belief in immortality, retributive justice, a concept of divinity, equality, duty, conscience and the idea of sin, reason and judgment, altruism and beauty. It will be noted that many seem contradictory, but Bancroft held that the instincts belonged to various faculties; thus a higher faculty could theoretically control the drives of a lower.

[46] *History,* III (18th ed., 1864), 398; ALR, II, 269. "Human nature," Bancroft wrote, "is the same in every age and in every climate." *History,* I (20th ed., 1864), 50; not in ALR.

[47] *Miscellanies,* p. 483. Bancroft continued, "His nature is changed neither by time nor by country." One must distinguish carefully between the occasions when Bancroft speaks of human nature as being the whole of man and when he speaks of human nature as essence—of man as a rational animal.

[48] *History,* X (1st ed., 1874), 410; ALR, V, 446.

trolled.[49] Time and again "an analysis of the human mind" and an examination of "the examples of history" had affirmed the existence of a "brutal part" of "human nature."[50] Man would cease to be man if ever he should become angelic. Perfection was an ever-receding goal. By his very nature, Bancroft wrote, "nothing is perfect which is the work of man."[51] No government seeking perfection could "perfectly succeed, because the materials of which society is composed partake of imperfection, and to extirpate all that is imperfect would lead to the destruction of society itself."[52] Progress did not rest in the "supposed possibility of [man's] acquiring new faculties, or coming into the possession of a new nature,"[53] but simply in attempting to eradicate "established abuses." Yet while one might recognize that absolutes were impossible of attainment and that by nature "imperfection clings to the works of his hands,"[54] an inner drive prompted man to a continuing effort to better his self.[55] "The blameless enthusiast, well aware of the narrow powers and natural infirmities of man, yet aims at perfection from sin" by subjecting his "base" powers to those of a higher order.[56]

From what has been said, it can be seen that Bancroft would place a high stress on education. He had studied under Schleiermacher and had absorbed completely the educational theories of Pestalozzi. Both had stressed education as seeking to develop harmoniously the full potentialities of men. With this theory of organic development, Bancroft was averse to the old method of pedagogy which considered the youngster a miniature man. It is significant, therefore, that, imbued with enthusiasm for concepts of education opposed to those in practice at Harvard when he taught there, he should leave to found the Round-Hill School. Educational techniques had to adapt themselves to the capacities of the individual. Intelligence flowered in proportion to the understanding of the individual. It did no good to seek to dam up emotions legitimate in man. Rather it was necessary to place the emotions in perspective, to organize them in relation to one

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[49] *History,* VIII (3rd ed., 1864), 371; not in ALR. But in the ALR (VI, p. 446), Bancroft wrote that John Adams "with vehemence and sound reasoning" championed the "tripartite division" of government as a check on the natural passions of human nature. Adams's words on the subject, he said, should "be inscribed on the memory and ears of every convention that would constitute a republic."

[50] *History,* VIII (3rd ed., 1864), 371; not in ALR. Also *History,* III (18th ed., 1864), 273; ALR, II, 107.

[51] Bancroft to the Reverend Johnson Jan. 2, 1868. Howe, II, 185.

[52] *Miscellanies,* p. 486.

[53] *Ibid.,* p. 483. Thus men could not hope individually to become more godlike than Shakespeare or Dante or Bacon, Leibnitz or Kant. *Miscellanies,* p. 513.

[54] *History,* IX (1st ed., 1866), 282–283; ALR, V, 125.

[55] See "Ennui" (1830), in *Miscellanies,* p. 47, for Bancroft's early statement that man by his nature seeks the unattainable and that this is essential to his nature.

[56] *History,* II (20th ed., 1864), 344; not in ALR.

another and all in relation to the reason. The individual was continuity just as was nature. According to Bancroft, latent faculties could be encouraged in the individual; because the individual was influenced by the manifold happenings in the universe about him these happenings could be controlled to produce the best individual possible. In a sense, man was as man became.

Coincident with his belief in environmental and hereditary determinism, is Bancroft's belief that events of the world follow God's inexorable decree. While at Harvard he had come into contact with the thought of Jonathan Edwards.[57] What Edwards had to say about the human will was adopted and, supplemented by his readings in German philosophy, remained his primary doctrine throughout life. "The believer in God," Bancroft wrote George Ripley in 1857, "instead of asking God to break his laws, [should seek] to bring his own will into harmony with the divine will. Piety studies the law, obeys the law, loves the law, and through perfect obedience becomes perfectly free. For liberty is the daughter of necessity."[58] There was both motivational and Providential determinism. Man was free only in his volitional capacity to act.[59] No "human policy or force" could breast the dictates of Divine Wisdom, for they "proceeded as uniformly and as majestically as the laws of being, and . . . as certain as the decrees of eternity."[60] Belief in Providential determinism was not "fatalism." Such a belief achieved the highest degree for action by "discerning the counsel of God." It made for individual happiness by individual conformity. "The glory of God," Bancroft intoned, "is not contingent on man's good will, but all existence subserves his purposes. The system of the universe is as a celestial poem, whose beauty is from all eternity, and must not be marred by human interpolations."[61] Man had not as yet progressed to the point where he could read the future by interpret-

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[57] During Bancroft's Harvard days the philosophy text was Locke's work on the understanding. But according to William Sloan, in Bancroft's junior year " 'Edwards on the Will' fell into his hands. It seems to have had much the same fascination for him that Locke himself is said to have had for Edwards, but with a far different result. Instead of rousing Bancroft to opposition and polemics, Edwards' philosophy fascinated and convinced him, and in the writing and talk of his later life he has often referred to it as his creed." "George Bancroft—In Society, in Politics, in Letters," *Century Magazine*, n.s. XI (Jan. 1887), p. 475.

[58] Howe, *op. cit.*, II, 114–115.

[59] "Nothing appears more self-determined than the volitions of each individual; and nothing is more certain than that the providence of God will overrule them for good. The finite will of man, free in its individuality, is, in the aggregate, subordinate to general laws." *History*, III (18th ed., 1864), 399; ALR, II, 269–270.

[60] *History*, VII (7th ed., 1864), 21; not in ALR.

[61] *Miscellanies*, p. 490. In Bancroft's eulogy of Wm. Ellery Channing at the latter's death, he could nevertheless pay his respects to Channing's belief in the "free agency of man" and point out how Channing's belief had been the copestone in his theology, morals, metaphysics and politics, and how it led naturally to a repudiation of slavery, an institution which Bancroft always emphatically condemned. *Miscellanies*, p. 442.

ing the past, but, because creation followed inexorably a "well-adjusted" and "perfect harmony," such a point in time could be theoretically realized when the "self-consciousness" of the "great mind of collective man" had sought out its full potentialities.[62] For, said Bancroft, "All is . . . one whole; individuals, families, peoples, the race, march in accord with the Divine will; and when any part of the destiny of humanity is fulfilled, we see the ways of Providence vindicated."

## II. Religious Beliefs

Bancroft's ideas on human nature and his religious beliefs mutually supported one another. He believed in the duality of human beings, that they were partly spiritual, partly animal. Man was contingent, imperfect, fallible. In addition, Bancroft was a Christian, believing, as we shall see, in most of the concomitants such a creed entails. His father had reacted against the degraded Calvinism with which he was acquainted, and, while he insisted on remaining a Congregationalist all his life, became an Arminian minister in Worcester. Bancroft was born into this theologically liberal household and for the most part adhered to the principles on which he was fostered.[63] For a time, when transcendentalist fever was running high, he was caught up in the movement, but it can hardly be said that he projected Transcendentalism into the sort of *Weltanshauung* of Emerson and Thoreau.[64] He borrowed from both Calvinism and mid-

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[62] *Ibid.*, p. 491.

[63] Bancroft's general principles were those which he wrote to William Sprague were possessed by his father. Aaron Bancroft's "knowledge of human nature," wrote his son, made him much sought after. He was a "federalist of the old school," but he nevertheless "maintained a steady, consistent attachment to freedom of conscience and of thought, the right of free inquiry, the right of private judgment." Howe, *op. cit.*, I, 8. In some respects Bancroft was frankly conservative. His idea of determinism goes back to Calvinistic doctrine and his adherence to Christianity, when projected against a nineteenth-century Transcendentalist background, is symptomatic of a conservative strain. His two most loved teachers at Harvard were President Kirkland (to whom he made a fullsome dedication in the 1824 edition of his Poems) and Andrews Norton, men who could hardly be termed radicals. At one time Bancroft wrote Norton, speaking of himself in the third person, that there was "some hope" of getting through his studies at Göttingen "without being essentially altered in his ways of thinking." Howe, I, 74. Later, when a friend took umbrage at his supposed defection from his father's faith, Bancroft answered: "It would be most candid to compare what I have written in former days with what I have written lately. Perhaps you will find less discrepancy than you imagine." Howe, II, 120.

[64] From about 1830, when Bancroft began seriously writing for the *Christian Examiner* and other periodicals, until about 1852, when he published the fourth volume of his *History,* Bancroft's Transcendental strain ran highest. After that there is a distinct tapering off, although his ideas on reason, self-reliance and an inner monitor parallel those of Emerson. See Carroll Hollis, "Brownson on George Bancroft," *South Atlantic Quarterly,* XLIX (Jan. 1950), 42–52. Bancroft's ideas are within the context of a Christian faith. According to Howe, II, 310–311, Bancroft was definitely Trinitarian in 1854; in 1887 he thought that Christ, the perfect Redeemer, had redeemed man; and in 1888 he declined membership in a Unitarian Club in Boston and declared himself a Congregationalist to a Washington, D. C.

nineteenth century Transcendentalism. Bancroft rejected the Calvinist doctrine that "the senses were a totally-depraved foundation" which could accommodate neither goodness nor truth; but he was drawn to Puritans like Henry Vane and Anne Hutchinson for their concept of a continued revelation, just as he liked the Quakers for the same reason. Calvinism in America, he believed, was of different stock than its European cousin. In America, having no prelacy or aristocracy to overthrow, the harsh side of predestination, he believed, was tempered into a form of benevolence. Jonathan Edwards summed up "the old theology of New England" and became "the fountain head of the new."[65] Bancroft stood for universal love framed within the image of Christ, Who had come onto earth for "the regeneration of the world." Far from being the "distant Providence" of the rationalists, Christ became "God present in the flesh," a "creative spirit, indwelling in man, his fellow-worker and guide."[66] Biblical critics were anathema who forgot "the true end of criticism" and made of Christ only a "skilful physician" who had no "supernatural powers."[67] For Christ as Divinity was "goodness itself, incarnate and interceding."[68] And for Bancroft this meant that Christianity was "the whole of the eternal Reason itself."[69]

On a purely philosophical level Bancroft embraced the "critical philosophy" of Kant, particularly as concerns the Kantian doctrines of sensibility, understanding, and reason. Kant had passed "between dogmatism and doubt to the school of reason," had learned the limitations of the mind and had discovered the truths to be found in the moral and material worlds.[70] "For power of analysis and universality," Bancroft said of Kant, "he was inferior to none since Aristotle."[71] The three antinomies about which Kant had fussed so much were easily avoided by Bancroft. Edwards had demonstrated to him the truth of a determined will. As for immortality and God, Bancroft simply made them

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Unitarian minister. But as early as August 8, 1821, Bancroft had noted in his Diary that he had met in London the Unitarian, Belsham, who had discoursed on the possibility or probability of the soul's materiality. Bancroft's comment was: "Good Christianity is better than bad metaphysics." Howe, I, 116.

[65] See Bancroft's sympathetic sketch of Edwards in Appleton's *Cyclopaedia of American Biography,* III (1887), 309–311. In 1837 Bancroft wrote that the "early legislation" of Calvinist Connecticut "is the breath of reason and charity, and Jonathan Edwards did but sum up the political history of his native commonwealth for a century, when, anticipating, and in his consistency excelling, Godwin and Bentham, he gave Calvinism its political euthanasia, by declaring virtue to consist in universal love." *History,* II (20th ed., 1864), 462–463; ALR, I, 616–17.

[66] *Miscellanies,* p. 503.

[67] Review of Dwight's *Travels in Germany, op. cit.,* p. 214.

[68] *Miscellanies,* p. 495.

[69] Howe, *op. cit.,* II, 262–63. In the same letter Bancroft states his continued adherance to "the New England Congregational System" and to "the great teaching of Luther, that every man is his own priest."

[70] *History,* X (1st ed., 1874), 87; not in ALR.

[71] *History,* V (15th ed., 1864), 6; not in ALR.

innate ideas in man. Besides, in his *Critique of Practical Reason* Kant had made these ideas dependent upon faith, and Bancroft certainly had faith. Bancroft was more interested in reason. To Kant pure reason was the power of the mind to utilize its forms and categories independent of sensuous experience. Accepting this, it was but a step for Bancroft to assert that there was "but one mediation between God and created reason."[72] Pure reason was an "internal sense" independent of the five bodily senses; it existed "within every breast," a faculty "which from the infinite treasures of its own consciousness, originates truth, and assents to it by the force of intuitive evidence."[73] Kant would have agreed with the first statement; toward the second, which Bancroft more than likely derived from Schleiermacher, he would have raised a critical eyebrow. To man alone, said Bancroft, was given that "reason which looks upward as well as before and after, and connects him with the world that is not discerned by the senses."[74] From the "dictates of pure reason" came the flowing forth of truth.[75]

As reason, implanted in man by God, discovered truth, so conscience was the God-given faculty which discerned justice.[76] Conscience was the "voice within," the categorical imperative of Kant and the "inward monitor" of Christianity. It was possessed by all sects, all nations, all men. Conscience provided moral direction. It impelled men to act for their freedom and to subscribe to the laws of God. It could, as Francis Bacon and Cotton Mather might attest, be disregarded—but the results carried terrible penalties. We know, by an intensely personal intuition, when we are about to do wrong.

But while universal reason enabled all men to discern truth and conscience enabled them to act justly, there was still the problem of evil. Physical evil, in line with Christian thought over the centuries, was easily explained as in itself a nonentity, that is, it was the privation of good. The problem of moral evil was a knottier question. "No man that lives has not sinned," Bancroft

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72 *Miscellanies,* p. 510. In a reminiscence of his father, Bancroft said that Aaron Bancroft "considered reason as a primary and universal revelation of God to men of all nations and all ages; he was sure of the necessary harmony between reason and true religion." Howe, I, 11.

73 *Miscellanies,* p. 409.

74 *Ibid.,* p. 483. In his *History,* III (18th ed., 1864), 373; ALR, II, 266, Bancroft gave an enthusiastic account of Bishop Berkeley's "intuitive reason." And in his 1842 eulogy of W. E. Channing, Bancroft said that Channing's mind was like on "Æolian harp" which when placed high "the winds of heaven breathed through it." *Miscellanies,* p. 443.

75 *Miscellanies,* pp. 409–410.

76 "In questions of practical duty, conscience is God's umpire, whose light illumines every heart. There is nothing in books, which had not first, and has not still its life within us." He felt that individual conscience may be corrupted, but yet "the rule of morality is distinctly marked." *Miscellanies,* p. 410.

wrote.[77] Since the days of Cain and Abel and even before, moral evil had been an uncomfortable reality in the world.

Bancroft skirted alike the stands of Manichaeism and Pelagianism. Evil was neither a distinct principle nor inherent in man. Like physical evil, moral evil was the absence of good. But pragmatically, moral evil was distinctly a fact. Bancroft's solution was in line with Schleiermacher's. Since man had a dual nature the presence of moral evil had to be related to how his nature worked. Reason was not corrupted. Nor was nature corrupted. Nevertheless, when reason and nature acted jointly, as they necessarily must in dualistic man, moral error sometimes resulted.[78] It should be remembered, too, that Bancroft had located instincts in man's nature operating for both good and bad. Because they belong to the various faculties of man they cannot be evil in themselves since they belong to the perfection of man's nature. Yet they are inferior to reason and sometimes operate to circumvent reason. If we remember also Bancroft's insistence on the organic wholeness of man, then it is possible to see why he so insisted on a harmonious relation of the working elements. Man progressed toward the perfection of his moral nature insofar as there was a concord of faculties. On the other hand, "The extraordinary development of one faculty may sometimes injure the balance of the mind,"[79] so that the man could not order his being to the right end. When a faculty asserted itself beyond its intrinsic importance then one gained a "perverse or imperfect view of creation,"[80] and this was sin.

Bancroft had little use for those who through a "slavish interpretation of the Bible" held that there was a Devil actually and physically present in the world. He sympathized with the Quaker belief that "no spirit was created evil" and that therefore "God made no devil."[81] According to Bancroft, man was aware that he was a "dependent being" and saw the infinite outside of himself. But "superstition" saw these things too, and developed ghosts

[77] *History,* VIII (3rd ed., 1864), 116; not in ALR.

[78] Bancroft, of course, was always interested in theological matters and could have derived much of his thought from Andrews Norton and President Kirkland at Harvard. But the strong resemblance between his thought and that of Schleiermacher on religious and educational matters can hardly be incidental. Bancroft studied education under Schleiermacher and almost certainly came into touch with his religious theories. In November, 1820, Bancroft wrote President Kirkland that he was studying the "science of education" under Schleiermacher, which "is the most interesting which I have yet attended. He brings to his subject a mind sharpened by philosophical meditation and enriched with the learning of all ages and countries. He applies to his subject all his vast acquaintance with the different systems of ethics, and with the human mind . . . . I honour Schleiermacher above all the German scholars, with whom it has been my lot to become acquainted." Howe, I, 90.

[79] *History,* I (20th ed., 1864), 372; not in ALR.

[80] *Miscellanies,* p. 506. In the context Bancroft is speaking of atheism.

[81] *History,* II (20th ed., 1864), 340; ALR, I, 536.

and myths and horoscopes, "or, yielding blindly to fear, [beheld] in the evil that is in the world, the present malignity of Satan."[82] There being no actual Satan, Bancroft undoubtedly took a poetic view of the apple episode in the Garden of Eden. As a Christian, however, and feeling constrained to explain how evil had occasioned itself in the world, there was in some sense a fall of man from original goodness.[83] Since it is evident that he believed that man had fallen from his original position of being God-oriented, the original sin had probably occurred at the moment when sense asserted itself at the expense of reason, beginning the long warfare St. Paul termed the war between the Law and the Members. It was a disaster not to be taken lightly. For, instead of leading a life of moral earnestness and perfection, man was reduced to a fearful combat from which only God could save him.

That Bancroft believed that God had redeemed man is evident from his attitude toward Christ. Enmeshed in his own blunderings about and becoming increasingly prone to evil through hereditary transmission, man had an absolute need for a redeemer and for grace. That is why he thought that Jonathan Edwards, who nevertheless has been "cramped and perverted by theological forms," had so excelled Bossuet and Vico, since Edwards had developed a method which illustrated "the whole 'work of redemption'—the history of the influence of all moral truth in the gradual regeneration of humanity."[84] With the coming of Christ the "truth of the triune God" had been "clearly announced." God was not so distant and not so sternly mechanical as the deists had thought. Instead, "Christ appeared as all that is good and beautiful and true; as goodness itself, incarnate and interceding, redeeming and inspiring; the union of liberty, love, and light; the infinite cause, the infinite mediator, the infinite in and with the universe, as the paraclete and comforter."[85] It was the doctrine of 'GOD WITH US" and gave vitality to "every soul that sighs for redemption."[86] Thus it was that Bancroft felt he could be no Darwinist and why he approved the *London Quarterly* review "refuting" Darwin, writing his wife: "I believe 'preventing grace' precedes the formation of every living thing; as well as of every regeneration of a soul, or any event in history."[87]

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[82] *History,* III (18th ed., 1864), 73; not in ALR.

[83] Frequently in the early volumes Bancroft asks rhetorically such a question as, "Who denies that the heart of man is deceitful, and desperately wicked?" These should be understood in their context, but they do indicate that Bancroft was far from adhering to Rousseauistic natural goodness, where the dictates of the sentiments were unspoiled.

[84] *History,* III (18th ed., 1864), 399; ALR, II, 269.

[85] *Miscellanies,* p. 504.

[86] *Ibid.*

[87] The letter was written in 1860. Howe, *op. cit.,* II, 115.

## III. PHILOSOPHY OF HISTORY

As early as 1819 Bancroft indicated an interest in history, writing Edward Everett for his opinion of history as a suitable vocation, and adding, "This has always interested me, suits well with my philology, and as the church history must be taken, too, with my theology, I think I could become useful by means of it."[88] But Bancroft's later letter to Everett, thanking him for his favorable review in the *North American Review* of the first volume of the history, need not be taken too seriously in its statement that he remembered well his early query and that "for sixteen years my main purpose in life has been unchanged."[89] Before Bancroft turned to history he had other irons to heat, and at the progressive failure of each one of them to prove suitably remunerative he turned to another, until finally there remained history. All the time, however, there lurked in the background his love for his country and his belief that "my chance of being remembered rests upon my attachment to it."[90]

In Germany Bancroft was from the first absorbed into an atmosphere of historicism. It was evident in biblical criticism, in the approach to literature and theology, and of course in the analysis of the past. One of his first instructors was Heeren, a republican at heart who had supported Jefferson's Embargo and who developed one of the truly significant historical methods. In Heeren, Bancroft found insistence on impartiality, concern with economic events, an interest in documentation, a passion for accurate statement.[91] In addition, Bancroft was familiar with the work of Savigny, Eichhorn, Schleusner, Thiers and Herder and somewhat less with Wolfe and Hegel, all of whom to a greater or lesser degree emphasized ideas of nationalism, morality, organicism, determinism and the culture concept.

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[88] *Ibid.*, I, 65.

[89] *Ibid.*, I, 208.

[90] *Ibid.*, I, 159. In the same letter (to S. A. Eliot, Sept. 24, 1822) Bancroft confides that he thinks of the United States as a refuge for "pure religion," civil liberties, domestic happiness, and "the kindly affections of social life."

[91] In 1824 Bancroft published his translation of Heeren's *Reflections on the Politics of Ancient Greece,* praising Heeren in the Preface for his "rational and literary method." In 1829 he translated and published Heeren's *History of the Political Systems of Europe,* which marks the point where Bancroft was turning from education to politics and history. From first to last Bancroft stressed the importance of impartiality. In the Preface to the first volume of his *History* (1834) he says that he has rigidly applied "the principles of historical skepticism," and in 1884 he wrote Chief Justice Waite (Howe, II, 299) that "The historian like the judge must strive for impartiality, and the only way in which impartiality can be obtained is to seek the truth for the sake of truth." Bancroft was somewhat shaken when Ranke praised his history as "written from the democratic point of view," and wrote his wife that democracy in American history was "objective" and not "subjective." Thus Bancroft's emphasis on impartiality would seem to mean not impartiality in the modern sense but that nothing should cloud the *a priori* assumptions which properly applied could interpret history truthfully.

The New England tradition which Bancroft brought with him to Germany fitted in peculiarly well. Puritan historians had had the idea of a superintending Providence Who had led his people to found a new Canaan and to there realize the Millenium; American historians of the Revolution had seen the development of the colonies as a move toward freedom and liberty. With this for a framework and with new ideas flowing in on Bancroft at the same time as he was defining for himself his views on human nature and religion, a philosophy of history could be propounded.

To Bancroft, history was an empirical science that substantiated the great findings of philosophy. It was not enough to declare that there was a "perfect order and unity of creation" sustained by God and understood by reason; "history, testing that idea by observation, traces the vestiges of moral law through the practice of the nations in every age, proves experimentally the reality of justice, and confirms by induction the intuitions of reason."[92] Bancroft's idea of God as the sole repository of overriding cause supplemented and defined the more secular aspects of the "manifest destiny" of the United States. It was, as he wrote his wife in 1847, the idea that "Each page of history may begin and end with Great is God and marvellous are his doings among the children of God and marvellous are his doings among the children of men."[93] The concept elevated the office of the historian to just below that of the poet, for, although the historian lacked the poet's *furor divinus*, his proper study was man, "the last work of creation, and the most perfect in its relations with the Infinite."[94] By a comparison of documents and by analyzing facts and referring them to the Kantian "laws of the human mind," by separating idea from its formal concretization and checking events with the "movement of humanity," then history could assert itself as "a science" which ascribed the guiding deterministic principles of the universe to the "providence of God."[95]

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[92] *History,* VIII (3rd ed., 1864), 118; not in ALR. *Cf.* the statement of William Sloane, *op. cit.*, 484, that "Bancroft's devotion to Kant as well as Edwards is explained by the fact that, meeting the skeptics on their own ground, Kant still proves the existence of *a priori* truth and of *a priori* synthetic judgments. His [Bancroft's] standpoint, therefore, as an historian, is that of the newer scientific school, which views history as a unit, its forces as constant, and their manifestations as parts of an organized whole. Every individual must have his place in the picture, but the background is the history of the race."

[93] Howe, *op. cit.*, II, 77. Bancroft continued: "I defy a man to penetrate the secrets and laws of events without something of faith. He may look on and see as it were the twinkling of stars and planets and measure their distances and motions; but the life of history will escape him. He may pile a heap of stones, he will not get at the soul. This is my commentary."

[94] *Miscellanies,* p. 493.

[95] *History,* III (18th ed., 1864), 398; ALR, II, 398. Thus in Bancroft's very first volume of his *History* he set forth his aim: "It is the object of the present work to explain how the change in the condition of our land has been accomplished;

Thus history was the analysis of idea as absorbed in the mundane world. "The moral world is swayed by general laws," Bancroft wrote, and it in turn animated men and events.[96] History was the companion of philosophy and the interpreter of philosophy through an appeal to actual events. "Let not human arrogance assume to know intuitively, without observation, the tendency of the ages."[97] Facts "faithfully ascertained" and properly related formed "the firm links of a brightly burnished chain" of cause and effect.[98] As philosophy elaborated the "study of ethics" history checked it against the broad background of experience. The historian, "to find moral truth . . . must study man in action."[99] "The laws of which reason is conscious can be tested best by experience; and inductions will be the more sure, the larger the experience from which they are drawn."[100] Possessed then of the truth that God revealed Himself through an inexorable chain of events, the student would be incited to an active participation in this "grand drama of time," sustained by the "tranquil conviction" that "the Redeemer of the nations liveth."[101] Idea made events; chance was an idle man's fancy; history was science seeking out God's laws.

The great dividing line between the past and the present growth toward liberty was drawn by the principles of the Reformation. Justification by faith as expounded by Luther and the "republican spirit of religion" advanced by Calvin—"the keenest dialectician of his century"—crashed to the ground the structure of canon law and priestly hierarchy of a church content to remain within the boundaries of the Middle Ages. The individual assumed his innate importance. Freedom of conscience paved the way for freedom of action according to God's decrees. Republicanism meant revolution.[102] Institutions were swept aside in the grand march of humanity to its appointed end. "Out of Calvinistic Protestantism rose in that day four great teachers of four great nationalities, America, Great Britain, Germany, and France. Edwards, Reid, Kant, and Rousseau were all imbued with religiosity, and all except the last, who spoiled his doctrine

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and, as the fortunes of a nation are not under the control of a blind destiny, to follow the steps by which a favoring Providence, calling our institutions into being, has conducted the country to its present happiness and glory." *History,* I (20th ed., 1864), 4; ALR, I, 3.

[96] *History,* III (18th ed., 1864), 397; ALR, II, 268. *Cf.* also Bancroft's statement that "the principles of public justice . . . emanate directly from God." (4 July, 1826 Oration)

[97] *History,* III (18th ed., 1864), 397; ALR, II, 268.

[98] *Ibid.,* p. 398; ALR, II, 268.

[99] *History,* ALR, VI, 7.

[100] *Ibid.*

[101] *Ibid.*

[102] Thus Bancroft had no deep-seated antipathy to war but felt it good—and almost necessary—in the march of freedom.

by dreamy indolence, were expositors of the active powers of man. All these in political science, Kant most exactly of all, were the counterparts of America . . ."[103] The Reformation inculcated intelligence, moral uprighteousness, courage and a love of freedom in all men. Its theological principles precipitated the great political awakening.

In America, Protestantism activated alike the Calvinists, the Quakers, the freemen of Virginia, the backwoodsmen. It was a "renovating principle" that declared for "the immutable principles of human nature and human rights," duplicated in politics what it had achieved in religion, elevated the common man to his rightful peerage. But since "Protestantism [was] not humanity," because fundamentally it was a protest movement, in America it took on new garb befitting its new geographical location. It had fought the battle against tradition and had affirmed again the eternal rights of justice, truth and equality. Now predestination lost its position as the leading precept; instead came the concepts that God was all being, that to love God meant to include all humans, that God was the fountain of knowledge, that He was the source of Happiness, his own chief end in creation, an absolute sovereign. New England, for instance, "ceased to make predestination its ruling idea, and, maturing a character of its own, 'Saw love attractive every system bind.' "[104]

Inherent in Protestant Christianity was the love of liberty and the movement toward democracy. To Bancroft, "democracy is practical Christianity."[105] In spite of the fact that a "mixture of good and evil is the condition of our earthly being," the impulse for liberty had to be located in "human nature";[106] in the organic development of America the principle had attained a lodging that could never be preempted.[107] The colonists had been neither skeptics nor sensualists, but Christians. And fundamentally, because Protestantism logically led to freedom of conscience and consequent equality before the law, this led to individual liberty and communion on an equal basis. America was an example to the world of the workings of democracy. Its colonists upon arriving found a virgin land uncluttered by traditions and insti-

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[103] *History,* IX (1st ed., 1866), 501; not in ALR.

[104] *History,* IV (18th ed., 1864), 154–155; ALR, II, 405. In 1868 Bancroft felt that Catholics were massing power and he wrote the Reverend Dr. Samuel Osgood that the secular aspect could not be treated with "forbearance of sentimentality and imagination; the attempt at tyranny over mind and in the state is too terrible to be favoured or forgiven. We must rekindle the lights of Puritanism . . ." Howe, *op. cit.,* II, 204.

[105] Howe, I, 216. The remark was made in a speech at Springfield on the 4 July, 1836.

[106] 4 July Oration, 1826, *op. cit.,* p. 4.

[107] "The democratic principle is the true American principle; it is as safe as our independence." Howe, *op. cit.,* I, 234.

tutions. They bore with them the seeds of democratic procedures.[108] And since organic development proceeds true to the inward energies of self, democracy was destined to become the distinguishing trait of the national character.

Furthermore, there were philosophical reasons for the beneficent rule of the commonalty. Since, Bancroft argued, "the gifts of mind and heart are universally diffused, [and] the sentiment of truth, justice, love, and beauty exists in every one, then it follows, as a necessary consequence, that the common judgment in taste, politics, and religion, is the highest authority on earth, and the nearest possible approach to an infallible decision."[109] It should be noted that Bancroft does not state that the common mind is infallible on all occasions. He admits that although reason is "a universal faculty" there may be "differences of opinion." On the other hand, "Truth is one." Consequently, in making men at large the criterion of government, he goes on the statistical basis that if enough men participate then the errors of individuals will be cancelled out by the majority will that has certified truth through reflective consciousness.[110] "The popular voice is all powerful with us; this is our oracle; this, we acknowledge, is the voice of God."[111]

Whereas Emerson had exalted the individual because of reason, Bancroft used reason to forge the idea of collective action. To Bancroft individuals were of "limited sagacity." "The individual is often lost; Providence never disowns the race."[112] He would have decided the slavery question by the "collective judgement of the nation" because at the bottom of United States institutions and union lay the "principle of popular power."[113] When war between the states did come it was because of the "fallacy" of the "doctrine of individualism, pushed to its extremest limit."[114] His emphasis on the social group no doubt arose from an early acquaintance with German nationalism,[115] his belief that

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[108] "As the Pilgrims landed, their institutions were already perfected. Democratic liberty and independent Christian worship at once existed in America." *History,* I (20th ed., 1864), 313; ALR, I, 209.

[109] *Miscellanies,* p. 415.

[110] This was no primitivistic doctrine. His thinking was similar to Jefferson's. "Education of the people, good morals, moderation, decentralization, individual liberty with deference to law—these are the conditions for organising a republic." Howe, II, 242–243.

[111] 4 July Oration, 1826, *op. cit.,* p. 20. *Cf.* John Barnard's election sermon of 1734, when he said: "This voice of nature is the Voice of God. Thus *'tis that vox populi est vox Dei."*

[112] *Miscellanies,* p. 434. But on at least one occasion Bancroft remarked that "The people are swayed more by their emotions than by dialectics; . . . the majority is most readily roused for that . . . which appeals to the heart." *History,* ALR, I, 183; this passage not given in the parallel section of the 20th edition of vol. I, 280–281.

[113] Howe, *op. cit.,* II, 37.

[114] *Ibid.,* II, 137.

[115] Later, when Bancroft was minister to Germany (1867–74), he incurred French disapproval in a military rigidness which nearly out-Junkered the Junkers.

the Americans were forging a new race or at least a national consciousness, and his awareness of a dark side to human nature. "The numbers, purity, culture, industry, and daring of [America's] inhabitants proclaimed the existence of a people, rich in creative energy, and ripe for institutions of their own," Bancroft remarked of the early colonies.[116] New conditions and geographical factors and the influence of a new age contributed to distinguish Americans in the mass from their European brethren. The individual was important; but it was the social group that the historian must keep constantly before his mind's eye.

While Bancroft held that progress was a continuing factor throughout the world, the conditions unique to America placed her first in the march to the realization of destiny. Over the nations of the world hovered the spirit of God, "a superior power of intelligence and love, which is moved by justice and shapes their course."[117] ". . . the eternal flow of existence never rests," he remarked, "bearing the human race onwards through continuous change. Principles grow into life by informing the public mind, and in their maturity gain the mastery over events; following each other as they are bidden, and ruling without a pause."[118] Since man's nature in its essence was fixed, progress in the race could not stem from a fundamental change in human nature. Progress came from without man, from God, who worked both "within and around" man to accomplish his ends. Man's progress, as Herder and others had said and as Aristotle had been the first to say, rested on the accumulative power of culture. There could be no turning back, no nostalgia for the primitive days when man was most himself, for the promise lay in the present and even more so in the future.[119] The faculties of the individual mind were limited to their development; but the race, through the grace of God, moved ever in advance.

There were breaths of dissent to Bancroft, but they were drowned in the good-will of a nation emerging into national consciousness. No man mirrors so well as Bancroft a period when a people conceived of itself as peculiarly favored by the gods. The

[116] *History,* VII (7th ed., 1864), 22; ALR, IV, 3.

[117] *History,* IV (18th ed., 1864), 4; ALR, II, 319–320.

[118] *Miscellanies,* p. 483.

[119] *History,* IV (18th ed., 1864), 8–9; ALR, II, 323. In a footnote Bancroft cites Kant's *Idee zu einer allgemeinen Geschichte in Welturgerlicher Ansicht (Sammtliche Werke,* vii, i, 319). Later he remarked, "The method of Kant being that of the employment of mind in its freedom, his fidelity to human freedom has never been questioned and never can be. He accepted the world as it is, only with the obligation that it is to be made better. His political philosophy enjoins a constant struggle to lift society out of its actual imperfect state, which is its natural state, into a higher and better one, by deciding every question, as it arises, in favor of reform and progress, and keeping open the way for the elimination of all remaining evil." *History,* X (1st ed., 1874), 88; not in ALR.

march of America toward freedom had been of epic character. Its heroes were of the stature of Ulysses and Aeneas, considered hardly less than saints in many an American household. God was on the American side, succoring it and confounding its enemies.

Historians since have shown how pitiably wrong Bancroft so often was. He was rich in theories but poor in proofs. He wrote within the context of a faith, possessed by *a priori* assumptions that naturally colored his interpretation. All men have a particular bias; the fault with Bancroft was that he had so many—and that they were so strong. For us his failure lies in his inability to see the rich complexity of events. He saw things whole, from a theoretical point of view. American history was the result of one all-embracing national character. Yet he could lay claim to some firsts. He was an indefatigable fact-finder, however much he shaded them.[120] He carefully documented his sources.[121] Although primitively interpreted from our point of view, he had an appreciation for economic and social data, demography and geography.[122] He understood the various colonies had played various roles in the movement towards independence, and that the west had been a conditioning factor on the way people thought. Above all, he treasured the values of impartiality and of historical skepticism.

Most important for any final evaluation of Bancroft is his concept of cultural relativism.[123] Throughout Europe a profound mental change had taken place, and Bancroft, always sympathetic to theoretical thought, was affected. It was expressed in the attitude that "unceasing movement is the law of whatever is finite." "Everything is in movement, and for the better," he wrote, "except only the fixed eternal law by which the necessity of change is established; or rather except only God, who includes in Himself all being, all truth, and all love." From the idea rose the consequent belief that the actions of men could be interpreted in terms of environment and heredity. A developmental thesis could explain why men thought, felt, and acted as they did and reduce seeming contradictions to consistency. Here in Bancroft is a resolute attempt to view history in terms of genetic explanations. There was no hiatus, he thought, between one moment of

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120 Howe (*op. cit.*, II, 104–105) wrote that Bancroft in utilizing the vast amount of source material used each page of a blank quarto book for a particular day, then wrote down all that had occurred, even to the phases of the moon.

121 Bancroft explained he had not documented vols. VII–VIII of the *History* because of "the variety and multitude of the papers which have been used, and which could not be intelligibly cited." Howe, *op. cit.*, p. 103, II.

122 See N. H. Dawes and F. T. Nichols, "Revaluing Bancroft," *New England Quarterly*, VI (1933), 278 ff.

123 I am at present engaged in tracing the genesis and development of the theory of genetic historical scholarship in America from 1800 to 1850.

time and another, or between the acts of states, groups and individuals; attention to the complex of causal sequences could transform a chaos of facts into a model of scientific order. His religious and philosophical views of human nature taught him that in essence the individual would always remain what he was, a man contingent upon God. But when it came to the view of society, it was a different matter. His idea of organicism led to the concept of national character. The Edwardsian element and the notion of national character are essential to his thought, both acting as mediating links between his views of human nature and his philosophy of history.

# SPRING EMERGENCE AND FLORAL HOSTS OF WISCONSIN BUMBLEBEES

R. E. FYE AND J. T. MEDLER[1]

Queen bumblebees were collected in the spring on floral hosts and the species determined. In southern Wisconsin the first queens appear about April 20 in an average season. However, the first queens may appear as early as the first week in April, and in a very late season, such as in 1953, they may not appear until the first week of May.

*Bombus terricola* Kirby is the first species to appear and *B. bimaculatus* Cress. and *B. ternarius* Say are not far behind. Succeeding these three species are *B. pennsylvanicus* DeGeer, *B. auricomus* (Robt.), *B. separatus* Cress., *B. affinis* Cress., *B. impatiens* Cress., *B. vagans* F. Sm. and *B. fervidus* F.

In northern Wisconsin the dates of emergence are about one week later. There *B. borealis* Kirby probably appears about mid-May and *B. rufocinctus* Cress., which is the last species to appear in the spring, is slightly later.

A study of the floral hosts of bumblebees is important in regard to increasing their numbers. The provision of spring floral hosts may have considerable effectiveness in attracting and holding the queens in a given area. Later in the season the floral hosts are of interest in their capacity of competitors with cultivated legumes which need pollination for the production of a seed crop.

Frison (1923) pointed out that the bees follow the floral succession, i.e., the first bees out in the spring are essentially bees which nest in the woods where the blossom at the time of their emergence is located and those emerging later nest in the field where the bulk of the bloom has moved by the time of their emergence. Since an area which presented the entire sequence in sufficient amounts should provide some inducement for the bees to nest in the area it would appear that any individual interested in bumblebee propagation would do well to provide the entire sequence.

In Wisconsin we find the first emerging bumblebees visiting the various species of willow. This plant with its copious quan-

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tities of readily available pollen undoubtedly is of great value to the queen who must initiate a colony and procure the necessities without any aid. As the willow wanes the wild and cultivated plums become the source of pollen and nectar and these are succeeded by the cherries, both native and cultivated. As these decline the dandelions and apples become the important sources of provisions. Lilac, *Crataegus* spp. and *Lonicera* spp. which follow then become the main food sources. This brings the bees to the early bloom of white Dutch clover which inaugurates the period during which the various clovers, white, Ladino, red, sweet and alsike, and alfalfa become the most used sources of provisions. These legumes, particularly in farmed areas, satisfy the bulk of the requirements of the bee colony throughout the summer with only a little competition from sumac, basswood, thistles, asters and goldenrod. However, when the males and new queens emerge they are commonly found on the latter two plants. Other plants included in Table 1 either have short-lived bloom or provide insufficient bloom to provide the essential amounts of pollen and nectar.

Bumblebees show marked preference for certain species or families of plants. Plath (1934) gave information on the bees in New England. The floral hosts in Wisconsin have been listed in Table 1, and supplementary data are presented here.

*B. rufocinctus* which is generally speaking, a late season bee shows a marked preference for the Compositae which are in bloom at the time the colonies reach their peak populations. Particularly visited are the goldenrods, asters and sunflowers, which were probably native hosts before man introduced the legumes.

*B. separatus* is rather faithful to the legumes and shows preference for red and white clover. An excellent tripper of alfalfa its workers are too few in number to be of more than minor importance in that capacity in northern Wisconsin.

*B. borealis* shows an extremely marked preference for red clover and in its presence seldom visits other flowers. However, it has occasional lapses and visits other legumes showing a preference for the white clovers in the absence of red clover. Occasionally workers and males are found on a variety of blossoms but they are usually few in number. Queens are found rather frequenty on vetch in the spring.

*B. fervidus* probably shows the extreme in a marked preference. The workers of this bee are found on red clover and virtually no other flower except when there is a lack of red clover. At these times they switch to white clover and alfalfa, but may occasionally be found on other flowers, usually those of the family Compositae.

TABLE 1

THE WISCONSIN FLORAL HOSTS OF THE BOMBUS COLLECTED IN 1951, 1952 AND 1953

Q = queen, W = worker, M = male

| FLORAL HOSTS | auricomus | rufocinctus | separatus | borealis | fervidus | pennsylvanicus | affinis | terricola | bimaculatus | impatiens | perplexus | vagans | ternarius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Salicaceae | | | | | | | | | | | | | |
| *Salix* spp. | | Q | | | Q | | Q | Q | Q | Q | | Q | Q |
| Caryophyllaceae | | | | | | | | | | | | | |
| *Lychnis alba* Mill. | | | | W | | | | W | | | | | |
| Ranunculaceae | | | | | | | | | | | | | |
| *Ranunculus septentrionalis* Poir. | | Q | | Q | | | | | | | | Q | Q |
| *R. repens* L. | | | | W | | | | | | | | | |
| *R. acris* L. | | | | W | | | | | | | | | |
| Cruciferae | | | | | | | | | | | | | |
| *Brassica nigra* (L) Koch. | | Q | | Q | Q | | | Q | | Q | | Q | Q |
| Saxifragaceae | | | | | | | | | | | | | |
| *Philadelphus hirsutus* Nutt. | | | | | Q | | | | | | | Q | |
| *Ribes* sp (gooseberry) | | | | | Q | | | | | | | | |
| Rosaceae | | | | | | | | | | | | | |
| *Pyrus* sp. (Malus) | | | Q | | | | Q | | Q | Q | | | |
| *Pyrus Malus* L. | Q | | Q | Q | Q | | Q | Q | Q | Q | Q | Q | Q |
| *Crataegus* spp. | Q | | Q | | Q | | Q | | | Q | | | |
| *Geum rivale* L. | | | | | | | | | | | | Q | |
| *Rubus* spp. (raspberry) | | Q | | Q | | | | | | | Q | Q | Q |
| *Rubus* spp. (blackberry) | | Q | Q | | | | | QW | | | | QW | Q |
| *Rosa* sp. | | | | | | | | | | Q | | | |
| *R. carolina* L. | | Q | Q | Q | Q | | | QW | | | | | |
| *Prunus* sp. (ornamental) | | | | | | | Q | | Q | | | | |
| *Prunus* sp. (cherry) | Q | | Q | | | | | Q | | Q | | Q | Q |
| *Prunus* sp. (plum) | Q | | Q | | Q | | Q | Q | Q | Q | | Q | Q |

TABLE 1—*(Continued)*

THE WISCONSIN FLORAL HOSTS OF THE BOMBUS COLLECTED IN 1951, 1952 AND 1953

Q = queen, W = worker, M = male

| FLORAL HOSTS | SPECIES | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | auricomus | rufocinctus | separatus | borealis | fervidus | pennsylvanicus | affinis | terricola | bimaculatus | impatiens | perplexus | vagans | ternarius |
| Leguminosae | | | | | | | | | | | | | |
| *Cercis canadensis* L. | | | | | | | Q | | | | | | |
| *Lupinus* sp. (ornamental) | | | | | Q | | | | | | | | |
| *Trifolium pratense* L. | Q | QW | QW | QWM | QW | | Q | QW | W | Q | | QW | QW |
| *Trifolium repense* L. (Dutch) | | QW | QW | QW | W | | | QW | | Q | W | QW | QW |
| *T. repens* L. (Ladino) | | Q | W | | | | | QW | | | | | |
| *T. hybridum* L. | | QW | W | W | W | | | QW | | | W | WM | W |
| *Melilotus* sp. (yellow sweet clover) | | Q | | Q | | | | W | | | | W | QW |
| *Melilotus alba* Desr. | | W | | W | | | | QW | | | | W | QW |
| *Medicago sativa* L. (trip) | | Q | QW | QWM | | | QW | QW | | | | W | QW |
| *M. sativa* L. (not tripping) | | QW | QWM | QWM | W | | W | QWM | | | Q | W | QW |
| *Vicia* spp. | Q | Q | Q | Q | QW Q* | Q | | W | | | | Q | |
| *Vicia tenuifolia* | | | | | | | Q | | Q | | | Q | |
| *Lotus corniculatus* L. | Q | Q | Q | | | | Q | QW | | | | | |
| Linaceae | | | | | | | | | | | | | |
| *Linus* sp. | | | | | | | | W | | | | | |
| Ancardiaceae | | | | | | | | | | | | | |
| *Rhus typhina* L. | | | | | | | | QW | | | | W | QW |
| Balsaminaceae | | | | | | | | | | | | | |
| *Impatiens capensis* Meerb. | | | | | W | | | | | | | W | |
| Guttiferae | | | | | | | | | | | | | |
| *Hypericum perforatum* L. | | | | | | | | W | | | | | W |
| Onagraceae | | | | | | | | | | | | | |
| *Epilobium angustifolium* L. | | Q | QWM | WM | | | | WM | | | W | WM | QW |

TABLE 1—(*Continued*)

THE WISCONSIN FLORAL HOSTS OF THE BOMBUS COLLECTED IN 1951, 1952 AND 1953

Q = queen, W = worker, M = male

| FLORAL HOSTS | SPECIES | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | auricomus | rufocinctus | separatus | borealis | fervidus | pennsylvanicus | affinis | terricola | bimaculatus | impatiens | perplexus | vagans | ternarius |
| Ericaceae | | | | | | | | | | | | | |
| *Vaccinium angustifolium* Ait. | | | | | | | | | | | | | Q |
| Oleaceae | | | | | | | | | | | | | |
| *Syringa vulgaris* L. | Q | Q | Q | Q | Q | | Q | Q | Q | Q | Q | Q | Q |
| Apocynaceae | | | | | | | | | | | | | |
| *Apocynum androsaenifolium* L. | | QW | | | | | | | | | | | W |
| Asclepiadaceae | | | | | | | | | | | | | |
| *Asclepias* spp. | | W | | W | | | | QW | | | | | W |
| Labiatae | | | | | | | | | | | | | |
| *Prunella vulgaris* L. | | | | Q | | | | | | | | W | |
| *Galeopsis Tetrahit* L. | | | | W | W | | | | | | | QW | |
| Scrophulariaceae | | | | | | | | | | | | | |
| *Linaria vulgaris* Hill | | | | | | | | W | | | | | |
| Caprifoliaceae | | | | | | | | | | | | | |
| *Diervilla Lonicera* Mill. | | | Q | | | | | | | | | | |
| *Lonicera* spp. | | Q | Q | Q | Q | | Q | Q | | | Q | Q | Q |
| *Viburnum Lentago* L. | | | | | | | | Q | | | | | Q |
| Compositae | | | | | | | | | | | | | |
| *Liatris aspera* Michx. | | | | | | | | W | | | | | |
| *Solidago* spp. | | QWM | M | WM | | | W | WM | | | M | WM | QWM |
| *Aster* spp. | | QWM | W | | Q | | | QWM | | M | | QM | WM |
| *Aster azureus* Lindl. | | | | | | | | WM | | | | | W |
| *Anaphalis margaritacea* (L.) C. B. Clarke | | W | | W | | | | W | | | | | W |
| *Heliopsis helianthoides* var. *scabra* | | W | | | | | | | | | | | |

TABLE 1—*(Continued)*

THE WISCONSIN FLORAL HOSTS OF THE BOMBUS COLLECTED IN 1951, 1952 AND 1953

Q = queen, W = worker, M = male

| Floral Hosts | Species: auricomus | rufocinctus | separatus | borealis | fervidus | pennsylvanicus | affinis | terricola | bimaculatus | impatiens | perplexus | vagans | ternarius |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Rudbeckia serotina* Nutt. | | W | | | | | | | | W | | | |
| *Helianthus* spp. | | WM | | Q | | | W | W | | | | WM | W |
| *Arctium* spp. | | | | | | | | | | | | WM | |
| *Cirsium vulgare* (Savi.) Tenore | | QW | | QWM | W | | | W | | | W | WM | W |
| *C. altissimum* (L.) Spreng. | | | W | | | | | | | | | W | |
| *C. arvense* (L.) Scop. | | W | | W | | | | QW | | | | W | QW |
| *Taraxacum* spp. | Q | | Q | Q | Q Q* | Q | Q | Q | Q | Q | Q | Q | Q |
| *Sonchus* spp. | | W | | | | | | | | | | | |
| *S. oleraceus* (L.) | | W | | | | | | | | | | W | |
| *Hieracium aurantiacum* L. | | Q | | | | | | | | | | Q | Q |

*Variety *dorsalis.*

*B. terricola* shows a preference for white clovers, both white Dutch and alsike, but it is not as marked a preference as that of *B. borealis* and *B. fervidus* for red clover. The bee goes readily to alfalfa. This is fortunate since it is an excellent tripper of alfalfa blossoms and is among the most important pollinators of the crop in northern Wisconsin. The floral hosts of this bee are actually rather diverse and it may be found on flowers of most any sort but seems to place the composites after the legumes in order of preference.

*B. vagans* seems to show little preference being a visitor of a variety of flowers. However, red clover seems to draw fair numbers of the workers and might be noted as a preferred blossom. It is also commonly found on the white clovers and less commonly on the composites, a family in which it shows a preference for the thistles.

*B. ternarius* shows some preference for white Dutch and alsike clovers but is found on a wide range of hosts apparently preferring the composites to other bloom. This gives us a clue as to the native hosts before the introduction of cultivated legumes.

Inadequate data were obtained on the floral preference of the other species of Wisconsin bumblebees but generally it may be stated that the white clovers draw the most attention when they are available. In fact, legumes in general seem to have the greatest attraction for the bees during the summer and among themselves create the greatest competition for pollinators of the seed crops. Goldenrod and thistles are the major native competitors. Although such bloom as fireweed, raspberries, basswood, jewel weed and sumac may attract a considerable number of bees their bloom is either too short lived or occurs in insufficient quantity to be important as competing bloom.

## Summary

In Southern Wisconsin bumblebee queens emerge from their winter hibernacula during the latter part of April.

The spring floral sequence, i.e., the presence of plants blooming in succession, markedly effects the ability of an area to attract and maintain bumblebee populations.

A wide range of flowers, both native and cultivated, are visited by the Wisconsin bumblebees. However, the various species show preferences for certain groups of flowers. The legumes seem to be the major food source during the summer. The composites are frequently utilized after mid summer.

In the production of legume seed crops, the different cultivated legumes are the most serious competitors for bumblebee populations.

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# IDENTIFICATION OF THE LARVAE OF THE MORE IMPORTANT INSECT PESTS OF SOUR CHERRY IN WISCONSIN[1]

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In a field study on the biology and control of the insect pests infesting sour cherry it is relatively easy to identify the majority of the species involved. There is apt to be confusion, however, when the larvae of certain of these pests are being studied simultaneously. In Wisconsin the species that may be incorrectly identified because of morphological and environmental similarities are the cherry fruit worm, *Grapholitha packardi* Zell.; the destructive prune worm, *Mineola scitulella* Hulst.; the fruit tree leaf roller, *Archips argyrospila* (Walk.); the bud moth, *Spilonota ocellana* (D. & S.); the codling moth, *Carpocapsa pomonella* (L.); and the plum curculio, *Conotrachelus nenuphar* (Herbst). Although the codling moth, *Carpocapsa pomonella* (L.), is not a major pest of sour cherry in Wisconsin, it is included here because of its similarity to the cherry fruit worm.

Of course the adults of the plum curculio can be readily distinguished from the adults of the other pests. Adults of the others, all Lepidoptera, are not difficult to identify if reference is made to published descriptions. Since these descriptions are readily available they are not included here.

Morphological differences are present in some of the larval forms but the developmental cycles, types of injury, and general larval configuration may be similar and the larvae may be identified incorrectly. For example, the prune worm and the bud moth have similar developmental cycles, they cause similar injuries, and are of the same general body configuration in all but the last instar. Since numerous points of similarity exist it is believed that a key for the identification of the larval forms of the various species will be of value.

The characters used in the preparation of this key were those ordinarily used in larval taxonomy (Peterson, 1948). The detailed larval descriptions were made from specimens collected in the Door County area of Wisconsin. Setal patterns for each of the species are presented in Figure 1. On the basis of these larval

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[1] Approved for publication by the Director of the Wisconsin Agricultural Experiment Station.

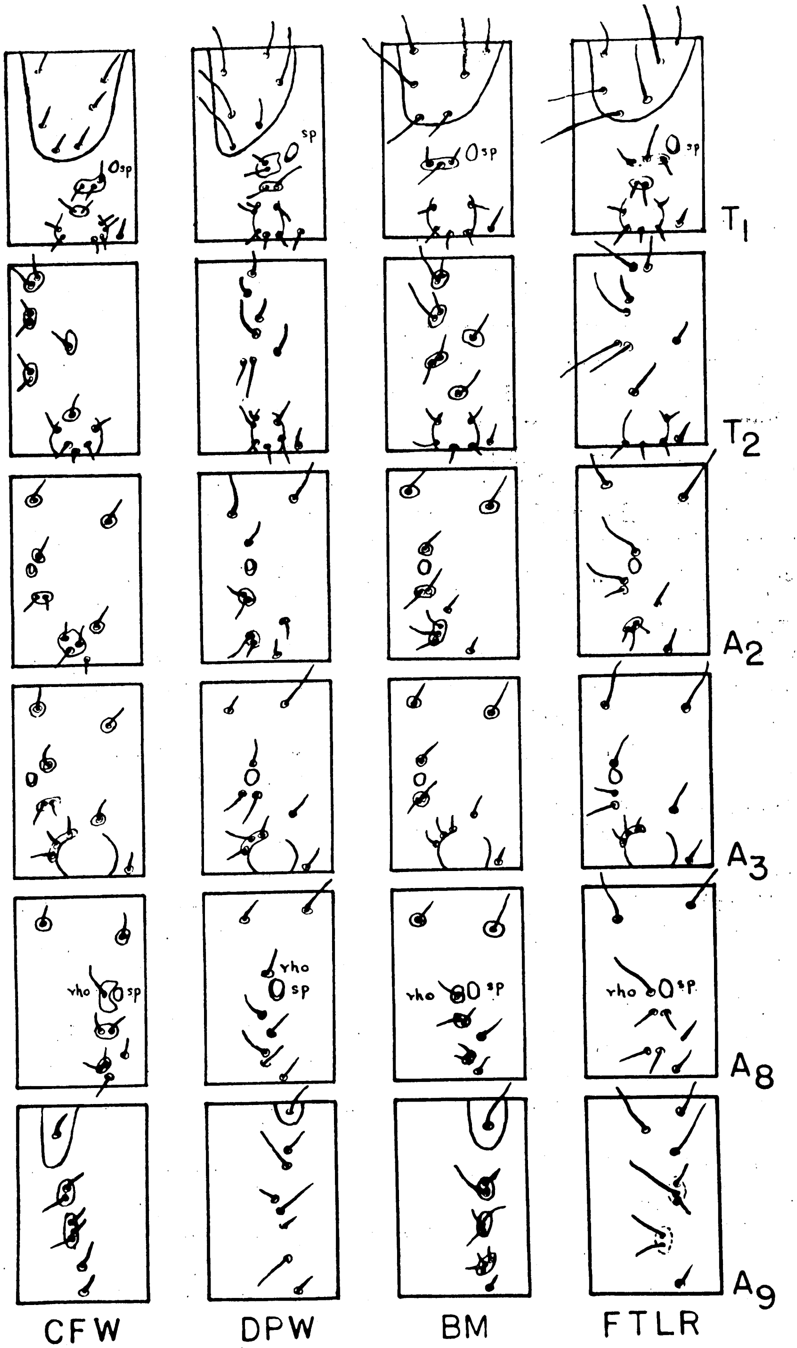


FIGURE 1. Setal maps of the cherry fruit worm, the destructive prune worm, the bud moth, and the fruit tree leaf roller.

*Legend*

CFW—Cherry fruit worm
DPW—Destructive prune worm
BM—Bud moth
FTLR—Fruit tree leaf roller
$T_1$—1st thoracic segment
$T_2$—2nd thoracic segment
$A_2$—2nd abdominal segment
$A_3$—3rd abdominal segment
$A_8$—8th abdominal segment
$A_9$—9th abdominal segment
rho—Seta rho
sp—Spiracle

descriptions and setal patterns the following key to all instars of the six species was constructed.

KEY TO THE LARVAE

1. Abdominal prolegs present .................................... 2
   Abdominal prolegs absent ............................*plum curculio*
2. Crochets on abdominal prolegs uniordinal, uniserial, and in a complete circle; general body color whitish pink .................. 3
   Crochets biordinal or triordinal ................................ 4
3. Anal comb absent ...................................*codling moth*
   Anal comb present ...............................*cherry fruit worm*
4. Crochets on abdominal prolegs biordinal, uniserial and in a complete circle; general body color chocolate brown, somewhat paler on ventral surface; seta rho of the eighth abdominal segment cephalad-ventrad of the spiracle ...........................*bud moth*
   Crochets on abdominal prolegs triordinal, uniserial and in a complete circle .................................................. 5
5. Seta rho of the eighth abdominal segment distinctly dorsad of the spiracle; general body color chocolate brown in all but final instar; final instar, chocolate brown on dorsal surface, ventral surface orange-brown, two colors distinctly separated laterally by spiracles ..........................................*destructive prune worm*
   Seta rho of eighth abdominal segment distinctly cephalad-ventrad of the spiracle; general body color greenish yellow..*fruit tree leaf roller*

## PLUM CURCULIO

The description of the larva is given by Quaintance and Jenne (1912) as follows:

### THE LARVA

When full grown—length 6 to 9 mm., breadth 1.75 to 2.5 mm.; a yellowish-white, footless grub; nearly cylindrical, slightly flattened on ventral side; body curved toward ventral side, bow-shaped; sides of each segment from second thoracic to eighth abdominal expanded into a fleshy lobe above and below a depressed lateral line.

Head as broad as long, about 1 mm. each way; color nut-brown; epistoma, clypeus, labrum, and mandibles darker; epicranial suture and its continuation as a median line extending beyond the middle of the front also darker; frontal suture light yellow, submentum yellowish white; antennae minute, one-jointed, situated at base of mandibles at ends of frontal suture; minute eye-spots usually present directly laterad and caudad of antennae; mandibles with two blunt teeth; palpi two-jointed; seven hairs on each side of the epicranium, two on the front, two on epistoma, two large and many small hairs on labrum, two on each mandible, two on submentum, two on mentum, one on stipes, two on palpifer, and eight on lacinia.

Thorax.—Prothorax with a light brown chitinized shield on the dorsum and a slightly chitinized area on each side of the venter; a conspicuous oblong spiracle situated above the middle of the side, its long axis extending dorso-ventrally; three pairs of large hairs on the dorsum, two pairs of large and five pairs of minute hairs below the lateral line.

Mesothorax and metathorax without spiracles; each with one pair of large and four pairs of minute hairs on the dorsum, a large hair on the upper and one on the lower lateral lobe, one pair of large and four pairs of minute hairs on the venter.

Abdomen.—Segments 1 to 7 each with an oblong spiracle above the middle of the side, its long axis extending longitudinally; two pairs of large and three pairs of minute hairs on the dorsum, one large and one minute hair on each lateral lobe, and three pairs of minute hairs on the venter.

The eighth abdominal segment is smaller than the preceding, truncate posteriorly, has no spiracles, and bears two pairs of large and one pair of minute hairs on the posterior dorsal margin and two pairs of minute hairs on the venter.

The anus, surrounded by three anal lobes, is situated on the ventral posterior part of the ninth abdominal segment.

## CODLING MOTH

Mature larva—General color grayish-white to cream, dorsal surface with pink tints showing through the skin; head, mottled deep brown to black, shiny; mouth parts, dark to pale brown; antennae, grayish-white; thoracic shield, shiny, light brown on anterior half, posterior half dark brown, divided in the middle by a longitudinal paler line; thoracic legs, white with pale brown scleratizations; prolegs, white, crochets, uniordinal, uniserial, and in a complete circle; setae on slightly differentiated pinaculae; anal shield, light brown, anal comb absent.

## CHERRY FRUIT WORM

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; antennae, 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.

## BUD MOTH

Mature larva—General color chocolate brown, ventral surface paler than dorsal; head, from medium brown to black; mouth parts brown, lighter than head; antennae pale at base, remainder black; thoracic shield shiny, dark brown to black, divided in the middle by a longitudinal paler line; thoracic legs black, shiny; prolegs lighter than body, crochets biordinal, uniserial, and in a complete circle; crochets on anal prolegs biordinal, uniserial, and in a transverse band; setae on pinaculae which are darker than body; anal shield medium to dark brown; anal comb short, black, two to five prongs of irregular length.

## DESTRUCTIVE PRUNE WORM

Mature larva—Dorsal surface dark brown, ventral surface orange, two colors meet on pleural walls at spiracles; head pale brown, fringed with dark brown to black, shiny; mouth parts pale to dark brown; antennae whitish at base, brown to black towards tip; thoracic shield shiny, brownish orange, divided in the middle by a longitudinal paler line; thoracic legs black; prolegs brownish-orange; crochets triordinal, uniserial, and in a complete circle; crochets on anal prolegs triordinal, uniserial, and in a transverse band; setae rarely on pinaculae; anal shield roughened, yellowish-brown; anal comb absent.

## FRUIT TREE LEAF ROLLER

Mature larva — General color greenish-yellow; head black, shiny; mouth parts black; antennae white at base, remainder black; thoracic shield shiny, yellowish-white, mottled with black near caudal edge; first thoracic legs black, remaining pairs paler, nearly concolorous with body; prolegs concolorous with body; crochets triordinal, uniserial, and in a complete circle; crochets on anal prolegs uniserial, triordinal, and in a transverse band; anal shield not distinct, concolorous with body; anal comb present, four to eight prongs of irregular length; setae on pinaculae which are hardly differentiated from general body color.

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# CERTAIN MICROBIOLOGICAL CHARACTERISTICS OF SELECTED GENETIC TYPES OF FOREST HUMUS[1]

D. L. MADER[2]

Investigations of forest humus in the past were largely confined to the morphological and physico-chemical properties of ectorganic and endorganic layers (Mueller, 1887; Romell and Heiberg, 1931; Heiberg and Chandler, 1941; Hoover and Lunt, 1952). The microbiological characteristics, on the other hand, received only casual attention, and the fragmentary information now available is of questionable value because it was obtained with little regard to the genetic nature of humus. This study attempted to detect by laboratory methods the behavior of microorganisms in four pronounced genetical types of humus layers. Three of these were selected from the ectorganic and the fourth from the endorganic forms. The description of these types follows.

1. *Arthropod bran mor* (foliogenous ecto-humus) developed by the macerating activity of arthropods on morainic loams supporting hemlock-hardwood stands. The humus layer consists of friable or granular remains of leaves and needles, sharply delineated from the podzol horizon and averaging about 1 inch in thickness. This type of forest floor was frequently referred to as "forest litter," "förna," or "superficial mull." Samples were collected in the vicinity of Clear Lake Field Station, University of Wisconsin. The chemical characteristics of this type were previously studied by Lafond (1950) and Mader (1953).

2. *Mycelial matted mor* (partly lignified ecto-humus) developed from plant remains and interwoven fungal hyphae under stands of hemlock on morainic loams. This typical representative of "raw humus" is made up of a thick, firmly consolidated superficial layer derived primarily from fungous mycelia penetrating the partly decomposed or lignified plant remains. Chemical properties were previously reported by the author (Mader, 1953). Samples of this form were collected at Camp Filibert Roth, University of Michigan, northern peninsula of Michigan.

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[2] Research Assistant in Soils, University of Wisconsin. The writer acknowledges the helpful suggestions and assistance in laboratory determination of Dr. S. A. Wilde, Professor D. J. Persidsky, and Mr. C. B. Davey. Appreciation is expressed to S. B. White of the Newaygo Timber Co., Ontario, and Dr. André Lafond of the Laval University, Quebec, for supplying humus samples.

3. *Sphagnum bog mor* (moss-originated ecto-humus) composed of slightly decomposed remains of bog moss which accumulate on poorly drained soils under stands of black spruce. The depth of organic layer approaches 1 foot. Reaction varies from pH 3.5 to pH 4.2, average content of total carbon is 41.5 per cent, and that of total nitrogen is 1.06 per cent. Samples collected in northern Quebec, Canada.

4. *Earthworm crumb mull* (zoogenous endohumus) developed by the action of *Lumbricidae* from morainic silt loams supporting stands of hard maple, basswood, and white elm. This type is characterized by a thin layer of litter overlying a deep horizon of earthworm castings, i.e., aggregates of intimately mixed organic and mineral matter. Samples were collected in the vicinity of the Marshfield Branch Experiment Station, University of Wisconsin. The pH value of the sampled layers varied between 5.3 and 5.7, a rather unusual reaction for this humus form. The chemical analyses of this type of humus layer were previously reported by Wilde, Buran, and Galloway (1937) and by Lafond (1950).

The microbiological properties of these humus layers were studied by employing analytical procedures which promised results of practical significance. The nitrification capacity was determined by the phenoldisulphonic acid method after the samples had been incubated for two weeks (Fred and Waksman, 1928). The rate of decomposition of cellulose and protein was measured by a modified method of Richard (1945). The tensile strength of the cellulose and protein cords was determined after seven-day and fourteen-day incubation, respectively. The effect of volatile substances on the growth of excised root tips of blue lupine was determined using the method described by Cholodny (1948) and Persidsky and Wilde (1953). The membrane filter technique (Clark, *et al*, 1951) was employed to determine the population of aerobic micro-organisms. The colonies were grown on Albimi M nutrient medium for 72 hours at 23° C. The results of analyses, presented in Table 1, reveal a sharp picture of the microbiological characteristics of humus layers of different origin.

Arthropod bran mor, in spite of its acid reaction and rather high C/N ratio, is an immensely active material; it is probably one of the most active humus types of the temperate zone. It exhibits a very high rate of decomposition of both cellulose and protein. The volatile substances emanated by this humus produce a highly stimulatory effect on the growth of excised root tips. The number of aerobic microorganisms detected on molecular membrane filters approaches an enormous density of 22 millions per cc.

TABLE 1

REACTION, CARBON-NITROGEN RATIO, AND MICROBIOLOGICAL CHARACTERISTICS OF REPRESENTATIVE TYPES OF HUMUS LAYERS

| Humus Types | Reaction | C/N Ratio | Nitrification Capacity | Cellulose Decomposition | Protein Decomposition | Volatile Substances | Number of Aerobic Micro-organisms |
|---|---|---|---|---|---|---|---|
| | pH | | p.p.m. | lbs./cord | lbs./cord | root length mm. | $10^6/cm^3$ |
| Arthropod Bran Mor | 5.3 | 17.9 | 20.25 | 3.5 | 5.5 | 4.1 | 21.4 |
| Mycelial Matted Mor | 4.1 | 18.7 | 2.42 | 2.6 | 12.1 | 0.8 | 4.2 |
| Moss Bog Mor | 3.9 | 39.2 | Trace | 10.8 | 15.2 | 0.2 | 1.8 |
| Earthworm Crumb Mull | 5.5 | 11.1 | 5.42 | 1.5 | 7.5 | 2.5 | 0.2 |

Moss bog mor, on the other hand, presents a direct contrast to the arthropod mor. Its extremely acid reaction and high carbon-nitrogen ratio are correlated with negligible nitrification capacity and extremely slow rate of cellulose and protein decomposition. This type produced no noticeable effect of volatile substances on the growth of excised roots, and the number of detected aerobic microorganisms did not exceed 2 million per cc.

Mycelial matted mor occupies an intermediate position between the active and inert mor types. The results of analyses suggest that this prototype of raw humus, is far from being an inert material as has been often believed in the past.

Earthworm crumb mull has been usually pictured as the most active form of humus. Actually it is not vastly different in its microbiological characteristics from the mycelial mor, and is certainly much less active than anthropod mor. The results of analyses suggest that the development of this type proceeds with very restricted participation of aerobic organisms.

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# EVALUATION OF COMPOSTED FERTILIZERS BY MICROBIOLOGICAL METHODS OF ANALYSIS[1]

CHARLES B. DAVEY[2]

In the course of fermentation composts undergo progressive changes during which they increase their microbial population, narrow the C/N ratio, lose inhibitory effects, and thus become nutritive and safe fertilizers. These changes are influenced by a whole complex of factors and cannot be determined by ocular examination. Therefore, an attempt was made to detect the degree of "ripeness" of composts by the determination of several microbiological characteristics. The rate of cellulose and protein decomposition was determined by the cord tension method (Richard, 1945), the consumption of carbohydrates on the basis of the C/N ratio (A.O.A.C., 1950), the population of aerobic organisms by the use of molecular membrane filters (Clark *et al.*, 1951), and the nature of compost-emitted volatile substances through the growth of excised root tips (Cholodny, 1951; Persidsky and Wilde, 1954).

The study was conducted with decay resistant sawdust which was subjected to drastic chemical treatments and inoculated with a highly effective cellulose-decomposing fungus, *Coprinus ephemerus* (Davey, 1953a; 1953b). The analyses were performed on composted material in four stages of decomposition: untreated sawdust, composted for two months; similar sawdust treated with anhydrous ammonia, potassium sulfate, and phosphoric acid, ten days after treatment; similar, chemically treated sawdust, inoculated with *Coprinus ephemerus,* 30 days after inoculation; and similar chemically treated sawdust, inoculated with *Coprinus ephemerus,* 90 days after inoculation. For sake of comparison, analyses included hardwood-hemlock leaf mold which is known to be a highly active and excellent fertilizer (Wilde, 1937). The microbiological population and effect of volatile substances on excised roots were also determined on microbiologically inactive moss peat.

The results of analyses given in Table 1 indicated that in the process of fermentation chemically treated sawdust loses its alkaline reaction and reduces its C/N ratio. Hand-in-hand, fermentation greatly stimulates both cellulolytic and proteolytic

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TABLE 1

CARBON-NITROGEN RATIO, AND MICROBIOLOGICAL CHARACTERISTICS OF SAWDUST COMPOST AT FOUR STAGES OF DECOMPOSITION AND OF HARDWOOD-HEMLOCK LEAF MOLD

| NATURE OF ORGANIC MATERIAL | CARBON-NITROGEN RATIO | CELLULOLYTIC ACTIVITY Loss of cord's strength | PROTEOLYTIC ACTIVITY Loss of cord's strength | MICRO-POPULATION FILTER COUNTS IN THOUSANDS | EFFECT OF VOLATILE SUBSTANCES ON EXCISED ROOTS OF BLUE LUPINE |
|---|---|---|---|---|---|
| | | pct. | pct. | cells per cc. | growth in mm. |
| Untreated sawdust, composted for two months; pH 5.4 | 384.1 | 36.02 | 28.92 | 200 | 1.29 |
| Similar sawdust treated with anhydrous ammon-nia, potassium sulfate, and phosphoric acid; te days after treatment, pH 8.1 | 56.8 | 38.88 | 37.30 | 35 | none |
| Similar chemically treated sawdust; 30 days after inoculation with *Coprinus ephemerus*, pH 7.4 | 39.2 | 45.41 | 39.89 | 1,050 | 2.78 |
| Similar chemically treated sawdust; 90 days after noculation with *Coprinus ephemerus*, pH 6.1 | 18.7 | 55.51 | 43.51 | 1,450 | 4.00 |
| -ardwood-hemlock leaf mold; pH 5.6 | 26.8 | 35.92 | 38.65 | 800 | 7.00 |

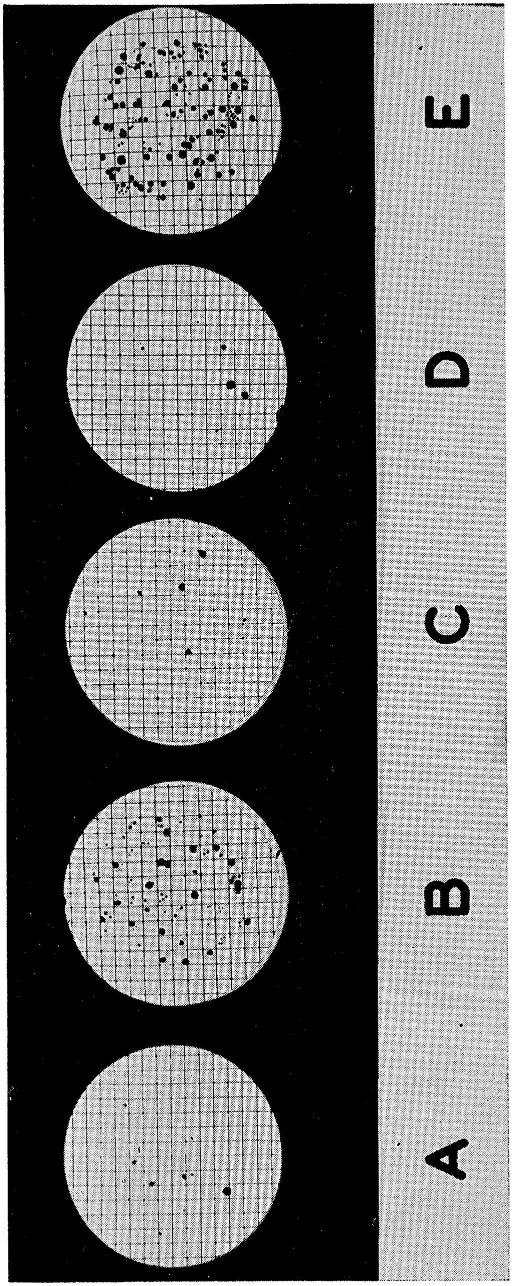


FIGURE 1. Number of colonies on molecular filter membranes obtained from 1 : 5,000 suspensions of different incubated organic materials: A—moss peat; B—hardwood-hemlock leaf mold; C—fresh hard maple sawdust; D—sawdust treated with anhydrous ammonia and phosphoric acid; E—chemically-treated sawdust decomposed by *Coprinus ephemerus*.

activity. It increases the population of aerobic organisms, and removes the inhibitory effects of toxic volatile substances. Judging from the results of analysis, fully fermented sawdust compost compares favorably with hardwood-hemlock leaf mold.

Figure 1 shows colonies developed on molecular filter membranes by 1:5,000 suspensions prepared from different sources. Figure 2 illustrates the growth of excised roots of blue lupine under the influence of volatile substances emitted by different organic materials.

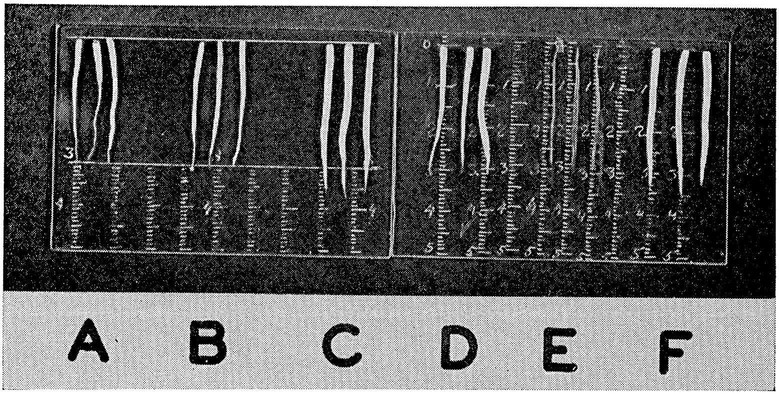


FIGURE 2. Effect of volatile substances emitted by different organic materials on excised roots of blue lupine: A—distilled water; B—moss peat; C—hardwood-hemlock leaf mold; D—fresh hard maple sawdust; E—sawdust treated with anhydrous ammonia and phosphoric acid; F—fermented sawdust.

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# THOMAS CAREW AND THE CAVALIER POETS

RUFUS A. BLANSHARD

English lyric poetry achieved, in the first half of the seventeenth century, a kind of perfection not matched in any other period. The major figures, Donne, Jonson, Herbert, Marvell, have been given their due, and even the early Milton has been invited to join them once again. But it was an age also of very good minor poetry. Indeed, a look at any anthology of the period will show that men who were less than great in range or depth were yet capable of flying high. This is as much as to say that there were traditions within which poets could perfect their craft, work out their individual themes without discovering wholly new mines of invention. Of these minor poets—and "minor" is not a disparagement in such an age—Thomas Carew deserves more attention than he has received. Carew is both a good poet in his own right, and a "typical" poet of his period, who perhaps would not have done so well if he had lived either earlier or later. I shall try briefly to indicate, first the inherited, and then the individual characteristics of his poetry. The latter —the individual qualities—can best be seen, I think, in comparison with those of three of his contemporaries who are often grouped with him in critical discussions: the so-called "Cavalier" poets, Herrick, Suckling, and Lovelace.

First, there is the poetic inheritance, in which the legacy of Donne is most noticeable. However Dryden, Johnson, and later critics came to censure or to praise Donne for his "metaphysical" wit, Carew openly avowed his discipleship in the best piece of Donne criticism of the seventeenth century, the *Elegie*. The following passage has not been improved upon as a statement of Donne's originality, force, and toughness. It is a comparison of Donne with the ancients:

Thou shalt yield no precedence, but of time,
And the blinde fate of language, whose tun'd chime
More charmes the outward sense; Yet thou maist claime
From so great disadvantage greater fame,
Since to the awe of thy imperious wit
Our stubborne language bends, made only fit
With her tough-thick-rib'd hoopes to gird about
Thy Giant phansie, which had prov'd too stout

For their soft melting Phrases. As in time
They had the start, so did they cull the prime
Buds of invention many a hundred yeare,
And left the rifled fields, besides the feare
To touch their Harvest, yet from those bare lands
Of what is purely thine, thy only hands
(And that thy smallest worke) have gleaned more
Than all those times, and tongues could reape before.

The passage itself is Donnian, and the many echoes of Donne throughout Carew's poetry attest to the sincerity of the praise. Knowing that he could not mimic Donne too closely in paradoxical wit, or in startling conceits, or especially in the rhetorical wrenching of rhythm to fit the thought, Carew yet assimilated some of the tone and some of the force of Donne's innovations. What he learned from Donne was to probe, explore, question, ring changes on the old conceits. Even apart from what he called Donne's "Mine of rich and pregnant phansie," which he tapped as often as most of Donne's followers, Carew found congenial the Donnian intellectual attitudes toward love in the *Songs and Sonnets* and the *Elegies.* His longest, best, and least printable poem, *A Rapture,* was called by Professor Grierson "the most daring and poetically the happiest of the imitations of Donne's clever if outrageous elegies." There is time here for only a smaller, and in fact a more typical, lyric which shows the influence. *Ingrateful beauty threatened* reflects the chiding attitude of Donne's *Elegie VII,* adapted to Carew's own ends and talents:

Know *Celia,* (since thou are so proud,)
   'Twas I that gave thee thy renowne:
Thou hadst, in the forgotten crowd
   Of common beauties, liv'd unknowne,
Had not my verse exhal'd thy name,
And with it, ympt the wings of fame.

That killing power is none of thine,
   I gave it to thy voice, and eyes:
Thy sweets, thy graces, all are mine;
   Thou art my starre, shin'st in my skies;
Then dart not from thy borrowed sphere
Lightning on him, that fixt thee there.

Tempt me with such affrights no more,
   Lest what I made, I uncreate;
Let fooles thy mystique formes adore,
   I'le know thee in thy mortall state:
Wise Poets that wrap't Truth in tales,
Knew here themselves, through all her vailes.

But the differences are as striking as the similarities. Here is the closing passage of Donne's *Elegie:*

Thy graces and good words my creatures bee;
I planted knowledge and lifes tree in thee,
Which Oh, shall strangers taste? Must I alas
Frame and enamell Plate, and drinke in Glasse?
Chafe waxe for others seales? breake a colts force
And leave him then, beeing made a ready horse?

There the poem ends, not, one feels, for want of other means to illustrate the relationship, but because an additional metaphor would be anticlimactic after that last one. Carew's movement is less nervous, his imagery less audacious. Beside his delicately ironic conclusion, Donne's "ready horse" produces a brutal shock, not only because it is a horse, but also because it is a complete departure from the images which led up to it.

Partly responsible for these differences is the other influence which I want to touch on, the influence of Ben Jonson. The "hostility" of the two schools has been over-emphasized in later criticism. It should not be forgotten that Jonson, though he censured Donne's rhythms, called him "the best poet in the world in some things." Jonson's lyrics, as different as they are from Donne's in both motivation and effect, are written in a mode opposed, like Donne's, to softness of sentiment and flaccidity of expression. Both poets put a premium on intellect in poetry, if Jonson did not believe in charting so minutely as Donne the fits and starts of the mind.

But that "if" is a key to the (often deceptive) simplicity of many Caroline lyrics, among them some of Carew's best. "Pure and neat language I love," wrote Jonson in *Discoveries,* "yet plaine and customary. A barbarous Phrase hath often made mee out of love with a good sense; and doubtful writing hath wrackt mee beyond my patience." As a poet-critic, Jonson generally practices what he preaches. He usually has something fairly straightforward to say, and says it with clarity and precision. Jonson's careful attention to form and decorum, his distaste for tortured and obscure displays of wit, his solid classical learning, his control of tone and idea, set a critical and practical standard comparable to Dryden's in its authority. It is a discipline that leaves its mark not mainly on separate lines and passages, nor on individual attitudes toward subject matter, but on the artistic integrity of complete poems. Carew, as we might expect, has fewer "echoes" of Jonson than of Donne. A conceit or a pose picked up from Donne, however, may be simplified, stripped of some of its overtones, and fitted into a more regular pattern of sound and thought; and the result may remind one as much of Jonson as the detail recalls Donne. As a single example in the amorous vein (Carew's chief vein), one thinks of Carew's "Aske me no more," which achieves a kind of lyric perfection similar to that of Jonson's "Drinke to me, onely, with thine eyes." Not that the thought isn't partly "metaphysical," but that the form, the tone, the total impact of the poem combine to prevent the mind from wandering into what Dryden impatiently called "nice speculations of philosophy."

That the two influences were not "hostile" may be seen in Carew's epitaph on Maria Wentworth.

And here the precious dust is layd;
Whose purely-tempered Clay was made
So fine, that it the guest betray'd.

Else the soule grew so fast within,
It broke the outward shell of sinne
And so was hatch'd a Cherubin.

In heigth, it soar'd to God above;
In depth, it did to knowledge move,
And spread in breadth to generall love.

Before, a pious duty shind,
To Parents, courtesie behind,
On either side an equall mind,

Good to the Poore, to kindred deare,
To servants kind, to friendship cleare,
To nothing but her selfe, severe.

So though a Virgin, yet a Bride
To every Grace, she justifi'd
A chaste Poligamie, and dy'd.

Learne from hence (Reader) what small trust
We owe this world, where vertue must
Fraile as our flesh, crumble to dust.

F. R. Leavis has rightly called attention to the double influence here. Donne and Jonson, if they had collaborated to celebrate Maria Wentworth, could not have done better.

What is left, it might be asked, that is uniquely Carew's? If he owed so much to Donne and to Jonson, not to speak of the Elizabethan sonneteers, the classical amorists, and the continental *concettists,* can he be said to have had any individual characteristics? The mere posing of the question reminds us of the homogeneity, and at the same time of the eclecticism, of so much seventeenth-century poetry: it would be very difficult to identify the author of many a fine lyric in the manuscript anthologies of the time, which somehow does not seem to be less good for being "typical." But Carew, in his best poems, is a little more than merely "typical." It seems to me that he stands slightly apart from his "traditions," and from his contemporaries who shared them, in three respects: in the careful working out of single metaphors, in the logical persuasiveness of argument, and in the combined variety and smoothness of rhythm. I say "stands slightly apart" because I do not wish to claim for Carew qualities which no other poets had, especially in an age when just these qualities were prized so highly; I mean that in his best poems Carew exploited them more consistently than any of his contemporaries.

The third quality, which I have called combined variety and smoothness of rhythm, is more easily heard than analyzed. The way Carew "overflows" his couplets, shifts has caesuras, reverses occasional feet for momentary cross-patterns—and yet does all this subtly so as not to violate the basic form but to give it flexibility and strength—this is the way of a poet whose ear is finely attuned to the special "music" of the lyric.

The other two qualities, the powers of metaphorical elaboration and logical persuasiveness, are found in varying degrees: a long poem like *To A. L. Perswasions to love* reveals Carew's argumentative skill as equal to Marvell's in *To his Coy Mistress,* which it anticipates in many respects; while some of the shorter pieces give Carew his best opportunity to develop a single image or a cluster of images. This last skill seems to me the most important distinguishing feature of Carew's power, and it can be illustrated briefly by a quotation of one of his little epitaphs on the child Mary Villers.

The purest Soule that e're was sent
Into a clayie tenement
Inform'd this dust, but the weake mold
Could the great guest no longer hold,
The substance was too pure, the flame
Too glorious that thither came:
Ten thousand Cupids brought along
A Grace on each wing, that did throng
For place there, till they all opprest
The seat in which they sought to rest;
So the fair Modell broke, for want
Of roome to lodge th' Inhabitant.

The whole poem is a sustained conceit. The appropriateness of the conceit is that it fits a child, and at the same time draws an ageless contrast between the immortal soul and its earthly resting-place. The words stick precisely to this conceit: tenement, guest, place, seat, rest, room, lodge, inhabitant. The body is too frail and the soul too great, but it is mainly the "want of roome," since she was only a child, that broke the "weake mold." Greatness of soul in a child, a hyperbolic notion, is strangely and aptly made believable by equating it, still more hyperbolically in one sense, with an infinite number (twenty thousand!) of *tiny* graces belonging to the *tiny child* of Venus; whereas it would have been outrageous to compare her outright with Venus herself. And so the soul is finally exalted without detracting from the purity of the substance which temporarily contained it.

With these characteristics in mind, I should like to suggest a few points of comparison with the three Cavalier poets, Herrick, Suckling, and Lovelace.

Herrick and Carew both polished their poems, Herrick with a sharp eye on publication:

Better 'twere my Book were dead,
Then to live not perfected.

But they polished to different purposes. Herrick's sense of form might almost be equated with the title of one of his best poems, *Delight in Disorder*. A kind of esthetic theory may be read into the poem itself: "A sweete disorder . . . An erring Lace . . . Doe more bewitch me, then when Art/ Is too precise in every part." What is prized is not natural simplicity, but a calculated "wantonness" (to use another favorite word of Herrick's). If a word or a phrase catches the ear or eye partly because it does not quite fit into the usual pattern, or calls up another image than the one immediately in question, or rolls "winningly" on the tongue independent of its logical function, it is not very different from the "lawne . . . thrown / Into a fine distraction." For example, the final couplet of *Upon Sylvia, a Mistress* does not "follow" from the images of the rest, but it is worth all the rest:

Upon thy Forme more wrinkles yet will fall
And coming downe, shall make no noise at all.

Carew has few such flashes; Herrick specializes in them. He relies much more than Carew on sensuous impressions:

Numbers ne'r tickle, or but lightly please,
Unlesse they have some wanton carriages.

Herrick is tickled by sights and smells, and tickles the senses of his readers in turn. No other poet has responded with such palpitations to feminine clothes. It is a sensitivity to surface things which has its obverse in the unreflective coarseness of some of his epigrams. He never introduced a love-scene, as Carew did in *A Rapture,* with "No curtaine there, though of transparent lawne"; for him, the lawn was as thrilling as the flesh.

The connotative richness of Herrick's language has been noted by F. W. Bateson, who spoke of "the vague splendour" of *The Primrose.* The word "Infanta" in the second line is partly responsible for this impression: "This sweet *Infanta* of the yeere." The word was added by Herrick for the final version; an earlier version (which incidentally appeared in the 1640 edition of Carew's *Poems*) began with this couplet:

> Aske me why I send you here,
> This firstling of the infant yeare.

The change is away from precision, toward exotic association. This kind of suggestiveness is akin to Herrick's interest in sensuous impressions. He is seldom systematic, in the sense in which Carew, in *To A. L. Perswasions to love,* is systematic. His lovers' complaints are generally more pathetic than prophetic. The warning theme of *The cruell Maid* is sandwiched between an apologetic introduction and a more or less inconsequent conclusion asking for a tear and a kiss of pity over his tomb. *To Dianeme* is more single-minded, but there are noticeable differences between its pathetic argument and Carew's marshalling of unanswerable "points." Herrick's single line, "Sunk from the tip of your soft ear," conveys more melting affection than the whole poem cancels; while Carew's details of beauty are grudgingly listed and effectually belittled, as by a man always on his guard. Again, to take another poetic cliché of the day, the rose in the mistress's bosom: Carew's *On a Damaske rose* rises to a kind of devotional eloquence, while Herrick's *Upon Roses,* for all its "flowrie Nunnery," appeals primarily to the senses. If Carew's poem is the more commonplace, Herrick's is the slighter. Both poets recognized their limitations, Carew in his modest tributes to other poets (such as the elegy on Donne), Herrick in such disarming lines as these:

> A little streame best fits a little Boat;
> A little lead best fits a little Float;
> As my small Pipe best fits my little note.

The other two poets, Suckling and Lovelace, do not challenge Carew in his special qualities. They share with him the urbanity of the courtier, but not the consistency of the artist. Both are comparatively careless poets, though in different ways. Suckling, who chided Carew's "hard-bound muse," is most characteristically a cynical amorist whose cynicism extends to matters of craftsmanship. His conversational style, which recommended itself to the Restoration inheritors of the "Cavalier" tradition, is suited to his careless tones and his scoffing attitudes. His rhythms seem at times improvised; his lines do not always rhyme; and his colloquial, parenthetical padding works for the same effect, as though he composed quickly, brilliantly (perhaps with "given" rhymes), for a wager. There is a natural grace, which is seldom sustained through a whole poem. He uses metaphor much less than Carew, and does not develop a poem around it but brings it in by way of *exemplum,* which may be broken off or shifted at random to suit his whim. When he does, rarely, develop a figure, as in *Love's World,* the development is pedestrian, as though he were concentrating more than he liked on writing a consistent poem:

> The sea's my mind, which calm would be,
> Were it from winds (my passions) free;
> But out alas! no sea I find
> Is troubled like a lover's mind.

At other times, and more characteristically, he frankly abandons the attempt to be "poetic," and carries off the failure by throwing the whole problem overboard. The humor saves him, but when he is following Donne, as in "I prithee send me back my heart," the failure to sustain the intellectual effort is not amusing. Suckling admired Donne as much as Carew did, and echoed Carew's praise of the monarch of wit. But, though neither poet matched Donne in intellectual or metaphorical complexity, Carew's poetic fancy comes closer to the wit of the master than Suckling's, if Suckling's cynical humor is an easier and more immediately recognizable substitute.

The carelessness of Lovelace is not, like Suckling's, a product of indifference, but of curiosity. Professor R. C. Bald has said that, of the three, Carew, Suckling and Lovelace, the last is "the least naturally a metaphysical poet." It is true that his best-known poems, which are also his best—*To Lucasta, Going to the Warres,* and *To Althea, From Prison*—reduce paradox to the simplest terms; but it is not clear, judging from the relative paucity of such poems in his canon, that this simplicity was "natural" to him. His range is wide, and in all his variety he exhibits a strong wit of the kind carried to extremes by Cleveland and deplored by Doctor Johnson. Perhaps it is fruitless to speculate which is the more natural, the wit or the simplicity; but his wit is certainly more "metaphysical" than either Suckling's or Carew's. In these lines from *Love made in the first Age: to Chloris,* a poem which in many ways parallels *A Rapture,* there is a grotesque ingenuity unlike Carew's most contrived bee-simile:

Then unconfined each did Tipple
Wine from the Bunch, Milk from the Nipple,
  Paps tractable as Udders were;
Then equally the wholsome Jellies,
Were squeez'd from Olive-Trees, and Bellies,
  Nor Suits of Trespasse did they fear.

Lovelace often wanders beyond the limits imposed by his subject, and the reader may lose interest before the poet does. There is a lack of tightness in the longer poems, and a multiplicity of images, which recall Donne. The active imagination is closer to Donne's in its working than Carew's or Suckling's, in spite of the wide gap between his and Donne's powers of psychological and philosophical penetration.

Lovelace's facility of invention, however, does not prevent a few of his poems from revealing a serious vein of honor and chivalry which Carew never matches. If Carew had lived into the decade of the civil wars (he died in 1639), he might have developed into a more active and less decorous royalist; and if he had been imprisoned, as Lovelace was, he might have written a poem to Celia from prison, thus adding to the very small collection of poems which suggest, as Professor Grierson has said, "what 'Cavalier' came to mean when glorified by defeat."

There is undoubtedly a certain "decay of feeling" in much Caroline verse, and two poets as different as Habington and Cleveland manifest the extent to which convention, be it tearful or witty, eventually dries up. Both of these poets have something in common with Carew—Habington in the adoption of the time-worn symbols of the love poetry of the previous century, Cleveland in the extravagant and intellectualized wit of the Donne tradition. Yet Carew is generally free of the completely commonplace, as he is of the completely fantastic. He re-informs the old conceits with new meanings, creates ironic contexts for the expression of traditional attitudes, and argues or pleads with a combination of grace and ingenuity that disguises platitude.

# THE GROWTH OF PSYCHOLOGY WITH SOME PRESENT IMPLICATIONS AND ATTENDANT PROBLEMS

CYRIL C. O'BRIEN

Since the first psychological laboratory was founded by Wundt at Leipzig in 1879, psychology has made tremendous strides not only in the extent and variety of curricular offerings in the colleges and universities throughout the United States, but also in the increasing numbers of psychologists working in the fields of applied psychology.

In the latter instance three broad areas have evolved and are being defined, viz., clinical psychology, industrial psychology, and counseling and guidance. What the ultimate picture will be with respect to the alignment of specific, applied disciplines is a major problem for careful prognosis besides one which involves considerable conjecture.

At the present time the American Psychological Association has seventeen divisions, which in certain cases overlap to some extent, but on the whole are distinct in their respective settings. The mere mention of the Divisions of General Psychology (Div. 1), Teaching of Psychology (Div. 2), Experimental Psychology (Div. 3), Evaluation and Measurement (Div. 5), Childhood and Adolescence (Div. 7), Personality and Social Psychology (Div. 8), The Society for the Psychological Studies of Social Issues (Div. 9), Esthetics (Div. 10), Clinical and Abnormal Psychology (Div. 12), Consulting Psychology (Div. 13), Industrial and Business Psychology (Div. 14), Educational Psychology (Div. 15), School Psychologists (Div. 16), Counseling and Guidance (Div. 17), Psychologists in Public Service (Div. 18), Military Psychology (Div. 19), and the Division of Maturity and Old Age (Div. 20), gives one some idea of the present ramifications and specialization in the field. The American genius for analysis, classification and delimitation of subject matter is demonstrated in the strong trends towards thorough training in specific disciplines. In this respect American psychology is different from European psychology of the present day, which, while giving evidence of continued growth and virility, has not shown the vast expansion characteristic of American psychological research and application.

There are at least 12,000 legitimate psychologists in the nation today. The majority of these—about 11,000—are members of the American Psychological Association. Barring a catastrophe like a major war, a conservative estimate of the number of APA members by 1960 would be about 20,000. The prestige of psychology is rising. Accompanying its heightened values, however, is also an increase in the number of pseudo-psychologists, who are attempting to ride the crest of the wave. At present there are no available national figures of those in this latter category. Suffice it is to say that they continue to prey on many unsuspecting sincere people, who seek help for their problems of a varied and oftentimes complicated nature. Exaggerated promises on the part of such charlatans have challenged on occasions the work of the trained psychologist. At times their failure to live up to such claims have even brought discredit upon legitimate psychological endeavour through the fact of suggestion and association alone.

In the rising tide of increased psychological activity have also come those who are inadequately prepared for the tasks confronting them. Bona fide psychologists themselves have felt a need for a set of ethical standards for their profession. The growth of psychology within recent years has been so rapid that relationships involving the profession, its members, and clients, require clarification. Many situations among psychologists and their activities are not ethical in nature, but are concerned with courtesy, diplomacy, and etiquette.

Two immediate, pressing problems associated with the growth and development of psychology are the ever-present "quackery" in the field and the resulting need for protection of the public by means of a careful process of certification. Although difficult to attain, licensing can be handled successfully at the State level. Connecticut, Minnesota, Georgia, and other states have certification laws for psychologists. The American Psychological Association through the American Board of Examiners in Professional Psychology has set up standards in the areas of clinical, industrial, and counseling and guidance. These promise to be an effective means of helping to discourage charlatanism and inadequate preparation for a professional career in psychology. The national organization through the ABEPP is concerned solely with the competence and character of the individual psychologist. Two states list citizenship as a requirement for certification as a psychologist.

Just as the unethical or "quack" doctor or unscrupulous psychiatrist may inflict psychological damage through his being morally unfit or professionally unprepared for dealing with the normal and abnormal deviations of personality traits, so also, the untrained, unethical, or pseudo-psychologist can do likewise.

The American Psychological Association is fully aware of its responsibilities and in the mid-month of April of 1953 issued a monograph entitled, *Ethical Standards of Psychologists,* a provisional set of standards to be tried for a three-year period. A revision is then planned, after which all Association members will have an opportunity of voting on all the completely revised principles.

The Committee on Ethical Standards for Psychology, in organizing the many ideas and specific cases and formulating statements by members of the APA, have classified all such considerations in psychology into six main divisions as follows:

Ethical Standards and Public Responsibility
Ethical Standards in Client Relationships
Ethical Standards in Teaching
Ethical Standards in Research
Ethical Standards in Writing and Publishing
Ethical Standards in Professional Relationships

Each division lists many kinds of problems followed by specific incidents illustrating the problems. Then, there is enunciated the particular ethical principle involved. Using the same sequence of presentation, I shall give an example for each main division with one specific incident drawn from personal experience. The statements of the problem and the ethical principles are the result of the efforts of the APA Committee.

1.

PROBLEM—PUBLIC RESPONSIBILITY

"In offering professional services, does it make any difference to whom the psychologist sells his skill or how he carries out an assignment so long as he satisfies the customer?"

*Incident*

As a consulting psychologist I was approached by the head of a firm to design a test for screening and measuring employees for their attitudes and esprit-de-corps in the shops. It was suggested by the executive as a means of saving time that the employees answer the items of the test in their own homes. I explained to the man why such an approach was unacceptable and why I could not accede to his request.

The ethical principle enumerated by the APA for such a case reads:

*Principle*

"As a practitioner the psychologist should strive at all times to maintain highest standards in the services he offers. Because the psychologist in his work may touch intimately the lives of others, he bears a heavy social responsibility, of which he should ever be cognizant."

2.

PROBLEM—CLIENT RELATIONSHIPS

"As the public has learned more about psychology and as large numbers of people are trained in the field, there are increasing possibilities of incidents involving clinical and consulting activities in inappropriate settings and with unprofessional intent."

*Incident*

A psychologist who was employed by a college for teaching certain courses used his influence to obtain clients from the students in his classes to go to him with any problem, for which service, a fee was paid in each case. The conduct was all the more reprehensible, inasmuch as there were at this college services set up and designed for counseling and guiding students.

*Principle*

"The misuse of the clinical or consulting relationship for profit, for power or prestige, or for personal gratifications not consonant with concern for the welfare of the client, is unethical."

3.

PROBLEM—TEACHING

"The existence of specialties and schools within the field of psychology results in differences in points of view and in evaluations, which are often confusing to students and to the public. They are sometimes actually harmful in the narrowness which they produce in students, who are exposed to one point of view in such a way as to bias them against other fields or approaches, which might provide them with valuable ideas and data."

*Incident*

A teacher of psychology in a nearby institution frequently forces the students to accept only a neo-Freudian interpretation of psychological situations with which many students differed. One student felt that if he did not subscribe to the opinions of the instructor, he would receive a lower grade than he deserved or perhaps be failed in the course. Apparently, a subtle case of intimidation.

*Principle*

"As differing schools of, and approaches to the field of psychology are supported by competent and ethical psychologists, they should be presented to students in such a way as to encourage them to study the relevant facts and draw their own conclusions."

4.

PROBLEM—RESEARCH

"A number of questions about the interpretation and use of research findings are settled in the way the research is planned, conducted, and reported."

*Incident*

An instructor in psychology, who had a unique problem and an original approach to it was asked by a colleague if he might study the manuscript for a short time. After a lapse of one month, the instructor requested that it be returned. The colleague gave many excuses, but finally after four more months gave it to the instructor, who then had it submitted and later published in a psychological journal. This colleague unnecessarily delayed the publication of worthwhile findings.

*Principle*

"As a scientist, the psychologist is expected whenever possible to communicate the results of his research to other investigators, provided he judges the results to be of value for the development of psychology as a science or for the welfare of the public."

5.

PROBLEM—WRITING AND PUBLICATIONS

"The most common cause of ethical concern in publication is the apportioning and indicating of credit for authorship."

*Incident*

In one of his classes a department chairman received a student's research paper, which had publication possibilities. The student had put many hours of work on the project of his own choosing and involving entirely his own efforts. A few months after the student had handed the paper to the professor, he saw it published verbatim under the professor's name in a professional journal. A lawyer friend of his suggested he seek redress of the injustice. Since he expected his degree at the end of the semester, he feared some retaliatory measured and declined to take action.

*Principle*

"Credit should be assigned to all those who have contributed to a publication, in proportion to their contributions, and only to these; and the nature of the contribution (e.g., research design, collection of data, writing) should be made clear."

6.

PROBLEM—PROFESSIONAL RELATIONSHIPS

"High standards of conduct in professional relationships are as essential as professional competence, if psychology is to retain the confidence of related professions and of the public."

*Incident*

A teacher of psychology with some sphere of influence constantly engages in stifling the professional growth of his colleagues through misrepresentation, subtle disparagement, and belittling the activities of certain professional workers.

*Principle*

"It is the duty of psychologists to keep professional relationships on a mature, professional level and not to engage in petty, personal actions demeaning to themselves and to the profession."

The foregoing represent only a few of the great variety of problems associated with the practice and malpractice of psychology. Psychologists believe that with respect to ethical considerations on the average, they are probably no better or worse than individuals in other professions. Since at present there are no comparative, adequate studies of an objective nature on this point, one can only estimate and conjecture about the extent of professional misdemeanours.

Psychologists are convinced, however, that open and candid discussion of unethical conduct can merit a gain in public confidence rather than rebuke, even though many individuals in other professions prefer to discuss such deviations from accepted behavior, only in camera.

The growth of psychology with its concomitant activity has evoked other reactions. The American Medical Association has recently taken the stand that clinical psychologists have no right to practice psychotherapy independently, and psychotherapy must be subordinate to medicine. Although many clinical psychologists today work in co-operation with psychiatrists, the American Psychiatric Association has recently stressed that psychotherapy is the domain of medical practice. A bill introduced in February, 1953 in the New York State Legislature defined medicine as "the diagnosis and treatment of all physical and mental conditions." The bill would bring psychotherapy entirely within the confines of medicine. Owing to the difficulty of defining adequately such words as "treatment" and "mental conditions" it is probable that the bill will not be passed, but the trends of the time are clear. Fillmore H. Sanford, Secretary of the American Psychological Association, in the April, 1953 issue of the American Psychologist gives a clear espousal of the present, apparent impasse.

There are many thousands of persons in various professions, who now utilize psychotherapy in varying degrees in helping bring relief to troubled minds. Must the recipients of the presently effective work being accomplished through psychotherapy by non-medical individuals, such as clergymen, social workers, psychologists, Alcoholics Anonymous members, and the like be denied help? One may take the twelfth step work of A.A. members as a specific example. A.A. has developed a brand of psychotherapy, which has resulted in the rehabilitation of more than 100,000 alcoholics. Using their own psychotherapeutic approach, A.A. has accomplished in fifteen years what some have failed to achieve in two hundred years.

There is a crying need today for psychological help. Many mental institutions are understaffed. Scores of people with minor emotional disturbances or maladjustments seek assistance. With the great shortage of psychiatrists, to whom can they turn? If the legitimately trained, clinical psychologist is seriously restricted in his functions, no doubt many people will patronize the charlatans in the field. In New York State alone it is estimated there are about 25,000 catering to the gullible. Psychologists will agree that their training does not qualify them to practice medicine. But they will be the first to disagree to a domination and monopoly by any one professional group of the areas of psychological and social spheres of action.

Today, there are at least 200,000 physicians in the nation—twenty times the present number of all types of psychologists—or at least fifty times the numbers of psychologists employed in applied psychology. At present applied psychology would not appear to be a threat to medicine. It can and should be one of its greatest allies. There is a real shortage of M.D.'s in many sections of the nation, although the proportion on a national basis is one doctor to every 850 people. At the present rate of medical training, the prognosis for the year 1960 (President's Commission on the Health Needs of the Nation) will be a shortage of 22,000 doctors with the national census estimate about 171 million population.

Psychologists certainly cannot take the place of physicians, but a smoothly working, co-professional recognition will aid materially in easing the maladjustments of a great many, who will need only some form of psychotherapy. A multi-discipline approach would seem to be a sensible one. If psychotherapy becomes the sole prerogative of medicine numerous cases now and in the years to come will be deprived of much needed help.

Fillmore H. Sanford expresses the present antipathy between medicine and psychology—or more specifically—between the American Medical Association, the American Psychiatric Association and members of the profession of psychology, in these words:

> Since psychology has an enforcible code of ethics, and since there are adequate laws relating to fraud and damages, psychologists see no basis for the feeling that the practice of clinical psychology by competent individuals will be detremental to public welfare. Psychologists are not likely to take kindly to any real or apparent steps on the part of any other profession to police or supervise professional activities of psychologists. Making psychology ancillary to medicine in the field of mental health will be seen as no more reasonable than making the psychology professor an assistant to the professor of physiology or of making the professor of theology ancillary to the professor of psychology. Few will be able to see how the establishment of professional or scientific hierarchies will contribute either to public welfare or to the advancement of knowledge.

The Secretary has appended a final addendum to his article, which reads:

On March 30 it appeared likely, as a result of recent conversations between the two APA's, that several officers of each Association would sit down under a "cease fire" arrangement and seek further for amicable and rational ways of settling the present points of disagreement between psychology and psychiatry.

Let us hope that they accomplish their objectives. If they fail in their purpose and subsequent meetings on the matter do not bring agreement, then truly, the clock would be set back many years. The turn of events during the next year or two will be awaited with interest.

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# A GEOLOGIST'S POINT OF VIEW ON APPRECIATION OF OUR SURROUNDINGS

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Many a textbook on Elementary Geology opens with a statement relating geology to the other sciences. It seems to me that we can also find some interesting relationships with arts and letters. Perhaps I am prejudiced, but it seems to me that geology is the science which relates best to a great number of other fields. It draws on all the materials of the earth—the very stuff which the sciences study—the ground from which Man and his arts and letters have sprung.

How did Art begin? I don't pretend to know the answer, but it is not difficult to visualize Primitive Man tracing lines in sand and shaping rough stones; to guess the temptation to mark stones or cavern walls when soft, vivid rocks and minerals were found, such as hematite and limonite—red and yellow ochres—or to use bits of chalk or coal in this same manner. Stonecutters and brickmakers were among the early artisans, taking the materials they had and putting them to use. Others, more skilled and inventive, chipped or carved stones into the beginnings of sculpture, or molded the clay into representations that may have been less useful than brick, but which are an early art. I presume these beginnings of Art antedated the rise of Letters by some time—yet were not these attempts to represent something that had been seen. ancestral to a written language? Picture-writing and other methods of writing on stone and on clay tablets came before the use of papyrus and long before the development of paper.

Even earlier, perhaps, there arose the legends which were handed down by word of mouth for generations before someone wrote them down. And what were these early legends about? How does the Bible begin? You may not consider the story of Creation as geology—but certainly it represents the wondering of mankind about his surroundings—the seeking for an answer to questions that have not yet been solved satisfactorily. We find stories seeking to solve this matter of the Origin of the Earth and of Man among all primitive peoples. It is a thought of foremost importance to all—Where did we come from? How long has there been an Earth? How does it happen to be here, able to support life? And how unique is this situation?

This interest in Man and the Earth has been constant. Yet, with all the search for gold, iron, salt and other mineral products of early importance; with the sailing of seas and mapping of coastal lands; with the selection of road sites and the search for mountain passes—the development of geology as a true science is considered to be relatively recent. It is interesting to note that one of the earliest men to think and write along the lines of modern scientific geology was Leonardo da Vinci—great man in so many fields. It was he who first recognized the true significance of finding marine fossils high above sea level, and insisted that they were evidence of ancient life and that the rocks in which they were found must have been deposited beneath the sea, even though they might now be parts of mountain tops.

How many casual observers of today would reason that way for themselves, if they had not already picked up rudiments of such knowledge? How much more fully they could appreciate some of the things they see, if instructed a little more in the processes at work on the crust and in the interior of the earth!

Most of us today recognize the tremendous value of science to modern civilization. Some feel that perhaps there is too much stress on science and technology as all important—that our sense of values may be lost as too much faith is placed in these false gods. Arts and letters, being older than modern science, have long standing as cultural studies. They, along with religion and philosophy, are the counter-balance against a machine-type civilization. But science is by no means all machines, and in addition to its technical and economic values, it may also have definitely cultural aspects.

From what do we derive pleasure and satisfaction as adults? Partly from hobbies, partly from sports, and to a large extent from what we might call the cultural pursuits—such things as art, music, literature, the theatre, the dance, lectures, travel; often by means of radio, television and motion pictures. Geology may well fit into any of these three categories. Many have made a hobby of collecting and identifying fossils, minerals and rocks —in fact, this is frequently the hobby for a whole family. Thousands of others are especially interested in the cutting and polishing of stones, which may combine an interest in both geology and art, along with technical skill. In sports, there are those who walk for the pleasure of the exercise alone, but how much more interesting hiking can be if done with the viewing and studying of nature, at the same time. One of the most exciting sports is mountain-climbing, which by its very nature demands some study of geologic conditions in advance, and very probably adds a great deal more to the understanding of the climber in the appearance of rocks and landforms, the action of frost on rocks, the accumulation of talus slopes, and the basic structure of mountains. Travel may or may not be undertaken for cultural and recreational purposes. Even if traveling is done for purely utilitarian reasons, in the course of one's business, the opening of the traveler's eyes to the geological bases of what he sees should make the trip more enjoyable and give him interesting new knowledge.

There are those who pick up these prizes of nature without instruction from others. One of these was Hugh Miller, the English quarryman whose book "The Old Red Sandstone" is considered one of geology's few real contributions to classic literature. His account of his first day at work—of the change from his heavy heart at starting his "life of labour and restraint" to one of wonder and amazement as ancient ripples and mud-cracks were uncovered in the rocks of the quarry—is well worth reading. He *saw* and was fascinated by what he saw. How many of us look about with unseeing eyes? Perhaps there are some who will never see the wonders of nature, even when taken by the hand and shown them, because people do differ—but instruction can help most of us to see more clearly and to *appreciate* what we look at.

Many of us *enjoy* things without truly appreciating them. Few would deny that music, art, literature and *scenery* can be enjoyed without special training. What is the difference between *enjoyment* and *appreciation?* According to the American College Dictionary, *enjoyment* is "the possession, use or occupancy of anything with satisfaction or pleasure"; *to enjoy* is "1. to experience with joy; take pleasure in. 2. to have and use with satisfaction; have the benefit of." These all involve pleasure—perhaps even rapturous pleasure—but not, necessarily, *understanding* and judgment. On the other hand, the meaning of *appreciation* is given as "1. act of estimating the qualities of things and giving them their due value. 2. clear perception or recognition, especially of aesthetic quality." To *appreciate* is "to place a sufficiently high estimate on. 2. to be *fully* conscious of. To exercise wise judgment, delicate perception, and keen insight in realizing the worth of something."

How many, then, really *appreciate* their surroundings? All who travel to our national parks and other scenic spots *enjoy* them, but how many truly perceive the worth of these scenic wonders?

More and more, liberal arts colleges are stressing the study of art appreciation and music appreciation, along, of course, with that of literature in our own or other languages. Study of a laboratory science is generally required, too—because of the feeling that it is a part of a liberal education to have training in the scientific method, and to know the basic elements of at least one of the fields of science.

Might not more emphasis be placed on the cultural values to be attained in studying the sciences, too? Certainly, it seems as important to me to have an understanding and an appreciation of our environment and the landscapes about us, as to appreciate the art and music and literature that afford us recreation and enjoyment.

Does *appreciation* increase enjoyment? There may not be a simple answer to this question, if we remember that many people agree with the old saying "Ignorance is bliss."

Who enjoys a symphony concert more—one who goes to listen with an untrained ear—who is stirred by the sounds he hears, but who may relax through the concert and let the music as a whole pass over him; or one who can appreciate the intricate blending of many tones—who can detect the roles of the many instruments—whose mind is constantly analyzing the blend that reaches his ears as he considers the skill and artistry of the individual players, of the conductor and of the composer, and who may be either stimulated or exhausted at the end of the evening?

Who enjoys looking at a painting more—one who chooses it for a combination of pleasing colors and pattern, and perhaps familiar subject matter; or one who looks critically and approves the line, the composition, the choice and use of colors, the technique of application?

Who enjoys a good book more—one who approves the idea and the way in which the points are made; or one who not only likes the development of the theme or plot, but who savors the details of description, the choice of words?

Who, then, enjoys looking at the Grand Canyon more—one who is breathless at the great gap stretching before him, the depth at which the muddy waters of the Colorado flow below him? Or one through whose mind rush the thoughts of eons of time laid bare before him—of the work done by the river and its tributaries in eroding and carrying away the material that once filled the gap between where he stands and the other rim, ten miles away—material cut away to the depth of a mile—cut away in but a fraction of the time that was involved in the formation of those same rocks, layer on layer deposited on top of some of the oldest rocks of the earth—and then the tremendous lifting of those beds before the rain and rivers began cutting downwards?

There is no denying that all of these people get (or should get) satisfaction and enjoyment from the examples I have cited.

Otherwise, we would not have the sales of art, records and books that we do, nor the great interest in travel to scenic spots. It takes work, effort and study for most people to attain that higher form of enjoyment called appreciation. It may be true that those who have not developed real appreciation are more easily pleased, because they are less critical—but do they ever receive the emotional satisfaction and uplift from true works of genius that occasionally thrill the one who has been trained in what to look for—who can recognize a master touch? I doubt if anyone who has attained a sense of appreciation in any one or more of these fields would consider going back to the more passive form of uneducated enjoyment, although he may not have gone beyond that stage with respect to enjoyment of others of these pursuits.

There is one big difference in this comparison that I have been making between geology and the arts and letters, and that is the fact that Man does not create the things that call for appreciation in geology. Critics may say "This is good" or "This is bad" about man-made works, because judgment can be based on superior or inferior works of other men. But the earth was here long before man, and geologic processes that are at work today are like those at work in ages past. We take what is here, rather than set the rules ourselves, and as we recognize the processes and results, we can always find something to appreciate in the features of the earth. Whether we call them works of Nature or works of God, we can recognize the methodical development which traces back, step by step, revealing the story of the earth's past. If we consider scenery, of course, there are places that will appear uninteresting and dull to many. For aesthetic reasons, such areas will not attract people. Yet geologically, such an area may prove to be extremely interesting, as underground deposits are studied. Not only may resources of oil or gas lie below the surface, but drilling may reveal unsuspected structures—old beach lines, or even buried mountains. The delving for such requires more training than what might be called an introductory course in appreciation, and accordingly will involve a more acute sense of appreciation than would be developed by most—one perhaps partially based on economic reasoning.

Still, tastes differ, and we will find that there are people who prefer the flat, endless plains, with unlimited horizons, to the towering mountains, and vice versa. There are those who prefer the wooded hills to the pounding surf and gleaming sands—and again, vice versa. Others may prefer still coves and quiet waters, or fields of ice and snow. Training is not the only factor in developing a sense of appreciation; we must acknowledge the importance of background. Understanding of what has been closest to us usually comes before a true appreciation of that which is strange to us. The person versed in geology comes to have an understanding of all these diverse landscapes, and to him they can all be fascinating areas, evoking not only an appreciation of the present vistas, but also of the factors which brought them about. In other words, appreciation does enhance enjoyment.

There is nothing more basic to us than the Earth. Even city-dwellers live in a maze of transported rocks, and if they open their eyes to the variety of building stones, they can see—in addition to the beauty of polished marble and granite—some of the story of past ages.

I feel strongly that there should be more emphasis in our schools on the cultural value of studying science—not just to become acquainted with the scientific method and laboratory procedure, along with the subject matter of a particular course—but to gain a sense of appreciation on a par with that involved in the study of art, music and literature. Our natural surroundings, all around us, are as worthy of delicate perception and keen insight—of an appreciative study—as are the works of man.

Few students have had much training in appreciation of what they may see outdoors before they enter college, except as it is taught them by their families, or perhaps in such activities as Scout work. Many never do receive much training of this type. And still, they are so receptive to it! When I take my freshmen on a field trip to Terry Andrae State Park, a few weeks after they have begun their study of Geology, most of them are amazed and fascinated by the simple things that they have never noticed before—grains of sand rolling up over the crest of a ripple mark and falling down the other side; the circular markings made by a bending blade of long dune grass, as the wind swishes it around in the sand like a compass; the concentration by the waves along the shoreline of heavier, darker grains of sand in certain spots; the holes that open in the damp sand as the weight of their footsteps forces the air from between the grains to the surface.

On this and other trips they learn to recognize the shapes of pebbles and boulders scraped and pushed along under a glacier as different from those rolled along in streams and currents, or sand-blasted by the wind; to appreciate the record left by former seas, millions of years ago, as layer on layer of lime or mud or sand accumulated; to realize that where Milwaukee is now, there once was a vast sea of warm, clear, salt water—a sea full of living creatures, which here and there added their shells to masses started by great colonies of corals, and built up huge reefs; that while this sea teemed with invertebrate forms, the land areas were practically barren of life. By spring, when they travel west-ward across Wisconsin, I hope that these students of mine are able to appreciate the *reasons* behind the difference in the scenery of the Driftless Area and that of the rest of the state—to visualize a snowclad Baraboo Range as a protective barrier warding off the massive ice sheet to the north and east from southwestern Wisconsin. I hope that they can picture Devil's Lake as the great river canyon it once was—that they can sense the tremendous earth movements involved in the upturned beds to be seen at Rock Springs. These are just a few of the appreciative points of view that can give all Wisconsin people a feeling of appreciation and pride in their state—an understanding of differences in topography, soils, land use, and economic conditions.

I feel that we cannot stress too much the idea that the sciences are valuable not only for their technical and methodic side—for their training in thought and logic—but also for cultural reasons. For a full life, is it not as important to have a true appreciation of our surroundings outdoors as indoors? A well-educated person should see what he looks at as he goes by, and should derive from his surroundings a feeling of awe and appreciation when he realizes all that has gone before. He should recognize the enormity of geologic time and his own relative insignificance. At the same time, he can recognize Man as the culmination of evolution thus far, and can appreciate more fully all that Man has accomplished in the relatively short time that he has been on the earth. He should have a basis for scientific speculation as to what may lie in the future—of the intricate balance and relationships in nature, and of all that may be involved when one factor is thrown out of balance.

These are not new thoughts. Most people who have devoted much study to geology have similar ideas about their subject, and feel that it has given them such a sense of appreciation of their surroundings that they want to share it with all others. They are grateful for the help rendered by popular magazines and books, in the education of the public along these lines. At the same time, they feel that there should be more of an opportunity for all high-school and college students to receive such training.

# THE ABBÉ PRÉVOST AND THE JESUITS

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One of the most interesting chapters in the story of the lively religious controversies of the early eighteenth century is that of the Abbé Prévost's treatment of the Jesuits in his eight-volume novel *Le Philosophe anglais*. Only the first four volumes were published in 1731. These left unfinished the story of the English philosopher, Mr. Cleveland, and it was not until 1738–39 that Prévost brought out four more volumes which concluded with the conversion of the philosopher to what he designates as "true religion."

After the publication of the first part of the novel, Prévost was involved in a series of controversies with the Jesuits because he had satirized that order through his characterization of Father Ruel.[1] The second part of the novel gives a much kindlier interpretation of the Jesuits. Whether this contrast is due in any measure to the angry protests of that order or in some measure to the change in Prévost's relation to the Catholic church are questions that cannot be arbitrarily answered. We do know that he wrote the first four volumes when he was an exile from France and from the church because he had left the Benedictine monastery at Saint-Germain-des Pres without permission and that before he published the continuation volumes, he had been forgiven, received again into the order, and had settled down to a quiet life of writing and translating and acting as chaplain in the household of Prince Cònti.

No one who reads the story of Cleveland's first meeting with Father Ruel can wonder that the Jesuits took offense at the characterization: an ecclesiastic with an entirely worldly view of religion and an unprincipled casuist.

Father Ruel comes to Cleveland with an important message from the Duchess of Orleans, a matter concerning Cleveland's property in England. Having disposed of this business, he states that he has a still more important mission, for the Duchess has told him of the many misfortunes of Cleveland and of his failure to find consolation both in philosophy and in the religion presented to him by a Jansenist priest and by a Protestant minister.[2]

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[1] Paul Hazard, *Études critiques sur Manon Lescaut* (Chicago, University of Chicago Press, 1929), pp. 60–62; Henry Harrisse, *L'abbé Prévost: histoire de sa vie et de ses oeuvres* (Paris, Levy, 1896), pp. 238–244.

[2] *Le philosophe anglais* (Utrecht, Neaulme, 1736–39), V, vi, 139–143.

Father Ruel is not surprised that Cleveland has been thus disillusioned. There is no comfort, he says, in philosophy, which was never worthy of its name and is fit only for school-boys; and how can one expect to find help through a Jansenist or a Protestant? Then, this Jesuit offers to introduce Cleveland to the true religion, which is simple and easy, not obscure like that offered him at Saumur.[3]

The first step, he advises, is to distract the mind from sorrow by light reading, then to enjoy the pleasures of the senses, and also to fall in love. As an aid to finding a remedy for sorrow through love, the Jesuit introduces Cleveland to Ceçile, daughter of a Protestant neighbor whom Father Ruel is trying to convert to Catholicism.[4]

Cleveland's comments upon his first impressions of Father Ruel and upon his method of winning converts indicate that the Jesuits had some grounds for maintaining that their order had been maliciously satirized.

All he knew of the society, says Cleveland, was its name and some particulars which he had heard that did the Jesuits no credit.[5] The mannerisms of Father Ruel are those of a "church-fop": he speaks with gaiety and ease and liveliness which suggests this.[6]

When Cleveland tells the Duchess his impressions, she answers with words which the Jesuit order could scarcely regard as complimentary, although the Duchess herself seems to be sincere in regarding the Jesuits as agreeable people for these very characteristics. She replies that this manner not only fits Father Ruel but the greater part of the order and that, although she is not sure they would feel complimented to hear her say so, she likes them best of all the orders just because of these qualities. There are no other ecclesiastics that afford her so much diversion for they are so adaptable that everyone who has a taste for pleasure enjoys having them around; their presence gives sanction to a thousand pleasures which one can enjoy without remorse. They have made her actually love religion and feel it is not so severe a matter if it is as the Jesuits represent it.[7]

When Cleveland expresses reluctance to accept Father Ruel as a guide toward a religion that will meet human needs, the

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[3] *Ibid.*, pp. 144–149.
[4] *Ibid.*, pp. 151–162.
[5] *Ibid.*, pp. 139–140.
[6] *Ibid.*, p. 145.
[7] *Ibid.*, pp. 145–146.

Duchess overcomes his objections with the argument that he will run no risk. "If you consider it only as an amusement, it will at the worst divert your mind from trouble. You little realize what comical creatures these Jesuits are."[8]

Feeling obliged to yield to the urgency of the Duchess, Cleveland enters into a series of experiences, which he tells us cause him to blush a thousand times at his own weakness.[9]

In guiding Cleveland's reading, the Jesuit tells him to put away his Plato and his Socrates and to substitute for them a French catechism written by the Jesuit Canisius, a book "hardly bigger than my finger" but a text which in less than an hour will give the reader as much knowledge as the doctors and the bishops possess; yes, even as much as the Pope himself. There is also another work, *Devotion Made Easy,* which is a guide to morality. In addition to such books of devotion, Father Ruel sends a whole chest of poetry, romances, and novels to amuse and to divert; he advises also a gay social life.[10]

When Cleveland finds that the books on religion offer no proofs that meet the tests of logic and that the poetry and romance is too trifling a distraction to take his mind from his griefs, he decides to reject all the advice of the Jesuit except that of becoming acquainted with Ceçile.[11]

The conversation that follows this decision presents as the Jesuit's argument much matter to which the order might justifiably object as unrepresentative and unfair. Father Ruel tells Cleveland that he is insisting upon demonstration, whereas in matters of religion simplicity and submission are more important.[12] He is glad to know that Cleveland will accept one piece of his advice and asks permission to report this to the Duchess. This Cleveland refuses and adds in plain words that now he sees that the Jesuit's efforts in his behalf are motivated not so much by zeal for his welfare as by Ruel's vanity and the desire to ingratiate himself with the Duchess.[13]

Sometime later in the story when the renewal of persecution of Protestants in France leads Ceçile's parents to plan to leave for England, Cleveland decides to go with them and intrusts a member of his household, Mme. Lallin, with the secret of his preparations.[14] In his zeal to make converts, the Jesuit uses

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[8] *Ibid.,* p. 150.
[9] *Ibid.,* pp. 150–151.
[10] *Ibid.,* pp. 151–155.
[11] *Ibid.,* pp. 176–177.
[12] *Ibid.,* p. 178.
[13] *Ibid.,* p. 180.
[14] *Ibid.,* pp. 197–211.

casuistic arguments to persuade Mme. Lallin, a Catholic, to betray this secret.

He presents this dilemma: this revelation either injures religion or does not injure it; if it injures religion, you cannot hide it without running the danger of hell-fire; if it does not injure religion, you are assured of the peace of your conscience, by revealing it to your confessor; and you do not run any risk by revealing it since it remains hidden under the seal of the confession.[15]

Mme. Lallin accepts these arguments and gives the information, but Father Ruel promptly breaks the seal of the confessional and goes so far as to attempt to prevent the escape from France by trying to influence the bishop to seize Ceçile and put her in a convent and to throw Cleveland in the Bastille. Only the archbishop's respect for Cleveland's influence at court through the Duchess Henrietta frustrates Ruel's plans.[16]

When Cleveland learns what Ruel has tried to do, he comments that the Jesuit was motivated by hatred and revenge, since three conquests of such importance would have flattered his vanity and the plans for escape robbed him of the hopes of making converts; nothing at that time, says Cleveland was more fashionable among the clergy than zeal for the conversion of their erring brothers, as they called them.[17] The tone here is obviously satirical.

Romantic entanglements, resulting from Cleveland's infatuation with Ceçile, conclude the fourth volume to which Prévost promised a continuation that he did not get around to publishing until 1738–39.

As far as Prévost's relations with the Jesuits are concerned, both the preface to these continuation volumes and his treatment of Jesuit characters in the rest of the story show a desire to make peace with the order, although the sincerity of what he writes might be questioned by some readers.

In the preface to the fifth volume of 1738, Prévost explains that he needed a vicious ecclesiastic in his plot and that he felt that nothing would hold the interest of the reader more than the exceptional instance of one vicious character in an order where one is not accustomed to find such a character. He then requests any reader of the first four volumes to correct his copy by erasing from the word Jesuit all the letters except "J". Finally he calls attention to the complimentary picture he has given of the Jesuits in the College de Louis le Grand.[18]

[15] *Ibid.*, p. 264.
[16] *Ibid.*, pp. 267–268.
[17] *Ibid.*, p. 267.
[18] *Ibid.*, VI, "Preface," v–vi.

This is the preface to the volumes written after Prévost had returned to the Benedictine order.

The Jesuits enter the story in three ways in the four continuing volumes: the story of the vain and ambitious Father Ruel is concluded; Cleveland visits the Jesuit college to see his sons and discusses religion with the Père Recteur of the College du Louis le Grand; and after Cleveland's wife and daughter are converted to Catholicism, this same Père Recteur becomes their spiritual adviser.

All the episodes in which Jesuits appear show their zeal for making converts. They try to convert Cleveland and his Protestant friend Clarendon, but their zeal is that of sincere men, convinced that their religion is the only true faith. Cleveland disagrees with them, deals with them cautiously at times, makes some mildly satirical remarks with an attitude of amused tolerance, not with malice, and in most passages seems to respect the Père Recteur.

A few examples of the treatment of the Jesuits in these three groups of episodes will illustrate that they are treated in a manner which they have less cause to resent than in the case of the first four volumes.

On his death-bed, Father Ruel repents of his many machinations against Cleveland and his family. He confesses that his crimes were motivated by ambition and injured pride, for he felt that his prestige with the Duchess depended upon his winning Cleveland as a convert, and his vanity was mortally wounded by Cleveland's resistance to the efforts to convert him.[19]

Ruel further comments that the reason for corruption within so virtuous a body is that contact with the world they set out to reform brings strong temptations to the Jesuit to use the power of his profession so that it nourishes vanity and ambition.[20]

From Ruel's death-bed confession and repentance comes an ironic result: Gelin, who has tried to murder Cleveland and who is responsible for many of Cleveland's sorrows, is so impressed by Ruel's repentance that he is converted to Catholicism, becomes a Jesuit, and is the devoted tutor of Cleveland's sons.[21]

Whether Prévost was writing with tongue in cheek and saying in effect, "If you want this vicious Jesuit made good, I'll give you two good Jesuits by his repentance," no one can be sure.

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[19] *Ibid.*, VII, xi, 201–202.

[20] *Ibid.*, pp. 202–203.

[21] *Le philosophe anglais* (Rouen, Racine, 1785), VIII, xv, 230. The preceding references have been made to the Utrecht, Neaulme, 1736–39 edition because many passages concerning the Jesuits have been deleted in the Rouen, Racine, 1785 edition. Since no volume VIII of the Utrecht edition is available, the Rouen, Racine, edition is the reference wherever passages from volume VIII are used.

The treatment of the Jesuit school in the last two volumes is one of the evidences Prévost uses in his preface to support his assertion that he has given a complimentary picture of the Jesuits in the concluding volumes. But there are some reservations in Cleveland's mind when he visits the school.

Since Ruel's plots had placed the sons here as prisoners, it is hard for Cleveland to forget this fact now, even though the boys are perfectly free to come and go as they please after Ruel's schemes are frustrated. Cleveland feels a certain agitation as he enters the courtyard of the college and sees the great number of frocked men gazing at him with their sharp eyes.[22] He understands, he says, that men of character who live under the same discipline can not be either moderately good or moderately bad, but must be extremely one or the other. Such thoughts do not reassure him.[23]

In spite of these reservations, Cleveland is impressed by the college: the discipline is excellent; the children of the best families in France are found here in spite of the generally unfavorable attitude at that time toward the Jesuits. His comments to the Père Recteur give this Jesuit an opportunity to make a long dissertation upon the aims and purposes of the order. His discourse appears to be fairly represented, and upon it may rest Prévost's claim to have treated the Jesuits in a complimentary manner in these volumes.[24]

But what good opinions Cleveland forms of the school do not prevent his dealing cautiously with the Jesuits a little later in the narrative. This is when he is getting ready a second time to leave for England. He practices a mild deception in telling the authorities of the college that he is taking his sons on a visit to Rouen, instead of withdrawing them from the school, and he adds to some complimentary remarks on the college a present of a thousand pistoles.[25]

The Père Recteur stands in a dual relation to Cleveland's family, for not only is he head of the college the sons attend but he is also the spiritual adviser of Cleveland's wife, who has become a Catholic. When Cleveland's daughter is dying, she too embraces the Catholic faith through the guidance of the Père Recteur, and the narrative represents this Jesuit as being a great source of comfort to Mrs. Cleveland and in a lesser degree to Cleveland himself at the time of the daughter's death.

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22 *Ibid.* (Utrecht, Neaulme, 1736–39), VII, xii, 293.
23 *Ibid.*
24 *Ibid.*, pp. 294–300.
25 *Ibid.* (Rouen, Racine, 1785), VIII, xv, 189–190.

Because of this intimate connection with the family, the Père Recteur enters into many conversations upon religion with Cleveland. Always he appears as a man zealous to make converts, but kindly, sincere, and conscientious. Cleveland is conscious that the Recteur hopes to convert him, and this is consistent with the ideas he already has formed of the man's zeal for his faith.[26]

When Lord Clarendon, with unusual liberality of mind, congratulates Mrs. Cleveland upon having found satisfaction for her spiritual needs in the Catholic faith, the Recteur is overjoyed by the prospect which he thinks he sees of another convert and says to Clarendon that he need look no farther than the way now open to him. Then, recklessly he adds that he would embrace Clarendon's religion if he did not know the excellence of his own. But Clarendon is not converted. He replies frankly that he would listen to the Recteur's expositions if the mass of useless questions which are obstacles to the triumph of truth could be removed. Although the Recteur appears to be delighted, he hastens to change the subject to an ordinary topic of conversation, in order, Cleveland explains, to avoid the discussion of useless questions which would not contribute to his purpose.[27]

In this same scene after Clarendon has spoken highly of the College du Louis le Grand and added that Cleveland might as well leave his sons there since the kind of religious instruction they receive makes no difference until they attain the age of reason, the Père Recteur, who, of course, does not agree with Clarendon, is ready to seize this opportunity of influencing the boys, even though he can not approve the reason for leaving them at the school. Cleveland notes the Jesuit's reactions with more amusement than malice.[28] Then, he adds that although he is satisfied with Clarendon's view, he does not think less of the Recteur for the secret views he attributes to him. Cleveland has always been inclined to judge religion on the grounds that justice and goodness are the necessary virtues, and he judges not only the personal integrity of the Jesuit but also the truth of his religion by his zeal.[29] There is a satirical ambiguity of a sly sort in those words.

Since the Recteur fails to convert Cleveland, Prévost has denied the Jesuits a complete apology for the harsh treatment that they received in the earlier volumes, but he has made some generous concessions in three conversions which would please the Jesuit readers and in a generally more kindly tone of the narrative wherever the Jesuits appear.

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[26] *Ibid.* (Utrecht, Neaulme, 1736–39), VII, xii, 303.
[27] *Ibid.*, p. 260.
[28] *Ibid.*, p. 258.
[29] *Ibid.*

It would appear, however, that the controversy regarding the treatment of the Jesuits continued for four editions of *Le Philosophe anglais,* those of 1757, 1778, 1781, 1785, have been censored by the deletion or revision of passages concerning the Jesuits. That problem was treated in an earlier paper read before the Academy. When it is solved, it will make another chapter in the story of Prévost's relations with the Jesuits in the eighteenth century.

# POPULATION FLUCTUATIONS OF THE MALLOPHAGAN PARASITE *BRÜELIA VULGATA* (KELLOGG) UPON THE SPARROW[1]

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The purpose of this investigation was to determine if seasonal fluctuations of an ectoparasite occur in the relatively constant environment such as among the feathers of a bird host. Matthysse (1946) and Allen and Dicke (1952) reported that the chewing louse *Damalinia (Bovicola) bovis* (L) followed a seasonal cycle in which the maximum population occurred in the late winter, usually February or March. Although this fluctuation has been attributed to various physical and physiological causes by many investigators, none of the explanations have gained wide acceptance. Cursory observations of the louse, *Damalinia lipeuroides* Megnin of the white tail deer, indicated that seasonal fluctuations may also occur upon this host.

*Methods.* For this investigation the body louse, *Brüelia vulgata* (Kellogg) of the house sparrow, *Passer domesticus* L. was chosen because of the abundance of the host. An attempt was made at the beginning of this investigation to collect ten birds per week for one year but this was not accomplished because of the reduced population of the sparrows during the summer months. Birds were collected by shooting with .22 cal. bird shot.

The ectoparasites were removed from the body of the host within two hours after the time of collection by placing the sparrows in a paper bag containing a pad saturated with chloroform or ether. After five to ten minutes the body was removed and the feathers were manually roughed over a sheet of white paper. The parasites, when anesthetised, released their grasp on the feathers and could then be easily collected from the paper.

*Discussion and Results:* A total of 391 house sparrows were collected. Of this number 174 were free of mallophagan parasites. No correlation was found between the ratio of infested and noninfested hosts throughout the year and it is assumed that the infestation of the individual bird host is due to chance. The percentage of infested sparrows was 55.5%. The total parasite pop-

[1] Approved for publication by the director of the Wisconsin Agricultural Experiment Station. These studies were aided by a grant of the Research Committee of the Graduate School from funds provided by the Wisconsin Alumni Research Foundation.

**TABLE 1**

MONTHLY SUMMARY OF BIRDS AND PARASITES. 1953

| | JAN. | FEB. | MAR. | APR. | MAY | JUNE | JULY | AUG. | SEPT. | OCT. | NOV. | DEC. | JAN. | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number Infested Hosts | 3 | 21 | 15 | 29 | 27 | 7 | 15 | 10 | 12 | 28 | 29 | 5 | 16 | 217 |
| Number Parasites | 5 | 105 | 64 | 268 | 108 | 150 | 87 | 19 | 21 | 111 | 215 | 24 | 113 | 1290 |
| Number Parasites per infested bird | 1.6 | 5.0 | 4.3 | 9.2 | 4.0 | 21.4 | 5.8 | 1.9 | 1.7 | 4.0 | 7.4 | 4.8 | 7.0 | 6.0 |
| Total birds | 10 | 43 | 39 | 44 | 41 | 8 | 32 | 27 | 21 | 54 | 41 | 8 | 23 | 391 |

ulation was lowest in the summer, intermediate in the fall and winter and highest in the spring. See table 1.

The results were analyzed using the standard analysis of variance F-test. Unequal samples were compensated by using the log number of parasites plus one for each of the individual hosts for the month. The number of parasites varies from one to sixty-eight per individual sparrow. Significant differences in the monthly louse population was found only between the months of May and June at the 0.05 probability level.

Because this increase in the total parasite population occurs at the time of maximum nesting activity of the house sparrow in this area, it may be caused by changes in the habits of the host during this period. This hypothesis of relationship of parasite incidence to breeding season might also be extended to other animals in the temperate areas in which the peak of the louse population occurs when the young and adults are closely associated and would thus insure the distribution of the parasites from the adults to the young.

Small numbers of the amblyceran species, *Menacanthus annulatus* (Piaget) were found upon ten sparrows during the months of October and November. Their absence throughout the remainder of the year is unexplained.

*Summary:* A total of 391 house sparrows were collected of which 217 were infested with a variable number of mallophagan parasites. The approximate average number of parasites per infested host for the year was six per sparrow.

Statistically significant differences in louse populations were indicated between the months of May and June. This increase may be correlated to the change in habits of the birds during the time of maximum nesting activity.

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# FOREST HUMUS: ITS GENETIC CLASSIFICATION[1]

S. A. WILDE[2]

He who would study organic existence,
First drives out the soul with rigid persistence
That the parts in his hand he may hold and class;
But the spiritual link is lost, alas!
MEPHISTOPHELES, Goethe's *Faust;* 1:4

The dearth of information on the concealed properties of forest humus precludes treating this subject on a rigorous academic plane, and compels the employment of a discretionary and speculative approach. Under similar circumstances, Josiah Royce, one of the greatest speculative minds that America has produced, pointed out one way to an objective as follows: "Not to demonstrate in fair and orderly array, from any one principle or axiom, what must be . . ., but to use every and any device that may offer itself, general analysis, special example, comparison, and contrast of cases"; in brief, "anything that shall lead to the insight of what the objective is and implies."

It is only in the spirit of Royce's philosophy that one may justify or excuse the unconventional style of this paper, borrowings from Goethe's immortal masterpiece, and the insufficient deference paid to certain established trends of thought.

## FORESTERS FAIL TO COME TO TERMS

That I may detect the inmost force,
Which binds the world, and guides its course;
Its germs, productive powers explore,
And rummage in empty words no more.
Goethe's *Faust;* 1:1

Classification of forest humus is an old problem which, instead of mellowing with age, has grown more and more troublesome. One hundred and twenty years ago Hundeshagen (1830) pointed out in his text that forest humus occurs in two principal morphological forms which differ in their silvicultural effects. This important statement, however, failed to impress Hundeshagen's contemporaries; in those days differences in the nature of soil could not interfere with the assembly line of timber production set in motion by Cotta and Hartig on a hundred-year cycle. Not until four and a half decades later was the task of humus classi-

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fication revived by Emeis (1875) who suggested that three types of forest humus be recognized: one made up of well-decomposed organic matter incorporated with the mineral soil and containing nitrogen in the form of "nitric acid"; the other two made up of "raw" or "coarse" organic remains.

Shortly after the appearance of Emeis' paper, Müller (1879, 1884) issued two monographs on the morphology of humus forms, their relation to forest growth, and their effects on soil development. Müller's reports attracted wide attention, far beyond the boundaries of his native Denmark. The simultaneous publication of Darwin's work on earthworms and vegetable mould (1881) still further increased general interest in humus. For some time it appeared as though Müller's two principal types, "mull" and "mor," placed the problem of humus classification on a sound scientific basis.

However, the favorable silvicultural effects of some forms of Müller's "mor" led Ramann (1893) to recognize three main types: mull, mor (Trockentorf or "dry peat"), and "coarse humus" (Rohhumus). The last variety was characterized by a friable structure, showed a rapid decomposition on cut-over lands, and in a way resembled the mull-like mor (Mullartiger Torf) originally described by Müller (1887, p. 37). Eventually, however, Ramann retailored his classification twice (1905, 1911) and thus established the precedent for numerous other proposals published in the course of the past forty years. These proposals undoubtedly broadened the knowledge of humus forms, but they introduced a number of misconceptions and brought about nomenclatural chaos; almost every expression of international use has now two or more meanings, and the same material is known under several names (Aaltonen, 1948, p. 183). The simple concept of superficial organic matter was at one time or another referred to as "mor," "mar," "moor," "Torf," "dry peat," "raw humus," "surface humus," "duff," and "holorganic layer." In some writings the terms mull and mor were used to designate forms of organic matter (incorporated or free), rather than natural types of humus (Lindquist, 1931; DuRietz, 1942). Thus, the seed of discord and confusion planted by Ramann in time grew into an ideological and terminological monstrosity, a hydra with the heads of Janus.

The existing turmoil did not arise only from the disagreement of opinionated authors of different classifications, but is a consequence of more deep-seated reasons, such as a generally insufficient knowledge of the subject, intrusion of unqualified generalizations, and underestimation of the pedological and silvicultural importance of humus layers. To a great degree, the development of a workable system of forest humus classification was handicapped by the fact that the recording of the visible morphological features was rarely supplemented by the study of the concealed physico-chemical and microbiological characteristics of humus, all important in the life of forest vegetation (Waksman, 1938).

## THE STORY OF THE LOST HORIZON

Hereon they base the law
There's no disputing,
To give the undermost
The topmost footing.
MEPHISTOPHELES, Goethe's *Faust;* 2:4,1

The existing, nearly a century old, framework of soil science was largely fashioned by geologists. In accordance with their background, these students of the non-living world visualized soil as a natural body derived by weathering from the underlying substratum. The coined term "parent material" clearly indicated a picture of the soil as originating from below.

Timber growers, in their more than two hundred years of reforestation experiences, had untold opportunities to observe thin-littered and crumb-structured soils harboring earthworms, as well as leached hardpan soils covered with a thick mat of organic debris (Figure 1). Even though foresters failed to attribute any scientific importance to their observations, they knew that the soil originates from above, not from below; and they visualized soil in terms of "parent litter," rather than "parent substratum." These ideas were conclusively proven by Müller (1887, p. 156) who investigated the soil of an abandoned forest nursery which was homogenized by frequent cultivation and subsequently planted to spruce and oak; within less than forty years this soil produced a garden-like mull under the oak stand, but a layer of raw humus and pronounced signs of podzolization under the spruce stand.

Since the time of Müller's research, the problem has been repeatedly investigated in many countries; the results of all these studies led Aaltonen (1948, p. 206) to conclude recently that: "Der Mull gehört zu der Braunerde, der Rohhumus zum Podzol."

Following in the footsteps of dynamic geology, soil scientists concentrated their attention on the translocation of mobile soil fractions and presented soil as a profile comprising a sequence of horizons.

Few students of forest environment failed to acknowledge the importance of organized soil morphology, but the geological pattern of soil did not entirely satisfy their needs. Under the pressure of practical tasks, foresters were not so much interested in the soil "profile" as in the soil "face," that is, the epidermal

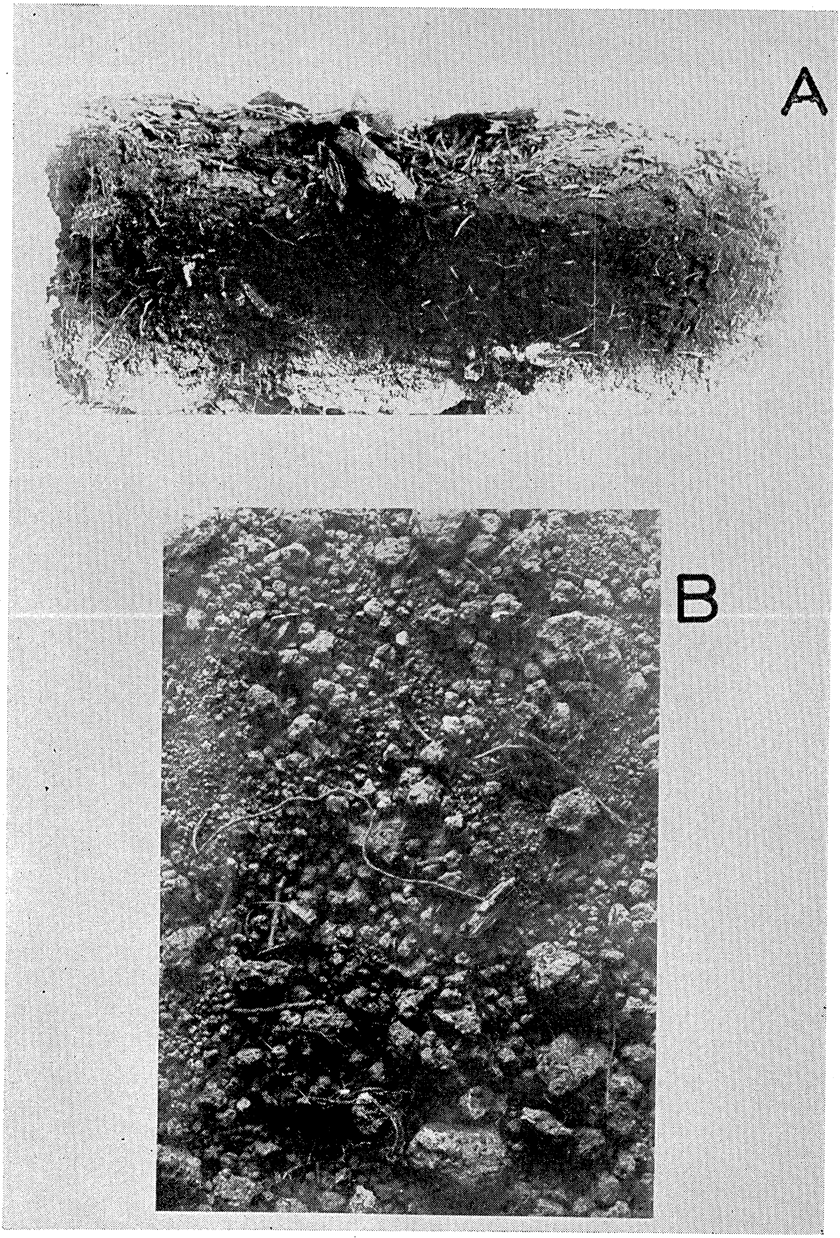


FIGURE 1. (A) Matted mor or raw humus of a mature loam podzol developed under a hemlock and balsam fir stand in northern Wisconsin; organic matter is sharply separated from the bleached, nearly white layer of silica. (B) Earthworm crumb mull of a weakly podzolized loam developed under a hard maple, basswood, and white elm stand in central Wisconsin; organic matter is intimately mixed with the mineral soil by the action of night crawlers.

organic layer which serves as a seed bed and decides the fate of natural forest regeneration. This layer, however, slipped through the fingers of the founders of pedology. Not until the soil profile was divided into A, B, C, and later $A_1$, $A_2$, B, C horizons, did the existence of the forest floor receive recognition as the $A_0$ layer or "super-solum" material (Zakharov, 1931, p. 61). In truth it may be said that soil scientists did not see the soil for the horizons.

Beyond incorporation of the so-called "dead litter" into the profile of forested soils, the morphology of forest humus received no further consideration by soil scientists. In vain one could search through pedological textbooks for a reasonably accurate description of humus layers. Glinka (1931), one of the mainstays of pedology, failed to even mention the A sub-zero layer in the chapter of his book devoted to the classification of the soil profile (pp. 159–163).

In time pedologists correlated the composition of the soil profile with conditions of environment and devised a broad scheme of climatic-zonal classification of soils. In this classification again the factors of the organic world received only token consideration (Romell and Heiberg, 1931, p. 569). The distribution of northern forests was identified with the occurrence of sesquioxide-impoverished or podzol soils and designated as the "podzol region." Since not all the soils in this enormous area showed signs of podzolization, the concept of zonality was made good by the introduction of such equivocal terms as "weakly podzolized soils," "latent podzols," "crypto-podzolic soils," and more recently the ambiguous expression, "brown podzolic soils."

Many unnecessary complications would have been spared if the originators of the climatic-zonal classification had made reference to, let us say, the "taiga region," rather than the "podzol region," and stressed that the development of soils in boreal forests is governed by two diametrically opposed processes: mor humus formation and mull humus formation.

A classificational approach of this kind, incidentally, was not advocated by foresters alone, but by some agronomists as well, particularly by Kostychev (1889) and his student Williams (1927) of the Moscow Agricultural Academy. In Williams' opinion the development of true podzol soils is entirely a result of the activity of fungi which release "crenic" and other acids whose salts of iron and aluminum are water soluble and cannot be retained in the surface layer. On the other hand, the development of chernozem soils and the chernozem-like weakly podzolized soils is the result of activity of aerobic and anaerobic bacteria whose metabolic by-products consist of "huminic" and "ulminic" acids; the salts of these acids are insoluble in water and are permanently fixed in the soil profile. In spite of the grossly hypothetical nature of Williams' ideas, eventually his views found support in the work of the geochemist Vernadskii (1939) and his followers (Geltzer, 1943; Lazarev, 1949).

At present, there seems to be enough evidence to state that when pedologists brushed off the "dead litter" they not only removed with it the practical interests of silviculture, but also the scientific foundation of soil genesis.

## Sense of Humus

To bring the Upper World, erewhile asunder,
In happier conjunction with the Under.
EMPEROR, Goethe's *Faust;* 2:1,4

Aside from its indisputable effect on the genetic development of the soil profile, humus plays an important part in production of nursery stock, selection cuttings, fire hazard, soil erosion and flood control, wildlife ecology, and the utilization of forest lands for agricultural purposes.

Since the earliest days of artificial reforestation, humus has served as fertilizer for nursery soils. It fulfills the same function today, being applied broadcast, as an ingredient of composts and briquettes, or in the form of suspensions (Wilde, 1946). One may question why the great progress made in the manufacture of commercial fertilizers has not eliminated the use of bulky natural organic deposits which are costly to procure and awkward to handle. The reason is that certain types of humus provide a safer and better balanced diet than do chemical fertilizers. This claim does not stem from the inherited prejudices of foresters, but finds constantly increasing support in the results of investigations dealing with physiology of planting stock.

Aside from nutritional aspects, humus is steadily gaining recognition as a means of controlling damping-off disease, the scourge of forest nursery practice (Wilde and Hull, 1937; Leibundgut, 1950; Mikola, 1952). It is believed that pathogenes are suppressed either through direct attack by certain humus-inhabiting organisms, or through nutritional, growth-promoting, and antibiotic influences of the humus milieu. Recent progress in the study of antibiotics promises to place the subject of humus on a level of unparalleled importance, not only in regard to forest vegetation, but in regard to the health of man as well.

The mineral portion of the soil is animated by roots of vegetation and some organisms, but its "life" is mainly confined to the metaphoric expressions of pedologists. Changes in the composition of the soil profile below the organic layers become apparent only after scores of years, or even centuries. Humus, on the other hand, is an entity teeming with life and a dynamic system extremely sensitive to environmental conditions. In some instances even a light thinning of a forest stand by axe, wind, or destructive organisms modified the biotic equilibrium of humus (Tamm, 1950, p. 190). This modification is accompanied by marked changes in the intensity of respiration, rate of nitrification, oxidation-reduction potential, nature of released volatile substances, and other measurable manifestations of microbiological activity. Hence, an episode in the life of mineral soil is history in the life of the humus layer.

The responsiveness of the organic horizons of forest soils to environmental changes offers an invaluable tool to silviculturists in their endeavors to create optimum conditions under the forest canopy, and thus to utilize to the maximum the productive forces of the habitat. Even at the present state of silvicultural knowledge, it is possible to maintain that the road toward truly scientific management of forest stands leads via careful observations of the behavior of humus layers and their inhabitants from either the plant or animal kingdom (Romell, 1935).

It has long been known that the morphology of humus layers, particularly the thickness and structure of the ectorganic fraction, has a pronounced influence on the rate of natural forest regeneration (Morozov, 1912; Hesselman, 1926). Recent evidence has pointed out that certain concealed properties of the humus layer predetermine not only the rate, but also the kind of natural reproduction (Lafond, 1951; Cholodny, 1951; Persidsky and Wilde, 1954).

The morphology of forest layers influences the susceptibility of forest stands to fire and the fertility of burned-over soils. Mor humus ignites readily and burns persistently; soils with this form of humus lose their nitrogen through combustion and much of their available nutrients through leaching of ash constituents. Soils with mull humus, on the other hand, expose only a thin layer of litter to ground fires and are as good as immune to fertility losses.

Many recent investigations have clearly demonstrated the far-reaching role played by shriveled leaves and their leftovers in the absorption of precipitation, moderation of run-off, and control of erosion (Kittredge, 1948). In some regions the high infiltration capacity of soils that tames the raging fury of rain water is linked with the depth and crumb structure of earth mull; in other regions it is the thick mat of mor that is largely responsible for the capacity of land to prevent catastrophic floods and resist the processes of denudation.

Few foresters would care to by-pass in their management plans the task of sustenance of the feather and fur clad members of the forest community. In many instances, the supply of game food depends upon the protection of desirable forms of humus with their associated ground cover plants, insects, worms, and other organisms. European silvicultural experiences have demonstrated beyond any doubt that high-pressure mercantilism, which buried the natural forest floor under pure spruce plantations, achieved nothing save creation of "biological vacua" and huge financial losses (Nechleba, 1923).

In forest management it is seldom feasible or desirable to divorce the problems of silviculture from those of agricultural land utilization. As often as not, the success of farming forest lands depends on the nature of forest humus. Mor humus carries an abundant supply of energy material and decomposes a few years after the land is cleared; mull humus consists of resistant "ligno-proteinates" and may persist for centuries even under intensive cultivation. The knowledge of this behavior of different humus forms is of ancient origin. In fact, pioneer farmers whose plows followed the axe realized the difference in the productive capacity of mull and mor soils much better than farmers of long cultivated areas. As testified by many writings, the first aim of homesteaders in forested regions was to find land with incorporated organic matter, be it called "terreau," "mould," or "black dirt." Not too long ago, virgin soils of North America taught an object lesson in land utilization to newcomers from the old agricultural regions of Central Europe; shortly after breaking seemingly fertile soils with mor humus they were faced with a sterile quartzose residue, drastically declined crop production, and, ultimately, tax delinquency. The statement of Emerson that "The first steps in agriculture . . . teach that Nature's dice are always loaded" proved to be correct.

## Spirit of the Soil

Come on, then! We'll explore what'er befall;
In this, thy Nothing may I find my All!
Goethe's *Faust;* 2:1,5

One problem of paramount importance, the relation between the form of humus and rate of forest growth, has always been and still remains a highly controversial issue.

Some Scandinavian silviculturists, following in Müller's and Darwin's footsteps, are inclined to regard mor humus as an evil and mull as a condition ideal for forest growth. They invariably refer to "good mull" and "bad mor" types, but never with a reversal of adjectives.

An American forester acquainted with the Lake States region sees the situation in an entirely different light. With few exceptions the best crumb mulls of this area occur on soils of the prairie-border transition or on poorly drained soils; such soils support inferior stands of oak and lowland hardwoods with yields seldom exceeding 10,000 board feet per acre.

On the other hand, stands of white pine yielding over 30,000 board feet per acre are found on soils with a forest floor of pronounced mor type. Even the worst thick mors, approaching wood peat in composition, at times support stands of white cedar and hemlock that attain 18,000 board feet per acre. Consequently, on the enormous acreage of the United States the high rate of forest growth coincides with the occurrence of mor humus and podzolized soils.

A still different viewpoint is held by some central European foresters. For example, in the opinion of Bühler (1910) "The principal task of practical forestry is to promote the accumulation and uninterrupted (regelmässig) decomposition of forest humus." Süchting (1929), going still further, regards humus as a nuisance and feels that the best type of humus is one that is never formed. These ideas are likely to be warmly seconded by foresters who have had an opportunity to observe hardwood stands in southern Indiana and Ohio which produce record yields of nearly 40,000 board feet per acre on soils that lack both free and incorporated organic matter (Wilde, 1951). The same viewpoint would be shared by some silviculturists working in a tropical or semi-tropical environment where the entire process of tree feeding is not dissimilar to that of flowing solution cultures (D'Hoore, 1949).

Thus, a comparison of observations from different parts of the world suggests that the effect of the humus form on the rate of forest growth varies with both geographical location and tree species. Moreover, the old views which regarded "black matter" or the "humus proper" as the essence of soil fertility are not always applicable to mature forest stands, especially those of warm regions. This in part may be explained by the fact that all forms of humus, whether raw organic remains or lignoprotein aggregates, are more or less incidental leftovers that have survived the processes of decomposition; the fraction of organic matter most essential for nutrition of trees is utilized by plant roots and by microorganisms, or is lost through leaching. Chemically, this fraction may or may not have any relation to the partly humified material. This implies that the true "spirit of the soil" is not necessarily carbonized residue, but, as appropriate to spirits, the ethereal end-products of organic matter decomposition.

In this connection, one should recall the words of Ruprecht, an outstanding student of chernozem soils, who in 1866 stated "The quantity of humus does not determine the property of black earth, since in certain provinces true chernozems are found which are completely exhausted in fertility, in spite of the fact that they still preserve the crumb structure and contain as much as 8½ per cent of humus on a dry weight basis."

All of these observations strongly suggest that foresters should begin to pay attention to the works on polyuronides and other colorless by-products of microbial activity (Winogradsky, 1929; Vageler, 1933; Gillam, 1939; Vernadskii, 1939; Norman, 1943; Fuller, 1947).

## CONTEMPLATION OF THE OBVIOUS

Life's elements with due caution fitting
The What consider and more the How and Why!
Meanwhile, about the world at random flitting,
I may detect the dot upon the i.

HOMUNCULUS, Goethe's *Faust;* 2:2,2

Most of the existing classifications of forest humus are based on the visible morphological features of the holorganic and hemorganic layers. This is apparently a legitimate *ap*proach, but not one that can be accepted without restrictions and amendments.

The ocular determination of the morphology of forest humus is not a simple matter and invariably leaves the specialist or practitioner wavering between objectivity and subjectivity. Moreover, a classification based solely on external characteristics may easily lead to hair-splitting details and a multitude of abstract concepts divorced from their context. This is particularly true when the classification emanates from the thesis that the truly scientific spirit requires a precise recording of morphological characteristics without any preconceived regard for the possible relation of these characteristics to forestry practice. A philosophy of this kind is parallel to the credo of "pure aesthetes" or modernistic artists who indulge in the production of abstract geometrical patterns and organized smudges.

However, in art, as well as in a utilitarian classification, the intrinsic values are not arrived at by either photographic recording of objects or by creation of hodgepodge conglomerates, but by expression of actual life experiences and significant physical relationships. In the case of humus classification, these relationships embrace the ability of soil to conceive young plants, to nourish vegetative cover of a certain composition, to retard runoff, arrest or promote the downward movement of salts and colloids, and regulate the balance of useful and harmful organisms. In other words, the recordable make-up of humus is nothing but an abstraction constituting the first step from experience to expression of something objectively useful. If the identifying features of humus are not used as a means to an end and are separated from their teleological basis, the classification will become a medley of terminolgy, meaningless to men of practice.

If practicing foresters are to become interested in humus classification, such classifications must first become interested in practicing foresters. The road to this objective is well marked by the five-hundred-year-old axiom of Leonardo da Vinci which declares "O, Marvelous Necessity, thou with supreme reason constrainest all effects to issue from their causes in the briefest possible way."

## Cosmopolitan Microcosms

That brain, alone, not loses hope, whose choice is
To stick in shallow trash forevermore,
Which digs with eager hand for buried ore
And, when it finds an angle-worm, rejoices.

Goethe's *Faust;* 1:1

It has been mentioned more than once that foresters, particularly P. E. Müller, have failed to receive their share of credit in the development of soil genesis, a body of knowledge which raised soil studies to the level of a science (Romell, 1944). In all fairness, however, it must be admitted that it was the difference in the nature and magnitude of classificational approaches which placed Müller's name in the shadow of Dokuchaev's and Hilgard's.

The founders of scientific pedology first of all grasped climatic-zonal relationships and visualized great geographic landscapes which spread across continents. Tundra, podzol, chernozem, and other great soil groups are the principal biomes of the globe which decide the destiny of entire nations. In contrast, foresters of central Europe were concerned with mull and mor, or two "microcosms" which have only limited geographical distribution and which were in no way correlated with macroclimatic factors. And this same lack of comprehension of climatic-zonal influences makes the existing classification of forest humus a jumble of ambiguous terms. In recent years mull and mor have become climatic aliens, flotsam and jetsam of soil science; they drift like tumble weeds at the pleasure of enterprising classifiers from Arctic Scandinavia to the Indian Ocean and from the Canadian tundras to the Gulf of Mexico.

It is a well-established fact that indiscriminate transplanting of foreign species frequently brings disappointments. A few living reminders of misguided enthusiasm in the American past are Scotch pine, carp, and the starling. It is equally true that the translocation of foreign nomenclatural concepts, systems of forest management, or silvicultural ideology can not be accomplished successfully without adherence to the laws of ecological or climatic-zonal adaptation. The scientific classifications acquired at a bargain from abroad frequently carry with them conceptual and nomenclatural starlings. Once released in a new environment, these acquisitions often spread far beyond the territory assigned for them, and become a liability rather than an asset. "Podzol" is a good word for raw humus soils impoverished in sesquioxides, but at present this term confuses genetic classification of soils on every continent (Wilde, 1953).

As the past has shown, the shift of Müller's classification from the Danish peninsula to the comparatively similar environment of the northeastern United States required a long period of "acclimatization" during which many graftings and prunings back of grafted scions were performed (Romell and Heiberg, 1931; Bornebusch and Heiberg, 1935; Heiberg, 1937; Heiberg and Chandler, 1941; Lunt *et al.*, 1949; Hoover *et al.*, 1951). An attempt to transplant the central European scheme to other regions of America threatens to increase the already unduly long list of misnomers and may call for even more painful surgery.

A striking illustration of the chameleon-like behavior of humus forms under diverse climatic-zonal conditions is provided by Romell (1935), who writes "The same measure may affect a mor, not only to a different degree but also in opposite directions, under different conditions. A selective cutting may be fairly good silviculture with the better forms of mor in central Scandinavia, but in the north it has produced a mor worse than the average. Clear cutting is universally good in northern Sweden . . ., but is feared by foresters in the Black Forest, in southwestern Germany, as aggravating instead of improving a mor condition." These observations bear witness to the fact that classification of natural humus forms can not bear legitimate offspring if it is divorced from its lawfully wedded mate—environment.

## ORIGIN OF THE SPECIES

The mystery which for Man in Nature lies
We dare to test, by knowledge led;
And that which she was wont to organize,
We crystallize, instead.

WAGNER, Goethe's *Faust;* 2:2,2

The nature of humus-forming remains, type and rate of organic matter decomposition, mode of migration of decomposition products, petrographic and textural properties of the mineral substratum, and other conditions give rise to an untold number of morphological and physico-chemical varieties of humus layers. The recording of all these numerous varieties, however, is a problem of secondary importance which may be best solved on a regional scale. The essential prerequisite for a broad humus classification is the delineation of physiographic and biotic conditions which determine the prevailing trends in metamorphosis of fresh organic remains. The original, basically correct, approach of P. E. Müller can be brought back to life on an extended scale only by an analysis of the underlying causes of humus formation and establishment of the *major genetic types of humus development*, rather than by empirical tallying of *different kinds of humus layers.*

Humus of forested soils consists of three fractions: surface deposit of partly decomposed organic remains which may be named the *ectorganic fraction* or *ecto-humus;* dark colored, finely dispersed organic matter incorporated with the mineral soil by the action of organisms, by infiltration, or as a residue of root systems, that is, the *endorganic fraction* or *endo-humus;* pale-colored organic suspensions and pseudo-solutions which are not detectable by ocular examination and which may be designated as the *cryptorganic fraction* or *crypto-humus.* The composition and the relative proportion of these fractions are correlative with environmental conditions and give rise to different humus forms.

The influence of climatic conditions determine to a considerable degree the yield and rate of decomposition of organic remains and delineates two distinct forms of humus layers: megorganic layers and oligorganic layers.

*Megorganic layers* develop in environments which produce large quantities of plant material or retard decomposition of organic remains; such layers are characterized by a high or at least appreciable content of organic matter, free or incorporated. They include *mull* and *mor* forms, as understood in their original connotation. The occurrence of these forms is confined to three large genetical groups of forest soils: podzolized soils, melanized or brownearth soils, and prairie-forest soils. *Oligorganic layers* are found in environments which effect an extremely rapid decomposition of organic remains or produce a sparse amount of plant material. Such layers include forest litter, or *velum;* less than one inch thick *incipient mors* or *felts;* horizons with concealed humus or *leucozones;* weakly developed endorganic sod layers or *lean swards* originated from the roots of xerophytic grasses; and dark hydrosolic *melazones* or stains which carry a negligible content of protein.

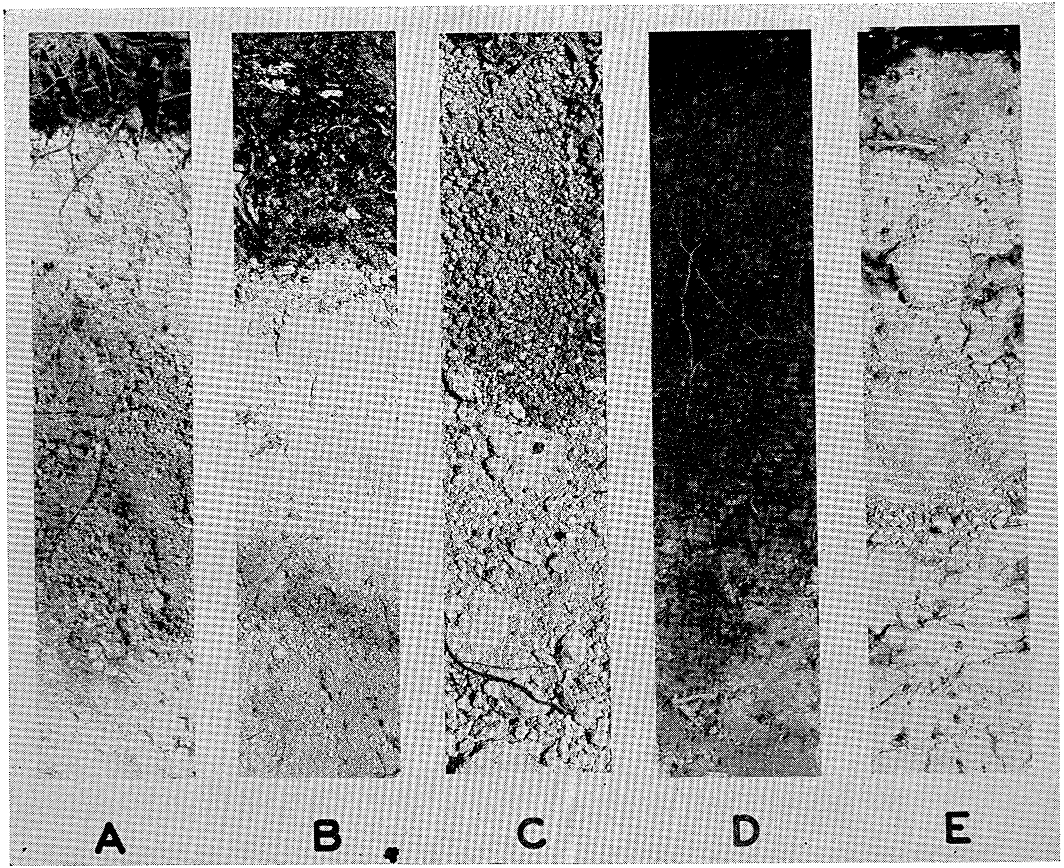


FIGURE 2. Representative forms of forest humus layers: (A) *Matted mor*, partly lignified mycelial ecto-humus of a strongly podzolized lacustrine clay; (B) *Sog mor*, peat-like saprogenous ecto-humus formed on a gley podzol; (C) *Earthworm crumb mull*, zoogenous endo-humus of a weakly podzolized silt loam influenced by a deep ground water table; (D) *Prairie sward*, rhizogenous endo-humus of a forest-invaded sandy loam soil; (E) *Crypto-mull*, leucorganic endo-humus of a yellow podzolic silt loam.

The line dividing broad zones of megorganic and oligorganic forms of forest floor has not only ecological implications; by coincidence of historical events it serves as a boundary between the two different silvicultural approaches: the traditional silviculture of the Old World, which in a large measure was accepted by foresters in the northern states of this country, and the youthful silviculture of the New World, which is developing in the southern and western states.

The principal organisms which contribute to the formation of humus layers, by *their life activity as well as by their dead tissues,* include earthworms, nematodes, members of arthropod phylum (crustaceans, mites, millipeds, and insects), protozoa, fungi, aerobic and anaerobic bacteria, actinomycetes, roots of grasses and heath plants, and tissues of mosses, lichens, and other ground cover vegetation. Surface remains of trees and shrubs, forming forest litter, provide energy material, but serve only in rare cases as significant constituents of humus layers.

Depending upon the predominant agent of humus development, humus layers may be subdivided into the following genetical groups: *foliogenous,* formed by superficial parts of plants, including lichens and mosses; *rhizogenous,* made up chiefly of remains of root systems, especially those of grasses and heath plants; *zoogenous,* formed largely by earthworms and arthropods; *microbiotic,* developed in the absence of macro-animal forms by diversified population of bacteria, fungi, actinomycetes, protozoa, and nematodes; and *mycelial,* consisting in a large part of decay-resistant tissues of fungi. Under conditions of impeded drainage, aerobic organisms are replaced, at least in part, by anaerobic organisms, and the organic remains are subjected to strong hydrolysis in the presence of reduced compounds; the resulting process of "putrefaction" or anaerobic fermentation of the methane or a hydrogen type gives rise to *saprogenous* humus layers.

Figure 2 illustrates several of the representative forest humus forms. The more important types of humus layers, developing under the influences of different environmental conditions and biotic factors, are briefly described in the following synopsis.

## Synopsis of the Major Types of Forest Humus Development

Velum. The term "velum" is derived from the Latin, meaning "veil." It was suggested by Wissotsky (1930) as a substitute for forest litter. This term well expresses the make-up of the embryonic humus layers consisting of mere cover of plant debris. Such cover is composed largely of the previous year's loose or friable litter which rests on a pale-colored eluvial horizon *impoverished in nitrogen.* The content of the total N in the surface mineral soil is usually below 0.03 per cent.

This typical representative of oligorganic humus layers is a result of a warm and humid climate which promotes the energetic activity of the diversified soil population and an intensive leaching of the products of organic matter decomposition. It bears the imprint of soil-forming conditions common to the tropics, and in this country it is largely confined to Red and Yellow Podzolic soils underlain by porous lateritic substrata.

FELT. This diminutive variety of foliogenous ecto-humus may be regarded as "consolidated velum" or as "embryonic mor." It consists of a thin layer of partly decomposed, laminated or compressed litter, interwoven by fungous mycelia or roots of ground cover vegetation. It does not exceed ¾ of an inch in thickness and is underlain by a humus-free mineral soil.

Felt layers, or "thin mors," are encountered most frequently on podzolized lateritic soils, especially those of the southern Appalachians (Hoover, 1949), where they appear to form a stable type of forest humus development. Similar oligorganic layers are also found near the podzol belt of mountain forests of conifers or hardwoods with rhododendron ground cover (Ohmasa, 1951); their occurrence often coincides with incipient podzolization. In many instances, felt layers represent a temporary successional phase in soil development, caused either by natural alterations of forest milieu, fire, or planting of podzol-forming species.

CRYPTO-MULL. A leucorganic endo-humus similar to velum, except that litter rests on pale-colored soil *enriched in nitrogen* by infiltration of protein-bearing humates. The depth of the humate infiltration, varying from about one to three feet, may be best established by the Kjeldahl analysis. As a rule, the upper portion of the mineral soil contains more than 0.1 per cent of the total nitrogen (Wilde, 1951).

Crypto-mull is distributed in warm and moist climates, predominantly on fine textured soils of either sialitic or lateritic substrata (southern portion of the Grey–Brown Podzolic soils, Planosols, and Yellow Podzolic soils). It owes its existence to mild environmental conditions under which the nearly instantaneous and complete breakdown of litter is accompanied by the destruction of dark pigmentation. It may be suspected that the processes of decomposition of organic remains and accumulation of non-pigmented proteinaceous suspensions are largely accomplished by the activity of bacteria and actinomycetes. In some instances soils with crypto-mull humus support exacting hardwoods that attain a yield of nearly 40,000 b.f. per acre.

MICROBIOTIC MULL. The plant remains in this endorganic type undergo gradual *decay* rather than the disintegration or destruction caused by arthropods or earthworms in zoogenous types. The litter, therefore, is characterized by the presence of coarse fragments of leaves which tend to resist decomposition. It preserves a reasonably loose structure, although it has a tendency to form localized "lumps." The dark $A_1$ horizon, or mull layer proper, has a finely aggregated, massive, or single grain structure; it varies in thickness from a few inches to nearly two feet. The carbonized colloidal residue is distributed in the soil profile largely in the form of suspensions or pseudo-solutions (Maran, 1944). In some instances, the translocation of organic matter is aided by migration of microorganisms, particularly nematodes.

There is a strong probability that the development of microbiotic mull was at times attributed to purely chemical processes and this form identified with "pseudo-mull," "abiotic orthumus" (Lang, 1932), or "chemorganic humus" (Frei, 1946). Investigations employing the use of the molecular filter developed by Clark *et al.* (1951), however, suggested that "abiotic" humus layers have very restricted distribution. Perhaps "hydrosolic stains" of alkali soils and "infra-melazones" formed in some poorly drained soils (U.S.D.A., 1938, p. 113) may qualify as chemogenic phenomena. Microbiotic mull is sometimes classified as "firm mull," a highly unfortunate designation since this type of humus layer usually has a soft, mellow consistency and fine grain structure of very stable aggregates.

Mull layers formed predominantly by the action of microorganisms are widely distributed throughout the forests of the world and have numerous morphological varieties determined by texture of the mineral soil, content of organic matter, and thickness of the endorganic layer. Such varieties may be characterized by a combination of the following terms: lean, rich, shallow, deep, sandy, fine-textured, aggregated, dense, and amorphous.

EARTHWORM MULL. This is the prototype of the mull group and the best known representative of the zoogenous or coprogenous form of humus development. It received the particular attention of both Müller and Darwin. In fact, Darwin went so far as to suggest that the expression "animal mould" might be more appropriate than "vegetable mould" (Glinka, 1931, p. 39).

The devouring of organic debris by worms and their burrowing produce an intimate mixture of mineral and organic matter covered by a thin, often sporadic layer of forest litter. The structure of the endorganic horizon is determined by the size of earthworms; *Lumbricus* and other large worms produce coarse or crumb-like aggregates of castings, whereas small worms produce fine grain-like aggregates.

Earthworm mull layers form surface horizons of many soils in the temperate zone, particularly those belonging to the groups of weakly podzolized soils, melanized or brownearth soils, and prairie-forest soils in advanced stages of their metamorphosis. As a general rule, the occurrence of this humus type is confined to fine-textured substrata influenced by the ground water table, extended capillary fringe, or seepage, and supporting hardwood stands. Occasionally, however, earthworm mulls are found under mixed hardwood-coniferous and even pure coniferous stands. The rate of forest growth on soils with this type of humus varies from about 20,000 b.f. to a few cords per acre, and hence generalizations concerning the beneficial effects of earthworms on forest growth are utterly unjustifiable.

ARTHROPOD MULL. The activity of crustaceans, mites, millipedes, and insects causes the disintegration or pulverization of forest litter and leads to an accumulation of organic remains in the form of a detritus enriched in castings and shells of animals. Depending upon humus-forming organisms and nature of litter, the organic layer attains an appearance of brownish bran, finely ground dark-brown coffee, or very fine black sawdust. In a pure form, arthropod mull is essentially a superficial deposit and from a strictly morphological view-point should be regarded as a transition to the mor group of humus (Hartmann, 1951). In some instances the depth of the ectorganic layer of arthropod mull exceeds six inches, and the loss on ignition exceeds 70 per cent. If it were not for the ambiguous homonym, this form should have been designated as "mor-like mull."

The distribution of arthropod mull embraces a wide range of climatic conditions, including those of the cold and humid belt of Canada. In the majority of cases, this type is confined to soils derived from calcareous rocks and deposits, including those with pronounced podzol profiles. The rate of growth of forest stands on soils with this humus type varies from a few cords, produced by struggling oaks on melanized rendzinas in the American midwest, to 30,000 b.f., produced by spruce and other conifers on calcareous podzols or Grey Wooded Soils of Canada.

SWARD OR ROOT MULL. The term "sward," synonymous with "turf" and "sod," is defined by Webster as "The upper stratum of earth and vegetable mold filled with the roots of grass and other small plants." This definition fits admirably the concept of a rhizogenous endo-humus developed by incomplete decomposition of roots of herbaceous vegetation and found universally in prairie, semi-desert, and alpine meadow regions. When either of these formations is invaded by the forest, the humus layer may remain rhizogenous in nature for a period of several centuries (Pierce, 1951); only gradually does it undergo a metamorphosis into mull or other forest-originated forms of forest floor. When the small density of forest cover allows the existence of a solid grass cover, the rhizogenous humus layers of prairie-forest and desert-forest ecotones are maintained for an indefinitely long time by root systems of herbaceous vegetation. For example, the greater share of humus layers in pine stands of southern and central Wisconsin (Sparta, Boone, Plainfield, and Dunning series) are originated from grasses, sedges, and prairie herbs, rather than forest litter. The same is true in many open stands of ponderosa pine of lower elevations or sporadic spruce stands of high mountains. An apparent morphological similarity between sward and earthworm mull layers is purely coincidental; as often as not, sward layers harbor no earthworms.

Depending upon climatic conditions and nature of herbaceous cover, three types of rhizogenous endo-humus may be recognized: *prairie sward, alpine sward,* and *grassland sward.* In a more detailed way, these types may be classified as: *bluejoint sward, gramma sward, fescue sward, bunchgrass sward,* etc. Swards of different geographic regions vary in thickness from two feet (prairie sward) to a few inches (grassland sward); their content of organic matter ranges from a fraction of 1 per cent to more than 20 per cent (alpine sward).

FEN MULL. This type of saprogenous endo-humus of mildly acid or alkaline reaction is found on lowland soils underlain at a shallow depth by ground water enriched in bases. It is composed of sparse forest litter and a muck-like layer of partly mineral, partly organic material varying in depth from about two to eight inches. The organic matter is finely dispersed and usually saturated with calcium and magnesium. The name for this hydromorphic form of humus is construed on the basis of terminology for organic deposits advanced by Dr. Oswald of Sweden (Tacke, 1929).

This type is formed under the influence of hydrolysis and activity of anaerobic bacteria, protozoa, and other inhabitants of water-logged soils. Periodic saturation of the humus layer does not necessarily prevent the existence of a rich population of organisms, including enchytraeids and larger worms. It is possible that some free oxygen is provided by algae.

Fen mull is distributed throughout the entire broad zone of mesophytic hardwoods, being particularly common in the prairie-forest region. The predominant forest stands are made up of moisture-loving deciduous trees, such as white and slippery elm, black ash, swamp white oak, red maple, river birch, gums, cottonwood, and willows. As a rule, these stands have a very slow rate of growth and high percentage of cull.

DUFF MULL OR AMPHIMORPH. This is a stable type of ectendo-humus forming the transition between mull and mor (Wilde, 1946; Lafond, 1951; Hoover *et al.*, 1951). It is made up of forest litter (L), disintegrated organic debris (F + H), and a layer with incorporated humus ($A_1$). It is common on a vast area of podzolic soils of plains and mountains, strongly degraded prairie-forest soils, and podzolized brownearths. This type is the result of the activity of several groups of organisms, which at times include microbes, worms, and arthropods. It has several pronounced morphological varieties determined by the nature of its ectorganic and endorganic fractions, e.g. *friable duff-crumb mull, arthropod duff-grain mull,* and *matted duff-sand mull.* Favorable seedbed conditions and a generally high rate of stand growth are important characteristics of soils with this humus layer.

LICHEN MOR. The thin firmly consolidated crust-like layer of ecto-humus is derived largely from tissue of *Cladonia* lichens and is sometimes referred to as "crust mor" or "lichen crust." It occurs predominantly on rock outcrops, aeolian sands, and burnt-over areas in the region of podzol and podzolic soils, but may also be found on infertile substrata in other soil provinces. Soils with this type of forest floor usually support slow growing conifers, especially pines and black spruce. The shallow depth of the humus layer is largely due to the poverty of soil and sparse production of organic matter by stands lacking understory; the activity of ascomycetous symbionts of the lichen, especially their strong acidifying effect, may be a contributing factor. Lichen mor retains uniform morphology throughout the world.

ROOT MOR. A tenacious, strongly acid ectorganic layer of this type is interwoven by a dense network of roots of ground cover plants. It is found mainly on podzols of sandy or sandy loam texture supporting conifers with ground cover of *Vacciniaceae,* particularly blueberries. This form of rhizogenous ecto-humus was previously described in detail by Romell and Heiberg (1931) under the name of "fibrous mor." Morphological varieties are determined largely by the nature of humus-forming plants. Occasionally a variety of rhizogenous mor is formed by the fine roots of hardwoods, particularly hard maple and beech growing on podzolized soils.

MYCELIAL MOR OR LIGNO-MYCELIAL MOR. This is the typical representative of "raw humus." It consists of a firmly consolidated ectorganic layer derived in a large part from fungous mycelia penetrating the partly decomposed forest litter. It is sharply delineated from the bleached mineral soil and varies in thickness from two to about eight inches. This type is confined to upland podzols and strongly podzolized soils which support dense coniferous and hardwood-coniferous stands with ground cover of shade-tolerant acidophilous, so-called "raw humus" plants. The upper portion of the mycelial mor often exhibits fairly high biological activity. However, the consumption of the cellulose fraction of litter by microorganisms and the accumulation of decay-resistant fungous mycelia arrests are activity of fungi and thus converts mycelial mor into a ligno-mycelial or a lignified mor (Hartmann, 1951). Such metamorphosis takes place largely in the dense virgin stands of conifers and is especially pronounced in the lower portion of the ectorganic layer. The presence of a thick mycelial or lignified mor is in no way correlated with the depressed rate of forest growth; soils with this type of forest floor are known to support stands of white pine and spruce whose yields approach 50,000 b.f. per acre.

Sog Mor. This hydromorphic form consists of a thick layer of ecto-humus of amorphous, macerated, or fibrous structure. It is underlain either by an ashy grey podzol horizon or a leached layer stained with humates. This type is confined to the boreal forest regions where it occurs on gley podzols underlain at a shallow depth by a ground water table. The name "sog" is borrowed from English dialect and means to soak or to saturate.

The development of sog mor proceeds in part under hydrolysis and periodic anaerobic fermentation or saprogenation. These processes, however, are often supplemented by the activity of various other humus-forming agents including fungi and arthropods. The entire course of biological activity of these layers is greatly affected by periodic fluctuations of the ground water table. The forest cover is composed predominantly of conifers with some birch, aspen, and other incidental deciduous trees. Occasionally, saprogenous mor is formed on water-retaining rock outcrops, particularly those of calcareous origin; the latter variety was classified as "alkaline raw humus" or "rendzina mor" (Galloway, 1940).

Moss Mor. This name designates a type of forest floor transitional between mor humus and peat. It is characterized by a peculiar "stratum superficiale," or S-layer (Forsslund, 1943), consisting of live *Sphagnum* and sometimes *Polytrichum* mosses. Under climatic conditions of boreal regions and high mountains excessive humidity permits growth of bog moss species on swamp borders as well as on upland soils with somewhat impeded drainage. Once established, bog mor produces radical changes in the ecological status of the area, especially by decreasing the aeration and temperature of the soil. Aside from adverse physical effects, this type causes impoverishment of the root-inhabited zone through permanent fixation of available nutrients by the

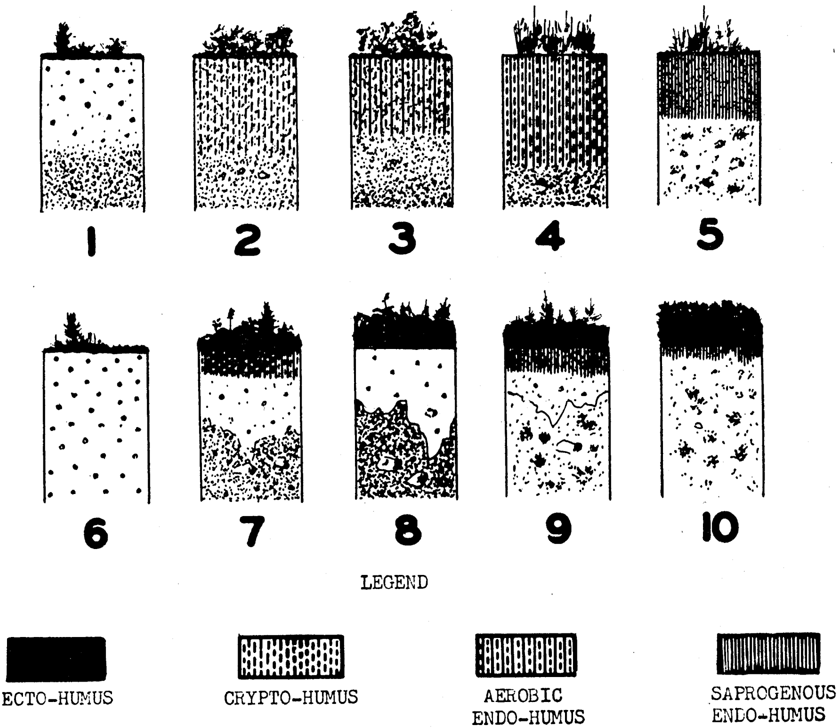


FIGURE 3. Profiles of the major types of forest humus layers (schematic presentation): (1) VELUM (oligorganic ecto-humus); (2) CRYPTO-MULL (leucorganic endo-humus); (3) EARTHWORM MULL (zoogenous endo-humus); (4) PRAIRIE SWARD (rhizogenous endo-humus); (5) FEN MULL (saprogenous endo-humus); (6) LICHEN CRUST MOR (oligorganic ecto-humus); (7) DUFF MULL (amphimorphic ectendo-humus); (8) MYCELIAL MOR (mycogenous ecto-humus); (9) SOG MOR (saprogenous ectendo-humus); (10) MOSS MOR (microbiologically inert Sphagnum ecto-humus).

tissue of moss cover. In time the combination of all these adverse influences leads to the replacement of the forest by *Chamaedaphne* muskeg, *Sphagnum fuscum* bog, and similar types of "xerophytic" swamps that deny sustenance to trees.

The analytical data which provided the framework for the proposed classification were previously published by the author

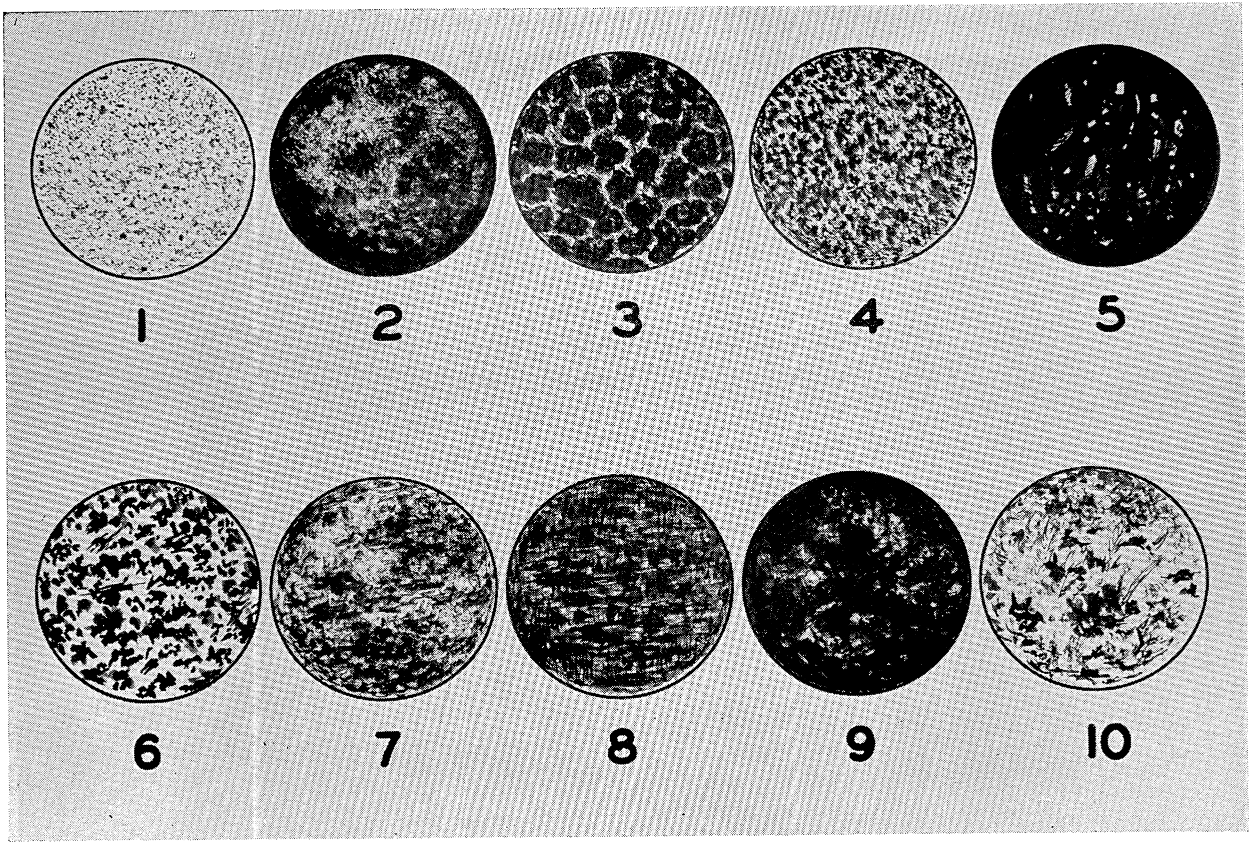


FIGURE 4. Structural features of representative types of humus layers: (1) Microbiotic mull; (2) Arthropod fine mull; (3) Earthworm crumb mull; (4) Rhizogenous prairie sward; (5) Saprogenous fen mull; (6) Arthropod bran mor; (7) Mycelial mor; (8) Lignified mor; (9) Saprogenous sog mor; (10) Sphagnum moss mor.

and his collaborators (Wilde, Buran, and Galloway, 1937; Galloway, 1940; Rosendahl, 1943; Wilde, Wilson, and White, 1949; Lafond, 1950a, 1950b, and 1951; Pierce, 1951; Wilde, 1951; Wilde and Mader, 1952; Mader, 1953a and 1953b; Davey and Mader, 1953). Figures 3 and 4 illustrate schematically the mor-

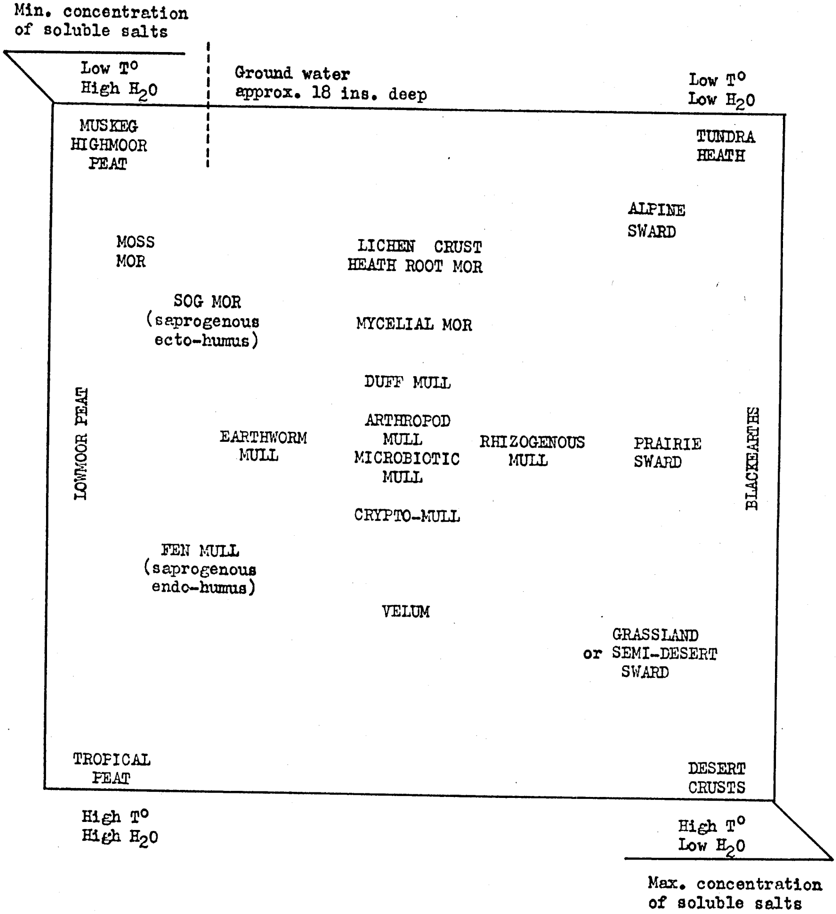


FIGURE 5. Schematic distribution of genetic types of forest humus in relation to temperature and moisture.

phology of the important humus layers. Figure 5 gives an outline of the distribution of the major forms of forest humus in relation to climatic conditions. With an increased temperature the microbiotic mull is replaced by oligorganic forms of crypto-mull and velum. Cold regions, on the other hand, are marked by the occurrence of different types of mor humus. An increase in soil moisture brings about the development of earthworm mull and saprogenous types of either endo- or ecto-humus. Deficiency of water is manifested by prominence of grass cover and the development of rhizogenous sward forms.

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# NOTES ON WISCONSIN PARASITIC FUNGI. XX

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This series of notes is based principally on collections made during the seasons of 1952 and 1953.

ENDOCONIDIOPHORA FAGACEARUM is the name given by T. W. Bretz (Phytopath. 42: 436. 1952) to the sphaeriaceous perfect stage of *Chalara quercina* Henry, the fungus causing oak wilt, widespread in Wisconsin and neighboring states. According to Ainsworth and Bisby, *Endoconidiophora* Münch. is synonymous with *Ophiostoma* Syd.

PHAEOSPHAERIA sp. occurs on telia of the microcyclic *Puccinia silphii* Schw. on *Silphium laciniatum,* collected at Arlington, Columbia Co., August 22, 1952. The perithecia simulate the pycnidia of *Darluca filum* in size and general appearance. They are scattered or clustered, somewhat more than globose, about 65$\mu$ wide by 80$\mu$ high, pseudoparenchymatous, and sooty. The asci are clavate, about 60 x 15$\mu$, while the ascospores are 20 x 6$\mu$, 3 septate, and clear olivaceous. Since this differs materially from *Eudarluca,* said to be the perfect stage of *Darluca filum,* it is supposed there is no connection between the *Phaeosphaeria* and *D. filum.*

METASPHAERIA GALIORUM Sacc. has been collected in mature condition on overwintered stems of *Galium aparine* at Madison, May 13, 1953. It seems possible that the fungus initiated its development the preceding season as a parasite. The conspicuously erumpent perithecia appear to have originated subepidermally.

ELSINOE VENETA (Burkh.) Jenkins, the name for the perfect stage of the organism causing cane and leaf blight of *Rubus occidentalis* and *R. allegheniensis* in Wisconsin, was reported in these notes (Trans. Wis. Acad. Sci. 32: 80. 1940) as *E. veneta* (Speg.) Jenkins, since at that time it was not known that *"Gloeosporium" venetum* Speg. is not the *Sphaceloma* imperfect stage of the cane blight, as later determined by Jenkins and Shear (Phytopath. 36: 1043. 1946). According to Jenkins and Shear, Ellis and Everhart described the North American organism under the name *Gloeosporium necator,* and the latter authors provide the name *Sphaceloma necator* (E. & E.) Jenkins & Shear for the imperfect stage.

ELSINOE sp. on *Desmodium illinoense*. A mature specimen was collected on the C. & N. W. R. R. right-of-way, south of Ipswich, Lafayette Co. (approx. 3 miles SE of Platteville, Wis.), August 16, 1951. This does not appear to be one of the species which have been treated or distributed by Jenkins and Bitancourt. The stromata are grayish crustose-convolute, moderately elevated, mostly rather small and irregularly rounded or elongate, hypophyllous, asci subglobose, about 15–25$\mu$ diam., rather irregularly dispersed throughout the stroma; ascospores hyaline, cylindric, approx. 11 x 4$\mu$, 3 septate, number per ascus uncertain. Immature specimens collected near Delavan, Walworth Co., August 20, 1951, and near Brodhead, Green Co., August 9, 1952, bear what is assumed to be a *Sphaceloma* stage in which, lacking well-defined conidiophores, the conidia are produced in considerable numbers over the surface of the stromata. These conidia are hyaline, one-celled, subcylindric to ovoid, 4–6 x 3–3.5$\mu$. In my Notes XVII (Trans. Wis. Acad. Sci. 41: 122. 1952) this material was discussed as a questionable *Tuberculina*, for the perfect stage was detected only after later prepared permanent sections were studied.

TAPHRINA HIRATSUKAE Nishida, according to Mix, replaces the name *T. struthiopteridis* Nishida, a synonym, for the fungus on *Pteretis nodulosa (Onoclea struthiopteris)* in Wisconsin.

TAPHRINA COMMUNIS (Sadeb.) Giesenh. is the name under which Wisconsin specimens on *Prunus*, formerly listed under *T. mirabilis* (Atk.) Giesenh., are now cited since, according to Mix, the latter name is a synonym.

PHYLLOSTICTA sp. on *Carya cordiformis* from the New Glarus Woods, Green Co., September 4, 1952, is a micro-form with hyaline, rod-shaped conidia 4 x 1$\mu$, borne in small, black, globose pycnidia about 55–65$\mu$ diam., which are clustered on rather indefinite yellow and brown marginal spots. This does not match any of the early descriptions of *Phyllosticta* on *Carya* that I have seen. It is very likely the precursor of a perfect stage.

PHYLLOSTICTA sp. on shredded, dead areas on leaflets of *Gymnocladus dioica* perhaps developed parasitically, but the lateness of the season makes this questionable. Coll. at Madison, September 27, 1952. The pycnidia are subglobose, approx. 200$\mu$ diam., the conidia hyaline, 6–10 x 3–3.5$\mu$. Seemingly not *Phyllosticta gymnocladi* Tehon & Daniels.

PHYLLOSTICTA sp. on leaves of *Zizia aptera* at Madison, September 16, 1952, is similar to, but not identical with, an earlier collection made at the same station (Amer. Midl. Nat. 41: 715. 1949). In the current specimen the spots are flat white, angled, tending to be delimited by the venation. The pycnidia are epiphyllous, large and prominent, approx. 200–250μ diam., black, subglobose. The conidia are straight, rigid, rod-shaped, 5–7 x 1.5–2μ.

CONIOTHYRIUM (?) sp. is possibly parasitic on leaves of *Acer saccharum,* collected at Madison, August 2, 1952. The largely superficial pycnidia are flattened and imperfectly developed below and are epiphyllous on large, irregular, reddish-brown lesions. They are shining black, mostly about 70–100μ in greatest diam. The conidia are clear gray and short-cylindric, 3–5.5 x 3–3.5μ.

PHOMA sp. occurs on the green upper stem of a plant of *Anychia (Paronychia) canadensis* collected at Red Rock, Lafayette Co., July 24, 1948. The sooty-black subglobose pycnidia are deeply seated, about 55–75μ diam. The hyaline conidia are subfusoid, 6–10 x 2.5–3.5μ. Unquestionably parasitic, but too small a specimen for descriptive purposes. There is no report in Seymour of any fungus on this inconspicuous little host, so that *Septoria anychiae,* described by me (Amer. Midl. Nat. 48: 52. 1952) would seem to be the only other fungus record.

SPHAEROPSIS FOLIICOLA (B. & R.) Sacc., which has been collected several times on leaves of cultivated specimens of *Crataegus* on the University of Wisconsin campus at Madison, appears to have developed in intimate association with aborted aecia of presumed *Gymnosporangium globosum.* Even on leaves where no rust infection is obvious there are small, closely clustered, flask-shaped bodies in the center portions of the *Sphaeropsis* spots, which appear to be immature pycnia. Whether the *Sphaeropsis* was the primary agent in suppressing the rust, or is only weakly parasitic, or perhaps even saprophytic is unclear.

ASCOCHYTA on leaves of *Abutilon theophrasti,* at Madison, August 7, 1952, seems not to be *Ascochyta abutilonis* Hollos. The latter species is said to have conidia 8–9 x 3–4μ, while in the Madison specimen they are 11–16 x 4–4.5μ. In other than spore length, however, the current specimen corresponds fairly well with the description. The pycnidia are epiphyllous, single, or few and scattered on sordid whitish to tan spots which are variously rounded.

ASCOCHYTA sp. on *Leonurus cardiaca,* collected near Poynette, Columbia Co., September 3, 1952, is on a dull black orbicular lesion about 1.5 cm. diam. The olivaceous, thin-walled pycnidia are subglobose, about 125–175μ diam., the hyaline conidia 11–20 x 3.5–5μ. A specimen on the same host on a similar lesion, from Madison, has pycnidia about 125μ, and conidia 7–12 x 3–3.5μ. Both differ from an earlier specimen on *Leonurus* (Trans. Wis. Acad. Sci. 36: 248. 1944) where the angled, subzonate, blackish-brown spots are 2–3 mm. diam., and none match the description of *Ascochyta leonuri* Ell. & Dearn. with numerous small spots 1–1.5 mm. diam. and conidia 14–17 x 3.5–4$\mu$.

DARLUCA FILUM (Biv.) Cast. has been found on aborted aecia of *Puccinia extensicola* on *Aster shortii* at a station near Monticello, Green Co., June 10, 1952, adding to a still small, but growing series of this normally uredial parasite on aecia. In this connection, *D. filum* was found on telia of *Puccinia violae* on *Viola eriocarpa* at Poynette, Columbia Co., August 6, 1952.

STAGONOSPORA sp. was collected on leaves of *Scirpus atrovirens* at Madison, June 28, 1952. There seem to be no American records of *Stagonospora* on *Scirpus* and the European species so listed do not match the present specimen. The fungus is epiphyllous on elongate fusoid lesions which are a dull, pale brown with a narrow darker border. The black, globose pycnidia are gregarious to crowded, about 150–175$\mu$ diam. The conidia are large, 35–50 x 8–10$\mu$, 5–7-septate, hyaline, markedly guttulate, almost straight to moderately curved, usually tapered at both ends. Parasitism is questionable, as the leaves also bear *Xenogloea eriophori* (Bres.) Syd.

STAGONOSPORA sp. occurred on a leaf of *Habenaria flava,* collected near Avoca in Iowa Co., June 26, 1953. The numerous subglobose, sooty-black pycnidia are about 150–175$\mu$ diam., gregarious on elongate, immarginate, reddish-brown spots. The conidia are hyaline, 3–4-septate, variable in shape from curved-obclavate to sublunate, or even vermiform, approx. 20–32 x 3.5–4.5$\mu$.

STAGONOSPORA sp. on *Asclepias tuberosa,* collected at Madison, August 20, 1952, seems identical with a form on *Acerates lanuginosa,* discussed in my Notes XVI (Amer. Midl. Nat. 48: 745. 1952). The lesions are those of *Stagonospora zonata* J. J. Davis, but the spores, which are 7-septate and about 50 x 9–10$\mu$, are entirely outside the range of that species. If more examples are found, in view of the characteristic lesions, it would perhaps be advisable to describe this as a large-spored variety of *S. zonata.*

HENDERSONIA MALI Thum. has, according to Hesler (Mycologia 19: 222. 1927), a *Pleospora* perfect stage, as shown by studies of material from blighted apple twigs. However, *H. mali* was described as occurring on living leaves of apple, and the North American Fungi specimen No. 2164 very closely matches the original description, both in lesion and in microscopic characters. Of considerable interest is the fact that in my Notes XVII (Trans. Wis. Acad. Sci. 41: 117. 1952) I described *Mycosphaerella* sp. on apple leaf lesions which are very similar to those in N. A. F. 2164. I was unaware of this resemblance at the time the note was written but, on the basis of it, it seems possible that

Hesler may have been dealing with a different, although similar species of *Hendersonia,* and that the perfect stage of H. mali is a species of *Mycosphaerella* rather than a *Pleospora.*

SEPTORIA sp., of questionable parasitism, occurred on leaves of *Napaea dioica* at New Glarus, Green Co., August 9, 1952. The black, epiphyllous pycnidia are gregarious in small clusters on portions of the leaves already brown and dead. The pycnidia are subglobose, thin-walled, about 60–105$\mu$ diam. The spores are hyaline, continuous, acicular, straight or slightly curved, 17–26 x 1.2–1.5$\mu$. There seems to be no previous report of any *Septoria* on this host.

SEPTORIA sp. occurred in sparse developments on leaves of *Pastinaca sativa* at Madison, June 27, 1952. The few pycnidia are on dull brown, orbicular, rather sharply delimited lesions, about .5–1 cm. diam. The pycnidia are black with a subconical apex, in general outline almost globose, about 80–100$\mu$ diam., with filiform, straight or slightly flexuous spores, about 18–24 x 1$\mu$. In the field it was thought that this was probably *Phomopsis diachenii* Sacc. which has been found in previous years on somewhat similar lesions. However, there is absolutely no sign of the fusoid *Phoma*-type conidia which are in vast preponderance in the specimens of *P. diachenii,* and a comparison of the scolecospores likewise shows a seeming difference, although in length and thickness they are fairly similar. The pycnidia of *P. diachenii* are much larger than those of the specimen in question. *Septoria pastinacina* Sacc. is reported as occurring on stems of *Pastinaca,* and it seems possible that the Madison collection may be that species, although in *S. pastinacina* the spots are said to be diffuse and indefinite, the pycnidia 120–150 diam. and flattened, the spores filiform, curved or flexuose, 20–30 x .7–1$\mu$.

SEPTORIA sp. occurred in sparse development on leaves of its external pycnidial characters, and occurring on rather similar lesions on dead and languishing leaves of *Aster pilosus,* was collected at Madison, July 16, 1952. On the same plants other leaves bore *S. astericola* but, so far as microscopic examination has disclosed, the organisms do not occur together on the same leaves, and *S. astericola* would appear to be the more actively parasitic. The unknown has short, relatively thick spores, 13–17 x 2.5–3$\mu$, subcylindric to subfusoid, straight to moderately curved, and usually with a well-defined median septum, but if multiseptate only indistinctly so. Possibly referable to *Ascochyta,* although the ratio of spore width to length does not favor such a disposition.

ZYTHIA FRAGARIAE Laibach ? occurs on leaves of *Fragaria virginiana,* collected at Madison, August 14, 1952. The large, brown, conspicuous, zonate lesions are marginal, of orbicular outline, about 1.5–3 cm. diam. The epiphyllous, tan pycnidia are scattered to gregarious, erumpent, subepidermal, rounded above and flattened below, about 165–180$\mu$ wide by 120–130$\mu$ high. There is a very noticeable ring of sordid-whitish, more or less amorphous, perhaps mucilaginous material about the relatively narrow ostiolar aperture. The entire inner pycnidial wall is lined with closely ranked, slender, hyaline conidiophores, mostly about 8–10 x 1.5–2$\mu$, slightly enlarged below and tapering to a narrow apex. There is a prominent convex cushion of pseudoparenchymatous cells in the lower flattened portion of the pycnidium, and the basal conidiophore layer is arranged over this cushion. The numerous conidia are hyaline and cylindric, 5–6.5 x 1.5–2$\mu$. Although the pycnidia appear mature, it seems entirely possible that with age they may become darkened, so the assignment to *Zythia* is tentative.

ZYTHIA AURANTIACA (Peck) Sacc., on the basis of many field observations, occurs in Wisconsin in remarkably constant association with and on twigs of *Cornus alternifolia,* but not on any other species of *Cornus.* Seymour lists the fungus only on *C. alternifolia.* In Wisconsin, seemingly without exception, any sizeable shrub of *C. alternofolia* bears the fungus on one or more dead or dying lower twigs.

GLOEOSPORIUM CARPINICOLUM Ell. & Dearn. was described as having minute, rod-shaped conidia 3–4 x 1.5–2$\mu$. It seems possible that specimens of *Gloeosporium* on *Ostrya virginiana* collected by me near Poynette, Columbia Co., in August 1952 and by J. J. Davis at Lynxville, Crawford Co., in September, 1915, may be identical or related forms. Davis labeled his specimen as a questionable micro-conidial form of *Gloeosporium robergei* Desm., and the lesions produced do seem closer to those characteristic of that species than to those of *G. carpinicolum* as described.

BOTRYTIS sp. appears parasitic on large, orbicular, conspicuous, grayish-brown zonate lesions on leaves of *Thalictrum dasycarpum*, collected at Madison, July 8, 1952. The spots have a dendritic aspect at the outer margin and the whole is surrounded by a wide yellow halo. Contrary to the situation in an earlier specimen of *Botrytis* on this host (Farlowia 1: 577. 1944) there was no previous *Puccinia rubigo-vera* infection.

BOTRYTIS sp., which seems to have developed parasitically, occurred on leaves of *Rubus pubescens* at Madison, July 6, 1952. The fungus is amphigenous, but mostly hypophyllous, on sharply defined orbicular tan spots which range from 2 mm. to about 1 cm. in diam. The unbranched conidiophores are usually few to a spot. They are dark brown, shining, up to 2–3 mm. long, flexuous, tending to be decumbent, septate, about 18–20$\mu$ wide, and somewhat inflated at the sporiferous apex. The greenish-hyaline conidia are broadly ellipsoid, smooth, 10–12 x 5–6$\mu$.

CLADOSPORIUM sp. is sometimes observed localized on the principal veins on the under surface of leaves of *Betula papyrifera* where its relation to the host as regards parasitism is uncertain. An especially well-developed specimen was collected at Madison, August 18, 1952. There is a minimal amount of non-fruiting mycelium. The conidiophores are scattered as individuals or in small clusters. They are pale brown, non-septate so far as observed, straight to strongly curved, several times geniculate at tip (which may be more or less strongly denticulate), approx. 35–40 x 4$\mu$. The conidia, present in surprising profusion, considering the scanty mycelium, are somewhat verrucose, yellowish-gray, often slightly constricted at the septum, catenulate, with truncate scars at each end, 13–19 x 4–6$\mu$.

CLADOSPORIUM sp., evidently parasitic, occurred on living leaves of *Coreopsis palmata* at Madison, September 2, 1952. The fungus is hypophyllous in effused patches. The conidiophores arise individually, are rather thick-walled, dark brown, moderately curved to tortuous, 2–3-septate, usually constricted at the septa, 35–65 x 4.5–5.5$\mu$. The tips are simple to once or twice geniculate and are not noticeably paler than the rest of the phore. Only a few conidia were seen. These were subelliptic, pale olivaceous, smooth, 10–12 x 4–5$\mu$.

RAMULARIA (?) which occurs on small rounded, grayish-brown spots on leaves of *Circaea alpina*, from Parfrey's Glen, Sauk Co., August 24, 1950, is quite similar to the dubious *Ramularia arisaematis* discussed in my Notes X (Amer. Midl. Nat. 39: 447. 1948). The hyaline, cylindric spores are mostly 1-septate and about 17–20 x 3.5$\mu$, and seem to be produced in tufts without any recognizable conidiophores. The spots are sharply delimited on otherwise vigorous green leaves.

CERCOSPORA sp. has been observed on leaves of *Digitaria ischaemum*, collected near Suamico, Brown Co., September 14, 1952. There is no distinct spotting and the numerous small fascicles are amphigenous over the entire browned leaf surface. Microscopic notes are as follows: conidiophores pale grayish-brown, non-septate, from straight to moderately curved, simple or once geniculate at tip, 25–35 x 4–4.5$\mu$, in small fascicles of about 5–8, only slightly spreading, from a dark stromatoid base; conidia slender, mostly almost straight, pale grayish, narrowly obclavate, obscurely 3–5-septate, about 35–55 x 3–3.5$\mu$. Chupp states that this is close to, if not identical with *Cercospora fusimaculans* Atk.

EPICOCCUM NEGLECTUM Desm. was reported in my Notes XII (Amer. Midl. Nat. 41: 731. 1949) as a possible weak parasite of soy bean in Wisconsin. Similar material has been collected on hog peanut, *Amphicarpa bracteata,* at Madison, July 1953. The distal portions of otherwise still healthy leaflets consistently bear the fungus on languishing dull green to brownish areas.

ALTERNARIA sp., which may be parasitic, occurs on pycnidia of *Septoria sibirica* Thum. on *Ribes missouriense* from Madison, July 19, 1952. The fungus is strictly confined to the pycnidia which, in turn, are confined to small, sharply delimited, purple-bordered spots. The conidia are muriform, short-clavate, about 40 x 10$\mu$, with a short, obtuse beak. The phores are 65–80 x 5$\mu$, closely 6–8-septate, strongly curved above, non-geniculate, occasionally subtorulose, clear, light, uniform brown.

STYSANUS sp., starting development in the fall of 1952 on living leaves of *Physocarpus opulifolius,* but not coming to maturity until the following spring, has been observed and collected at Madison. It seems possible, but has not been demonstrated, that the spots were caused by *Ramularia spiraeae* Peck and that the *Stysanus* is secondary. The fall of 1952 was the driest in some eighty years in the Madison area, and it may be that the fungus would have come to maturity had moisture conditions been more nearly average. (On some of the spots on the overwintered leaves are what appear to be immature perithecia, so perhaps in a normal year the *Stysanus* would reach maturity in the current season, to be followed by a perfect stage the following spring). The following descriptive notes have been made: On living leaves —spots rounded, dull brown, immarginate, 3–6 mm. diam., closely studded below with the immature coremia which superficially resemble the beaks of rostrate perithecia. On dead, overwintered leaves — coremia hypophyllous, blackish-brown, straight, columnar, composed of closely packed parallel hyphae, approx. 475–600 x 17–23$\mu$, tapering to a moderately enlarged, but not markedly or abruptly swollen base. In shape the fertile heads are from clavate to almost globular, but do not account for more than about 1/10 to 1/8 of the overall stalk length. Conidiophores subhyaline, faintly asperulate, about 3$\mu$ diam., mostly not over 30$\mu$ long at point of departure from stalk, simple or closely geniculate at tip. Conidia catentulate, hyaline, smooth, subfusoid, 6–10 x 2.5–3$\mu$, with rather conspicuous scars. Determination is based on the Saccardian treatment which employs catenulation or lack of it as a primary characteristic in separating the genera of this group. It may be doubted that this is a reliable and constant feature in differentiating *Stysanus* from *Graphium*. Collections of immature material, of mature specimens overwintered in a wire cage, and of mature specimens gathered free under the infected shrubs have been placed in the University of Wisconsin Herbarium.

*Spartina pectinata,* collected September 21, 1952 near Mazomanie, Dane Co., had remarkably conspicuous, large, orbicular leaf spots, with grayish centers and wide purplish-brown borders on the upper surface of the leaves. On the lower surface and coinciding with the spots, are wefts of sordid-whitish, largely superficial, yet closely appressed mycelium. Microscopically this mycelium is hyaline, thin-walled, septate, and somewhat verrucose. If not parasitic it would seem that there is at least some sort of correlation with the spotting, which occurred throughout a large clone of the host and was noticeable from a distance of many feet. There is nothing to indicate any insect infestation as being responsible for the symptoms.

Fungi which seem essentially superficial, are usually sterile, and ordinarily have dark mycelium bearing sclerotia or sclerotium-like bodies have been collected occasionally in Wisconsin overrunning the leaves of living plants to a degree that, although they are not parasites, they probably are detrimental to the plants bearing them. A notable example is so-called *Sclerotiomyces colchicus* Woron. occurring on many and diverse host substrates. A recent find on leaves of *Solidago nemoralis,* from Madison, July 1952, is of interest. In the field this was assumed to be an extra heavy and profuse growth of *Cladosporium astericola,* often found on species of *Solidago* in Wisconsin. Microscopic examination, however, shows a seemingly superficial *Cicinnobolus*-like fungus with profuse, dark, faintly toruloid mycelium on which are borne clusters of subcylindric, widely open, more less pedicellate pycnidia, in which are hyaline, rod-shaped microconidia. If a powdery mildew is present it has been suppressed to the point where it is not detectable on ordinary inspection.

## Additional Hosts

The following hosts have not been previously recorded as bearing the fungi mentioned in Wisconsin.

PLASMOPARA HALSTEDII (Farl.) Berl. & DeToni on *Cacalia suaveolens*. Dane Co., Madison, July 7, 1953. Seemingly the first report on any species of *Cacalia*.

ELSINOE VENETA (Burkh.) Jenkins on *Rubus allegheniensis*. Lafayette Co., near Platteville, August 16, 1952. On leaves. Det. Jenkins & Bitancourt.

LOPHODERMIUM JUNIPERINUM (Fr.) DeNot. on *Juniperus chinensis* var. *pfitzeriana* (cult.). Dane Co., Madison, March 15, 1953.

PUCCINIA GRAMINIS Pers. II, III on *Arrenatherum elatius*. Dane Co., Madison, Univ. Wis. Hill Farm, October 21, 1947. Coll. J. G. Dickson.

PUCCINIA CORONATA Cda. II on *Lolium multiflorum*. Dane Co., Univ. Wis. Hill Farm, October 21, 1947. Coll. J. G. Dickson.

PUCCINIA SCHEDONNARDI Kell. & Sw. II on *Sporobolus asper*. Rock Co., Beloit, June 21, 1953. Coll. R. W. Curtis. Seemingly the first report on *S. asper,* and also the first collection from Wisconsin on any species of *Sporobolus*.

PUCCINIA MINUTISSIMA Arth. III on *Carex lasiocarpa*. Waupaca Co., White Lake at Weyauwega, September 13, 1931. Coll. N. C. Fassett & J. W. Rhodes. On a phanerogamic specimen in the University of Wisconsin Herbarium. Several collections have been made of the aecial stage on *Decodon verticillatus*.

PUCCINIA EXTENSICOLA Plowr. I on *Solidago ohioensis*. Jefferson Co., near Lake Mills, June 15, 1953.

UROMYCES ACUMINATUS Arth. I on *Phlox glaberrima*. Kenosha Co., near Kenosha, June 26, 1953. Coll. J. Butler.

UROMYCES HYPERICI (Spreng.) Curt. I on *Hypericum sphaerocarpum*. Rock Co., Beloit, June 14, 1953. Coll. R. W. Curtis.

CINTRACTIA JUNCI (Schw.) Trel. on *Juncus greenei*. Dane Co., Madison, June 24, 1953. Adjacent to a massive infection of plants of *Juncus dudleyi*.

PHYLLOSTICTA MINUTISSIMA Ell. & Ev. on *Acer saccharum*. Sauk Co., Baxter's Hollow, Town of Sumpter, September 1, 1952. Coll. D. H. Hall.

PHYLLOSTICTA DECIDUA Ell. & Kell. on *Boehmeria cylindrica*. Sauk Co., Ferry Bluff, Town of Prairie du Sac, July 11, 1952. Also on *Cicuta maculata,* Dane Co., Madison, July 6, 1952.

CICINOBOLUS CESATI DeBary on *Microsphaera euphoribae* on *Euphorbia preslii*. Dane Co., Madison, September 20, 1952; on *Erysiphe galeopsidis* on *Teucrium canadense* var. *virginicum*. Iowa Co., near Arena, September 21, 1952; on *Microsphaera alni* on *Syringa vulgaris*. Dane Co., Madison, September 25, 1952; on *Sphaerotheca humuli* var. *fuliginea* on *Agastache scrophulariaefolia*. Green Co., New Glarus Woods, August 23, 1949.

DARLUCA FILUM (Biv.) Cast. on *Puccinia angustata* II on *Scirpus cyperinus* var. *pelius*. Green Co., near Monticello, August 5, 1952.

*Selenophoma donacis* var. *stomaticola* (Bauml.) Spr. & Johns. on *Elymus virginicus*. Dane Co., Belleville, September 13, 1952. Confined to the sheaths where it has produced no distinct spotting.

COLLETOTRICHUM GRAMINICOLA (Ces.) Wils. on *Digitaria ischaemum*. Brown Co., near Suamico, September 14, 1952. Coll. N. V. DeByle.

COLLETOTRICHUM VIOLAE-ROTUNDIFOLIAE (Sacc.) House on *Viola adunca*. Oconto Co., near Sobieski, September 19, 1952. Coll. N. V. DeByle.

CERCOSPORA CYPERICOLA Chupp & Greene on *Cyperus houghtonii*. Douglas Co., Gordon, July 17, 1907. Coll. J. J. Davis. Originally filed as a doubtful specimen of *C. caricina* Ell. & Dearn.

CERCOSPORA JUNCINA Sacc. on *Juncus greenei*. Sauk Co., near Spring Green, August 12, 1952. Det. Chas. Chupp, who informs me that *Cercospora junci* J. J. Davis is a synonym. Also reported from Wisconsin on *J. brachycephalus*, *J. brevicaudatus*, and *J. dudleyi*.

CERCOSPORELLA DEARNESSII Bub. & Sacc. on *Soldigo canadensis*, Racine Co., Racine, September 4, 1893. Coll. J. J. Davis. Originally determined as *Cercosporella cana* Sacc. from which it seems distinct.

TUBERCULINA PERSICINA (Ditm.) Sacc. on *Puccinia vexans* I on *Acerates viridiflora*. Dane Co., near Sauk City, September 25, 1952.

## ADDITIONAL SPECIES

The fungi mentioned have not been previously reported as occurring in Wisconsin.

SPHAERELLA (MYCOSPHAERELLA) SICYICOLA Ell. & Ev. on *Sicyos angulatus*. Dane Co., Madison, August 30, 1952.

ELSINOE SOLIDAGINIS Jenkins on *Aster linariifolius*. Sauk Co., near Spring Green, August 12, 1952. On stems and leaves. A very interesting find which corresponds well macroscopically with specimens on *Solidago*, and microscopically closely matches Jenkin's description (Jour. Agr. Res. 51: 522. 1935). Most, if not all the specimens naturally occurring on *Solidago* seem to have been taken in Florida, so the Wisconsin collection greatly extends the range. It is of possible significance that the host was growing on almost pure sand, where daytime temperatures are often very high, so that if high temperatures favor this species, the habitat met the requisite condition. The *Sphaceloma* stage has not been seen in the Wisconsin material.

TAPHRINA AMERICANA Mix on *Betula papyrifera.* Douglas Co., Solon Springs, June 14, 1914. Coll. J. J. Davis and originally determined as *Taphrina betulina* Rostr. According to Mix the latter species does not occur in North America.

TAPHRINA ROBINSONIANA Giesenh. on *Alnus rugosa (A. incana* of earlier reports). Manitowoc Co., Two Rivers, July 31, 1917. Coll. J. J. Davis. Other collections from Ashland, Burnett, Door, Douglas, Kewaunee, Sauk, Vilas and Washington Cos. Earlier reported as *T. alni-incanae* (Kuehn.) Magn., itself a synonym of *T. amentorum* (Sadeb.) Rostr., which does not occur in the U. S., according to Mix.

TAPHRINA FLAVORUBRA Ray on *Prunus pumila.* Adams Co., Adams, June 22, 1917. Coll. J. J. Davis. Other specimens are from Douglas, Jackson, Manitowoc, Marinette, Portage, Richland, Vilas and Waushara Cos. All originally determined as *T. communis* (Sadeb.) Giesenh., which does not occur on *Prunus pumila,* according to Mix.

TAPHRINA WIESNERI (Rathay) Mix on *Prunus pennsylvanica.* Jackson Co., Millston, June 23, 1916. Coll. J. J. Davis. Other specimens are from Adams, Door, Grant, Green, Manitowoc, Portage, Sauk and Waushara Cos. Earlier reported as *T. insititiae* (Sadeb.) Johans. which is, according to Mix, a synonym of *T. pruni.*

**Aecidium avocensis** Cummins & Greene sp. nov.

Spermogoniis non visis. Aeciis hypophyllis, ad nervos aggregatis, cupulatis, 0.3–0.5 mm. diam., margine lacerato; aeciosporae globoideae (13–) 15–20 x (13–) 16–21 (–23) $\mu$, membrana hyaline, verrucosa, (2–) 3–3.5 $\mu$ cr.

Spermogonia not found, perhaps not formed. Aecia hypophyllous on chlorotic areas, tending to be grouped along the veins, 0.3–0.5 mm. in diam., cupulate, yellowish, opening apically, the peridium becoming lacerate or fragmented, peridial cells highly variable, sometimes simulating the aeciospores, sometimes oblong and attaining 54 $\mu$ in length, the inner wall 2–3 $\mu$ thick, verrucose, the outer up to 18 thick and transversely striate with usually continuous and discrete ridges; aeciospores mostly globoid, (13–) 15–20 x (13–) 16–21 (–23) $\mu$, wall hyaline or pale yellowish, (2–) 3–3.5 $\mu$ thick, verrucose with rounded warts or these sometimes confluent in a labyrinthiform pattern.

On *Callirhoe triangulata* (Leavenw.) Gray, near Avoca, Iowa Co., Wisconsin, U. S. A., June 22, 1951 (TYPE). Coll. H. C. Greene.

**Puccinia avocensis** Cummins & Greene sp. nov.

Urediis ignotis, verisimiliter nullis. Teliis epiphyllis, pulvinatis, usque ad 1 mm. latis et 2 cm. longis, obscure cinnamomeo-brunneis; teliosporae late ellipsoideae vel ovalibus, utrinque moderate rotundatae, medio non constrictae, (19–) 25–28 (–32) x (32–) 37–44 (–50) $\mu$; membrana uniformiter pallide castaneo- vel aureo-brunnea, (2–) 3–4 (–5) $\mu$ cr., ad apicem non vel vix incrassata; pedicello hyalino, plus minusve 100$\mu$ longo sed valde fragili et deciduo.

Uredia and urediospores not found, probably not formed. Telia epiphyllous (i.e., adaxial), subepidermal but early erumpent, intercostal, loosely pulvinate, linear, attaining 1 mm. in width and 2 cm. in length, dark cinnamon-brown; teliospores broadly ellipsoid or oval, not constricted at the septum, usually moderately rounded apically and basally, (19–) 25–28 (–32) x (32–) 37–44 (–50) $\mu$; wall uniformly pale chestnut- or golden-brown, smooth, uniformly (2–) 3–4 (–5) $\mu$ thick or only slightly thicker at and near the apex, the pore apical in each cell; pedicel hyaline, slender, thin-walled and collapsing laterally throughout, exceeding 100$\mu$ in length, but fragile and always broken near the spore at maturity. One-celled teliospores are common.

On *Stipa spartea* Trin., near Avoca, Iowa Co., Wisconsin, U. S. A., July 30, 1951; August 16, 1951 (TYPE). Coll. H. C. Greene.

If, as indicated by the close association in the field, the aecial and telial stages are related, *P. avocensis* is an additional species of the mallow-*Stipa* compex. The aecia, except for somewhat smaller spores, are like those of *P. interveniens* Bethel, as is also the life cycle, but the teliospores are entirely distinct because of the essentially uniform thickness of the spore wall and the thin-walled and very fragile pedicels. The teliospores are more like those of *P. burnettii* Griff. but differ particularly because of the nature of the pedicel. *P. burnettii* produces aecia on *Eurotia lanata* (Pursh) Moq. and has aeciospores with much thinner walls. The two species cannot be considered as synonymous.

USTILAGO HEUFLERI Fckl. on *Erythronium albidum*. Green Co., near Albany, May 13, 1953. The only other reported collection on *E. albidum* is from Missouri. The others are on *E. americanum* from the eastern U. S. and Canada.

ENTYLOMA LINARIAE Schroet. on *Linaria vulgaris*. Columbia Co., near Poynette, September 21, 1952. Coll. E. P. VanArsdel.

PHYLLOSTICTA DIRCAE Ell. & Dearn. on *Dirca palustris*. Columbia Co., Pine Hollow near Poynette, July 31, 1953. The spores are described as "narrow-ellipsoid, 2–7$\mu$". In the Wisconsin specimen they are 2–3 x 7μ. In other respects the material in hand corresponds quite closely to the description.

**Phyllosticta succinosa** sp. nov.

Maculis griseo-brunneis, immarginatis, orbicularibus, 3–6 mm. diam.; pycnidiis sparsis, erumpentibus, amphigenis, plerumque epiphyllis, succineis, muris tenuibus, subglobosis, ostiolatis, 75–160μ diam., plerumque 100μ ca.; conidiis hyalinis, subcylindraceis, 4–7 x 2.5–3μ.

Spots grayish-brown, immarginate, orbicular, 3–6 mm. diam.; pycnidia scattered, erumpent, amphigenous, but mostly epiphyllous, amber-colored, thin-walled, subglobose, ostiolate, 75–160μ diam., mostly about 100μ; conidia hyaline, subcylindric, 4–7 x 2.5–3μ.

On living leaves of *Ribes americanum*. Madison, Dane County, Wisconsin, U. S. A., June 25, 1952.

Some of the spots show a faint zonation, with the pycnidia mostly ranged on the zone lines, and occasional spots have a margin somewhat darker than the center. In my Notes XIII (Amer. Midl. Nat. 41: 742. 1949) reference was made to what seems to be a rather poorly developed specimen of *P. succinosa* which was at that time doubtfully and tentatively filed under *Phyllosticta grossulariae* Sacc. None of the Phyllostictae that I have been able to find described on *Ribes* have characters similar to those of *P. succinosa*.

**Phyllosticta corydalis** (Ell. & Davis) comb. nov.

*Septoria corydalis* Ell. & Davis. Jour. Mycol. 8: 13. 1902.

As Davis stated in his original note (Trans. Wis. Acad. Sci. 14: 100. 1903) "Hardly a good *Septoria*". As described, and as shown by re-examination of the type specimen, the conidia are approx. 3–5 x 1–2μ. Very few are as narrow as 1μ, however. Coll. in Vilas Co., Wis., July 7, 1901, on *Corydalis sempervirens (glauca)*.

**Phyllosticta entylomicola** sp. nov.

Maculis albis vel sordidis, marginibus angustis, brunneis, elevatis, orbicularibus vel angulosis, 1–3 mm. diam.; pycnidiis epiphyllis, sparsis vel gregariis, nigris, subglobosis, rostellatis, pseudoparenchymaticis, 90–165μ diam.; conidiophoris tenuibus, hyalinis, brevibus, prope obsoletis; conidiis angusto-cylindraceis, hyalinis, 3.5–6 x 1.5μ.

Spots white or sordid, with narrow, brown, elevated margin, orbicular or angled, 1–3 mm. diam.; pycnidia epiphyllous, scattered or gregarious, black, subglobose, somewhat beaked, pseudoparenchymatous, 90–165$\mu$ diam.; conidiophores slender, hyaline, short, almost obsolete; conidia narrow-cylindric, hyaline, 3.5–6 x 1.5$\mu$.

On living leaves of *Ratibida (Lepachys) pinnata* on lesions which also bear *Entyloma compositarum* Farl. University of Wisconsin Arboretum, Madison, Dane County, Wisconsin, U. S. A., August 27, 1945. Subsequent collections were made at the same station in 1946, 1951, and 1952. A small specimen was also taken near Tiffany, Rock Co., July 17, 1947.

This was originally reported in my Notes XI (Amer. Midl. Nat. 41: 715. 1949) at which time the consistent coincidence of position between smut and *Phyllosticta* was overlooked. The actual relationship of the *Phyllosticta* to host plant and smut remains obscure. It seems unlikely that the two fungi have any very definite connection with one another. The large black pycnidia are very conspicuous and striking on the white spots, on the smallest of which there is often but a single pycnidium and on the largest not more than a half dozen.

SEPTORIA GLADIOLI Pass. on *Gladiolus* sp. (cult.). Dane Co., Cambridge, Summer 1914. Coll. A. C. Burrill. Excellent material, corresponding closely with presumably authentic European specimens. Davis failed to record this.

SEPTORIA CONSOCIA Peck on *Polygala senega*. Jefferson Co., near Waterloo, June 15, 1953. Peck (Bot. Gaz 5: 34. 1880) states "The perithecia tend to grow in groups or clusters. They are associated with a species of *Aecidium*." The current collection is likewise associated with *Aecidium—Puccinia andropogonis* Schw. I—and the spores seem intermediate in length between *Septoria polygalae* Peck, reported by Davis on *P. senega* from Wisconsin, and *S. consocia*. It is perhaps doubtful that the two species are really distinct. The crowding and smaller spores of the latter may possibly be due to poor developmental conditions resulting from the presence of the aecia on the same lesions.

VERMICULARIA (COLLETOTRICHUM) COMPACTA C. & E. on petioles of living leaves of *Parthenocissus vitacea*. Racine Co., Burlington, August 11, 1952. Coll. A. O. Paulus. This corresponds very closely with North American Fungi No. 342, issued as this species on stems of *Vitis*.

CYLINDROSPORIUM FRAXINI (E. & K.) Ell. & Ev. on *Fraxinus pennsylvanica* var. *lanceolata*. Dane Co., Madison, September 27, 1952. A strikingly coarse form. Many of the strongly curved spores are well over 100$\mu$ in length, with granular contents and obtuse ends. Although I have not seen an authentic specimen of *Cylindrosporium fraxini*, I am convinced from a comparison of the description of *Ramularia fraxinea* J. J. Davis with that of *C. fraxini* that the Davis species is a synonym, and certainly not a species of *Ramularia*. Davis placed 18 specimens, all from stations in the Wisconsin River Valley, in the Wisconsin Herbarium as *Ramularia fraxinea*.

BOTRYTIS TULIPAE (Lib.) Hopkins (*B. parasitica* Cav.) on *Tulipa "gesneriana"* and on *T. "suaveolens"*. Dane Co., Madison, May 18, 1953. Appearing parasitic on the leaves.

MACROSPORIUM UREDINIS Ell. & Barth. on *Puccinia graminis* on *Avena sativa*. Dane Co., Madison, July 19, 1953. Only dubiously parasitic in my estimation, but evidently the same thing Ellis and Bartholomew had and considered to be a parasite. According to recent viewpoint this should probably be referred to *Alternaria*.

**Alternaria inconspicuum** sp. nov.

Maculis nullis; conidiophoris hypophyllis, inconspicuis, sparsis, unis vel paribus, interdum 3 conjunctim, simplicibus vel subgeniculatis cum cicatricibus acervatim prope apicibus, saepe tortuosis nonnihil, subnodulosis interdum, olivaceo-brunneis, apicibus pallidioribus, formis variis, 35–65 x 4–5$\mu$, 2–4–, plerumque 3-septatis; conidiis 4-cellis, 3-septatis plerumque, interdum muriformibus restricte, fumoso-olivaceis, formis variis nonnihil, plerumque cylindraceis vel brevo-cylindraceis, vel interdum ovoideis vel obovoideis, cellis basibus obconicis, cicatricibus truncatis, 14–22 x 6–8$\mu$, 6–6.5$\mu$ plerumque, non catenulatis.

Spots none, conidiophores hypophyllous, inconspicuous, scattered, single, or in pairs, occasionally 3 clustered together, simple or subgeniculate with a cluster of spore scars near the tip, often somewhat tortuous, occasionally subnodulose, olivaceous-brown, and paler at tip which is variable in shape, 35–65 x 4–5$\mu$, 2–4–, mostly 3-septate; conidia mostly 4-celled, 3-septate, occasionally sparingly muriform, sooty-olivaceous, rather variable in shape, usually cylindric or short-cylindric, sometimes ovoid or obovoid, the basal cell obconic with truncate spore scar, 14–22 x 6–8$\mu$, mostly 6–6.5$\mu$, non-catenulate.

On living leaves of *Fraxinus pennsylvanica* var. *lanceolata*. Madison, Dane County, Wisconsin, U. S. A., September 11, 1952. A collection was also made at Arena, Iowa Co., Wis., Sept. 17, 1952.

Placed in *Alternaria* in line with Wiltshire's emended and expanded conception of the genus (Trans. Brit. Mycol. Soc. 18: 156. 1933).[1] If the septation-type of the great majority of the spores determined placement this would be assigned to *Brachysporium* Sacc., as only a very small percentage of the spores are muriform. Even in the spores which lack vertical septations there is considerable diversity in the size and shape of the individual cells, resulting from differences in position of the septa from spore to spore. Many of the infected leaves show a dull yellowish to purplish discoloration, but it is not spotting in the usual sense, and does not seem sufficiently well-defined to be included in the formal description. On the Arena specimen the leaves of the host, dubiously determined as *F. pennsylvanica* var. *lanceolata*, are very hairy on the under surface, and the fungus has ascended many of the hairs and sporulated on them.

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[1] E. G. Simmons, in a personal communication, states that he considers the lack of beaks on the spores to be sufficient reason for not regarding this as a species of *Alternaria*, but, after careful consideration, it seems to me that the sum of the other features favors such a disposition nonetheless.

# DETERMINATION OF THE EFFECT OF APPLIED BIOCIDES ON SOIL FERTILITY BY CHEMICAL AND BIOLOGICAL METHODS[1]

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Modern agriculture involves the use of a number of toxic chemicals for the eradication of fungous diseases, insects, and noxious weeds. This is particularly true of the more specialized operations such as the production of nursery stock for reforestation purposes. In addition to fairly large amounts of commercial fertilizers, the soils of forest nurseries receive applications of various biocides employed for the control of detrimental organisms. It has been observed that some of these compounds suppress the metabolic activity of young root tips of coniferous seedlings (Voigt, 1952). However, the effect of applications of biocides on the availability of essential nutrients and associated fertility factors is obscure and was investigated using chemical and biological methods of soil analysis.

## Methods and Materials

The biocides studied included calomel, chlordane, and Stoddard oil applied individually or in combination with fertilizer salts and hardwood-hemlock leaf mold to a coarse outwash sand of the Plainfield series. The following rates of application per acre were used: calomel—9 and 27 lbs., chlordane—10 and 100 lbs., Stoddard oil—50 and 150 gal., ammonium nitrate—100 and 400 lbs., 20 per cent superphosphate—100 and 400 lbs., potassium chloride—150 and 600 lbs., and leaf mold—20 and 80 cu. yds. All materials were thoroughly mixed with the soil with the exception of Stoddard oil, which was sprayed on the soil surface. The treated and untreated soil was stored in ½ gallon jars in the greenhouse for four weeks. At the end of this period, samples were taken for analysis.

Chemical determinations included soil reaction, and the content of available nitrogen, phosphorus, and potassium (Truog, *et al.*, 1952; Truog, 1930; Attoe and Truog, 1945). Biological determinations comprised the *Aspergillus niger* method (Meh-

[1] Carried out in cooperation with the Departments of Entomology and Plant Pathology, Wisconsin Agricultural Experiment Station, Madison, Wisconsin, and the Wisconsin State Conservation Department. Publication approved by the Director of the Wisconsin Agricultural Experiment Station.

lich, *et al.*, 1933) and a modification of the Neubauer culture test (Kitchen, 1948). For the Neubauer procedure, a 2000 g. sample of soil in a ½ gallon jar was brought to field capacity with distilled water. Large soil samples were used because of the small rates of application of calomel and chlordane. Each treatment was prepared in duplicate. One hundred selected rye seeds were distributed evenly over the soil surface in each jar. The seeds were pressed into the soil and covered with a ½ inch layer of quartz sand. After emergence, the seedlings were allowed to grow for 20 days. At the end of this time the tops of the plants were harvested and allowed to air dry before their weights were recorded. The tops were then ground in a Wiley mill and the contents of nitrogen, phosphorus, and potassium determined using standard procedures. (A.O.A C., 1950; Barton, 1948; Attoe, 1947).

TABLE 1

THE EFFECT OF VARIOUS SOIL TREATMENTS ON SOIL REACTION AND THE CONTENT OF AVAILABLE NUTRIENTS

| SOIL TREATMENT AND RATE PER ACRE | REACTION pH | AVAILABLE N lbs./acre | AVAILABLE P lbs./acre | AVAILABLE K lbs./acre |
|---|---|---|---|---|
| Control | 5.7 | 100 | 29 | 49 |
| Calomel—9 lbs. | 6.3 | 100 | 28 | 45 |
| Calomel—27 lbs. | 6.0 | 125 | 30 | 47 |
| Chlordane—10 lbs. | 5.7 | 75 | 27 | 49 |
| Chlordane—100 lbs. | 5.8 | 100 | 30 | 52 |
| Stoddard oil—50 gal. | 5.7 | 75 | 28 | 50 |
| Stoddard oil—150 gal. | 5.7 | 125 | 29 | 47 |
| $NH_4NO_3$—100 lbs., $CaH_4(PO_4)_2$—100 lbs., KCl—150 lbs. | 5.5 | 200 | 39 | 95 |
| $NH_4NO_3$—400 lbs., $CAH_4(PO_4)_2$—400 lbs., KCl—600 lbs. | 5.3 | 275 | 63 | 268 |
| Leaf mold—20 cu. yd. | 5.5 | 150 | 31 | 50 |
| Leaf mold—80 cu. yd. | 5.4 | 215 | 39 | 59 |
| Calomel—9 lbs., chlordane—10 lbs., Stoddard oil—50 gal., $NH_4NO_3$—100 lbs., $CaH_4(PO_4)_2$—100 lbs., KCl—150 lbs. | 5.6 | 190 | 37 | 98 |
| Calomel—27 lbs., chlordane—100 lbs., Stoddard oil—150 gal., $NH_4NO_3$—400 lbs., $CaH_4(PO_4)_2$—400 lbs., KCl—600 lbs. | 5.4 | 250 | 60 | 273 |
| Calomel—9 lbs., chlordane—10 lbs., Stoddard oil—50 gal., $NH_4NO_3$—100 lbs., $CaH_4(PO_4)_2$—100 lbs., KCl—150 lbs., leaf mold—20 cu. yds. | 5.5 | 200 | 37 | 95 |
| Calomel—27 lbs., chlordane—100 lbs., Stoddard oil—150 gal., $NH_4NO_3$—400 lbs., $CaH_4(PO_4)_2$—400 lbs., KCl—600 lbs., leaf mold—80 cu. yds. | 5.3 | 300 | 62 | 281 |

## Results and Discussion

The effects of different biocides applied individually and in combination with fertilizer salts and leaf mold on soil reaction and the content of available nutrients are given in Table 1. Determination of soil reaction indicated a slight increase in acidity when fertilizer salts were applied in larger amounts. Significant changes in the contents of available nutrients were observed only where these nutrients were added to the soil either as fertilizer salts, or as leaf mold. The addition of biocides decreased

TABLE 2

THE EFFECT OF VARIOUS SOIL TREATMENTS ON THE GROWTH OF *Aspergillus niger* AND SEEDLINGS OF RYE PLANTS AND THE NUTRIENT CONTENT OF THE TOPS OF RYE SEEDLINGS

| Soil Treatment and Rate Per Acre | Aspergillus niger | Rye Seedlings | Nutrient Content of Tops | | |
|---|---|---|---|---|---|
| | Av. oven dry wt. of mycelium | Av. air dry wt. of tops of 100 plants | N | P | K |
| | mgm | g | p.ct. | p.ct. | p.ct. |
| Control | 206.6 | 1.85 | 0.54 | 0.09 | 0.41 |
| Calomel—9 lbs. | 215.0 | 2.00 | 0.50 | 0.10 | 0.46 |
| Calomel—27 lbs. | 171.5 | 1.65 | 0.52 | 0.09 | 0.37 |
| Chlordane—10 lbs. | 210.9 | 1.95 | 0.49 | 0.07 | 0.39 |
| Chlordane—100 lbs. | 189.5 | 1.55 | 0.53 | 0.09 | 0.41 |
| Stoddard oil—50 gal. | 217.1 | 1.90 | 0.61 | 0.08 | 0.41 |
| Stoddard oil—150 gal. | 190.6 | 1.90 | 0.50 | 0.10 | 0.43 |
| $NH_4NO_3$—100 lbs., $CaH_4(PO_4)_2$—100 lbs., KCl—150 lbs. | 364.1 | 2.15 | 1.98 | 0.13 | 1.05 |
| $NH_4NO_3$—400 lbs., $CaH_4(PO_4)_2$—400 lbs., KCl—600 lbs. | 583.2 | 3.65 | 2.20 | 0.18 | 2.11 |
| Leaf mold—20 cu. yds. | 211.2 | 1.85 | 0.61 | 0.10 | 0.49 |
| Leaf mold—80 cu. yds. | 354.2 | 2.00 | 0.90 | 0.09 | 0.45 |
| Calomel—9 lbs., chlordane—10 lbs., Stoddard oil—50 gal., $NH_4NO_3$—100 lbs., $CaH_4(PO_4)_2$—100 lbs., KCl—150 lbs. | 342.5 | 1.90 | 1.90 | 0.11 | 1.73 |
| Calomel—27 lbs., chlordane—100 lbs., Stoddard oil—150 gal., $NH_4NO_3$—400 lbs., $CaH_4(PO_4)_2$—400 lbs., KCl—600 lbs. | 448.0 | 2.60 | 1.95 | 0.15 | 1.76 |
| Calomel—9 lbs., chlordane—10 lbs., Stoddard oil—50 gal., $NH_4NO_3$—100 lbs., $CaH_4(PO_4)_2$—100 lbs., KCl—150 lbs., leaf mold—20 cu. yds. | 347.8 | 1.95 | 1.95 | 0.09 | 1.89 |
| Calomel—27 lbs., chlordane—100 lbs., Stoddard oil—150 gal., $NH_4NO_3$—400 lbs., $CaH_4(PO_4)_2$—400 lbs., KCl—600 lbs., leaf mold—80 cu. yds. | 501.1 | 3.05 | 2.15 | 0.15 | 1.80 |

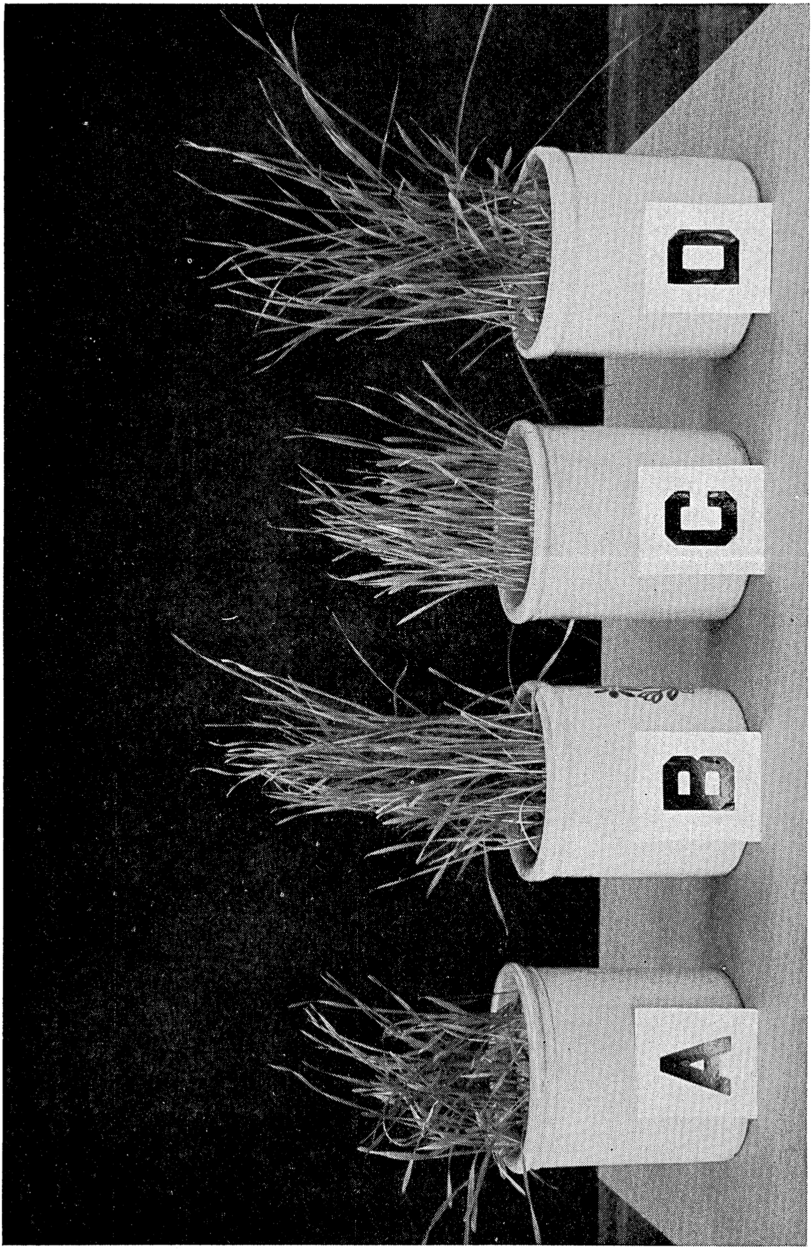


FIGURE 1. The effect of different soil treatments on the growth of rye seedlings: (A) control; (B) $NH_4NO_3$—400 lbs.; $CaH_4(PO_4)_2$—400 lbs., KCl—600 lbs. per acre; (C) Calomel—27 lbs., chlordane—100 lbs., Stoddard oil—150 gal., $NH_4NO_3$—400 lbs., $CaH_4(PO_4)_2$—400 lbs., KCl—600 lbs. per acre; (D) Calomel—27 lbs., chlordane—100 lbs., Stoddard oil—150 gal., $NH_4NO_3$—400 lbs., $CaH_4(PO_4)_2$—400 lbs., KCl—600 lbs., leaf mold—80 cu. yds. per acre.

the amount of available nitrogen normally released by leaf mold and fertilizer salts. This may be due to the toxic effect of calomel and chlordane on microorganism active in the decomposition of the organic matter (Cullinan, 1949).

The production of dry matter by *Aspergillus niger* mycelia and rye seedlings and the nutrient content of rye seedlings is reported in Table 2. These data indicate that the growth of both *Aspergillus niger* and rye seedlings is suppressed by calomel and chlordane. Applications of calomel at the rate of 27 lbs. per acre caused a reduction of 17 per cent in the growth of *Aspergillus niger* and 10 per cent in the growth of rye seedlings. Additions of 100 lbs. of chlordane per acre reduced the growth of *Aspergillus niger* 8 per cent and the growth of rye 16 per cent. This is in agreement with the findings of Cullinan (1947), who stated that the growth of plants may be suppressed by chlordane applications. Stoddard oil applied at the rate of 150 gal. per acre re-

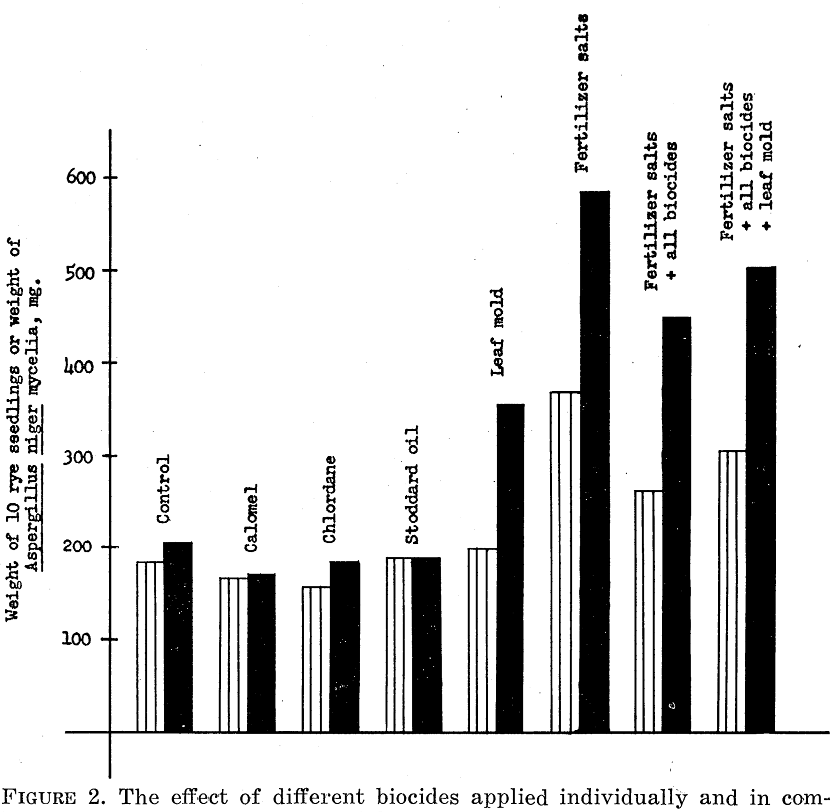


FIGURE 2. The effect of different biocides applied individually and in combination with fertilizer salts and leaf mold on the growth of rye seedlings (lined) and mycelia of *Aspergillus niger* (solid).

duced the growth of *Aspergillus niger* 8 per cent but had no ill effects on the growth of rye seedlings.

Combined application of all three biocides amplified the soil toxicity and produced an especially strong inhibitory effect on the growth of both rye seedlings and the fungus mycelia (Figures 1 and 2). The inhibitory effect of the chemicals was partially reduced by the application of leaf mold at the rate of 80 cu. yds. per acre. It has been reported that the toxicity of DDT, a chemical closely related to chlordane, is reduced as the content of organic matter is increased (Brown, 1951). Leaf mold applied at the lower rate had no significant effect on toxicity.

The contents of nitrogen, phosphorus, and potassium in the tops of the rye seedlings indicate a general tendency to reflect the soil fertility levels established by chemical analysis. Since the uptake of nutrients has not been significantly disrupted, it can be assumed that the reduced growth of the seedlings and the mycelia was caused by the direct toxic effects of the biocides rather than by the decreased availability of essential nutrients.

The results of the study indicate that in the appraisal of the fertility of a soil treated with eradicating agents, chemical determination of available nutrients should be supplemented by biological methods of soil analysis to evaluate the detrimental effects of the toxic compounds.

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# T. S. ELIOT AND THE DOCTRINE OF DRAMATIC CONVENTIONS

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Professor Harry Levin has rendered a service to literary criticism by showing the significance and tracing the history of the term "convention" when applied to literature.[1] He has filled out the unusually meager outline given in the *NED* and built up a full picture of the origins and ramifications of the term through more than one century and more than one literature. He points out that the word acquired its connection with literary criticism in eighteenth-century France (p. 64), and passed thence into nineteenth-century England and twentieth-century America. One could trace it still further back, and show the origins of the idea in the famous debate between the conflicting claims of Nature and Convention (φύσις and νόμος) in ancient Greek philosophy, which was summed up so neatly much later by Dr. Johnson: "to distinguish nature from custom, or that which is established because it is right, from that which is right only because it is established" (*Rambler,* No. 156). The latter is the conventional, and it became the object of criticism from the time of Diderot (1770). As Professor Levin says, "French criticism made convention a weapon for offensive and defensive use in contemporary polemics. Anglo-American scholarship made it an instrument for the reinterpretation of great works composed in obsolete forms" (p. 71). And he refers to T. S. Eliot's reply to William Archer, defending Elizabethan drama on the grounds that its supposed faults are really obsolete conventions. Even before that, of course, Professor Stoll had made convention the main weapon of his attack on Shakespearean criticism, which Professor Levin notes approvingly: "Professor Stoll's method has proved an effective counterweight to the tenuous psychologizing of the romantics" (p. 71).

In more recent days, T. S. Eliot's formula has been influential in stimulating important studies of Elizabethan drama. M. C.

[1] H. Levin, "Notes on Convention," in *Perspectives of Criticism* (Harvard University Press, 1950), pp. 55–84. The passage of Croce's *Estetica* (9th ed., 1950, pp. 35–36) rather summarily referred to on p. 80 does not deal with convention in literature but in its epistemological sense, outlining a theory which is fully propounded in his *Logica* (2nd ed., 1909, pp. 11–12 and 15–27). Levin opposes "Poincaré's empiricism" to Croce, unaware that Croce has made this "empiricism" a corner-stone of his own *Logic* (*op. cit.,* pp. 388 and 390). Croce discusses literary conventions elsewhere, e.g., in *Poesia,* 2nd ed., 1937, pp. 86–99.

Bradbrook and Th. Spencer (to name no others) have written books directly based on Eliot's pronouncements and have used his concept of convention as a major critical instrument. So that one could think that by this time the quality of the instrument must have been put to the test pretty completely and its efficacy thoroughly proven.

But apparently this is not so. The critical use of "convention" has not met with universal approval. For instance, Miss Bradbrook's book on *Themes and Conventions of Elizabethan Tragedy* (1935), instead of proving illuminating, has been found "confused and confusing, naively dogmatic and at times patently absurd."[2] Another critic has objected that "it would not be true to say that all we need to know is that Elizabethan drama is conventional."[3] This is the opinion of Mr. L. C. Knights, one of the foremost foes of traditional Bradleyan Shakespeare criticism. Yet Mr. Knights found that in Miss Bradbrook's book "one is continually jolted by the contradictions, the different levels of insight displayed," by its "equivocal attitude," "mixed quality" and "shifting meanings" of the critical terms used.

Likewise, Mr. Spencer's use of the term "convention" has been found "misleading"[4] and his concentration on conventional usage has been found sometimes conducive to critical obtuseness.[5] Alwin Thaler, reviewing still another book on Elizabethan conventions—this one on the comic conventions—observed: "even if the term were capable of satisfactory determination in all cases, there would still remain the fact that the exponents of the 'skeptic' attitude tend constantly to let their sweeping generalisation turn from details to larger issues of character and motive, and to reduce all things, perforce, to preconceived conventional levels."[6]

Professor Thaler's reference to the "skeptic attitude" brings us back to the discussions raised by Professor Stoll. Now Stoll's use of the term "convention" has been objected to by some critics who cannot fairly be called romanticists, such as Mr. F. R. Leavis, who has observed to Stoll that "when Shakespeare uses the 'same' convention as Beaumont and Fletcher, Dryden and Voltaire, his use is apt to be such that only by a feat of abstraction can the convention be said to be the same."[7] This goes to

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[2] W. H. Durham in *Modern Language Notes,* 53 (1938), 211–12.
[3] L. C. Knights in *Scrutiny,* 4 (1935), 90–95.
[4] J. H. Walter in *Modern Language Review,* 32 (1937), 294–95.
[5] K. Tillotson in *Review of English Studies,* 14 (1938), 346–49.
[6] A. Thaler, reviewing P. V. Kreider, *Elizabethan Comic Character Conventions* (1935), in *Journal of English and Germanic Philology,* 36 (1937), 127.
[7] F. R. Leavis, "Diabolic Intellect and the Noble Hero," in *Scrutiny,* 6 (1937), 279.

confirm the previous charges of "sweeping generalisation" and critical obtuseness as a result of the use of the term.

Something seems to be very wrong somewhere. Perhaps the term "convention" has not been used in the right way by these scholars. This makes it all the more imperative to give a good look at the term, and try and get at its exact meaning and correct use. But any attempt to define it meets with the difficulty that there are several kinds of things which can be called conventions. There are, first of all, social conventions, then literary conventions, dramatic conventions and stage conventions. We will find that all these occur, often indiscriminately, in the discussion of Elizabethan drama by T. S. Eliot and his school, so that it will be necessary to distinguish with some care between them. We will begin with stage conventions, since they seem to have a more limited application and have been lucidly defined by Professor A. R. Thompson:[8]

> In the broad sense a convention, according to Webster, is a rule or usage based on general agreement. Since the stage cannot represent everything in a lifelike manner, many substitutes for a direct mimicry of life have from time to time come into use. When well established, they are called conventions.

As instances of traditional stage conventions we may refer to the soliloquy and the aside, as well as the absence of the fourth wall on the stage. Some of them have been done away with in modern realistic productions. But even these have their own conventions:

> . . . it is conventional in them for the actors to face the audience most of the time, to "balance the stage" by not crowding all to one side, to speak exit lines on a pause by the door, and to do many other things which are not natural (p. 109).

To ask the reason for the existence of these stage conventions is to probe deeply into the nature of the theatre. Some critics will even tell us that "conventions . . . form a code, and are as a treaty made with the audience. No article of it is to be abrogated unless we can be persuaded to consent."[9] But this seems to be taking them a bit too seriously; they are made to sound like Rousseau's mythical social contract, that never was on sea or land. Professor Thompson says more plausibly that "many conventions are the result of convenience or necessity" (p. 109), and the next step is to inquire what is the convenience, or the neces-

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[8] A. R. Thompson, *The Anatomy of Drama* (California University Press, 1946, 2nd ed.), p. 108.

[9] H. Granville–Barker, *Prefaces to Shakespeare* (1927), I, xxx.

sity, that conventions are supposed to meet. It appears to me that the necessity generally arises out of some material difficulty on the stage which has to be overcome if the acting is to be seen or heard by the audience. That is the obvious reason why actors usually face the spectators: since space as we know it is three-dimensional, they cannot very well be seen or heard otherwise. And that of course is also the reason for the absence of the fourth wall, the place of which is taken by the proscenium. Since the laws of space prevent us from seeing inside a cube, we have to open one of its sides to make the interior visible. A material difficulty is met by a material change in the stage which may appear unnatural but makes production possible.

Soliloquies, spoken aloud on the stage, are also considered unnatural: people do not usually speak when they are alone, giving voice to their most intimate thoughts; though they may do so under the influence of strong emotion, as Lord Kames pointed out in his *Elements of Criticism*[7] (ch. 15) defending the soliloquy. More unnatural, perhaps, is the stage aside, which is loud enough to be heard by the whole audience, but not by the other people on the stage. The material difficulty which they both meet is obvious: no audience is a mind-reader, so it could not otherwise be acquainted with the thoughts of the characters, "no better way being yet invented for the communication of thought" than speech, as Congreve remarked in this context in the dedication of *The Double Dealer*. Again, "exit lines are spoken on a pause by the door" to make them clearly and completely audible: another physical difficulty is met by a customary deviation from normal behavior.

We seem therefore to have reached this conclusion: a stage convention is a stage usage which has been established in order to overcome some material difficulty or some physical obstacle on the stage, which would otherwise make acting impossible. As such, it is purely theatrical: it concerns problems arising only from the material conditions of the stage, and not problems of literary composition. And since there are many different kinds of stages and theatres, they may give rise to different sets of stage conventions. All conventions are therefore relative: the platform stage requires different conventions from the apron stage. Finally, the violations of verisimilitude are apt to disappear in actual production, absorbed as they are in the interest aroused by the action.

In any case, as Professor Thompson has pointed out, "a device is not strictly a convention until it is generally accepted by audiences" (p. 112). In other words, a device is not to be accepted because it is a convention, but it becomes a convention when it is accepted. There is therefore no compulsion in it: and it will cease to exist when stage conditions change or when audiences no longer accept it.

It should also be stressed that stage conventions refer primarily to production and not to the play considered as a literary composition. We have seen that the distinguishing trait of the stage convention is its initial artificiality. Take the monologue or aside, for instance: they may be unnatural on the stage, but they do not seem so on reading a play. When the play of *Hamlet* is read as a piece of literature, we do not find any difficulty in accepting Hamlet's soliloquies. He is Hamlet, an imaginary character in an imaginary situation, and his thoughts are part of the situation. It does not seem unnatural that he should reflect on his problems, or that we should know his reflections, any more than it is unnatural for us to enter into the innermost thoughts and feelings of a character in a novel. When we read a play as we read a novel, even an aside does not bother us: it is another instance of entering into a character's mind. It is also obvious that all difficulties relating to space, such as the fourth wall, and to the visibility and audibility of real actors on a physical stage do not arise on reading a play. And stage conventions, as we have seen, are called into existence in order to meet material difficulties. It would seem therefore that stage conventions do not have a necessary relevance to the play when considered as a piece of literature.

But there are also certain things called conventions in the sphere of literature itself. Such conventions are more difficult to define. We may tentatively describe them as a feature, or a detail, in a poem or other piece of literature which is repeated or taken over from some previous work. When certain features are taken over by a large number of writers working through a certain period or in a certain trend, these features become a kind of accepted usage, that is, a convention in literature. For instance, around the sixteenth century a large number of writers composed love poems adopting thoughts, emotions, expressions, and even metrical forms from the poems of Francis Petrarch. This fact is called in English the Petrarchan convention. Petrarch expressed frustration and melancholy at the lack of response to his love in the fair woman whom he called Laura: so, many other writers expressed similar emotions with similar phrases in similar sonnets for women who were likewise fair and cold. In his emotion, Petrarch compared the beauty of Laura to a variety of things: her hair was like gold, her neck was like milk, her cheeks were like roses white and red, her eyes were dazzling like the rays of the sun; and so, many other poets said the same things of their mistresses. Since it is not very likely that so many different poets should all go through the same experience with the same kind of woman and think the same things about her, the whole thing became artificial and conventional in the bad sense, and as such a legitimate object of ridicule and parody.

But it seems essential to distinguish this later stage of artistic degradation from the original experience which is at the source of the whole movement. Petrarch's passion was, for him, a burning experience: it overshadowed his whole life and deeply troubled his conscience, causing a spiritual conflict which he anxiously debated in his Latin works. The thoughts and emotions expressed in his Italian verse arose out of this central fire and made history: his admirers have called him, perhaps extravagantly, the first modern man. He certainly produced the best love poetry that had been composed in Europe for a long while, and enjoyment of it is an experience that was shared by many generations, and can be shared again today by those who take the trouble to read. Now out of this perfectly genuine love for what is a genuinely perfect work may arise the impulse to imitate it. This imitation was practised by a number of good poets, whose quality is manifest in the fact that even while using some of Petrarch's expressions they manage to convey a personality of their own, so that the Petrarchan label is hardly adequate to describe them. Such is the case, for instance, with the poets of the French *Pléiade* and with the greater Elizabethan sonnetteers, such as Shakespeare himself.

But thoughts and expressions, similes and metaphors may be detached from their context and repeated with little or no variation by some scribbler who is simply following a fashion without any feeling or talent of his own. The result will be a purely mechanical composition, with no touch of poetry in it, such as is found in hundreds of mediocre Petrarchan sonnets. Critics of Petrarch are well aware that the first writer to do this was Petrarch himself. He had periods of sterility when all he could do was to imitate himself in his brighter moments. As in the case of Wordsworth, critics have learnt how to distinguish his good verse from his bad,[10] and a similar distinction must surely be made between poets who were imaginatively stimulated by Petrarch and those who merely imitated his manner. The vital importance of this distinction lies in the fact that it involves the discrimination between good writing and bad writing. So if we speak of a tradition as a convention, we must be careful to

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[10] See the classic analysis by F. De Sanctis, *Saggio critico sul Petrarca,* 4.a ed. a cura di B. Croce, 1918, ch. VI.

specify whether it is a living tradition or a purely mechanical imitation.

Let me make this clearer by referring back to our original definition of a literary convention: a feature repeated, or taken over, from a previous work. This feature may be a phrase, a metaphor, a thought, an emotion, or a plot, or a character. Now, when the feature is taken over by a good poet, he makes it an integral part of a new unit: can we then say that it is the same thing? In Mr. Leavis' words—"only by a feat of abstraction," which leaves out what is essential in poetry. For instance, Verdi took over Falstaff from Shakespeare and made an opera out of him: is Verdi's Falstaff the same as Shakespeare's? Indeed, is the Falstaff of the *Merry Wives of Windsor* the same as the Falstaff of *Henry IV?* Most people would say he bears little resemblance. At the beginning of his *Elegy,* Gray takes over a famous simile of Dante's: "the curfew tolls the knell of parting day." It was also taken over by Byron in *Don Juan* (III, 108). Is it the same thing in the *Purgatorio* as it is in the *Elegy* or in *Don Juan?* Or does it convey different things in each of these very different poems? If therefore a literary convention consists in taking over or repeating something, we must know more about the process involved before we can say anything definite about it: is it merely a repetition, or is it absorbed in a new unity?

This applies also to the so-called dramatic conventions, when this name is given to features which are to be found in many dramatic compositions, such as plots, episodes, incidents, characters and situations. A very long list could be made of them, from the dawn of Western drama in Athens down to the contemporary theatre. The stock dramatic situations have been catalogued in a celebrated book by a French writer, G. Polti (1895), who set their number at thirty-six. A more recent critic, E. Souriau (1950), has brought up the number to 200,000. Traditional characters are so many that they have never been counted: the hero, the heroine, the villain, the confidant, the clever servant, the loyal retainer, the nurse, the braggart, the parasite, the miser, the pedant, the clown, and so on and so forth. And plot devices abound, such as the god from the machine, the recognition of long-lost relations, disguise and mistaken identity, the apparition of ghosts and other supernatural portents in tragedy, etc.

Now, when a play is produced, it may happen that a traditional feature in dramatic composition may correspond to a traditional device in theatrical production, but the two belong to different arts and although parallel are not the same. In particular, a traditional feature in the text may meet with some material difficulty on the stage which is obviated by means of some stage convention: but even here there is a parallel and not identity. This is the case of the soliloquy, which belongs to a hoary literary tradition and which on the stage gave rise, as we have seen, to a stage convention, since thoughts can only be conveyed by audible speech. But on the stage it is not a convention in the same way as it may be in a text, for there, as we have seen, it does not present any intrinsic improbability.

On the other hand, a feature like the ghost in tragedy may be considered intrinsically improbable, or the author may make it so through lack of skill. At this point some critics say:—The ghost is a stage convention, therefore it has to be accepted anyway, and all criticism is out of place.—This seems a deplorable confusion of thought. The ghost is a dramatic convention, in the sense that it is a device taken over and repeated; but it is definitely not a stage convention, which is invented because production must overcome some material difficulty.

And even for dramatic conventions there is that vital distinction between good and bad writing which must not be set aside by any juggling with words. In the wide field of Renaissance tragedy there are many ghosts: most of them, possibly, are just props, but some are genuine imaginative creations, as Mr. Eliot acknowledges the witches in *Macbeth* to be; and in any sound criticism the latter are not to be confused with the former.

Unfortunately this basic confusion between stage and dramatic conventions is very common.[11] It lies at the root of that criticism of the Elizabethans by Stoll, as well as by Eliot and his disciples, which was found so unacceptable by the critics that we quoted at the beginning. Stoll at one time believed that inconsistencies and contradictions in a character of a play could be smoothed out and vanish on the stage if the author simply appealed to some dramatic convention. According to his analysis, the character of Othello is inconsistent: Stoll cannot believe that Othello could have been deceived by Iago's slanders. Yet, even in the eighteenth century, Lord Kames considered it psychologically true that a man cannot evaluate evidence clearly when his emotions are involved, and he went so far as to say that Othello's acceptance of Iago's calumny shows "more knowledge of human nature that in any of our philosophers" (*Elements of Criticism,* 7th ed., ch. ii, pt. v).

But Stoll can see in Othello only a "heap of contradictions," which are not perceived on the stage because Shakespeare has resorted to what Stoll calls the convention of slander: all slander

[11] *Cfr.* also B. Matthews, "The Conventions of the Drama," in *The Historical Novel and Other Essays* (1901), p. 266.

is immediately believed in a play. The illusion only lasts as long as we are in the theatre; when we analyse the text, the inconsistencies become glaringly evident to Stoll, and Othello becomes a set of "contradictions . . . reconciled . . . by a conventional mechanism."[12] Stoll is confusing stage conventions, which make production possible, with dramatic conventions, to which an author resorts at his own risk and peril. There is no magic power in them: indeed, to crown poorly constructed characters with a tawdry plot device is to ruin a play. But such apparently Stoll thinks is the case with Shakespeare's great tragedies.[13]

The precedent of Stoll might have been a warning to Eliot; but seemingly it was not. Eliot at the time was concerned with finding an answer to William Archer's strictures against the Elizabethans.[14] In his book on *The Old Drama and the New* (1923) Archer argued that the old English drama of the sixteenth and seventeenth centuries was immensely inferior to the modern realistic drama since Ibsen. The old drama abounded in absurdities, crudities and inconsistencies. Eliot attempted a defence of the old drama by arguing that its defects were merely different conventions, but soon slipped into the charge that Elizabethan drama had the great shortcoming of not being written under a single convention. By convention he seems to mean something which can be positive and productive. He speaks of plays being written by "an individual dramatist, or a number of dramatists working at the same time" within a given convention: "it may be some quite new selection or structure or distortion in subject matter or technique, any form or rhythm imposed upon the world of action" (p. 11). Passing by the rather surprising idea that a poet may delegate to some one else the vital function of form, we may find that Eliot here is indistinctly referring to a theory of art which was fairly current, at the time he wrote, in a number of textbooks.[15] Eliot speaks of convention as "a form to arrest, so to speak, the flow of spirit at any particular point before it expands and ends its course in the desert of exact likeness to the reality which is perceived by the most common-

[12] E. E. Stoll, *Art and Artifice in Shakespeare* (Cambridge University Press, 1933), p. 111.

[13] *Cfr.* Leavis: "tricks or illusions passing off on us mutually incompatible acceptances in regard to Othello's behaviour or make-up *would* be cheating" (*op. cit.*, pp. 281–82).

[14] T. S. Eliot, "Four Elizabethan Dramatists: A Preface to an Unwritten Book" (1924), in *Elizabethan Essays* (1934). I have previously discussed Eliot's "conventions" and his connection with Archer and Bradbrook in "Eliot e gli elisabettiani" in *Il Saggiatore* (Milan, August 10, 1943), pp. 45–47, and Th. Spencer's idea of convention in "Caratteri estetici del dramma elisabettiano," in *Anglica*, II (1948), pp. 14–15.

[15] *Cfr.* "The whole of art rests upon convention. As we have seen, what appears actual reality is outside art," etc. R. G. Moulton, *The Modern Study of Literature* (University of Chicago Press, 1915), p. 266.

place mind" (p. 10). The idea seems to be that the natural tendency of the artist is to produce a copy or likeness of reality, but since obviously art is not that, there must be something that "arrests the flow" and by arresting it, makes it art. The nature of this check or brake, or whatever it is, is purely arbitrary: any "selection or distortion" of form or matter, as long as it is unlike reality. This would make verse a kind of arrested prose and poetry a kind of frustrated common sense, and the great characters of drama would be merely a repressed attempt at portraying commonplace reality.

This curious idea apparently arises out of an incapacity to conceive of any other imaginative process than that of mere realism: Eliot cannot even find a name for its opposite, which he once calls "an abstraction from actual life" (p. 11). But who abstracts what from life?[16] On this point, Eliot leaves us in the dark.[17] But his reputation as a poet has invested his critical writings with a special prestige, and his conception of convention as a productive factor, however hazy and confused, did not fail to impress itself upon younger writers. Under Eliot's influence, whole volumes have been written to collect and extol the conventions of Elizabethan drama. The first is Miss Bradbrook's *Themes and Conventions of Elizabethan Tragedy* (1935).

Following Eliot, she begins by justifying the inconsistencies and absurdities that critics like Archer find in Elizabethan tragedy by an appeal to contemporary convention.[18] But she ends by making the conventions themselves consist merely of contradictions and absurdities, of "strained coincidences," "rigidly defined types," "rapid and trivial intrigue," "events deliberately exaggerated," "action unnaturally rapid or farcical" and unconvincing disguises (pp. 38, 42, 50, 61–62, 69).

And here is her definition of convention:

> A convention may be defined as an agreement between writers and readers, whereby the artist is allowed to limit and simplify his material in order to secure greater concentration through a control of the distribution of emphasis p. 4).

This is Eliot's definition, with some complications thrown in to no good purpose, for it sounds as if the artist is allowed to con-

[16] A criticism of the realistic theory will be found in any good elementary book on esthetics: e.g., R. G. Collingwood, *Outlines of a Philosophy of Art* (Oxford University Press, 1925), pp. 74–76, or E. E. Carritt, *The Theory of Beauty* (London, 1914), pp. 75–92.

[17] See also "The Possibility of a Poetic Drama" in *The Sacred Wood* (London, 1920), and *cfr.* A. Oras, *The Critical Ideas of T. S. Eliot* (University of Dorpat, *Acta*, B, XXVIII, #3), pp. 39–42: "Literary Conventions."

[18] *Cfr.* also B. L. Joseph, *Elizabethan Acting* (Oxford University Press, 1951), pp. 115–16.

centrate his material to secure concentration through concentration. But Miss Bradbrook's vagueness and inconsistencies have been sufficiently denounced by the critics we have already quoted, and it should be recognized that she has a number of interesting things to say incidentally about Elizabethan drama. Her work is an acknowledged contribution to the subject, but it is clear that we do not receive from her enlightenment as to dramatic conventions.[19]

Neither do we receive it from Theodore Spencer's book on *Death and Elizabethan Tragedy, A Study of Convention and Opinion in the Elizabethan Drama* (1936), though it is a much more lucid and sensitive study. The author declares: "The subject of this book was suggested to me by a sentence in T. S. Eliot's essay, *The possibility of a poetic drama*: 'There is a book to be written on the commonplaces of any great dramatic period, the handling of Fate and Death, the recurrence of mood, tone, situation' " (p. xi). This is what Spencer means by convention: the common theme of death and the ideas, emotions, similes and phrases that cluster around it; and his book is a careful collection of all these things in Elizabethan tragedy.[20] Following Eliot, Spencer claims that they have a positive artistic function, though in practice he has to admit that the positive function belongs to the imagination of the individual poet rather than to the common material (pp. 69, 89, 107 etc.). For instance, he attempts to build a theory according to which "granted the poet's native gifts, the more rooted in convention he is, the more *imaginative* his writing will be" (p. 106), but he has to grant the poet's individual gift of imagination first. The argument that follows is that conventions first of all establish "a common basis . . . between the poet and his audience" (p. 105), and then somehow "are filled with the weight of a convincing emotion" by the poet (p. 107). But later he admits that the conventional material, when absorbed in a new synthesis, is no longer the same: "Frequently these ideas, like the words and phrases, become transformed, and were turned slightly from their previous position to reflect the new situation which they illustrated" (p. 158).

If so, the effort of the critic should be directed towards the definition of the new synthesis: to describe the special features of a play and the individual talent of the author. And in effect

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[19] For a more moderate statement on Elizabethan dramatic conventions, see M. C. Hyde, *Playwriting for Elizabethans, 1600–1605,* (New York, 1929), ch. VII, Conventions: "Those most difficult of acceptance by present day critics are the frequent lack of motivation, the inconsistencies in characterization, and the omission of promised action and requisite scenes" (p. 204).

[20] For a critical analysis of a book with a similar theme, see B. Croce, *Conversazioni critiche,* V, 1939, 86–87.

this is what Spencer does in the best part of his book. He reviews the feeling for death in Marlowe, Shakespeare, Chapman, Tourneur, Webster and Ford, and finds that it is different in each: heroical in Chapman, resigned in Webster, decadent in Ford, and "pagan" in Tourneur. In Marlowe the author's attitude varies from play to play: in Shakespeare it is not prominent, being overshadowed by his intense feeling for life.

Here at last we seem to have reached a fruitful approach to literary criticism: the study of the artistic personality of individual writers, as manifested in their work. To collect themes and commonplaces may be useful for a dictionary of quotations or a concordance, but as an approach to criticism it tends to blur individual features and destroy vital distinctions.

We can now see clearly—and this will be our conclusion—that the term convention is extremely vague and covers a multitude of sins. Its most exact use is to denote "stage conventions," which are stage usages established to overcome some material obstacle to production. In literature, conventions as mechanical repetitions of a previously used feature should be sharply distinguished from the creative adaptation of a feature to a new context, in which it is absorbed and transformed. Attempts to confer a more positive artistic function to conventions by Stoll, Eliot and their school seem to lead to blind alleys.[21] As a critical instrument, "convention" is definitely dangerous, for it tends to replace a standard of excellence with what is merely a test of conformity.

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[21] For a recent re-statement of a similar doctrine, see Y. Winters, "Poetic Convention," in *In Defence of Reason* (1947, 2nd ed.), pp. 75–89. And for an earlier attack on the term: "The pedantry of our own day has borrowed 'conventions' from history and 'technique' from science as substitutes for the outworn formulae of the past; but there are merely new names for the old mechanical rules; and they too will go, when criticism clearly recognizes in every work a spiritual creation governed by its own law." J. E. Spingarn, *Creative Criticism* (New York, 1925), pp. 24–25.

# CERTAIN PHYSICAL, CHEMICAL AND BIOLOGICAL ASPECTS OF THE BRULE RIVER, DOUGLAS COUNTY, WISCONSIN

## BRULE RIVER SURVEY REPORT NO. 11

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### INTRODUCTION

The first ten publications on the Brule River Survey were concerned each with a specific major phase of the investigation. These included detailed reports on the history of fishing, vegetation of the watershed, aquatic plants, parasites of the Brule fishes, vegetative cover, the brook lamprey and others. The present paper is the final one of the series and includes sections on a number of the physical, chemical and biological aspects, such as, anchor ice, fishes and populations, movement of fishes, spawning areas, food of fishes, chemistry and others. An aerial guide is included as an appendix indicating all check points.

### SOME ASPECTS OF ANCHOR ICE FORMATION, WITH PARTICULAR REFERENCE TO THE BRULE RIVER

From about November 15 to the latter part of April of each year the Brule River has ice conditions of one or all of the three types of ice. The earliest to appear is frazil ice and later anchor and surface ice. Likewise, frazil is the last to disappear in the spring.

Frazil ice forms when stream velocities are such as to prevent the formation of surface ice and the temperature of the water is 32 degrees Fahrenheit. Enough latent heat is released during formation to maintain the temperature of the water at 32 degrees Fahrenheit. Frazil ice forms in maximum quantities on clear windy nights and cloudy windy days and appears as fine, elongated needles of ice. Frazil occurs in the Brule River from the Stone's Bridge area to the mouth and since the river contains almost 200 riffles and falls in the ice area, such agitation is an important factor in frazil formation in maximum quantities. It moves long distances in open water and under ice cover and frequently combines with anchor ice to form anchor ice dams and increase the water level as much as three feet. (Figure 1)

Anchor ice is quite similar in crystal structure, but is formed in an entirely different manner. The accepted theory is that anchor ice formation is due to the transmission of heat by radiation. Anchor ice is never formed under ice cover or under bridges. It forms during the night when radiation from the ground is at a maximum, however, it will occasionally form in small quantities during very cloudy days. From our observations it was noted that formation occurred most rapidly on the darkest rocks and was also more abundant in shallow waters than in

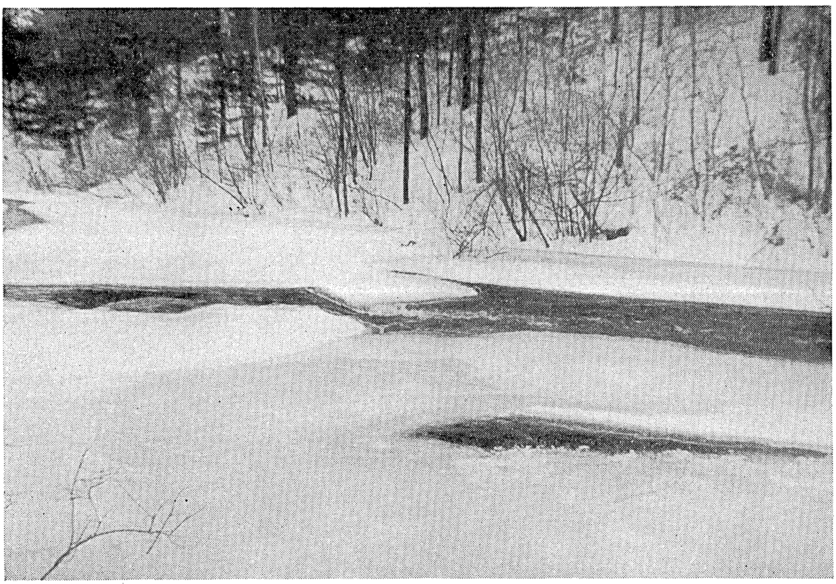

FIGURE 1. Anchor ice dam on Brule River, Douglas County, Wisconsin.

pools. As the sun rays reach the ice formation it is detached from the bottom, raising sand, rocks, vegetation and bottom organisms which then float downstream to gradually disintegrate and drop the material being carried or to lodge in some area and by the addition of frazil crystals form anchor ice dams. Anchor ice may become one foot thick and several feet in diameter during a single night.

Anchor ice has attracted considerable attention due to the peculiar manner in which it forms. It is found attached or anchored to the bottom of a stream, hence the name anchor ice. It has been observed in all countries where stream ice is formed and is known as ground ice, bottom ice, ground-gru, and lappered-ice. In France it is glace-du-fond; in Germany it is Grundeis and the French-Canadians call it moutonne ice because it appears like the white backs of sheep at rest.

From his personal observation, M. Beaun in 1788 wrote several papers on ground ice. Fishermen noted that their eel baskets would frequently rise to the surface and be incrusted with ice. Boat anchors were occasionally raised to the surface.

M. Desmarest was probably the first scientist to make observations on the actual formation of ground ice. Ireland in 1792 published his "Picturesque Views of the River Thames," and remarked, "The watermen frequently meet the ice meers, or cakes of ice, in their rise, and sometimes in the underside enclosing stones and gravel brought up by them ad imo."

The Reverend Mr. Eisdale published a paper on "Observations on Ground Ice" in the Edinburgh Philosophical Journal for 1834. He formulated an original theory by which to explain ground ice. He explained the formation of ice as commencing on the bottom and extending upwards to the surface and forming only in the most rapid streams.

In 1835 and 1841 the Reverend Dr. Farquharson published two papers on ground ice in the Philosophical Transactions. He concluded that ground ice is formed by radiation and he attempted to prove his conclusion by the use of the principle of dew formation.

The first use of the term anchor ice was in the United States when it was used in the Encyclopaedia Americana in 1831.

Much confusion existed on the relation of anchor ice to frazil ice. Barnes, in 1906, attempted to clear up this point by designating anchor ice as all ice found attached to the bottom irrespective of its nature of formation. In this way frazil ice becomes anchor ice when it becomes attached to the bottom. Frazil ice forms in the water itself by rapid surface cooling through wind or rapid agitation. Anchor ice is usually formed *in situ* on the bed of a stream, and may grow by attaching to itself frazil crystals brought down by currents.

Even as early as 1810, three kinds of river ice were known to Germany. They were distinguished as: (1) that which forms on the surface, (2) that formed in the middle of the water, resembling nuclei or small hail, and (3) ground ice, which is formed on the bottom, especially where there is any rough substance to which it may adhere. These three kinds of ice we now term sheet, frazil and anchor ice.

Barnes, in 1906, proposed that all of the evidence points to radiation as the prime cause of anchor ice and cites the following as proof. Water flowing over the bottom rocks of a stream is always very near the freezing point. Barnes has shown that deviations from the freezing point are seldom as great as 1/100 degree Fahrenheit. The bottom is continually warmed slightly by the conduction of heat from the earth. After a thin layer of ice is built up, further additions are rapid. The radiation of heat from the bed of a stream is continuous to the colder air above. Under a clear sky, during the daytime, the heat of the sun is radiated through the water and this offsets the cooling effect produced by space radiation. On a cloudy day, the heat rays are reflected back. A clear night in winter, with little air motion, is ideal for excessive radiation. Most of the heat from the sun is absorbed in the top water and a few rays reach the bottom. However, radiation from the bottom consists of long rays which penetrate the water more easily. The heat of the sun is absorbed by the water and little reaches the bottom while much of the radiation from the bottom is out into space.

The observed facts point to radiation as the prime cause of anchor ice formation. Anchor ice forms rapidly under a clear sky but never under a cloudy sky. A bridge or other cover prevents ice formation because heat waves are reflected back to the bottom. It forms on dark rocks more readily than light ones. Anchor ice is aided in its growth by the entangling of frazil crystals which are always present in the water. Under the influence of a bright sun, anchor ice is caused to lift and move downstream.

Surface ice is that which forms on the surface, beginning at the sides and spreading to the center, as the surface water continues to cool below 39.1 degrees Fahrenheit and down to 32 degrees Fahrenheit, at which time ice begins to form. Surface ice in five conditions may be encountered: (1) complete cover in flotation; (2) partial cover (shelf ice), usually in flotation; (3) complete cover bridged across; (4) jams due to piling up of ice; or (5) alternate layers of ice and water. The first four types have been found in the Brule River. Complete cover is quite general in the widespreads, such as Big Lake. Shelf ice is most common and is found throughout the length of the river. Complete cover bridged across results when an anchor ice dam, for example, releases. Jams are found during the late winter as shelf ice breaks away and moves downstream.

## ANCHOR ICE STUDIES

Since anchor ice was such an obvious phenomenon in the Brule River during the late winter season, it was deemed desirable to obtain some facts on the amount of disturbance to the environment caused by such ice.

Twenty separate samplings of anchor ice were made over a period of weeks. The method consisted in collecting a quantity of anchor ice with an estimation being made of the per cent of the collection to the total stream load during a definite time interval. The samples were allowed to melt and the water was measured, the aquatic organisms sorted and counted and the bottom materials (sand and rocks) measured and weighed. The size of samples varied from a few gallons (melt state) to 25 to 30 gallons. The anchor ice flow varied from very light to medium heavy (2,000 to 20,000 pounds, water weight). However, since the principle objective was to determine the average amount of disturbance of the bottom environment, the results of the samples were averaged to indicate the amount of materials moved by a given point in one hour.

The amount of ice (as water weight) moving past a given point in one hour varied from 2,877 to 22,918 pounds, with an average movement of 11,161 pounds, or almost six tons per hour. The amount of inert materials, such as sand, gravel, sticks, and leaves being carried by the anchor ice varied from 30 to 140 pounds, with an average of 75 pounds per hour. In addition to the bottom materials the ice carried large numbers of aquatic organisms utilized by trout for food. The number of these being carried past a given point each hour varied from 4,440 to 16,560 with an average of 9,480. Since, after lifting from the bottom, anchor ice frequently moved past a given point for hours, frequently ten hours, the average movement past a point in one day could amount to 111,611 pounds (56 tons) of anchor ice, 750 pounds of bottom materials and 94,800 fish food organisms. With almost daily anchor ice formation, lifting, movement, and dropping, through the winter months, the total disturbance to the bottom environment could reach such proportions as to be a limiting factor to the trout population.

Extensive scouring and movement of bottom materials occur when the anchor ice dams give way and suddenly discharge a large amount of water. The formation of and release of anchor ice dams has a marked effect upon the hourly stage and discharge of a stream. The U. S. Geological Survey has records of sudden and sharp changes in the stage and discharge at the gauging station on the Oconto River near Gillett, Wisconsin, due to anchor ice control. The water-level gauge reading dropped twenty inches within ten hours due to an anchor ice dam forming upstream and then with the release of the dam during the next two hours, the gauge increased thirty six inches. During the same period the discharge dropped from 699 second-feet to 93 second-feet and with the release of the anchor ice dam, the discharge increased suddenly to 1,475 second-feet and the excess discharge above mean continued for twelve hours.

Regular anchor ice formation and anchor ice dam formation and release may be an important limiting factor to the fish population in a stream. The repeated disturbance of the bottom environment must exert a variable influence upon the fish, whether trout, bass, or other species. The bottom materials are disturbed, the fish food supply is reduced, spawning areas and food areas may be smothered with sand and silt, aquatic vegetation is disturbed and lifted, and natural shelter may be damaged by anchor ice and anchor ice dam release.

## FISHES OF THE BRULE RIVER

An opportunity was afforded during the survey of the Brule River, to collect and examine thousands of fish as a result of sampling by electric shocker, seine, creel check, and by verifying reports of certain catches. The river contains a population which is typical of a trout stream as well as common fishes of the shoal area of Lake Superior which inhabit the estuary and migrate varying distances upstream. The fish fauna is composed of 29 species, of which the most common in the stream proper are the brook trout, *Salvelinus fontinalis,* (Mitchill); the brown trout, *Salmo trutta Linnaeus;* the rainbow trout, *Salmo gairdnerii* Richardson; the common sucker, *Catostomus c. commersonnii* (Lacépède); the longnose dace, *Rhinichthys c. cataractae* (Valenciennes); and the creek chub, *Semotilus a. atromaculatus* (Mitchill). The common fishes of the estuary include the yellow walleye, *Stizostedion v. vitreum* (Mitchill); the northern sucker, *Catostomus c. catostomus* (Forster); the golden redhorse, *Moxostoma erythrurum* (Rafinesque); the lake emerald shiner, *Notropis a. atherinoides* Rafinesque; and at certain times of the years, the American smelt, *Osmerus mordax* (Mitchill).

The following annotated list includes only those species which were collected or caught during the survey operations.

### *Petromyzonidae*

1. *Ichthyomyzon fossor* Reighard and Cummins, Michigan brook lamprey. At the time of the survey only one other locality in the state had been recorded for the species. Very common in the lower two-thirds of the stream. One or more taken in every shocker collection in the riffle and rapids area.

### *Osmeridae*

2. *Osmerus mordax* (Mitchell), American smelt. Taken in limited numbers in 1942, increasing in 1943, in the estuary of the river.

*Salmonidae*

3. *Salmo trutta* Linnaeus, brown trout. Brown trout fry were introduced in 1920 with a plant of 10,800 fish. After the initial plant, only 218 brown trout were planted during the next 14 years. A total of 376,042 trout were planted and further stocking was discontinued in 1942 when it became evident that the brown trout was becoming dominant. The brown trout is found throughout the river, more abundantly in the lower half.

Four specimens of "sebago" were taken during the survey. One at the mouth of the river, one at Johnson's Bridge, one at the ranger station and one in Nebagamon Creek (a feeder),—(see aerial guide in appendix). These are now considered to be almost certainly brown trout from the deep water of Lake Superior.

4. *Salmo gairdnerii* Richardson, rainbow trout. This species was the first trout to be planted in the river. The introduction of 30,000 fry was made in 1892. Over the next 50 years there were planted 1,449,952 rainbow trout. Distribution is throughout the stream, more abundantly in the lower half. The principal spawning migration from Lake Superior occurs in late fall and these fish are easily recognized as "steelheads."

5. *Salvelinus fontinalis* (Mitchill), brook or speckled trout. Trout are never mentioned in any of the accounts of the Indian history of the Brule River. Frequent mention is made of gathering wild rice, the hunting of game and the trapping of beaver and other small animals. Daniel Greysolon Du Lhut discovered the river in June, 1680, followed by an increasing number of travelers and fur traders and trappers through 1803. All commented on beaver and beaver dams and the difficult navigation. In 1803–4 Michel Curot, a fur trader, carried on intensive trapping of beaver and the river was cleaned of beaver and dams destroyed. One of the first Americans to visit the stream was Henry Rowe Schoolcraft. His party came to the river in 1831 and he wrote in his journal "the river is exceedingly cold and clear and filled with thousands of real mountain brook trout." The reputation for trout and trout fishing increased steadily with many outstanding catches reported, such as that of John Bardon netting 1,500 pounds of trout in one day, and that of "Long John" Murphy and a companion catching 500 trout by hook and line in three days.

The first state stocking of brook trout in 1894 consisted of 10,000 fry. During the next 50 years the state planted 1,946,800 brook trout in the stream. Complaints of poor fishing started about 1910, approximately five years after the main spawning grounds (34 acres of spring ponds in the middle section of the river) came under private ownership and access for spawning was denied by barricades. The same condition still prevails.

The brook trout inhabits the entire river in varying density, being more abundant in the upper half, from Winneboujou upstream.

*Catostomidae*

6. *Catostomus commersonnii commersonnii* Lacépède), white sucker.—Present throughout stream. Especially abundant in the slow water in the upper one-third.

7. *Catostomus catostomus catostomus* (Forster), longnose sucker.—Limited almost entirely to the lower one-half of the stream; ranger station to mouth. Increasing in abundance progressing downstream. Especially abundant in the estuary during spawning season.

8. *Moxostoma anisurum* (Rafinesque), silver redhorse.—Limited to the estuary at the mouth of the river and upstream approximately one mile. More abundant than the northern redhorse.

9. *Moxostoma aureolum* (LeSueur), northern redhorse.—Limited to the estuary at the mouth of the river and upstream approximately one mile.

*Cyprinidae*

10. *Couesius plumbeus plumbeus* (Agassiz), lake chub.—Only moderately abundant. Limited to the estuary at the mouth of the river.

11. *Rhinichthys atratulus meleagris* (Agassiz), western blacknose dace.—Taken in practically every collection. Extremely abundant. Found in varied habitats from Stone's Bridge to Johnson's Bridge, the middle half of the stream.

12. *Rhinichthys cataractae cataractae* (Valenciennes), longnose dace.—Abundant. Associate with the blacknose dace and distributed in the same area.

13. *Semotilus atromaculatus atromaculatus* (Mitchell), northern creek chub.—Distributed throughout the upper three-fourths of the stream, increasing in numbers from Johnson's Bridge upstream.

14. *Chrosomus eos* Cope, northern redbelly dace.—In small numbers in the upper one-third of the stream, more abundant in the headwater area.

15. *Notropis cornutus frontalis* (Agassiz), common shiner.—Distributed chiefly in the estuary at the mouth of the stream and in the widespreads and deeper portions of the upper river.

16. *Notropis atherinoides atherinoides* Rafinesque, emerald shiner.—Very abundant at times in the estuary of the stream.

*Ameiuridae*

17. *Ameiurus melas melas* (Raffinesque), northern black bullhead.—Occasional specimens taken from Big Lake, Nebagamon Creek (feeder from Nebagamon Lake), and the slow, deep water near Stone's Bridge.

18. *Schilbeodes mollis* (Hermann), tadpole madtom.—One specimen taken near McNeil's Bridge a short distance above the mouth of the stream.

*Umbridae*

19. *Umbra limi* (Kirtland), western mud minnow.—Distributed principally in the slow flats in the middle of the stream and in old oxbows in the same section.

*Esocidae*

20. *Esox lucius* Linnaeus, pike.—Present in moderate numbers in the slow flats and oxbows of the middle section of the stream, near the mouth of Nebagamon Creek and in Big Lake.

*Percopsidae*

21. *Percopsis omiscomaycus* (Walbaum), trout-perch.—Only taken in the estuary at the mouth and a few miles upstream. A lake species.

*Percidae*

22. *Perca flavescens* (Mitchill), yellow perch.—A few specimens were taken near the mouth of Nebagamon Creek and near the mouth of the main stream.

23. *Stizostedion vitreum vitreum* (Mitchill), yellow walleye. —Taken in limited numbers near the mouth of Nebagamon Creek (a feeder) and near the mouth of the main stream. The first planting of fish of any species consisted of 160,000 yellow pike perch in Big Lake, an expansion of the river. The planting was made in 1890.

24. *Percina caprodes semifasciata* (DeKay), logperch.—Taken in one collection near the mouth of the stream.

25. *Boleosoma nigrum nigrum* (Rafinesque), Johnny darter.—Spotty distribution. Limited in lower reaches. More abundant in upper one-half of stream.

*Centrarchidae*

26. *Lepomis macrochirus macrochirus* Rafinesque, bluegill.—A few specimens were taken in the extreme lower reaches of the stream and near the center of the stream.

27. *Ambloplites rupestris rupestris* (Rafinesque), northern rock bass.—One specimen taken near Scott's Bridge in extreme lower section of stream.

*Cottidae*

28. *Cottus bairdii bairdii* Girard, northern sculpin.—Very common. Found in varying numbers throughout the stream.

*Gasterosteidae*

29. *Eucalia inconstans* (Kirtland), brook stickleback.—Very common, especially in the middle section of the stream. Abundant in the Little Brule River (a feeder).

## FISH POPULATIONS

Information on the fish population was derived from three sources: a two-way weir and trap at Stone's Bridge (Figure 2), shocker collection (Figure 3) in the river and its tributaries, and creel census data. The latter has been discussed in a previous report.

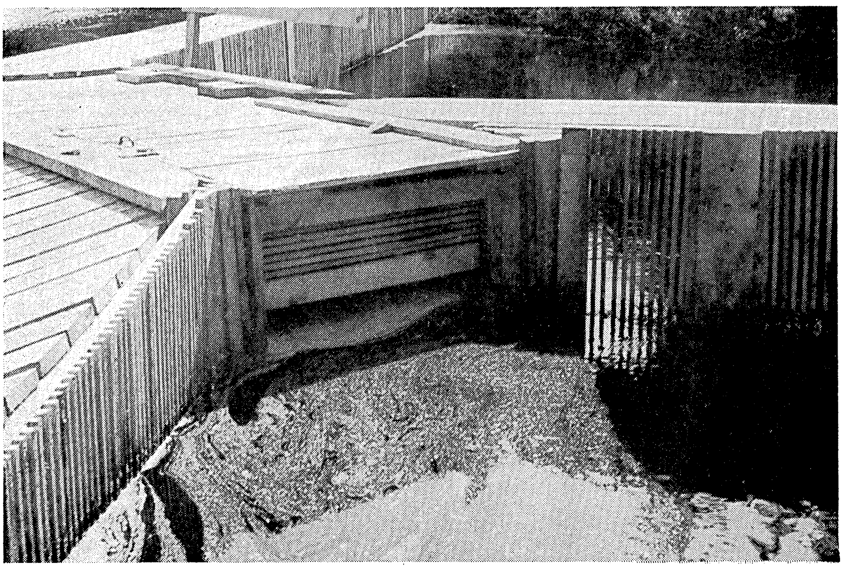

FIGURE 2. Two-way weir and fish trap, Stone's Bridge.

FIGURE 3. Fish collection by use of electric shocker equipment.

A weir was placed in the river at Stone's Bridge, completely blocking the channel and containing separate traps for fish moving up and downstream. Trout taken from the trap were marked with a metal tag and suckers by removal of a fin and returned to the stream in the direction of travel.

Collections were made with the electric shocker in the upper part of the river and its tributaries during the summer of 1944. Thirty-two samples were taken in the river proper, including the north and south forks, and 30 in the feeder streams.

## TROUT POPULATION

Brook, brown, and rainbow trout are abundant in the Brule River. All three species were taken in the weir and in shocker collections in the upper river.

TABLE 1

BOTTOM TYPES AND FISH POPULATION BASED UPON TWENTY-EIGHT QUANTITATIVE SHOCKER COLLECTIONS

| Bottom Type | Total Fish Per Acre-Foot | Trout Per Acre-Foot | Trout Per Foot-Mile |
|---|---|---|---|
| Mud | 90 | 21 | 3 |
| | 121 | 61 | 7 |
| | 138 | 121 | 15 |
| | 327 | 41 | 5 |
| | 1,449 | 1,014 | 123 |
| | 2,143 | 286 | 35 |
| | 3,415 | 244 | 30 |
| | 4,710 | 1,643 | 199 |
| Total | 12,393 | 3,431 | 417 |
| Average | 1,549 | 429 | 52 |
| Sand | 450 | 417 | 51 |
| | 573 | 485 | 59 |
| | 1,100 | 939 | 114 |
| Total | 2,123 | 1,841 | 224 |
| Average | 707 | 614 | 74 |
| Mud and Sand | 286 | 190 | 23 |
| | 306 | 204 | 25 |
| | 364 | 273 | 33 |
| | 973 | 708 | 86 |
| | 1,108 | 1,013 | 123 |
| | 2,692 | 962 | 117 |
| | 2,876 | 1,874 | 227 |
| | 3,102 | 2,591 | 314 |
| Total | 11,707 | 7,815 | 948 |
| Average | 1,463 | 868 | 105 |
| Gravel | 696 | 348 | 42 |
| | 1,176 | 1,176 | 143 |
| | 1,345 | 987 | 120 |
| | 1,783 | 1,338 | 162 |
| | 2,093 | 1,860 | 225 |
| | 5,263 | 3,684 | 447 |
| Total | 12,356 | 9,393 | 1,139 |
| Average | 2,060 | 1,566 | 190 |
| Rubble and Gravel | 4,467 | 4,133 | 501 |
| | 5,773 | 5,052 | 612 |
| | 8,780 | 2,195 | 266 |
| Total | 19,020 | 11,380 | 1,379 |
| Average | 6,340 | 3,793 | 459 |

TABLE 1—*(Continued)*

BOTTOM TYPES AND FISH POPULATION BASED UPON TWENTY-EIGHT QUANTITATIVE SHOCKER COLLECTIONS

| Bottom Type | Total Fish Per Acre-foot | Trout Per Acre-foot | Trout Per Foot-mile | |
|---|---|---|---|---|
| | | | | Per cent |
| Summary | | | | |
| Mud | 1,549 | 429 | 52 | 100 |
| Sand | 707 | 614 | 74 | 142 |
| Mud and Sand | 1,463 | 868 | 105 | 202 |
| Gravel | 2,060 | 1,566 | 190 | 365 |
| Rubble and Gravel | 6,340 | 3,793 | 459 | 883 |
| Total | 12,119 | 7,270 | 880 | |

Acre-foot—one surface acre one foot deep.
Foot-mile—one mile long, one foot wide and one foot deep.

Brook trout are present from the headwaters to the region of Cedar Island. Below this point none were taken by the shocker and very few by anglers. They are present in some of the feeder streams that enter the river below their preferred range.

Rainbow trout occur throughout the length of the river but the larger individuals are restricted to the lower part. No rainbows over ten inches in length were taken in the weir and only one in the summer shocker samples. The upper limit of the range of these larger fish seemed to be in the vicinity of the large spawning grounds at Cedar Island. After spawning they move downstream into the lake. Most of them probably winter there, but some move back into the river in the fall. A shocker survey in December of 1944 revealed many large rainbows in the vicinity of the spawning grounds, where they were not found in the summer.

Brown trout also occur throughout the length of the river, with the adults ranging farther upstream than those of the rainbow. Specimens up to 24 inches in length passed through the weir and 12 to 14 inch fish were taken in shocker samples near the forks.

Ages of trout were not determined but the growth rate of the first few years may be inferred from the length distribution of smaller trout. Brook trout taken with the shocker in July and August fell into three size groups presumably representing year classes, centered at about two and one-half, five, and seven and one-half inches. Two year classes of rainbow, centered at about two and one-half and six inches can be distinguished for the same period. Two year classes of brown trout, at three and seven inches are identifiable.

The ratio of suckers to trout passing through the weir was 7,690 to 755 or about 10 to 1. The ratio in shocker samples in the main stream was 635 to 362 or less than 2 to 1. The inference is that trout were more abundant in the region of weir than is indicated by the catch, but entered the traps less readily. Suckers were most abundant in shocker samples between the forks and Winneboujou.

The shocker samples also yielded a great many small fish of other species, mainly muddlers, minnows, and darters. The ratio of these fish to trout was almost 5 to 1. The species composition of all shocker collections in the main river was:

| | |
|---|---|
| Trout | 12.5% |
| Sucker | 22.0% |
| Miscellaneous | 65.5% |

In the feeder streams the ratio was:

| | |
|---|---|
| Trout | 56.0% |
| Suckers | 11.0% |
| Miscellaneous | 33.0% |

The density of population varies greatly throughout the stream. There appears to be a definite relation between bottom type and number of fish per unit of area. In all quantitative samples in the main stream the average density was 614 fish per acre and 126 trout per acre. Individual samples varied from 72 to 1,600 fish per acre. In the feeder streams, the average was 1,099 fish or 721 trout per acre.

In Table 1 population statistics are grouped according to bottom types. There is a very clear correlation between density of fish and bottom type, the population being lowest on mud bottoms and highest on rubble.

## THE MOVEMENT OF FISHES

It was deemed desirable to know the extent of movement of various species of fishes in the Brule River proper and some feeders during all seasons and during certain seasons of the year. The methods consisted of the use of two-way weirs of the Platte River Michigan type installed in two locations (Stone's Bridge and Ranger Station) and by using fyke nets set to collect fishes moving upstream and downstream.

A two-way weir was constructed immediately below Stone's Bridge in the upper section of the river, with eight miles of

TABLE 2

NUMBER AND SPECIES OF FISH MOVING UPSTREAM AND DOWNSTREAM IN THE BRULE RIVER AT STONE'S BRIDGE

| Month | Day | Moving Upstream | | | | | Moving Downstream | | | | | Miscellaneous |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Brook Trout | Brown Trout | Rainbow Trout | Common Sucker | Tagged Brook | Brook Trout | Brown Trout | Rainbow Trout | Common Sucker | Tagged Brook | |
| 1943 | | | | | | | | | | | | |
| June | 23–29 | 3 | 1 | 2 | 47 | 1 | 1 | ... | 3 | 86 | 2 | 1 Dace (U) 1 Shiner (d) |
| July | 30– 6 | ... | ... | ... | 21 | ... | 1 | ... | ... | 21 | 2 | 1 Chub (D) |
| | 7–13 | 1 | ... | 1 | 44 | ... | ... | ... | ... | 168 | ... | 1 Chub (U) 1 Dace (D) |
| | 14–20 | ... | ... | ... | 64 | ... | ... | ... | ... | 97 | ... | 1 Dace (U) 1 Muddler (U) |
| | 21–27 | ... | ... | 1 | 88 | ... | ... | ... | ... | 149 | ... | 1 Dace (D) 2 Bk. Bullheads (D) |
| August | 28– 3 | 2 | 2 | ... | 251 | ... | 1 | 2 | ... | 310 | ... | 1 Muddler (U) |
| | 4–10 | 1 | ... | 1 | 72 | ... | 3 | 5 | ... | 121 | ... | |
| | 11–17 | ... | ... | ... | 28 | ... | ... | ... | ... | 61 | ... | |
| | 18–24 | ... | ... | ... | 33 | ... | ... | ... | ... | 34 | ... | 1 Chub (D) |
| | 25–31 | ... | ... | ... | 7 | ... | ... | ... | ... | 6 | ... | |
| September | 1– 7 | ... | ... | ... | 15 | ... | ... | 5 | ... | 105 | ... | |
| | 8–14 | ... | ... | ... | 0 | ... | ... | ... | ... | 48 | ... | |
| | 15–21 | 7 | ... | ... | 7 | ... | 1 | ... | 2 | 27 | ... | |
| | 22–28 | 5 | 2 | 9 | 17 | 4 | 8 | 2 | 6 | 20 | ... | 1 Dace (U) |
| October | 29– 5 | 4 | 3 | 11 | 54 | 1 | 7 | 6 | 4 | 70 | 2 | |
| | 6–12 | 3 | 1 | 1 | 11 | ... | 8 | 5 | ... | 64 | 8 | |
| | 13–19 | 2 | 1 | 2 | 17 | ... | 8 | 11 | 3 | 2,755 | 8 | |
| | 20–26 | 7 | 3 | ... | 2 | 1 | 10 | 5 | 4 | 104 | ... | |
| | 27– 2 | 1 | ... | 2 | ... | 3 | 4 | ... | 2 | 14 | ... | |
| November | 3– 9 | ... | 2 | ... | ... | ... | 1 | 4 | 2 | 21 | ... | |
| | 10–16 | ... | ... | ... | ... | ... | ... | ... | ... | 77 | ... | |
| | 17–23 | ... | 2 | 1 | ... | ... | 1 | ... | ... | 8 | 1 | |
| | 24–30 | ... | ... | ... | ... | ... | 1 | ... | ... | 2 | ... | |
| December | 1– 7 | ... | ... | 1 | 3 | ... | ... | ... | 1 | 3 | ... | |
| | 8–14 | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | |
| | 15–21 | ... | ... | ... | 3 | ... | ... | ... | ... | 4 | ... | |
| | 22–28 | ... | ... | ... | 2 | ... | ... | ... | ... | 7 | ... | |

TABLE 2—*(Continued)*

NUMBER AND SPECIES OF FISH MOVING UPSTREAM AND DOWNSTREAM IN THE BRULE RIVER AT STONE'S BRIDGE

| Month | Day | Moving Upstream | | | | | Moving Downstream | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Brook Trout | Brown Trout | Rain-bow Trout | Com-mon Sucker | Tagged Brook | Brook Trout | Brown Trout | Rain-bow Trout | Com-mon Sucker | Tagged Brook | Miscellaneous |
| 1944 | 29– 4 | | | | 8 | | 4 | 3 | 5 | 388 | | |
| January | 5–11 | | | | | | | | | 1 | | |
| | 12–18 | | | | | | | | | | | |
| | 19–25 | | | | 1 | | | | | 25 | | |
| | 26– 1 | | 1 | 4 | 23 | | | | 2 | 80 | | |
| February | 2– 8 | | | | 14 | | 1 | | | 58 | | |
| | 9–15 | | 1 | | | | | 2 | 5 | 21 | | |
| | 16–22 | | 1 | | | | | | | | | |
| | 23–29 | | 1 | | | | | 1 | 3 | 217 | | |
| March | 1– 7 | 2 | | | 4 | | 2 | | | 8 | | |
| | 8–14 | | | | | | | | | | | |
| | 15–21 | | | 1 | 27 | | | | 6 | 30 | | |
| | 22–28 | | | | 8 | | | | 5 | 64 | | |
| | 29– 5 | | | 2 | 44 | | 3 | 3 | 17 | 44 | | |
| April | 6–12 | 2 | 2 | 2 | 37 | | 14 | 4 | 30 | 21 | | |
| | 13–19 | | | | 32 | | 7 | 2 | 13 | 34 | | |
| | 20–26 | | | 8 | 35 | | 3 | 6 | 25 | 39 | | |
| | 27– 3 | | | 1 | 39 | | 4 | 7 | 13 | 78 | | |
| May | 4–10 | 1 | | 1 | 16 | | | 2 | 5 | 37 | | 1 Muddler (D) 5 Cr. Chub (D) |
| | 11–17 | 1 | | 1 | 142 | | 2 | 3 | 17 | 304 | | |
| | 18–24 | 18 | 3 | 18 | 214 | 65 | 5 | 2 | 5 | 149 | 93 | 4 Horned Dace (D) |
| | 25–31 | 6 | 2 | 2 | 148 | 9 | 11 | | 2 | 45 | 2 | 1 Horned Dace (D) |
| June | 1– 7 | 1 | 1 | 3 | 7 | 1 | 2 | | 4 | 38 | | 1 Horned Dace (U) |
| | 8–14 | | | | | | 1 | | | 26 | 1 | |
| | 15–21 | | | | | | | | | 15 | 2 | |
| Grand Total | | 67 | 29 | 75 | 1,585 | 85 | 114 | 80 | 184 | 6,105 | 121 | 25 |

stream above the weir. Operation was continuous from June 23, 1943 to June 23, 1944, with the traps being checked daily. Records were kept of species, individual length, water temperature, and water levels. All fish were removed and then released in the stream in the direction of movement before being trapped.

The outstanding feature of the data is the movement of the sucker population in variable numbers throughout the year, except during short periods of extremely low water temperatures (Table 2). A sudden decrease in water level, which was probably due to ice control, caused a sudden downstream migration of 388 suckers during the week of December 29. The spawning migration of suckers was not in one direction but movement occurred in approximately equal numbers, upstream and downstream. The most unusual migration took place during the week of October 13 when 17 suckers moved upstream and 2,755 moved downstream and 1,381 of these were taken in the downstream trap on October 17. Again, the sudden movement coincided with a small, but sharp drop in water level. The movement of all species of fish was limited after the water temperature dropped below 40 degrees Fahrenheit. The water temperature remained under 40 degrees from November 3 to April 1.

The principal movement of brook trout occurred during the month of October and the movement was about equal in numbers, upstream and downstream. Good spawning grounds were available both above and below the weir. No heavy run occurred in brown trout although there was a slightly increased movement downstream during the middle of October. The rainbow trout exhibited some increased movement upstream during October and a great increase in movement downstream during the month of April.

There were 8,470 fish of all species taken in the traps during the period of 52 weeks. Of these, 7,690 were common suckers (90.79%), 181 were resident brook trout (2.14%), 206 were tagged brook trout (2.43%), 109 were brown trout (1.29%), 259 were rainbow trout (3.06%), and 25 were miscellaneous fishes (0.30%). The tagged brook trout were part of a stocking of 6,000 legal size brook trout which were tagged and scatter planted throughout the stream. A total of 755 trout of all species were taken in the traps and these consisted of 181 resident brook trout (23.97%), 206 tagged brook trout (27.28%), 109 brown trout (14.44%), and 259 rainbow trout (34.30%).

A similar two-way weir of the Platte River Michigan type was constructed in the middle section of the river near the Ranger Station and operated in the same manner as the Stone's weir

TABLE 3

NUMBER AND SPECIES OF FISH MOVING UPSTREAM AND DOWNSTREAM IN BRULE RIVER AT THE RANGER STATION (MID SECTION OF STREAM)

| DATE 1943 | MOVING UPSTREAM | | | | MOVING DOWNSTREAM | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Rainbow Trout | Brown Trout | Common Sucker | L. Supr. Sucker | Rainbow Trout | Brown Trout | Common Sucker | L. Supr. Sucker | Yellow Walleye | Northern Pike |
| March–April 29– 4 | 31 | 1 | 1 | ... | 3 | ... | 49 | ... | ... | 1 |
| 5–11 | 1 | ... | ... | ... | ... | 1 | 1 | ... | ... | ... |
| 12–18 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 19–25 | 2 | ... | 12 | 4 | 3 | ... | 4 | ... | 2 | ... |
| 26– 2 | 1 | ... | ... | 19 | 19 | ... | 6 | ... | ... | ... |
| May 3– 9 | ... | 1 | 11 | 90 | 12 | ... | 20 | ... | 2 | ... |
| 10–16 | ... | ... | 3 | ... | 10 | ... | 4 | 5 | 1 | ... |
| 17–23 | ... | ... | ... | ... | 3 | ... | 16 | 2 | ... | ... |
| May 24 through July 25—weir inoperative due to washout and repair. | | | | | | | | | | |
| July 26 through September 19—no fish movement through weir. | | | | | | | | | | |
| September 20–26 | ... | 2 | ... | ... | ... | ... | ... | ... | ... | ... |
| 27– 3 | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... |
| Totals | 35 | 5 | 27 | 113 | 50 | 1 | 100 | 7 | 5 | 1 |

(Figure 4). Many difficulties were experienced due to anchor ice, excessive water volume and washouts. The weir was operated from March 23, 1943, to May 23 at which time a washout occurred which kept the weir inoperative until July 25. No fish used the weir from July 26 through September 19 and only three trout moved through from September 20 to October 3. The numbers of fish moving through the weir are given in Table 3.

A total of 344 fish of all species used the weir during the period of operation and 91 of these were trout. Movement was approximately equal moving upstream (180 fish) and moving down-

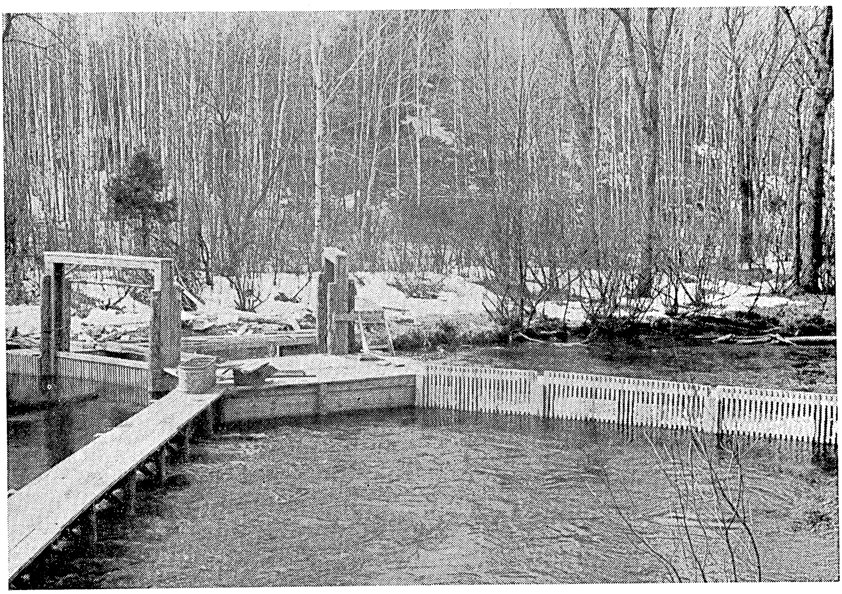

FIGURE 4. Two-way weir and fish trap, Ranger Station.

stream (164 fish). Rainbow trout were most abundant with 35 moving upstream with the peak movement during the last week in March, and 50 moving downstream with the peak during the last week in April and the first two weeks in May. Only six brown trout were recorded, five moving upstream and one downstream. In addition to trout, several other species moved through the weir. Common suckers moving upstream amounted to 27 and the Lake Superior sucker 113 with the peak movement during the first week in May. The movements downstream were reversed with 100 common suckers and only seven Lake Superior suckers. In addition, five yellow pike perch and one northern pike moved downstream.

## TABLE 4

NUMBER AND SPECIES OF FISH MOVING UPSTREAM AND DOWNSTREAM IN NEBAGAMON CREEK, A MAJOR FEEDER FLOWING FROM NEBAGAMON LAKE

| DATE 1942 | HxO TEMP. | MOVING UPSTREAM | | | | | | MOVING DOWNSTREAM | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Brook Trout | Rnb. Trout | Brown Trout | Steelhead Trout | N. Pike | Suckers | Brook Trout | Rnb. Trout | Brown Trout | N. Pike | Yellow Walleye | Suckers | Black Bullhead | Perch | Snapping Turtle |
| April | | | | | | | | | | | | | | | | |
| 3 | 35 | | 3 | 4 | | | | | | | | | | | | |
| 4 | 38 | | 4 | 3 | | | | | | | | | | | | |
| 5 | 36 | | 1 | 3 | | | | | | | | | | | | |
| 6 | 36 | | | | | | | | | | | | | | | |
| 7 | | 1 | 3 | | | | | 3 | 10 | 3 | | | | | | |
| 8 | 42 | | 5 | 1 | | | | | | | | | | | | |
| 9 | 42 | | 3 | 1 | | | | 2 | | | | | | | | |
| 10 | 39 | | 1 | 2 | | | | | | | | | | | | |
| 11 | 43 | | | 1 | | | | | | | 1 | | | | | |
| 12 | 40 | | | 1 | | | | | | | | | | | | |
| 13 | 43 | | 1 | | | | | | | | 1 | 1 | | | | |
| 14 | 46 | | 5 | 1 | | | | 3 | | 1 | 1 | 1 | 1 | | | |
| 15 | 48 | | 5 | | | | | 1 | | | 6 | 3 | | 2 | | |
| 16 | 41 | | 3 | 1 | | | | | | | | 1 | 1 | | | |
| 17 | 44 | | 3 | | | | | | 2 | | | 2 | 1 | | | |
| 18 | 45 | | | | | | | | | | | | 5 | | 1 | |
| 19 | 46 | | 1 | | | | 1 | | | | | | | | | |
| 20 | 47 | | | 1 | | | 1 | | | | | | | | | |
| 21 | 50 | | | | | | | | | | | | | | | |
| 22 | 55 | | | | | | 3 | | | | | | 16 | | | |
| 23 | 56 | | 1 | 1 | | | 4 | | | | 4* | | 19 | | | |
| 24 | 58 | | | | | | 12 | | | | 2 | | 25 | | | 1 |
| 25 | 53 | | | 1 | | | 16 | | | | | | 30 | | | |
| 26 | 58 | | | | | | | | | | | 2 | 14 | | | 1 |
| 27 | 56 | | | | 1 | 1 | 17 | 2 | | | | | 9 | | | 1 |
| TOTAL | | 1 | 39 | 21 | 1 | 1 | 54 | 11 | 12 | 4 | 15 | 10 | 121 | 2 | 1 | 3 |

*One 25 pounds.

Two fyke nets were set in Nebagamon Creek (major feeder) in such a manner as to block fish movements and sample movements upstream and downstream. The nets were lifted daily for 25 days during the month of April. The numbers of fish taken are tabulated in Table 4. The water temperature varied during the period from 35 to 58 degrees Fahrenheit. Sixty-two trout, principally rainbow, moved upstream, as well as one northern pike and 54 common suckers. The movements of fish downstream from Nebagamon Lake was more varied with 27 trout, 15 northern pike (one 25 pounds in weight), 10 yellow pike perch, 121 common suckers, 2 black bullheads, 1 perch, and 3 snapping turtles.

The fish population of Big Lake (a widespread of the Brule River) was checked for 28 net days during the month of July. Fyke nets were used and no trout were caught. The total catch consisted of 1,071 common suckers, 22 horned dace, 9 five-spine stickleback, 2 muddlers, and 1 Johnny darter.

It is most apparent from the weir collections, shocker collections, seine, and net collections that the common sucker is the most abundant fish in the stream and comprises almost 25 per cent of the total fish population.

## SPAWNING AREAS AND TROUT SPAWNING

A survey of spawning area and observations on spawning of trout were made in the fall of 1943. Most of the spawning activity was found in three areas: Winneboujou, Cedar Island, and South Fork Springs.

The South Fork originates in a series of springs. The current is moderately fast here and the bottom is gravel suitable for spawning beds. The first sign of activity was noticed on October 17 and on October 28,—about 75 brook trout, six to 12 inches long were seen spawning in about four inches of water in one area. Occasional nests were found for about one-half mile downstream. No brown trout were seen in this area.

The spawning beds at Cedar Island were used by both brook and brown trout. Brown trout spawned during most of October while brook trout activity began late in October and continued into November. The brown trout mostly spawned in deeper water, though the beds of the two species frequently overlapped.

The available spawning grounds in the Cedar Island area consists of the part known as May's Rip, about 400 feet long and a stretch about 200 feet long below the bridge. Both have fast water and a coarse gravel bottom. Brown trout were first observed on these beds on October 7 and by October 14 about 70

TABLE 5

ANALYSIS OF NESTS OF RAINBOW TROUT FROM CEDAR ISLAND AREA

| Nest No. | Total Eggs | Dead Eggs | % Dead | Viable Eggs | % Viable | Early sac-fry | Advanced sac-fry | Sucker Eggs | Date |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 703 | 460 | 65.5 | 243 | 34.5 | ..... | ..... | 282 | May 19, 1943 |
| 2 | 154 | 46 | 29.9 | 108 | 70.1 | ..... | ..... | 1,078 | May 19, 1943 |
| 3 | 45 | 40 | 89.0 | 5 | 11.0 | ..... | ..... | 800 | May 19, 1943 |
| 4 | 112 | 23 | 20.6 | 89 | 79.4 | ..... | ..... | 990 | May 19, 1943 |
| | | | | All above at May's Rip. | | | | | |
| 5 | 20(eyed) | ..... | ..... | 20 | 100% | 205 | ..... | 140 | June 4, 1943 |
| 6 | ..... | ..... | ..... | ..... | ..... | ..... | 150 | 110 | June 4, 1943 |
| 7 | ..... | ..... | ..... | ..... | ..... | ..... | 520 | 105 | June 4, 1943 |
| 8 | 11 | ..... | ..... | 11 | 100% | 190(+8 dead) | | 693 | June 4, 1943 |
| | | | | (Miscellaneous insect larvae in all collections.) | | | | | |

were present, spawning in about 18 inches of water. A few brook trout were also seen at this time. By October 28, the brown trout had left and the brook trout were spawning in the same area; some were still active on November 24.

The main spawning area at Winneboujou consists of about one and one-half acres of gravel bottom rapids above Highway B. Thirty-four nests were counted here on October 18 and it is probable that many more escaped notice. On the same day 12 more nests were counted in a gravel bar approximately 100 feet long, about one-half mile above the main area.

A considerable area at and below the ranger station appears suitable for spawning, but no activity was observed. Small patches of suitable gravel occur between Stone's Bridge and Winneboujou, and also in the lower part of the river. A few nests appeared on some of these spots, but no other large concentrations were seen.

Wilson Creek appears to be suitable, at least for small trout. The bottom is good gravel, though the water is shallow. No spawning was observed here. Stoney Brook is also suitable and trout eggs were found here in bottom samples. Some spawning grounds are present in the Little Brule. This stream also receives refugee fingerlings from the hatchery but they are blocked off from the main river by several beaver dams.

Spawning of rainbow trout has been observed in both the Cedar Island and the Winneboujou areas, on the same beds used by the brown trout in the fall. It is unlikely that this species utilizes the South Fork Springs.

Eight nests of rainbow trout were dug up in the spring of 1943 in the Cedar Island area. Eggs and fry washed out by the current were caught on a screen and counted. The results appear in the following table (Table 5). Large numbers of sucker eggs were recovered along with the trout eggs, showing that suckers spawn in the same beds. It is doubtful if this activity affects the trout nests since trout eggs are usually well buried in gravel.

There is a series of spring ponds totaling approximately 34 acres in the Cedar Island region. All have gravel bottoms and provide excellent spawning beds. They are interconnected and originally opened into the river at several points. When the Pierce Estate was developed, a private hatchery was established and the entire chain of ponds was blocked off from the river. Re-opening of these ponds would greatly increase the spawning area available to the stream population.

TABLE 6

OBSERVATIONS ON SPAWNING OF TROUT

| DATE | MAXIMUM AIR TEMPERATURE | ATMOSPHERIC CONDITIONS | SPAWNING AREAS—BRULE RIVER | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | S.S.R.R. | Pierce Estate Bridge | May's Rip | North Fork at Landberg's | South Fork at Rocked-in Springs | Blue Springs at Stone's Place |
| Sept. 23 | 59 | clear | — | — | — | — | ........ | — |
| Sept. 30 | 65 | rain | — | — | † | — | ........ | — |
| Oct. 7 | 67 | overcast and rain | — | † | †† | † | ........ | — |
| Oct. 14 | 62 | cloudy | † | †† | ‡†† | † | † | — |
| Oct. 21 | 60 | cloudy | † | ‡†† | ‡†† | † | † | — |
| Oct. 28 | 63 | partly cloudy | † | ‡†† | ‡†† | ‡ | ‡†† | — |
| Nov. 4 | 34 | overcast and snowing | † | ........ | ........ | ‡ | ‡†† | — |
| Nov. 11 | 39 | overcast | ‡ | ‡†† | ‡†† | ........ | ‡†† | — |
| Nov. 18 | 32 | overcast | ........ | ‡† | ‡† | ........ | ‡†† | — |
| Nov. 24 | 34 | overcast | ........ | ‡ | ‡ | ........ | ‡†† | — |

*Key.
— No evidence.
† Spawning preparations.
†† Heavy concentration.
‡ Spawn was found.

## OBSERVATIONS ON SPAWNING OF TROUT

The object of this investigation was to gather additional information on the spawning habits of brook and brown trout in the Brule River.

The observations were made at accessible areas along the upper section of the Brule River in Douglas County and recorded at one-week intervals. The atmospheric conditions with above normal precipitation hampered visibility materially. Six stations were set up on September 23, 1944, for observation (Table 6).

### S.S.R.R. BRIDGE STATION

Water was too deep and dark for good observations. However, on October 14 the first evidence of any preparations for spawning was observed. Three brown trout were working over two gravel beds that were 50 feet apart. Both beds were small. The largest had a diameter of four feet. The trout were from 12 to 15 inches long. It was not until November 11 that eggs were found in these beds and the eggs were definitely brown trout. On the same date and in the same area a fourteen-inch brown trout was found dead, apparently of internal hemorrhage. This station has a great potential as a spawning area for rainbow trout. The length of the area checked was five hundred feet. The bottom is of gravel and sand with very little cover.

### PIERCE ESTATE BRIDGE

The area checked at this station was two hundred feet long and the width of the river (50 feet). This area is of semi-rapids type with a coarse gravel bottom and shielded by many cedar trees in and over the water. Seven spawning beds were found, the largest having a diameter of eight feet. Five of these were definitely identified as brown trout and two were brook trout. Eggs were found in each. First evidence of spawning preparations was found October 7 with a heavy concentration of trout on October 14, when 21 trout were seen. Only two of these were positively identified as brook trout. Trout 24 inches in length were seen in the concentration. There was much fanning and stirring of the gravel. Eggs were found in this area on October 21 and by October 28 eggs of the brown trout could be found almost everywhere in five gravel beds. Several small brook trout were working two beds directly below the bridge on this date and by November 11 eggs were found in both beds. The brook trout ranged from six to 12 inches in size with white pectoral fins and red along the ventral surface. Brook trout were seen on the spawning beds as late as November 24.

### MAY'S RIP

This constitutes an excellent spawning area. It is roughly four hundred feet long with gravel bottom and trees projecting into the water for shelter. The river in the area is of semi-rapids type. Eleven large spawning beds were found here, the largest being 12 feet in diameter. They were located along the entire ripples. About 50 trout were seen here on October 14. Most of the trout were large brown trout 20 inches and more in length. On this day they were very active fanning and stirring the gravel with great anxiety. Gravel and rocks to a four-inch diameter were excavated and re-piled to form the beds for the eggs. Most of the eggs were found in 18 inches of water and covered with two inches of gravel. By November 11 all of the large trout had left but many small trout were spawning. Most of these were brook trout. They were working in shallower water and sometimes along the edge of the spawning beds of the brown trout. By November 24 the second trout concentration had dispersed.

### NORTH FORK OF THE BRULE AT LANDBERG'S

This is a small stream with clear cold water and gravel bottom. Much of the stream is covered by overhanging banks, logs, and willows which made it difficult to find the spawning beds. Evidence of spawning preparation was found October 7, and by November 4, five small spawning areas had been located with brook trout spawn in each one. The spawn was found in about four inches of water. The trout that were seen on the spawning beds were only six or seven inches long and acted exhausted when disturbed.

### BLUE SPRINGS ABOVE STONE'S BRIDGE

Huge springs bubble out of the earth at this station which flow into the Brule River. The bottom is sandy. Two brook trout were seen in the springs, but no evidence of spawning could be found. The sand bottom seemed improper for spawning.

### SOUTH FORK OF THE BRULE AT THE ROCKED-IN SPRINGS

This is one of the largest spawning areas for brook trout along the entire upper Brule River. It extends from the slow waters at the head of the meadows to the old dam. The water is clear and cold with springs bubbling up along much of the way. The upper part is covered with a heavy growth of alders. The stream at this station is of semi-rapids type with a gravel bottom. The area was first visited on October 14 when evidence of spawning preparations were found. By October 28 the entire area seemed to be a mass of spawning beds. At least 75 brook trout were seen on the beds that day and they ranged from six to 12 inches in length. As one approached the uncovered area the trout caused huge ripples as they swam away. The trout were spawning in about four inches of fast water and in gravel that reached two inches in diameter. Here one could see the larger trout take over their favorite spawning spot and should a small trout enter along the side, the larger trout would lash him with his tail. By November 24, the concentration had been reduced to about two-thirds. Brook trout spawn could be found along the entire way.

## Summary

1. Large trout spawn earlier than small trout.
2. Brown trout spawned earlier than the brook trout.
3. Brown trout spawn in deeper water than brook trout.
4. Both brown and brook trout are highly colored during spawning.
5. Brook and brown trout concentrate at definite places for spawning purposes.
6. Brown trout spawn was found on May's Rip one week before the hatchery trout at the Pierce Estate were ready to spawn.
7. Highly oxygenated water and gravel bottom determine the spawning areas.
8. Air and water temperatures are spawning factors.
9. Small trout appear to be driven away from the spawning spots of the larger trout.
10. Trout lose much of their vitality during spawning.

In the great urge for reproduction, trout travel far and wide to a place where the water is highly oxygenated and the bottom is coarse gravel. Here they concentrate in great numbers constantly twisting and turning with great anxiety to show their beautiful colors. Soon they begin to fan and excavate the gravel to build a place where they can deposit their eggs when the temperature is right. Many are bruised and battered during this time, and some die.

At about twelve noon on Friday, October 29, a pair of brook trout, about 24 inches in length, were observed working on a nest at Rand's landing. They were about two feet out from the log that joins the edge of the landing. There are several large rocks here, and the bottom is gravel covered with sand. They were clearly visible. Observations were made from 12 to 1 P.M. and from 2 to 4:30 P.M., at which time they were frightened by some movements and did not return.

When first seen, the nest was about 1 x 2 feet, of gravel one to two inches in diameter and well cleaned. The female was on the nest, the male close beside her and about one-half his length behind. Three small brook trout, presumably males, one about 12 inches long and the other two about eight inches, were swimming or resting a few feet away, behind or beside the large fish. When one approached within a foot of the fish on the nest, the male would turn and chase it away about eight to ten feet and return to his position.

The female was clearing the nest with no help from the male. While on the nest, she rested on the bottom with paired fins outspread and undulated slowly. In this movement her head remained almost stationary, her body moving in waves as in swimming, but slowly, and apparently with considerable effort. She gave the impression that she was actually rubbing the bottom with her pelvic and anal fins, perhaps loosening the gravel. Every few minutes she would turn on her side and fan violently with her tail, sending up a cloud of sand. After each fanning operation she would circle around and nose at the nest before resuming her position. At about ten-minute intervals she would drop back or move aside and rest. At such times the male would either rest beside her or swim around and keep the smaller fish off the nest.

During this procedure, the small fish remained a few feet away, either behind or beside the larger fish, occasionally trying to dart into the nest and being chased away by the male. The female paid no attention to them. The larger of the small fish would sometimes take up a position just behind the large male. When he came too close, the large male would turn and chase, apparently aware of his presence by movements of the water, since he could not see him. When both large fish were absent, the small ones swam around and over the nest until chased.

When the female rested off the nest, it seemed that toward the end of each rest period the male would nudge her as if urging her back to the nest.

At 2 o'clock, both fish were still on the nest, in the same position, but the movements of the female were different. She was weaving slowly, but in much wider sweeps without effort. The three small fish were still around.

After a few minutes, the large male swam away. His place was taken by the largest of the small males, who held it until he returned and then dropped back just behind him. This happened several times during the period; the large male was absent about one-half of the time. While the small male held this place, he sometimes turned to chase the smaller fish.

After about half an hour, the female stopped weaving and lay quiet on the nest. The large male was absent at this time, the small one in his place. After the female stopped moving the small male moved up beside her and rubbed against her side, then dropped back. This happened seven times in about 15 minutes. The female seemed to ignore him. Then she resumed her weaving and fanning and chased the male away on his next approach. This was the first time she seemed to notice him. He continued his attempts and was sometimes chased, sometimes ignored. The female kept on working. This continued until the large male returned.

The large male replaced the small one and behaved the same way; the female showed no response. Frequently, both fish left the nest together, circled about six feet downstream and returned. Soon the advance of the female changed; the male approached, pressed against the female, arched his back slightly and seemed to vibrate all over, especially the dorsal fin. The approaches became more frequent and lasted longer. After three or four long performances (each one-half minute) in close succession the male swam away.

This must have been the time at which the eggs were laid. They could not be seen because of the position of the fish. The time was about 3:30 P.M.

The female then moved up just above the nest and fanned as before, stirring up considerable mud. After each fanning she swam downstream four or five feet and waited for the mud to settle, then returned to the nest where she lay quiet until the next time. She continued this action for an hour or more, fanning toward the nest from all directions.

The covering was a long and careful operation. Each time after fanning, the female returned and lay on the nest, apparently investigating its condition. By 4:30 P.M. the nest was completely covered and indistinguishable from the rest of the bottom. The female worked more slowly toward the end.

During the covering process the male came and went at intervals. When present, he made advances as before, vibrating as before, but was not so insistent. He seemed to gradually lose interest, and at the end remained in the vicinity without making advances. The small fish stayed around for the entire performance.

Three times during the second period of observation the female left the nest, rose to the surface and gulped. It was impossible to determine whether she was feeding or taking in air. The male did not do this.

OTHER OBSERVATIONS—Pool at Solsich Place

| | |
|---|---|
| October 4 | Saw about 30 large browns, may have been more. Large area of gravel cleaned. |
| October 10 | Fish still there; no apparent change. |
| October 19 | Fish still there; several finished nests in and above the pool. |
| October 20 | Six fish clustered over one nest. Three large in V-formation, three smaller swimming around. Large fish in center moved the least, could be females, other large fish sometimes drifted away and returned. After about ten minutes all left, possibly frightened. One-half hour later, two large fish chased away the smaller ones and then took turns chasing each other. Both always returned. No other fish seen in pool but some might have been present. |
| October 26 | No fish seen; nests covered. |

*Channel East of Island Above Solsichs*

| | |
|---|---|
| October 4 | Four large fish, apparently all males, on two large cleaned areas. Chased each other frequently. |
| October 17 | Four large fish present; three nests started. |
| October 20 | One fish resting quietly on nest. |
| October 28 | Female making nest; lay quiet for a few minutes, drifted back, circled around and returned, turned on side and fanned violently, then rested and repeated the procedure. Male arrived from upstream, swam around aimlessly and went away again. This occurred twice. Female swam away, returned often, swam around but did not work on nest. Remained for a while at a short distance from the nest and then swam off. This was probably the end of the covering process. Two smaller fish were swimming around all the time; remained after large fish left. (All fish were brown trout) |

*Noyes Place*

| | |
|---|---|
| October 19 | About 12 fish and 12 nests seen from canoe. |
| October 26 | About 30 fish scattered over large cleared areas of gravel. No individual nests distinguishable. Occasionally one would approach |

| | |
|---|---|
| | another and drop back again. Sometimes one would chase another away. Saw one female fanning, turned on her side. Several smaller fish around the edge of the cleaned areas. |
| October 28 | Fish appear somewhat more closely grouped on four large beds, slightly more active than last time. |
| October 29 & 30 | No change. |
| November 2 | No fish seen. |

## SPAWNING AREAS IN THE BRULE RIVER

The term "spawning area" is applied here to any part of the river where the bottom is composed, entirely or in good part, of gravel from ½ to 3 inches in diameter which is bare or may be cleared off by the fish, where the water is deep enough for the fish to maneuver, and the current is steady but not too fast. It is assumed that smaller fish will spawn in smaller streams, and in such places, areas of smaller water are listed.

### *Above the Fork*

| | |
|---|---|
| North Fork: | Perhaps 1,000 square feet that appear suitable. |
| South Fork: | An area at the head about 20 feet by 100 feet. The upper part is quite clean; no nest identified but they could easily escape notice here. The lower part has a light sand cover; one nest identified, one brook trout observed October 22, 1944. About one-half mile below is a stretch about 10 feet by 20 feet where two nests were observed, one occupied by a pair of brook trout. Below this there are only occasional bare spots. |

### *Forks to Stone's Bridge*

This region has not been fully investigated. Three suitable areas, each about 20 feet square were found in the first two miles above Stone's Bridge. There were two nests on one of these; breeding fish (brown trout) were taken from another. There may be other suitable areas above, but in general this part of the stream is not suitable for spawning.

### *Stone's Bridge to May's Rip*

This section includes one 500-foot stretch where about 15 per cent of the bottom is usable. Aside from this there are only occasional areas of from 25 to 200 square feet where spawning might be possible, perhaps 1,000 square feet in all. One nest was observed just below a deflector on October 18.

### *May's Rip to Winneboujou*

There are three principle spawning areas in this section: *May's Rip:* a considerable area, 20 feet by 400 feet of gravel one to four inches in diameter. Twenty-one nests seen here October 18, one occupied by a pair of brown trout. *Noyes' Place:* A strip of gravel about 100 feet by 15 feet, finer and more uniform than at May's Rip. About 12 nests and about 12 fish counted here October 18. *Winneboujou:* A long strip of gravel about 1,500 feet long, 20 feet to 40 feet wide. The upper end is a large pool 50 feet by 100 feet. About 30 fish observed here October 4; twenty-three nests counted October 18. Below this the stream is narrower and the water faster. Eleven nests counted here October 18, but many were probably overlooked because of poor visibility.

In addition there are about a dozen smaller areas, totaling perhaps one-half acre. Eight nests observed on these areas October 18.

### *Winneboujou to Nebagamon Creek*

Two areas, each about 50 feet square, have been used in other years. Several smaller areas might be usable.

### *Nebagamon Creek to Little Joe*

No suitable bottom.

### *Little Joe to Highway 2*

Practically all good gravel to 500 feet below Ranger Station. Spawning reported in two places here in other years. For the next mile, about one-third of the bottom is good.

### *Highway 2 to Co-op Park*

For the last two miles above Co-op Park, about one-half of the bottom is rock and gravel, tightly packed with sand and mud. Some area spots might be usable, but in general the bottom appears to be too solid. Otherwise no suitable bottom.

### *Co-op Park to Johnson Bridge*

Not fully investigated. Good gravel bed about 50 feet by 200 feet above bridge, about the same at McNeal's Bridge. In general, this part of the river is similar to that between Co-op and Johnson Bridge, with probably about the same proportion of good bottom.

*Tributaries*

Wilson Creek

About one mile, average cross section 3 feet by 1 foot. About one-third of bottom bare gravel, another one-third lightly covered with sand. Spawning reported in past.

B 31–1

About one-half mile, average cross section 2 feet by 6 feet. Good gravel bottom but may be too shallow.

B 34

Reported good for spawning; not investigated.

Little Brule

Reported spawning between hatchery and Sandy Run.

Stony Brook

About one-half of bottom is good gravel. Trout eggs found in bottom sample last fall.

## The Food of Trout and Muddlers

During the summer of 1944, the stomach contents of 164 brook trout, 162 brown trout, 114 rainbow trout, and 60 muddlers were examined. These fish represented 47 collections from the Brule River and its tributaries in Douglas County, Wisconsin.

### Material and Methods

With the exception of one fish taken in a fyke net and 16 caught by hook and line, all collections were made with the electric shocker. Collections were made throughout the length of the river and in all the principal feeder streams, and represent all types of habitat found in the system.

Trout taken in these collections were separated into size groups with a 50mm. class interval, and one to six specimens of each species in each size group were selected at random for stomach analysis. Muddlers were not separated by size or species. When possible, stomachs were emptied immediately and the contents brought into the laboratory and kept on ice until examined. In a few cases it was necessary to preserve the contents in the field with formaldehyde. Individual stomachs were not kept separate; each sample examined represented all the fish of one size and species in one collection.

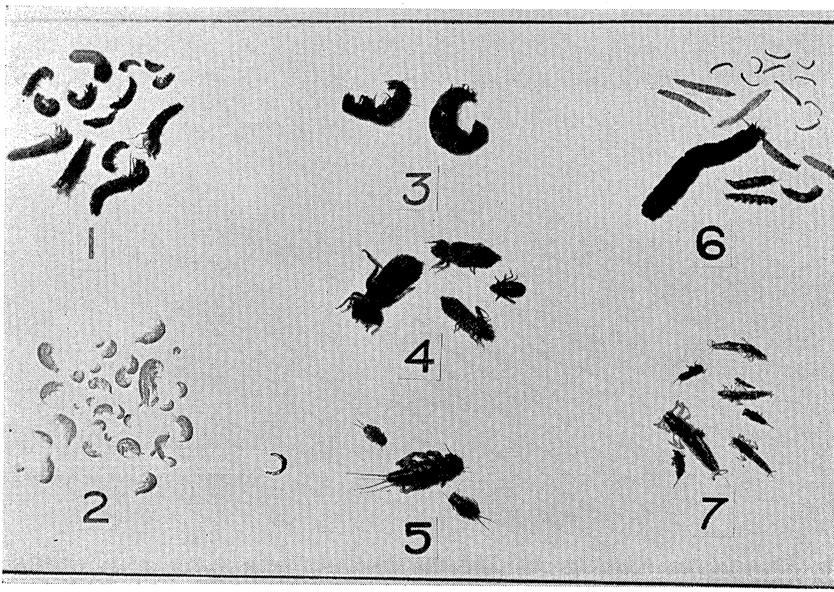


FIGURE 5. Trout Foods.

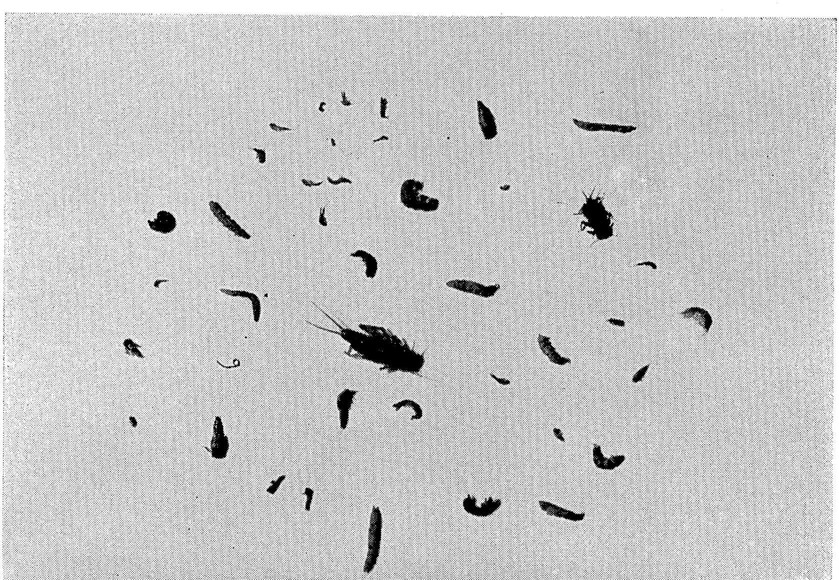

FIGURE 6. Trout Foods.

In the laboratory, unidentifiable material was removed from each sample and the volume of the remainder was measured to the nearest 0.1 ml. by displacement of water in a graduated centrifuge tube. The sample was then sorted and the percentage of the total volume made up by each group of organisms was estimated and recorded (Figures 5 and 6). The number of organisms in each group was also recorded. The volume was then calculated from the measured volume and the estimated percentage. In the case of larger samples, the volumes of the various groups were measured instead of estimated.

The following tables (7–10) show the percentage of the total food of each species and size provided by the various groups of food organisms listed.

TABLE 7

FOOD OF BROOK TROUT, ALL COLLECTIONS, 1944, BY VOLUME

| Total length, mm. | 0–50 | 50–100 | 100–150 | 150–200 | 200–250 | Over 250 |
|---|---|---|---|---|---|---|
| Number of stomachs | 11 | 44 | 41 | 48 | 17 | 3 |
| Total volume, ml. | 0.25 | 2.0 | 6.4 | 35.6 | 20.8 | 16.0 |
| % of total volume provided by: | | | | | | |
| Plants | ...... | 1.2 | 3.4 | 0.3 | ...... | ...... |
| Oligochaeta | 14.8 | 10.3 | 24.5 | 5.0 | ...... | 3.9 |
| Gastropoda | ...... | 0.5 | 3.6 | 0.7 | 0.7 | ...... |
| Amphipoda | 5.2 | 32.9 | 21.4 | 5.5 | 25.4 | ...... |
| Entomostraca | ...... | ...... | ...... | ...... | 4.2 | ...... |
| Plecoptera* | ...... | 0.3 | 0.3 | 2.2 | ...... | ...... |
| Ephemerida nymphs | 8.0 | 15.2 | 4.0 | 14.2 | 8.7 | ...... |
| Ephemerida adults | 1.2 | 1.0 | ...... | 0.3 | ...... | ...... |
| Odonata nymphs | ...... | 0.7 | ...... | 2.3 | ...... | ...... |
| Orthoptera | ...... | ...... | 2.6 | 20.7 | 0.5 | ...... |
| Coleoptera | ...... | 1.2 | 3.2 | 3.8 | 3.3 | ...... |
| Hemiptera | ...... | 0.5 | 5.4 | 0.4 | 11.0 | ...... |
| Trichoptera larvae | 16.8 | 15.5 | 14.2 | 5.1 | 3.5 | 1.5 |
| Diptera larvae | 30.0 | 10.2 | 7.1 | 3.0 | 0.3 | 6.3 |
| Diptera adults | 0.4 | 2.6 | 0.2 | 1.4 | ...... | ...... |
| Hymenoptera | 1.6 | 0.5 | 1.5 | 2.3 | 0.4 | 0.5 |
| Miscellaneous and unidentified insects | 22.0 | 5.4 | 6.6 | 1.5 | 2.1 | ...... |
| Insect eggs | ...... | ...... | 0.2 | ...... | ...... | ...... |
| Spiders and millipedes | ...... | 2.0 | 1.8 | 0.1 | ...... | ...... |
| Fish | ...... | ...... | ...... | 12.9 | 7.1 | 87.8 |
| Frogs | ...... | ...... | ...... | 18.3 | 32.8 | ...... |

*Larvae and adults.

Certain differences in the diet of the three species of trout are apparent upon comparing the three tables. Brook and brown trout consumed approximately the same proportion of aquatic insects, while rainbow trout ate more than either. Brook and brown trout ate more fish and frogs than did the rainbow trout. With the exception of a single group of rainbow trout, represented by only four individuals, Oligochaete worms were not significant in the diets of brown and rainbow trout. They formed as much as 25 per cent of the diet of brook trout. Brown trout consumed more land insects than either of the other species. Brook trout ate more crustacea than the other two species. The consumption of crustacea by brown and rainbow trout was limited to the smaller fishes. Diptera and nymphs of Trichoptera and Ephemerida made up the bulk of the aquatic insects eaten by all trout, however, the proportion of these groups varied in the diets of the three species. Brook trout ate the greatest number of Diptera and brown trout the least. Brook and brown trout consumed about the same amounts of Trichoptera, with rainbow taking somewhat less. Ephemerida were the largest item in the

TABLE 8

FOOD OF BROWN TROUT, ALL COLLECTIONS, 1944, BY VOLUME

| Total length, mm. | 50–100 | 100–150 | 150–200 | 200–250 | 250–300 | Over 300 |
|---|---|---|---|---|---|---|
| Number of stomachs | 16 | 40 | 49 | 19 | 12 | 26 |
| Total volume, ml. | 0.7 | 4.8 | 42.0 | 24.7 | 22.8 | 177.4 |
| % of total volume provided by: | | | | | | |
| Plants | ...... | 0.2 | ...... | 0.1 | ...... | 0.2 |
| Oligochaeta | ...... | 5.0 | ...... | 0.2 | 1.9 | 0.1 |
| Hirudinea | ...... | ...... | ...... | ...... | ...... | 1.1 |
| Gastropoda | 1.4 | 1.7 | 1.9 | 0.3 | 0.2 | 0.2 |
| Pelecypoda | ...... | ...... | ...... | 0.6 | ...... | ...... |
| Amphipoda | 8.6 | 19.6 | 2.2 | 5.9 | 0.5 | tr |
| Decapoda | ...... | ...... | 0.1 | ...... | ...... | 0.8 |
| Ephemerida nymphs | 50.5 | 5.7 | 53.0 | 11.3 | 54.2 | 2.6 |
| Odonata* | ...... | ...... | 0.3 | 1.8 | 0.1 | 0.9 |
| Orthoptera | ...... | 31.7 | 29.3 | 50.5 | ...... | 0.1 |
| Coleoptera | 1.1 | 0.4 | 0.3 | 1.1 | 0.8 | 0.2 |
| Hemiptera | ...... | 0.1 | 0.2 | ...... | 0.1 | tr |
| Neuroptera* | 4.3 | 2.6 | 0.1 | 0.2 | ...... | ...... |
| Trichoptera larvae | 30.4 | 17.8 | 6.0 | 8.1 | 3.6 | 0.1 |
| Lepidoptera larvae | ...... | ...... | 0.1 | ...... | 0.5 | ...... |
| Diptera larvae | 2.3 | 6.5 | 1.5 | 0.9 | 0.4 | ...... |
| Diptera adults | ...... | 0.6 | 0.3 | 0.1 | ...... | ...... |
| Hymenoptera | ...... | 2.1 | 1.0 | 0.6 | 0.8 | 0.1 |
| Miscellaneous and unidentified insects | 1.4 | 2.7 | 1.3 | 1.8 | 0.3 | ...... |
| Insect eggs | ...... | ...... | 1.6 | ...... | ...... | ...... |
| Spiders and millipedes | ...... | 3.3 | ...... | 0.8 | 0.7 | ...... |
| Fish | ...... | ...... | 0.2 | 15.7 | 35.9 | 91.7 |
| Frogs | ...... | ...... | 0.6 | ...... | ...... | 0.1 |
| Mice | ...... | ...... | ...... | ...... | ...... | 1.8 |

*Larvae and adults.

TABLE 9

FOOD OF RAINBOW TROUT, ALL COLLECTIONS, 1944, BY VOLUME

| Total length, mm. | 0–50 | 50–100 | 100–150 | 150–200 | 200–250 | 250–300 |
|---|---|---|---|---|---|---|
| Number of stomachs | 10 | 16 | 39 | 30 | 15 | 4 |
| Total volume, ml. | 0.3 | 0.5 | 17.2 | 62.0 | 19.3 | 6.4 |
| % of total volume provided by: | | | | | | |
| Plants | ...... | ...... | 1.6 | 0.5 | 3.4 | ...... |
| Oligochaeta | ...... | ...... | 5.0 | 0.1 | 0.1 | 62.9 |
| Gastropoda | 1.7 | ...... | 0.1 | 0.4 | ...... | ...... |
| Amphipoda | ...... | 10.9 | 1.6 | 0.2 | 1.3 | ...... |
| Ephemerida nymphs | 51.6 | 35.4 | 28.2 | 46.3 | 13.1 | 21.0 |
| Ephemerida adults | ...... | 1.6 | ...... | ...... | ...... | ...... |
| Odonata adults | ...... | ...... | 0.3 | ...... | 1.0 | ...... |
| Orthoptera | ...... | ...... | ...... | 6.0 | 68.0 | ...... |
| Coleoptera | 5.0 | 12.0 | 0.6 | 0.5 | 1.9 | ...... |
| Hemiptera | 1.7 | ...... | 0.3 | 0.4 | 1.4 | 0.3 |
| Trichoptera larvae | 8.3 | 18.5 | 12.7 | 3.9 | 0.9 | 0.4 |
| Diptera larvae | 20.0 | 10.9 | 12.0 | 6.5 | 2.0 | 0.1 |
| Diptera adults | ...... | 2.2 | 0.8 | 0.1 | 0.2 | ...... |
| Hymenoptera | ...... | 0.4 | 0.4 | 0.7 | 2.1 | 0.3 |
| Miscellaneous and unidentified insects | 6.7 | 5.4 | 4.8 | 0.5 | 1.8 | ...... |
| Insects eggs | 5.0 | 1.1 | 31.1 | 7.8 | 0.1 | ...... |
| Arachnida | ...... | 1.6 | 0.1 | 0.3 | 0.4 | ...... |
| Fish | ...... | ...... | 0.4 | ...... | ...... | 15.0 |
| Frogs | ...... | ...... | ...... | 25.8 | 2.3 | ...... |

TABLE 10

FOOD OF MUDDLERS, ALL COLLECTIONS, 1944, BY VOLUME

| | |
|---|---|
| Number of stomachs | 60 |
| Total volume, ml. | 7.8 |
| % of total volume provided by: | |
| Oligochaeta | 13.0 |
| Gastropoda | 0.1 |
| Amphipoda | 32.8 |
| Ephemerida nymphs | 1.5 |
| Coleoptera | 0.4 |
| Plecoptera nymphs | 0.2 |
| Trichoptera larvae | 14.7 |
| Diptera larvae | 1.4 |
| Fish | 35.9 |

diet of brown and rainbow trout but were taken sparingly by brook trout. Brook trout ate a greater proportion of insects, other than these three groups, the number increasing with the size of the trout.

The food of muddlers is not as varied as that of trout. Four groups,—fish, amphipods, oligochaetes, and trichoptera larvae, furnish 97 per cent of the diet, with fish being of most importance.

## CHEMISTRY AND WATER FLOW

The 22-year average mean rainfall for the Brule River basin is 27.5 inches per year. The elevations within the watershed vary from 602 feet at the level of Lake Superior to 1,220 feet for the high lands, however, the ridges are not high enough to affect the distribution of rainfall over the basin. The lowest average rainfall occurs in the month of January (.93), while February, March, November, and December have 1.00 to 2.00 inches, April, August, and October have 2.00 to 3.00 inches, and May, June, July, and September have 3.00 to 4.00 inches, with the peak rainfall occurring in July (3.96).

TABLE 11

WATER TEMPERATURES FROM HEADWATER TO MOUTH OF STREAM, TAKEN ON SAME DAY. DEGREES FAHRENHEIT

| Location | August | |
|---|---|---|
| | 2 | 9 |
| Highway P (headwater) | 70 | 74 |
| Stone chimney | 68 | 72 |
| Stone's bridge | 67 | 68 |
| Pierce bridge | 67 | 67 |
| Lower end Big Lake | 71 | 74 |
| Winneboujou | 72 | 73 |
| Ranger station | 73 | 75 |
| Highway 2 | 74 | 76 |
| Co-op | 72 | 72 |
| Johnson's bridge | 72 | 73 |
| Highway 13 | 76 | 75 |
| Mouth of Brule | 76 | 76 |

Run-off records have been kept at intervals since 1914. On March 20, 1914, a minimum discharge of 115 second-feet was recorded and on April 21, 1916, a maximum discharge of 1,490 second-feet was recorded with the drainage area above the gauging station being 162 square miles. Records were obtained again during 1928 to 1930 with the gauging station at a point covering a drainage area of 181 square miles. The maximum stage occurred on March 30, 1929 (discharge 905 second-feet), and a minimum discharge of 118 second-feet was recorded on August 18, 1930. The 1943 records of the survey were based upon a drainage area of 130 square miles. The maximum discharge was 426 second-feet on June 14 and a minimum discharge of 67 second-feet on March 13. Even considering the differences in drainage area above the gauging stations there is every indication that the maximum discharge is being reduced and the minimum discharge is becoming stabilized. Undoubtedly more of the rainfall is being retained in the watershed soils as the watershed cover increases.

TABLE 12

AIR AND WATER TEMPERATURES AT TWO STATIONS; STONE'S NEAR HEADWATERS AND RANGER STATION IN MIDDLE SECTION. DEGREES FAHRENHEIT

| Date | July | | | | August | | | |
|---|---|---|---|---|---|---|---|---|
| | Stone's | | Ranger Station | | Stone's | | Ranger Station | |
| | *Air* | *Water* | *Air* | *Water* | *Air* | *Water* | *Air* | *Water* |
| 1 | 74 | 62 | 74 | 70 | 84 | 62 | 81 | 72 |
| 2 | 78 | 64 | 78 | 70 | 89 | 62 | 81 | 72 |
| 3 | 84 | 62 | 71 | 72 | 88 | 64 | 80 | 74 |
| 4 | 74 | 61 | 71 | 72 | 86 | 69 | 85 | 74 |
| 5 | 69 | 59 | 76 | 66 | 78 | 66 | 76 | 70 |
| 6 | 79 | 60 | 67 | 67 | 75 | 66 | 58 | 68 |
| 7 | 89 | 61 | 75 | 70 | 85 | 65 | 72 | 67 |
| 8 | 74 | 66 | 69 | 70 | 86 | 64 | 79 | 69 |
| 9 | 68 | 61 | 70 | 65 | 88 | 64 | 78 | 74 |
| 10 | 78 | 57 | 69 | 63 | 81 | 66 | 84 | 74 |
| 11 | 72 | 55 | 62 | 62 | 82 | 66 | 76 | 72 |
| 12 | 65 | 54 | 69 | 66 | 84 | 68 | 78 | 70 |
| 13 | 75 | 56 | 77 | 70 | 82 | 67 | 76 | 72 |
| 14 | 70 | 58 | 74 | 65 | 80 | 65 | 70 | 69 |
| 15 | 72 | 60 | 76 | 68 | 70 | 62 | 65 | 65 |
| 16 | 83 | 62 | 69 | 68 | 78 | 62 | 64 | 65 |
| 17 | 81 | 63 | 73 | 70 | 72 | 60 | 64 | 65 |
| 18 | 92 | 64 | 69 | 71 | 70 | 59 | 70 | 66 |
| 19 | ...... | ...... | 60 | 65 | 64 | 58 | 76 | 62 |
| 20 | 65 | 55 | 68 | 66 | 84 | 62 | 64 | 66 |
| 21 | 81 | 54 | 70 | 65 | 80 | 62 | 71 | 66 |
| 22 | 80 | 63 | 80 | 68 | ...... | ...... | 65 | 64 |
| 23 | 82 | 65 | 65 | 70 | ...... | ...... | 56 | 62 |
| 24 | 69 | 59 | 75 | 70 | ...... | ...... | 61 | 62 |
| 25 | 84 | 65 | 79 | 72 | ...... | ...... | 72 | 62 |
| 26 | 88 | 64 | 73 | 70 | ...... | ...... | ...... | ...... |
| 27 | 82 | 60 | 63 | 66 | ...... | ...... | 58 | 58 |
| 28 | 60 | 58 | 59 | 62 | ...... | ...... | 65 | 58 |
| 29 | 61 | 59 | 72 | 62 | ...... | ...... | 66 | 60 |
| 30 | 88 | 63 | 71 | 67 | 69 | 55 | 65 | 60 |
| 31 | 89 | 62 | 70 | 67 | ...... | ...... | 62 | 56 |

TABLE 13

CHEMICAL DATA FOR BRULE RIVER, DOUGLAS COUNTY (SEE AERIAL GUIDE, APPENDIX)

| SECTOR | DATE | TEMPERATURE Air F. | TEMPERATURE Water F. | pH | COLOR PPM. | DISOLVED OXYGEN PPM. | FIXED CARBON DIOXIDE PPM. | WEATHER | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Sector AB.......... | May 21 '43 | ........ | 57 | 7.7 | ......... | 9.1 | 43.5 | .......... | |
| Sector DE.......... | Aug. 7 '42 | ........ | 65 | ......... | ......... | ......... | ......... | clear | |
| | Oct. 3'42 | 53 | 47 | 7.0 | 33 | 10.5 | 30.1 | cloudy | |
| | Nov. 8 '42 | 36 | 36 | 7.0 | ......... | 15.3 | 23.7 | clear | |
| | June 6 '43 | 56 | 56 | 7.5 | 130 | 9.9 | 18.5 | cloudy | 1,005 cfs. |
| Sector GH and HI.. | Oct. 3'42 | 58 | 48 | 6.9 | 32 | 11.3 | 25.5 | clear | |
| | Nov. 7 '42 | 28 | 33 | 6.8 | ......... | 12.6 | 22.0 | clear | |
| | June 6 '43 | 52 | 51 | 7.2 | ......... | 9.8 | 18.0 | clear | |
| Trib. 28........... | June 3 '43 | 61 | 57 | 7.0 | 200 | 8.7 | 13.6 | clear | Turbidity 40 |
| Sector IJ.......... | Oct. 2 '42 | 67 | 50 | 6.8 | 13 | 10.9 | 24.8 | cloudy | |
| | Dec. 31 '42 | 26 | 32 | 6.8 | 7 | 10.7 | 25.7 | cloudy | |
| | June 3 '43 | 70 | 54 | 7.4 | 57 | 9.0 | 20.2 | clear | |
| Sector KL.......... | Oct. 2 '42 | 70 | 44 | 6.8 | 36 | 8.0 | 22.2 | clear | Highway P |
| | Nov. 6 '42 | 29 | 36 | 6.8 | 55 | 11.6 | 18.9 | clear | do. |
| | June 3 '43 | 51 | 52 | 6.5 | ......... | 6.7 | 12.3 | .......... | do. new beaver pond |
| | June 21 '43 | 82 | 78 | 6.3 | 400 | 0.35 | 20.2 | clear | do. new beaver pond |
| Trib. 36........... | June 21 '43 | 84 | 66 | 6.7 | 400 | 5.6 | 12.7 | clear | 4 cfs. |

Since water temperature is a prime factor in the life requirements of trout, a series of water temperatures was taken on the same day from the headwaters to the mouth of the river. These readings were taken during August, a month when peak temperatures prevail. The results are shown in Table 11.

The headwater pond is somewhat exposed and has a higher water temperature than further downstream. The stream continues to cool down through the Stone Chimney, Stone's and Pierce Bridges, a section of good cover and numerous springs. The wide expanse of Big Lake causes an increase in temperature which continues to the mouth except for some cooling in the Co-op and Johnson Bridge areas.

Air and water temperatures were recorded at two stations, one near the headwaters (Stone's) and one in the middle section of the stream (Ranger Station), during the months of July and August. The data are given in Table 12.

During July, the upper station reached water temperature peaks of 65 degrees Fahrenheit and the middle station 72 degrees. During August, the peaks were 69 degrees and 74 degrees respectively.

Considerable chemical analyses were made at many points along the main stream as well as feeders. The general water chemistry of the river is satisfactory as may be seen in Table 13, a tabulation of data from certain sections of the river. Sector AB is near the mouth and Sector KL is near the headwater.

## Summary and Recommendations

The Brule River system drains an area of 185 square miles and flows northward to Lake Superior. In early past glacial times, a much larger stream, the outlet of Lake Duluth flowed southward through the valley. Valley characteristics are the reverse of the "normal" watershed. The stream rises in the bog bottom of a mile-wide trench one hundred feet below the level of the sandy barrens and at an elevation of 1,022 feet. Total fall amounts to 420 feet. Fall from the headwaters to the beginning of the copper range (near Brule) is only 92 feet in a distance of 30 stream miles. Most of this occurs in the lower part of sector JK and in sectors HI and GH. The fall through the five miles of copper range amounts to 85 feet, while the falls in the lower reaches, starting about midway between Co-op and Johnson's Bridges, amounts to 243 feet. The most rapid fall is in sector EF with a fall of 110 feet in three stream miles.

The Brule flows through a broad, flat, boggy valley in the headwater area down to Cedar Island. Then through a series of short rapids and the "lakes" down to the mouth of Nebagamon Creek. The stream is generally sluggish and meandering from Nebagamon Creek to the rapids above Co-op Park. Few aquatic plants are found in this section. The lower course from the Co-op rapids to the mouth is a series of short rapids and falls with short pools of quiet water. Little aquatic vegetation is present. This is the area of red clay and the majority of the 29 major slump banks occur in this region.

The flow of the Brule is subject to less fluctuation than that of any other stream in the drainage area. The lowest observed flow (22-year record) being 118 second-feet and the highest, 1,490 second-feet. Natural regulation is due primarily to the yield from the spring bog area of the headwaters and downstream to the rapids below Cedar Island. Discharge is affected somewhat by ice cover during the winter, and especially to anchor ice formation. Anchor ice occurs from the lower end of Big Lake downstream to the mouth and frequently forms anchor ice dams.

The fish population consists of at least 29 species, the most conspicuous of which are brook, brown, and rainbow trout, white sucker, and pike. In addition, there are variable numbers of yellow pike perch, longnose sucker, 5-spine stickleback, muddlers, mud minnows, Johnny darter, horned dace, sharpnosed dace, black bullhead, rock bass, smallmouth black bass, sunfish, perch, and silver redhorse.

Available trout foods are extremely abundant in the upper river (above Big Lake) and are reduced gradually toward the mouth. Caddis and scuds are predominant in the upper section, caddis and mayfly in the middle section, and stone flies in the lower section. The food grade in general is very rich.

Most of the trout contain food in the stomach except during the spawning season. The trout food consists of insects principally; the proportion of aquatic forms being very high during the spring and decreasing during the summer. In late summer and early fall, land insects are the predominant food. Aquatic foods, except for mollusca, are in about the same proportion as found in the bottom samples. Other animal groups forming appreciable percentages of the total diet are: entomostraca (in small fish), scuds, crayfish, fish, lampreys, and in addition, trout eggs. Plant material was found in large amounts only in rainbow trout where such materials frequently composed up to one-third of the total contents. Fish have been found in all three species of trout, mostly in brown trout. Sticklebacks, muddlers, dace, and small trout have been identified. Trout eggs were eaten during the month of May. Twenty-nine tags from the tagged brook trout plants were found in the stomach of a four-pound brown trout.

Molluscs form a very small proportion of the food. A few snails were found in stomachs, no bivalves. The principle food of the small suckers was found to be entomostraca. In large suckers, molluscs and insects were predominant.

1. Chemistry—pH—main stream 6.8 to 7.8 progressing downstream; tributaries all slightly alkaline. Alkalinity 14–31 ppm $CaCO_3$ in the main stream, increasing downstream; feeders 20–30 ppm $CaCO_3$. Dissolved oxygen 9.3–12.63 ppm throughout the year. Highest water temperature 78 degrees (August), Big Lake and below. Food conditions good. Severe silting from ranger station to Lake Superior. Anchor ice formation from Big Lake to mouth.

2. Suckers vary from 10 per cent to 95 per cent of total fish in sections sampled by electric shocker equipment. High percentage in main stream, low in tributaries. Suckers not found in trout stomachs. Recommend further study on relation of suckers to trout.

GENERAL SPECIES COMPOSITION

| *Species* | *Main Stream* | *Feeders* |
|---|---|---|
| Trout | 12.5% | 56.0% |
| Suckers | 22.0% | 11.0% |
| Other | 65.5% | 33.0% |

3. Average number of trout per acre in feeders—2,590. (Approximately 300 per 1,000 feet of stream, 5 feet wide.) Recommend all feeders to be open to fishing.

4. Condition factor of all trout collected and checked in creel is good—(1.52–1.72). Excessive planting of trout might reduce average condition and result in lean fish.

5. Recommend that present fishing season remain in effect and include all species. In addition, we recommend an open period in the fall to take advantage of any fall run of rainbow trout in that area between Lake Superior and Highway U. S. 2.

6. Recommend public acquisition of Cedar Island spring ponds to make area accessible as natural spawning grounds.

7. Protect the headwaters swamp.

(a) There should be no cutting of timber or removal of dead timber.

(b) The alders should not be cut except insofar as to allow a very narrow passage for a canoe.

(c) No roads, trails or other "improvements" should be placed through the headwaters swamp.

(d) None of the springs in the Upper Brule should be opened up or otherwise interfered with or altered.

(e) There seems a possibility that control of overbrowsing by deer may be necessary.

8. In the large spreads, i.e., Big, Lucius, and Spring Lakes, if it seems desirable to narrow the stream and reduce isolation, the planting of wild rice and water lilies is recommended on the mud flats.

9. Control of the barrens is not necessary. (See report No. 5)

10. Institution of an erosion control program for the Nebagamon Creek Watershed is very desirable.

11. Problems of the lower Brule.

(a) Anchorage of slip banks by vegetative and other means may reduce somewhat the silt load in the river, although such banks are a normal feature of geologically young streams and can not be controlled.

(b) The area open to cattle for watering along the river should be limited in order to reduce that possible source of erosion.

(c) The cutting of timber on the immediate banks of the stream and along the banks subject to slumping should be very limited.

(d) No attempt to straighten or otherwise "improve" the stream is recommended.

(e) Control of the erosion on highways, ditches, and banks by changing the method of grading in order to obtain more permanent slopes and a vegetative cover is recommended.

(f) The erosion on the access roads to cottages should be controlled.

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FARQUHARSON, REV. JAMES, 1841. On ground gru or ice formed under peculiar circumstances at the bottom of running water. Philosophical Trans. of the Royal Soc. of London. Vol. 131, p. 37.

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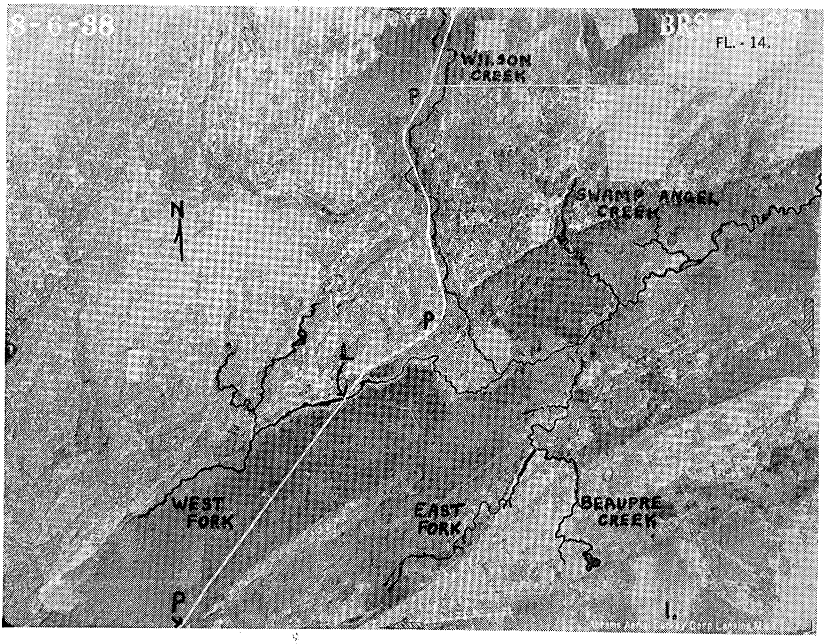
# APPENDIX

# AN AERIAL GUIDE TO BRULE RIVER DOUGLAS COUNTY

**WISCONSIN**

**1952**


8-6-38
BRS-6-23
FL. - 14.
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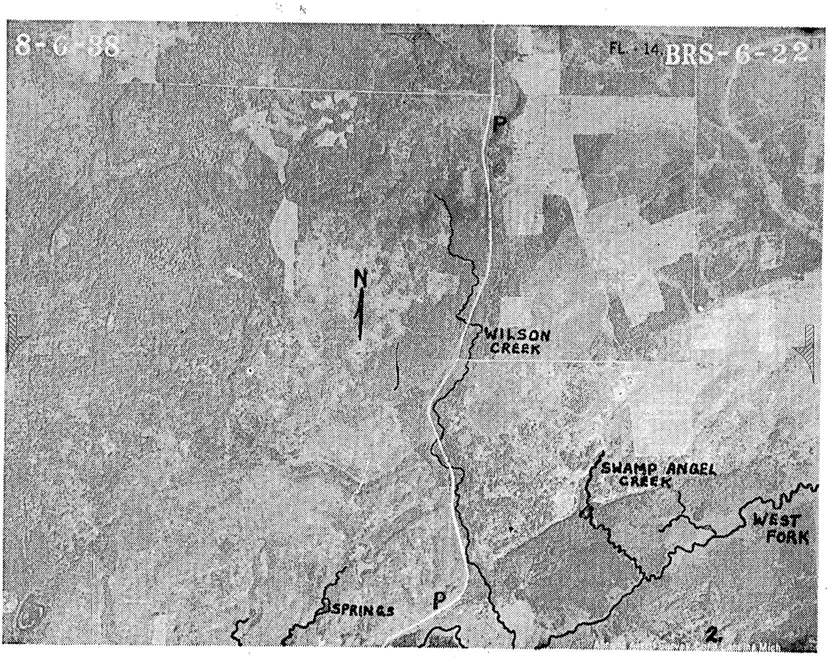
SWAMP ANGEL CREEK
N
P
L
WEST FORK
EAST FORK
BEAUPRE CREEK
P
1.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BRS-6-22
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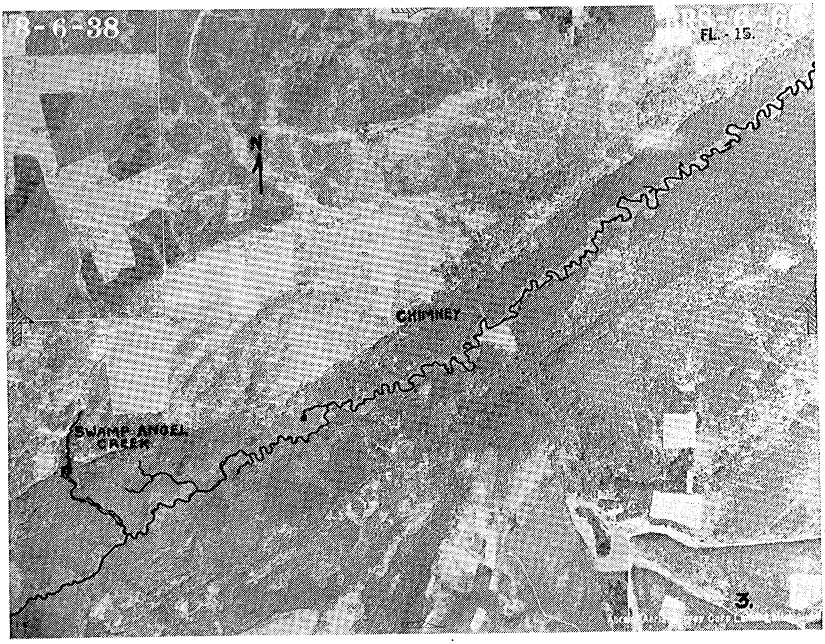
WILSON CREEK
SWAMP ANGEL CREEK
WEST FORK
SPRINGS
P
2.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N
CHIMNEY
SWAMP ANGEL
CREEK
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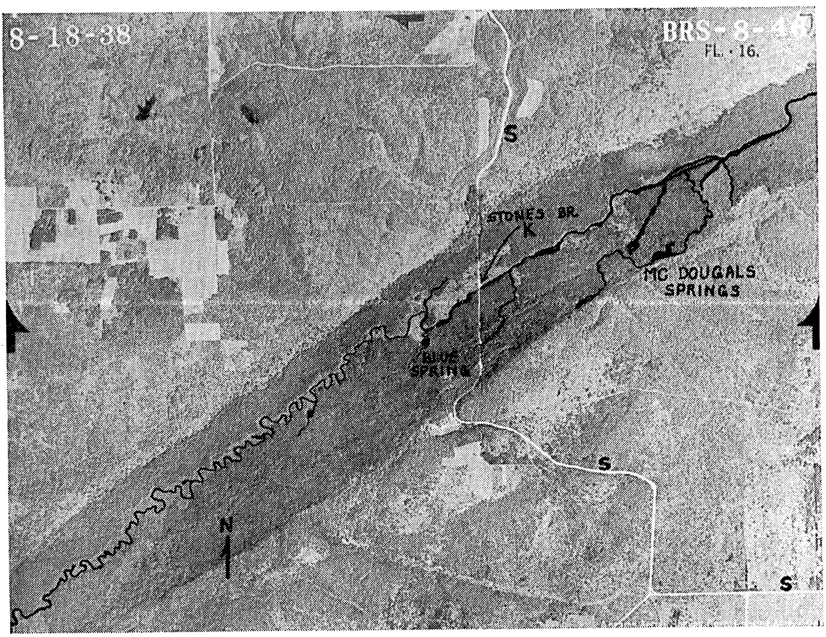
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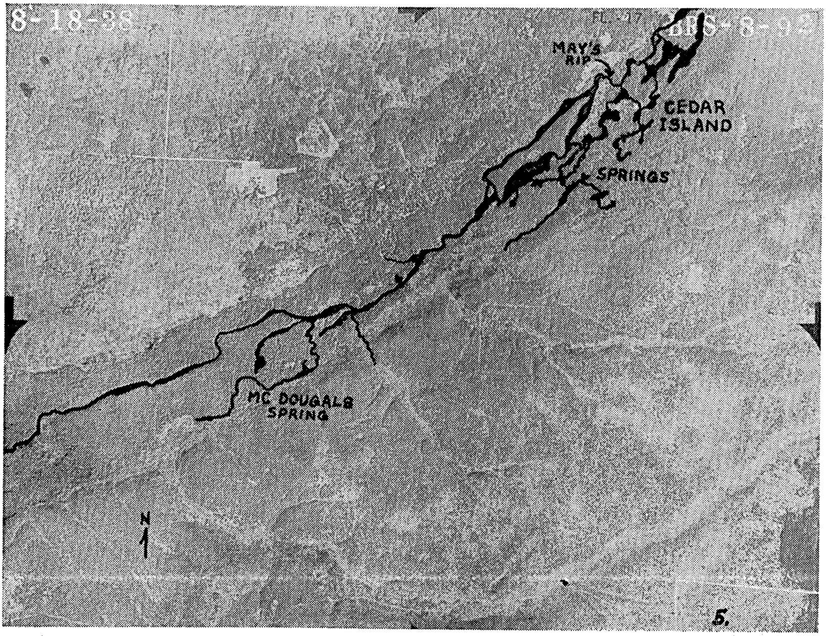
FL. - 16.
S
STONES BR.
K
MC DOUGALS
SPRINGS
BLUE
SPRING
S
N
S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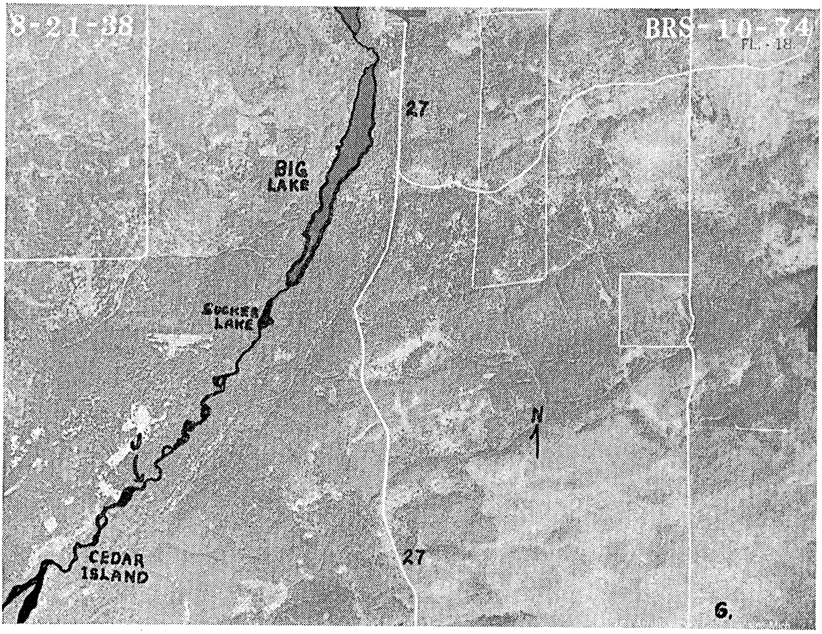
BRS-8-92
MAY'S
RIP
CEDAR
ISLAND
SPRINGS
MC DOUGALS
SPRING
N
5.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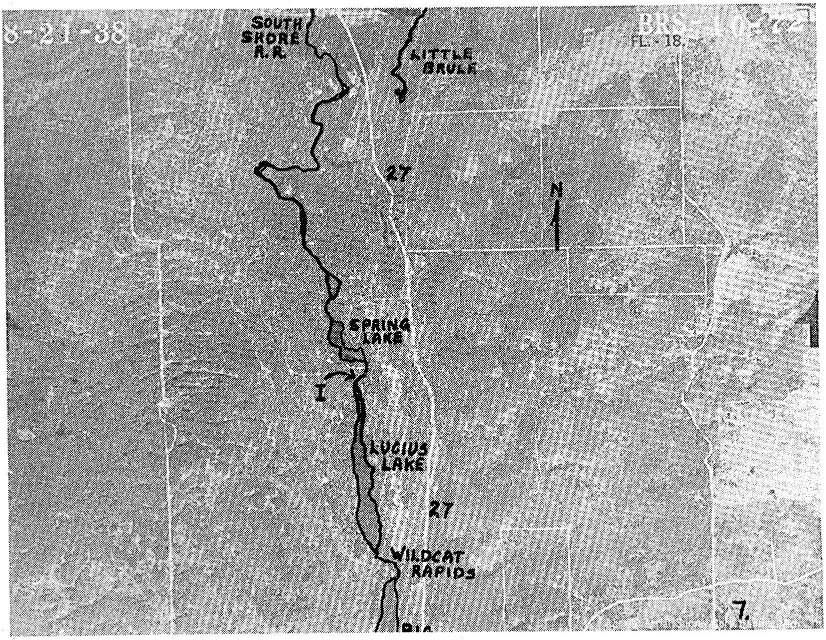
BIG
LAKE
SUCKER
LAKE
J
CEDAR
ISLAND
27
N
6.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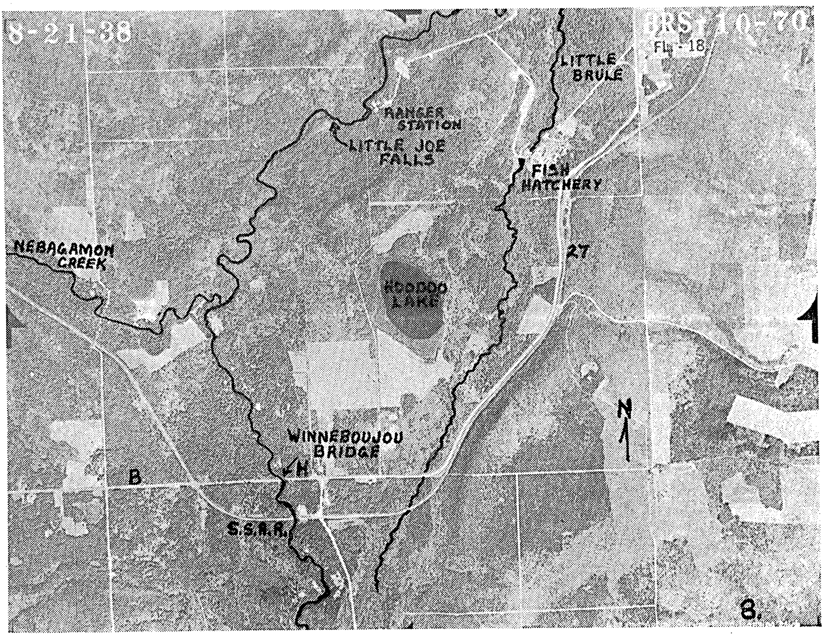
FL.-18
SOUTH SHORE R.R.
LITTLE BRULE
27
N
SPRING LAKE
I
LUCIUS LAKE
27
WILDCAT RAPIDS
7.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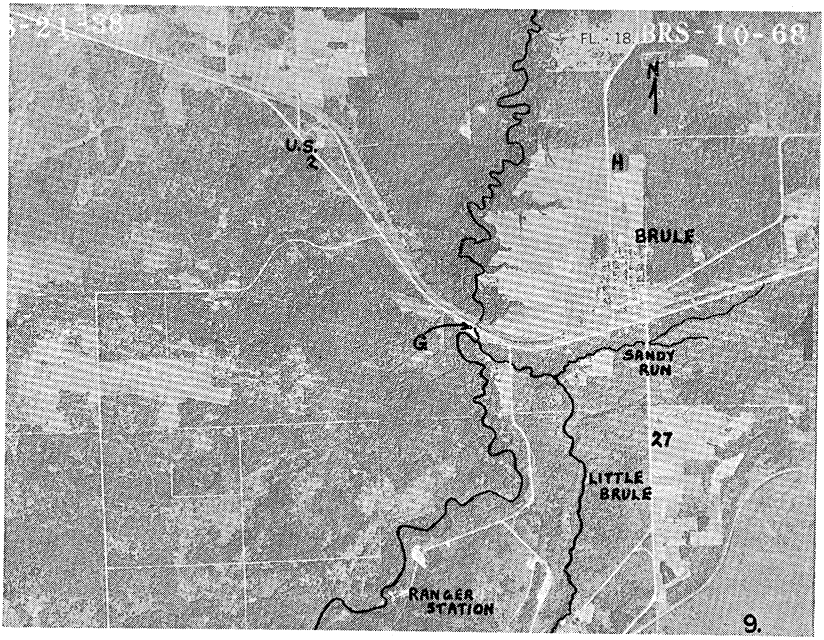
BRS-10-70
FL.-18
LITTLE BRULE
RANGER STATION
LITTLE JOE FALLS
FISH HATCHERY
NEBAGAMON CREEK
27
HOODOO LAKE
N
WINNEBOUJOU BRIDGE
H
B
S.S.R.R.
8.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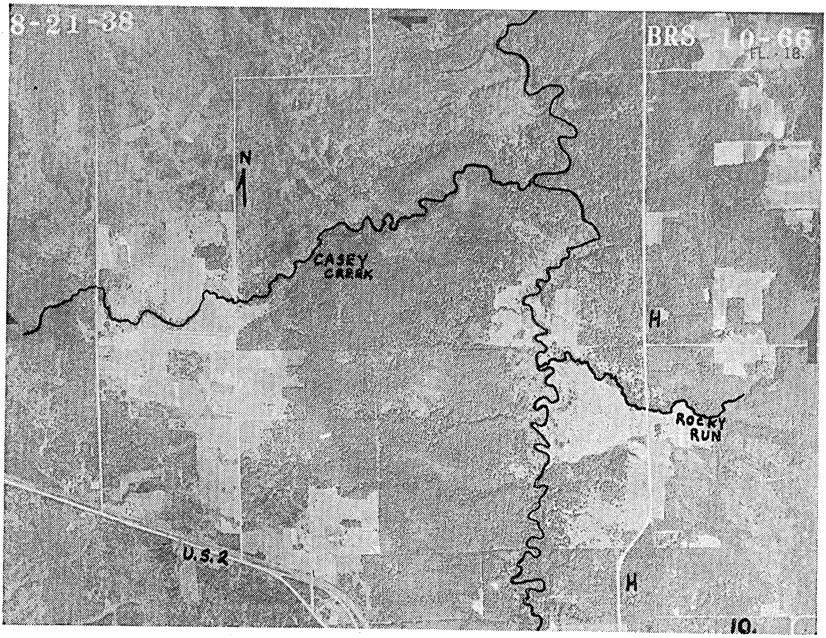
FL. 18
BRS-10-68
N
U.S. 2
H
BRULE
G
SANDY RUN
27
LITTLE BRULE
RANGER STATION
9.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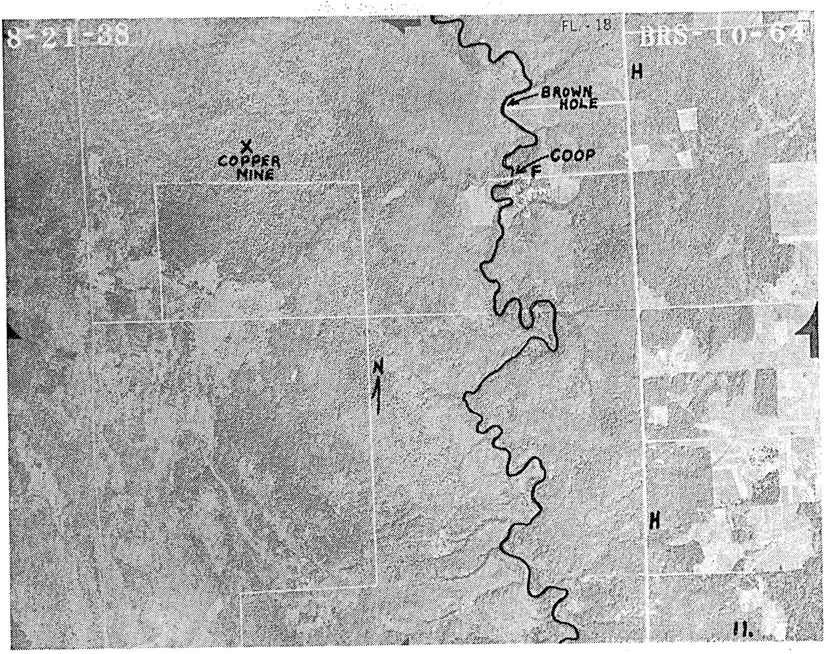
FL. 18
N
CASEY CREEK
H
ROCKY RUN
U.S. 2
H
10.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FL. - 18.
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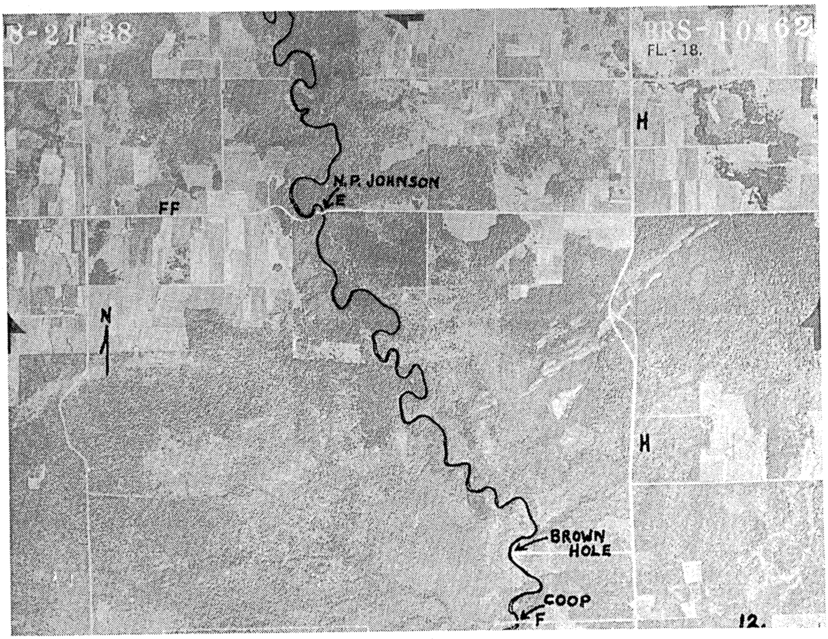
H
BROWN HOLE
X COPPER MINE
COOP
F
N
H
11.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FL. - 18.
H
N.P. JOHNSON
E
FF
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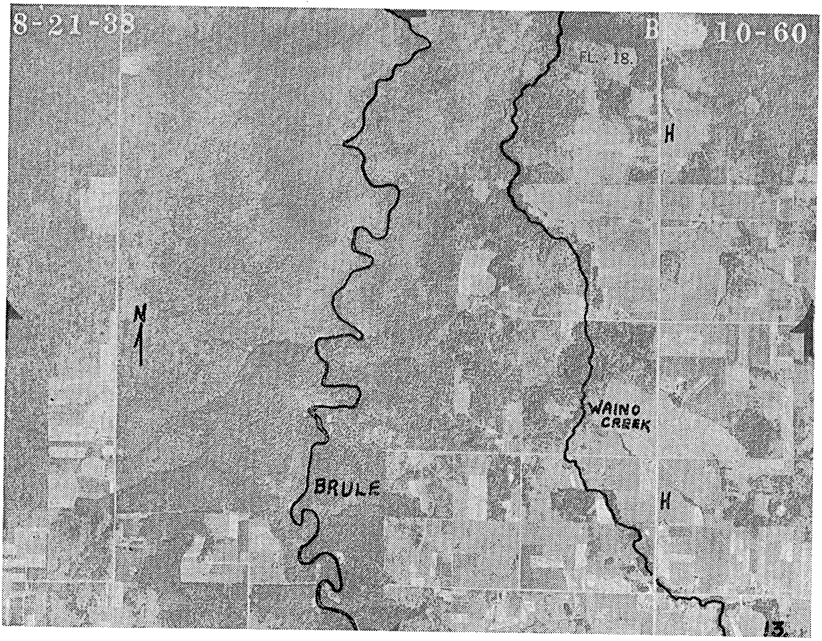
H
BROWN HOLE
COOP
F
12.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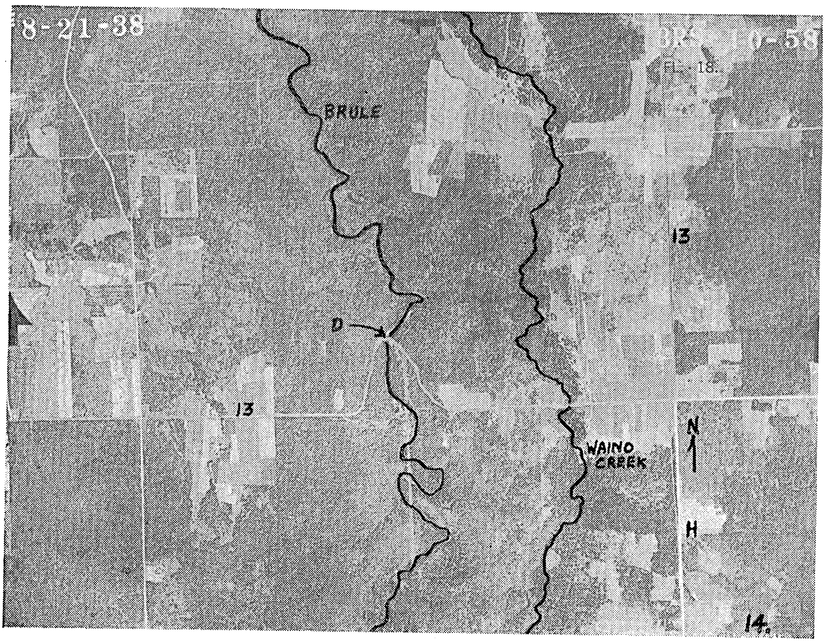
10-60
FL. 18.
H
N
WAINO CREEK
BRULE
H
13.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FL. 18.
BRULE
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D
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WAINO CREEK
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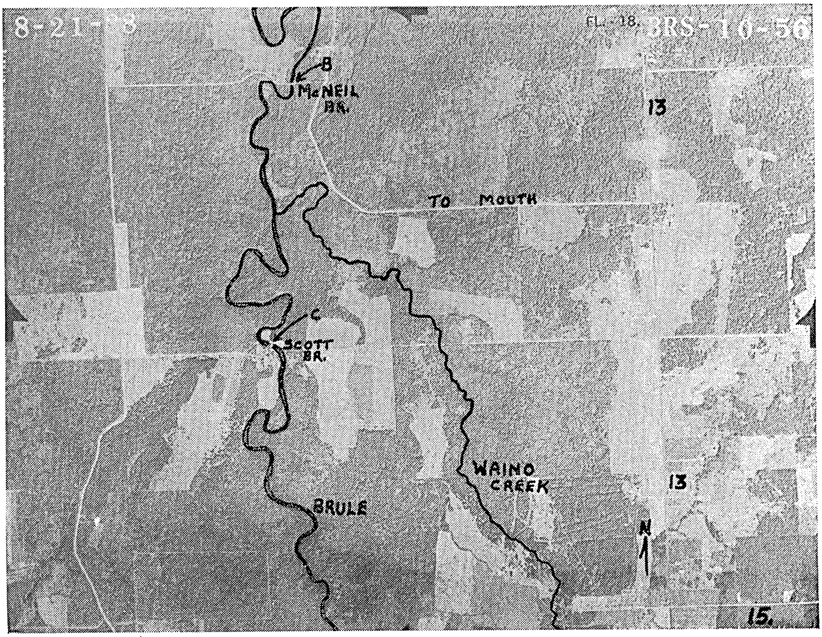
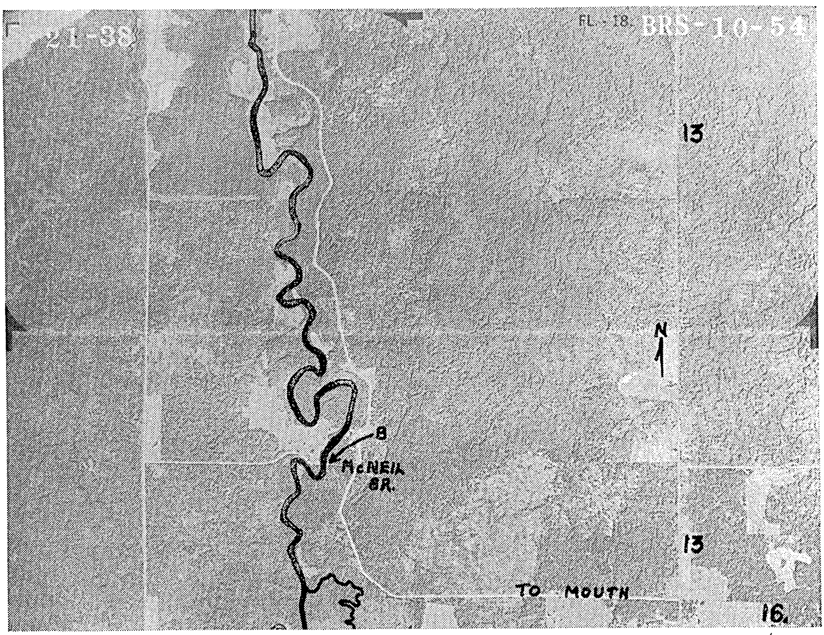

BRS-10-56
B
McNEIL BR.
13
TO MOUTH
C
SCOTT BR.
WAINO CREEK
13
BRULE
N
15.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McNEIL BR.
13
TO MOUTH
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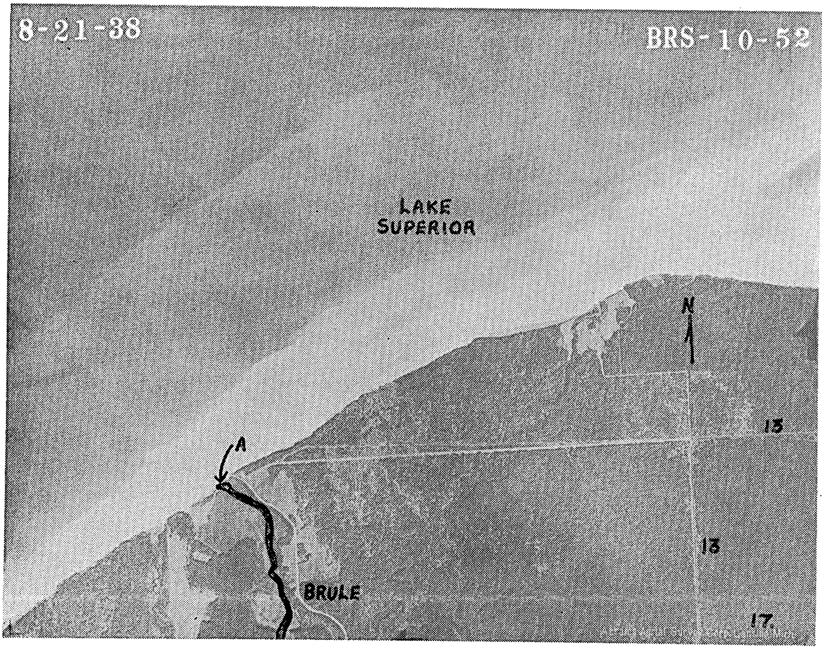
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BRS-10-52
LAKE SUPERIOR
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A
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BRULE
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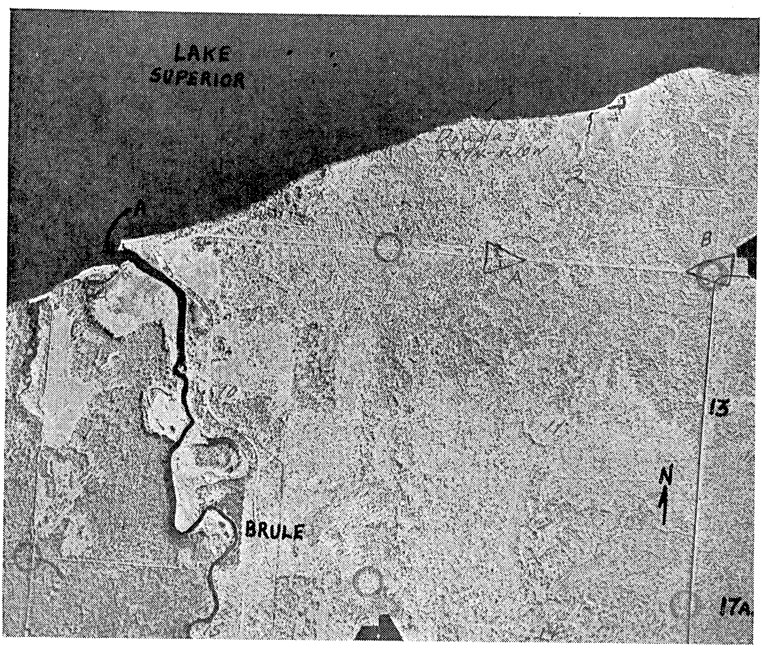
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BRULE
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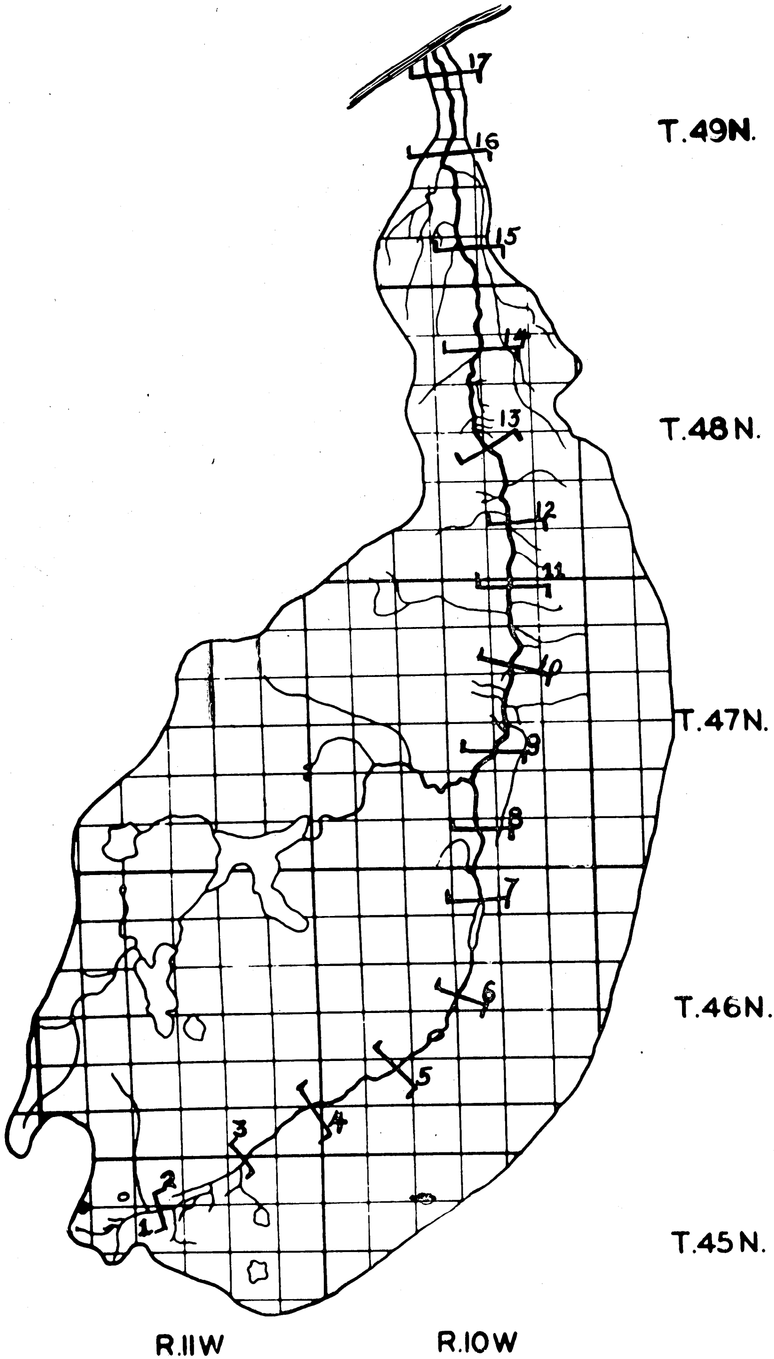
17
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T.48N.
T.47N.
T.46N.
T.45N.
R.11W
R.10W